Implementation of an emission trading scheme in Japan: Evaluation of the current propositions

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In its "Action Plan for Achieving a Low-carbon Society", Japan has proposed to share globally the long-term goal of "halving total global greenhouse gas (GHG) emissions by 2050 from its current level of emissions". In this objective, the government made the commitment to reduce the Japanese GHG emissions by -25% between 1990 and 2020 in the 2009 Copenhagen Agreement.[2]This imposes to increase the effort to reduce greenhouse gas emissions from all the Japanese sectors. All the more so as in 2008a review of the Japanese climate policy estimated that the country would face 22-36 MtCO_2ein excess by 2012 comparatively to the commitment under the Kyoto Protocol.

For the industry, after several voluntary emissions trading system (ETS), a consensus to implement a mandatory scheme has emerged. A smooth transition period keeping the current voluntary ETS is planed until 2013 before making it obligatory. During this period the public authorities must define the ETS structure, especially the scheme period, the total quantity of emission allowances, the covered entities and the allocation method (Ministry of the Environment, 2009). Besides, a particular attention is given to the impact of the scheme on the international competitiveness of the Japanese firms as well as carbon leakage risk. In other terms, the possibility that carbon pricing in Japan could induce trade exposed, energy-intensive industries to replace domestic production by imports, or to relocate production to foreign countries, will be crucial in the structure which will be chosen finally.

The aim of this paper is to assess quantitatively different design options for an ETS in Japan, especially their impact on the carbon leakage as well as on the industrial production. We develop a model, called CASE-ASIA, which represents several Japanese industrial sectors which would be strongly impacted by the CO_2 constraint implementation. With this model, we analyse different design of a mandatory ETS as well as different "anti-leakage" options. Then, we provide a quantitative assessment of the impact of these different schemes on the activity of the different industries included in the model. The results show that there is no a "best option" and the Japanese government should decide where its priorities lie. The analysis makes explicit the trade-offs implied by the different possible schemes and provides "food for thought" for the policy-makers.

This paper is organised as follows: Section 1 briefly gives some elements of context; Section 2 presents the model CASE-ASIA and Section 3 the different simulations made; Section 4 discuss the results.

1. The context

1.1 From a voluntary to a mandatory emission trading scheme for industry

In order to decrease the industrial GHG emissions, Japan started with the Keidanren Voluntary Action Plan, based on the voluntary adoption of intensity targets, and then introduced a voluntary emission trading scheme (ETS). Keidanren's Voluntary Action Plan was developed in 1997 with the aim of stabilizing energy-source and industrial-source CO_2 emissions at their 1990 level by 2010. It has been reviewed and

[1] The author is grateful and indebted to Xiangchun Lu (Tohoku University) and Jusen Asuka (Tohoku University and IGES).
[2]The Fukishima nuclear accident might compromises these decisions about both the global emission reduction target and the start date of the ETS.

strengthened by the government in the Kyoto Target Achievement Plan (KTAP), while being not legally binding.

In 2005 Japan introduced a voluntary emission trading scheme, the JVETS, based on absolute targets. This scheme however attracted only a very small number of participants. For participating firms, one-third of the cost of new facilities to reduce emissions was borne by the government (Jones and Yoo, 2009). Firms that failed to achieve their objective had to purchase credits from firms that had achieved larger-than-targeted reductions or return the subsidy to the government. The participating firms accounted for less than 1% of CO_2 emissions from the industrial sector, which provided an incentive for the government to change its policy (Kimura and Tuerk, 2008).

In 2008, a consensus to implement a mandatory ETS in the Japanese climate policy has emerged following a review of the KTAP which estimated that Japan will face a shortage 22-36 $MtCO_2e$ by 2012.[3] However, a transition period to a mandatory ETS is foreseen and it is expected to allow for a smooth transition from the current approach under Keidanren's Voluntary Action Plan. In October 2008, the government launched an experimental emissions trading system that includes the JVETS as an option. The main objective is to gain experience in using an ETS system. After an intensive recruitment process, 715 firmsagreed to participate, including 521 firms which agreed totargets accounting for about two-thirds of CO_2 emissions by the industrial sector.

Moreover, an Advisory Committee on the Emissions Trading Scheme has been established by the Ministry of the Environment. Its objectives are, among others, to make an in-depth study on the specific design of a possible ETS, in particular its effectiveness and feasibility and its impacts on domestic industries and employment. Moreover, the Committee must evaluate possible options for the industrial sectors that would be substantially affected in terms of international competitiveness or would run a major risk of carbon leakage.

1.2 The anti-leakage policy options in an ETS

When designing an ETS, two main options to reduce carbon leakage are generally considered: free allocation and border adjustment.A border adjustment (BA) is a trade measure designed to level the playing field between domestic producers facing climate policy measures and foreign producers with no or little constraint on their GHG emissions. They could be designed for example as import tariff, export rebate or export tariff. As a trade measure, a BA may be contested by a World Trade Organisation (WTO) member under its dispute settlement mechanism. There is a considerable literature debating the legality of BA for climate policies under WTO rules. Recent analyses, including a report by WTO/UNEP (2009), concluded that, under specific conditions, such a measure may be WTO compatible.[4] A BA was the option retained in the American Waxman-Markey bill which suggested to implement a cap-and-trade scheme from 2016 onwards with an "international reserve allowance program" for imports from 2020 (James, 2009; van Asselt and Brewer, 2010).[5]

In the EU, the Directive 2009/29/EC, which revises the EU ETS for Phase III (2013-2020), liststhe use of a BA on imports but the EU finally opted for continued free allowance allocation to the "sectors or subsectors which are exposed to a significant risk of carbon leakage" (Article 10a-12). As explained in Matthes and Monjon (2008) and Ellerman (2008), since allocation in the EU ETS is linked to production capacity, not to actual output, this can reduce the incentive to relocate production capacity (investment leakage). However, it cannot reduce the incentive to use existing plants abroad rather than EU plants (operational leakage). A suggested approach to tackle this problem is output-based allocation (OBA), under which for example a steel producer would receive a given amount of allowances per tonne of steel actually produced. Practically, this requires an update of the allocation when production is known. An output-based allocation, called "home rebate" by Fischer and Fox (2009a), levels the playing field between the domestic and the foreign market. However, this does not give an incentive to reduce emissions by reducing consumption.

[3] See Kimura and Tuerk (2008).
[4] See Droege (2011) on this issue.
[5] The bill was approved by the House of Representatives on June 26, 2009 by a vote of 219-212, but was rejected by the Senate.

In order to identify the sectors impacted most by a carbon cost in Japan, Asuka et al. (2009) followed the method proposed in Hourcade et al. (2007). They evaluated the carbon intensity or the "value at stake" of the Japanese (sub-) sectors defined as:

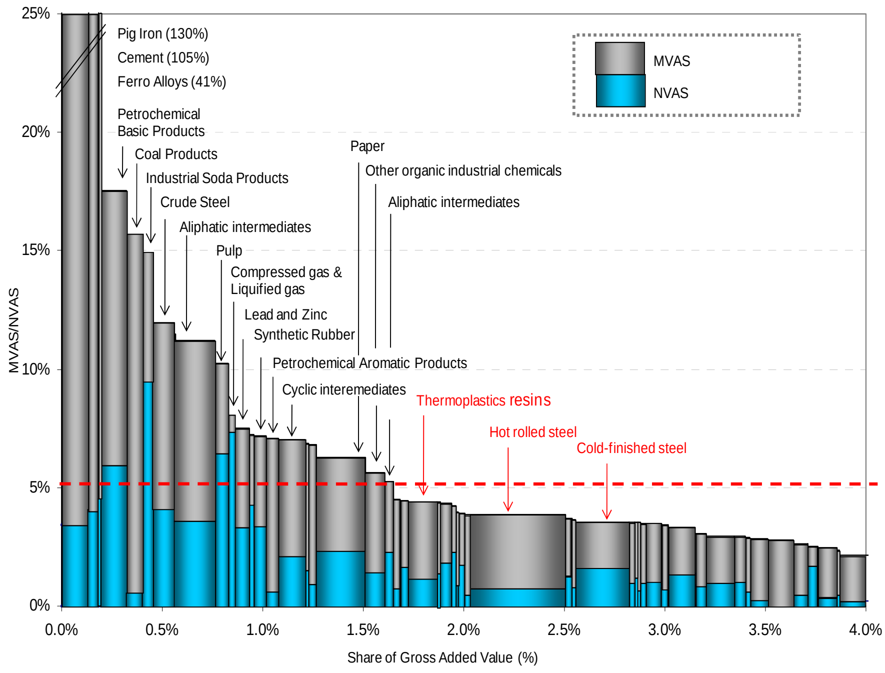
$$\text{Carbon Intensity} = \frac{\text{Purchasing Costs of Emission Allowances}}{\text{Gross Value Added (GVA)}}$$

The numerator shows the range of carbon costs expressed in terms of costs borne by the corporations to purchase emission allowances for their direct and/or indirect CO_2 emissions. The denominator shows the extent of industry sectors' profits – expressed in gross value added. To estimate the cost of the indirect emissions, it is assumed that 100% of the additional costs from electricity production will be passed on by raising electricity prices.

The Net Value Added at Stake (NVAS) for each industry is calculated by assuming that the Government of Japan auctions allowances to the power sector only and gives free allowances to the other sectors. Consequently, the numerator only takes into account the increase of the electricity price. The Maximum Value Added at Stake (MVAS) is calculated by assuming the auctioning of the allowances to all industry sectors. The allowances price is exogenously set at 3000Yen/tCO_2e.

Figure 1 shows the calculation results of carbon intensity for the sectors with a MVAS of 2% or greater. The vertical axis indicates MVAS and NVAS, with the horizontal axis showing the share of each sector in overall domestic production. The analysis covers 401 sectors designated under the inter-industry relations table from the year 2000.

Figure 1: Sector-by-sector evaluation of the impact of a carbon constraint



Source: Asuka, Kanamoto and Xiang Chun (2009)

Asuka et al. (2009) conclude that the share of industry sectors with a MVAS of 2% or greater represents 3.2% of total Japanese GDP. There are 17 industrial (sub-) sectors with a MVAS of 5% or greater. Lastly, pig iron and cement sectors have a relatively higher MVAS compared to the other sectors studied.

Following the conclusion of Asuka et al. (2009), our analysis focuses on some sectors exposed to carbon leakage, in particular on the steel and cement sectors, as well as the petrochemical basic products. The first two sectors are large net exporters, while the third sector is a net importer.

2 The Model

The model CASE-ASIA follows the logic of the CASE II model developed to represent the Emission Trading System (EU ETS) implemented in EU since 2005 (Monjon and Quirion, 2011a). CASE-ASIA is a static and partial equilibrium model which represents four sectors: cement, steel, refined petroleum products and electricity. The model comprises two regions: Japan and the Rest of the World (RoW). All sectors have a potentially large cost impact from carbon pricing but will face different direct and indirect emissions costs as well as different cost structures (Asuka et al., 2009).

The model aims to evaluate the impact of different designs for an ETS in 2020 with respect to: production levels, price levels and trade flows in each industry. The model also allows for the calculation of the leakage-to-(emissions) reduction ratio for each sector and for the whole ETS.

When carbon pricing policy is carried out in Japan, domestic firms face three types of additional costs:

- Abatement cost: The abatement costs are based on Marginal Abatement Cost Curves (MACC) taken from the POLES model for the year 2020 in which Japan is explicitly modelled. In POLES, the MACCs are available for CO_2 energy emissions from, among others, non-mineral materials, chemical, steel and electricity sectors. The MACCs have been used to define a curve which gives, for each CO2 price, the decrease in unitary emissions. The abatement costs are incorporated into the model as variable costs, i.e. per product ton.
- Purchase of allowances: Firms may need to buy allowances, which increases the variable costs, or sell the allowances they do not use, which decreases the variable costs.
- Indirect cost from electricity pricing: The marginal production cost of cement, refined petroleum products and steel firms increases when there is a rise in the electricity price. We assume a cost pass-through of 100% in the power sector, whatever the policy scenario modelled. This part of the cost increase corresponds to the numerator of the NVAS defined in Asuka et al. (2009).

According to Hourcade et al. (2007) the risk of carbon leakage is highest for carbon-intensive primary commodities and semi-finished products. Consequently, the CASE-ASIA model focuses on this stage of the production chain.

In the model, all sectors consume electricity. We do not take into account the fact that some industrial companies produce their own electricity. Moreover, we do not consider electricity savings due to the rise in power prices but we extrapolate the recent trends in the electricity consumption per ton of product.

In the cement sector, we take into account the substitution of clinker (the CO_2-intensive intermediate product) with CO_2-free substitutes (e.g. fly ashes or blast furnace slag).

All sectors included in the ETS are linked through the CO_2 market. The CO_2 price is determined by equalizing the demand and the supply of allowances: thanks to specific emissions abatement and the decrease in production, the sum of the emissions from these sectors equals the total amount of allowances allocated for free or auctioned.

We do not model emissions in the rest of the economy. These emissions could differ across our scenarios, due to some indirect effects (e.g. substitution between electricity with gas in building heating) but this effect is most likely to be negligible.

3. The Scenarios

Our goal is to evaluate the consequences of implementinga mandatory ETS in Japan. As explained above, neither the design of the ETS nor the allocation mode of the permits are decided yet. Based on the Executive Summary released by the Advisory Committee on the Emissions Trading Scheme (2008), several designs of the ETS and several allocation modes will be examined.

3.1 The Different Designs

The Japanese government envisages implementing an ETS not targeting the electricity sector, which might pay a CO_2-tax instead. This would be an important difference to the EU ETS setup. Following the Japanese policy plans, our scenarios will include two designs:

- **Design 1:** An ETS covering only the cement, steel and refined petroleum products. A CO_2 tax is applied to the electricity sector.
- **Design 2:** An ETS covering both the industrial and electricity sectors.

3.2 The Allocation Mode

The scenarios considered for the allocation mode focus on some representative configurations including specific treatment of the sectors exposed to carbon leakage risk (free allocation based on output, border adjustment). Each allocation mode is examined under both designs.

- **Auction** features full auctioning of allowances or a CO_2 tax in the electricity sector. In the other sectors, there is full auctioning of allowances, without rebating the auction revenues to the firms covered by the ETS, and without any anti-leakage provision.
- **BA_full** features **Auction** in the electricity sector. For the other sectors, there is 100% auctioning, with border adjustment on imports and exports and for direct emissions. The import and export adjustments are proportional to the Japanese average specific emissions (direct emissions).
- **BA_imports** features **Auction** in the electricity sector. In the other sectors, there is 100% auctioning with border adjustment only on the imports and for direct emissions. The import adjustment is proportional to the Japanese average specific emissions (direct emissions).
- **OBA** features **Auction** in the electricity sector. In the other sectors, there is free output-based allocation in exposed industries (cement, steel and refined petroleum products) for direct emissions. The amount auctioned is 83.3%[6] of the electricity sector emissions in 2005 when included in the ETS. In every other sector, the amount of allowances allocated per unit produced is calculated by applying a reduction ratio to the 2005 specific emissions. The reduction ratio is equal across sectors and calculated so that the emission cap is 83.3% of 2005 emissions.

Due to missing data on electricity price elasticity in the industrial sectors, we do not consider in this report an allocation mode which would attribute indirect emissions to the cement, steel and refined petroleum products sectors (downstream allocation). However, this allocation mode is envisaged in Japan and would need further investigation (Advisory Committee on the Emissions Trading Scheme, 2008).

We analyse eight climate policy scenarios and compare them to a no-policy scenario, which is simulated for 2020 without climate policy. The no-policy scenario is based on a growing Gross Domestic Product (GDP) and changing technical coefficients (specific emissions, specific electricity consumption). Other exogenous variables stay constant (in particular production costs).

3.4 Emissions Reduction[7]

The national target announced by Japan under the future climate regime is to reduce its GHG emissions by 25% between 1990 and 2020, but there is not yet a decision about the reduction share to be delivered by

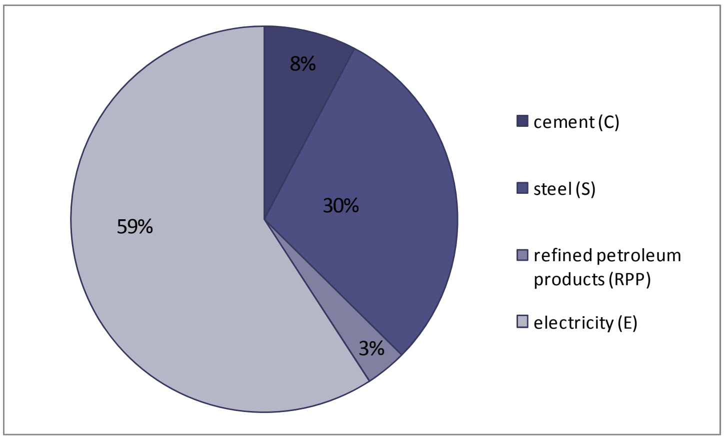
[6] See the explanation in the following.

[7] The simulations will be made assuming unilateral carbon pricing by Japan. This ignores that the EU has already implemented an ETS covering GHG-intensive industries until 2020. However, as EU and Japan firms seldom compete on the same markets in cement, steel, and refined petroleum we stick to this assumption. Other efforts on carbon pricing in a number of regions, including the USA and South Korea, remain very uncertain and thus cannot be incorporated in the RoW part of the model. Moreover it is unclear how the national pledges made under the Copenhagen Accord and the Cancun Agreements would affect the production cost of these industries. Our focus is on comparing the relative impact of policy options rather than on estimating absolute values, and there is no reason to think that these uncertainties regarding international climate policies will change the ranking of policy scenarios in terms of their impact.

sectors covered bythe ETS.[8] Moreover, the 2011 Fukushima nuclear accident may modify the Japanese climate policy, both on global and industrial emission targets.

In 2005, the four sectors included in the model CASE-ASIA emitted around 615 MtCO2e. The electricity sector is the biggest emitter (59%) following by the steel sector (30%) (Figure 2).

Figure 2: Share of the different sectors in 2005 GHG emissions



Based on the evaluation by the Japanese Ministry of Environment (2010), the Institute for Global Environmental Strategies (IGES) evaluated a specific reduction scenario between 2005 and 2020 for the following sectors:

Table 1: Emission reduction ratio between 2005 and 2020

Sector name	**reduction ratio (2005-2020)**
Cement	-7.5%
Hot rolled steel	-15.3%
Aliphatic intermediates	-5.6%
Electric power	-18.7%

Source: evaluation by IGES based on Ministry of Environment (2010)

It is then possible to apply these reduction ratios to the sectors included in the model and to evaluate the different caps applied in the ETS depending on the inclusion of the power sector. By applying the reduction ratio from table 1, the cap in 2020 would be 512.3 MtCO2e for the four sectors modelled, i.e. a decrease of 16.7%.

Table 2: the emission reduction between 2005 and 2020 depending on the design and of the sector

	Emission reduction 2005-2020	
	ETS (C, S and RPP)	Electricity sector
Design 1	-13%	-18.7%
Design 2	-16.7%	

Source: own calculations

[8]A 25% reduction in emissions from 1990s levels by 2020 is equivalent to about a 37% reduction from 2005 levels (Pielke, 2009)

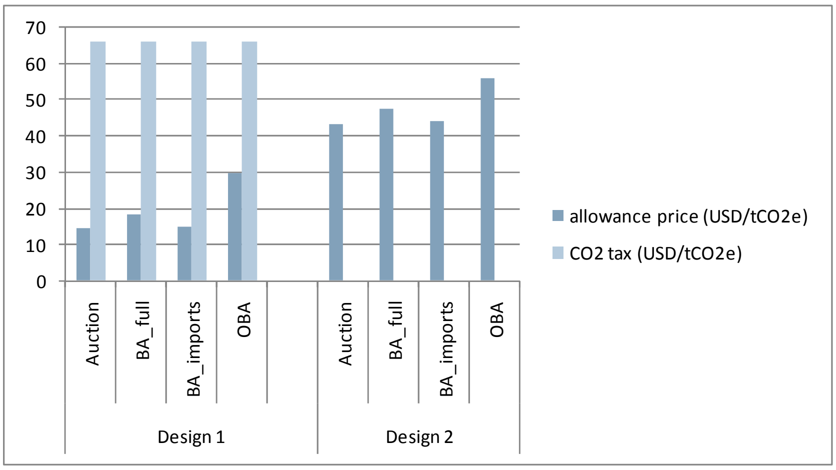
4. Results

4.1 The Design matters

The inclusion or the exclusion of the electricity sector in the ETS is a crucial element of the ETS approach modelled. When a CO_2-tax is applied in the electricity sector, its amount will need to be around USD 65-67/tCO_2 to reduce the emissions of the sector by around 18.7%, while the CO_2-allowance price will need to be between 14 and 30 USD/tCO_2e depending on the allocation mode (see Figure 3).[9]

Under Design 2, the allowance price is between 40 and 55 USD/tCO_2e, that is between the allowance price and the CO_2 tax under Design 1. Under Design 2, the allowance demand of the electricity sector pushes upward the allowance price. Consequently, more reductions in specific emissions are carried out in the industrial sectors than under Design 1, because these reductions are cheaper. The abatement costs between the sectors are equalised verifying the well-known equi-marginality principle.

Figure 3: Allowance price and CO2 tax



Note: Under the Design 1, the CO_2-tax is USD66 on the figure, which does not ensure exactly the same emission reduction in the electricity sector (between -18.39% and -18.86%).

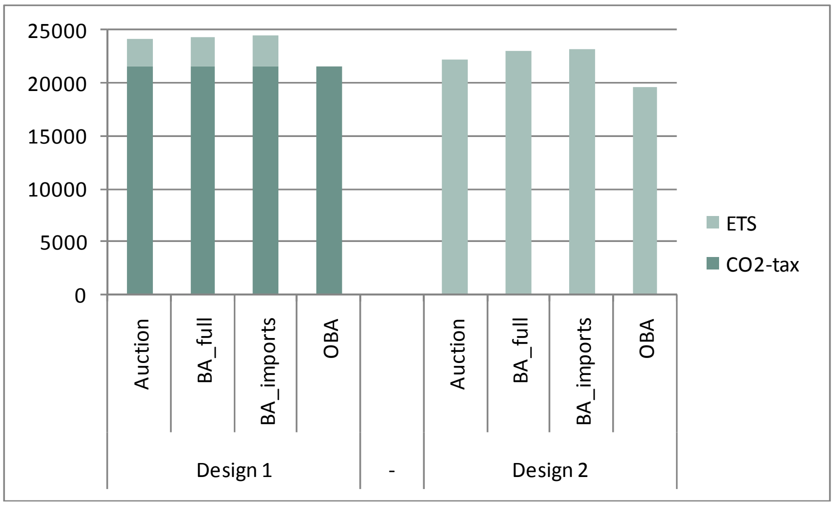
The ordering of the allowance price among the scenarios is the same under both designs, but the levels vary. Indeed, the allocation mode plays a crucial role in determining the price level. The allowance price is lowest under "Auction" and highest under "OBA". The allowance price is higher under the "BA" scenario than under "Auction", because border adjustments limit the substitution of Japanese production by foreign production, which is one way of reducing CO_2 emissions. Hence a higher allowance price is needed to get lower unitary emissions. The price is higher under "OBA" than under "BA" because free allocation constitutes a subsidy to the production of polluting goods, which increases the demand for allowances, and hence the CO_2 price. This leads to higher production levels than under the "Auction" and "BA" scenarios (Figure 9). Consequently, to generate the same aggregate emission levels under "OBA" as in the other scenarios, lower CO_2 emissions per unit produced are required, which implies a higher CO_2 price.

4.2 The potential of public revenues is large

Figure 4 presents the public revenues generated by the allowance auctioning and/or by the CO_2-tax. Under Design 1, more public revenues are generated since the biggest emitter, the electricity sector, pays more for each tCO_2e. Regarding all other features, the ordering among the scenarios is the same regardless of the design.

[9] In Asuka et al. (2009) the exogenous allowance price is 3000Yen/tCO_2e, about USD 27/tCO_2e by applying the 2005 change rate.

Figure 4: Public revenues from carbon pricing policy (million USD2005)

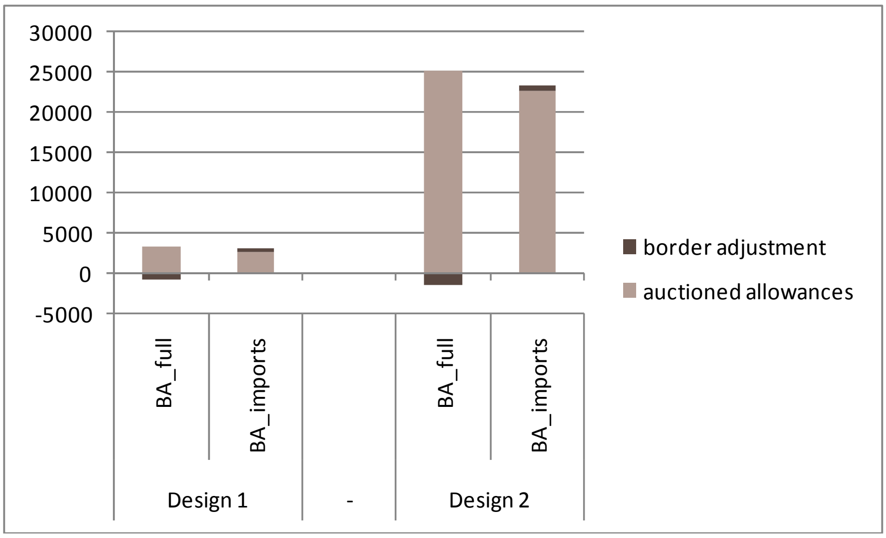


Note: Under Design 1, the CO_2-tax is USD66 in the figure. The revenues from ETS include the revenues or expenditures related to the BA if required.

The "BA" scenarios generate more revenues than the "Auction" and "OBA" scenarios. The proximity between the amount generated under "BA_full" and "BA_imports" hides in fact an important element. When the BA includes an export part, the mechanism induces public expenditures as is shown in Figure 5. Indeed Japan's exports of GHG-intensive products are a lot higher than its imports.

The "OBA" scenario generates the lowest amount of public revenues. Nevertheless, the collected money is still significant even though a large percentage of allowances is allocated for free. This is because the remaining allowances are sold at a higher price.

Figure 5: Public revenues from the ETS (million USD2005)

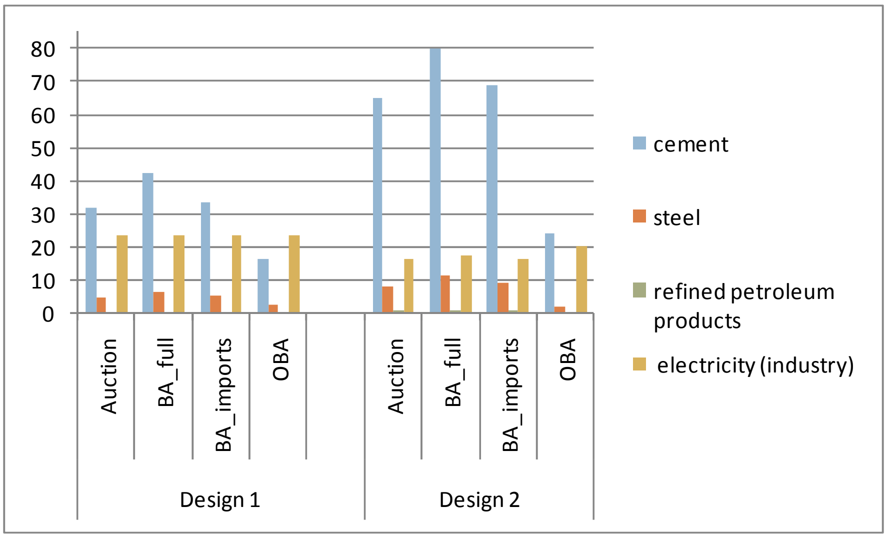


Note: Under the Design 1, the CO_2-tax is USD66 on the figure.

4.3 A trade-off between limiting the increase of the electricity price and the GHG-intensive product prices

As explained above, the choice of the design implies a different impact on the electricity price and on the industrial product prices. Indeed, under Design 1, the electricity price is higher than under Design 2. This affects the production costs of the industrial sectors but as these sectors have also access to less expensive allowances, the increase of product prices is limited as we can see on Figure 6. There is then a trade-off between limiting the increase of the electricity price or of the industrial product prices.

Figure 6: Price change between the scenario with carbon pricing and the no-policy scenario (%)

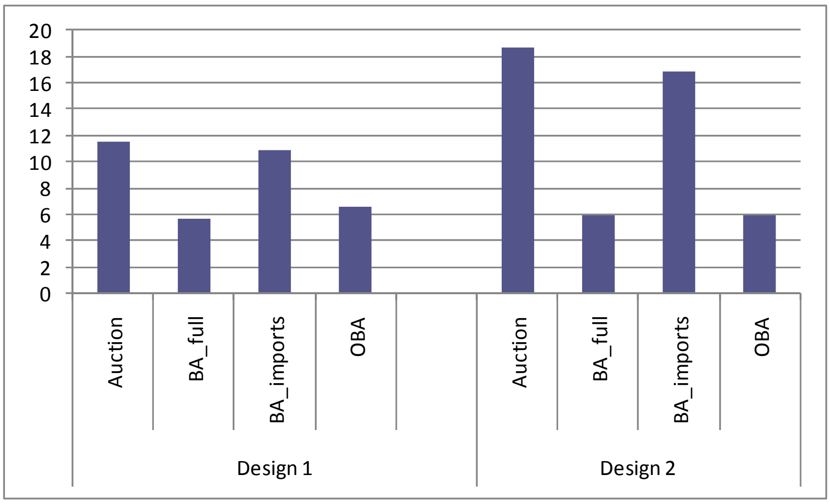


Note: Under the Design 1, the CO_2-tax is USD66 on the figure.

To exclude the electricity sector from the ETS allows preserving the exposed sectors from a high allowance price. Therefore, we could expect that requesting a bigger effort to be taken by the electricity sector allows preserving the exposed sectors and preventing large carbon leakage.

But, even under Design 2, carbon leakage can be limited in a significant way if the allocation mode is correctly defined. Figure 7 reveals that "BA_full" and "OBA" have similar performances to limit carbon leakage regardless the design. On the other hand, under "Auction" and "BA_imports", Design 1 outperforms Design 2 in terms of carbon leakage prevention.

Figure 7: Leakage-to-reduction ratio (%)

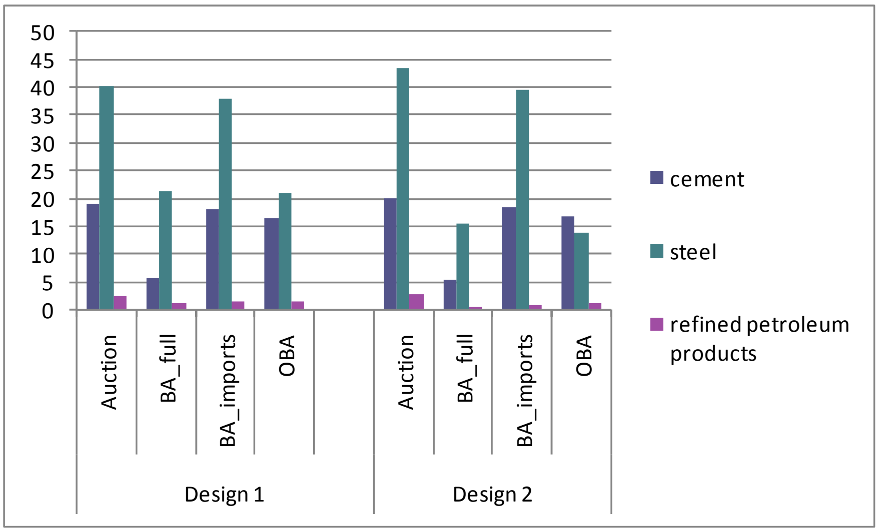


Note: Under Design 1, the CO_2-tax is USD66 in this figure.

Regardless of the design, a crucial result is the importance of BAs for exports in Japan. Indeed the leakage-to-reduction ratio under "Auction" and "BA_imports" are relatively close, revealing the poor performance to limit carbon leakage of a BA covering only imports. On the other hand, when exports are included in the "BA" scenario, carbon leakage is significantly reduced. This is because Japan is a big exporter of steel and even more so of cement, while its imports of these products are limited. Consequently, the challenge to limit carbon leakage is to limit the substitution of Japanese production by foreign production on foreign markets. This differs from results for the EU (Monjon and Quirion, 2011a).

Figure 8 disentangles the aggregated leakage-to-reduction ratio in order to examine the situation in each sector. The steel sector is the most exposed sector to carbon leakage with a ratio around 35 and 45% under "Auction" and "BA_imports". "BA_full" and "OBA" lead to similar decreases of the leakage-to-reduction ratio in the steel sector, while "BA_full" clearly dominates "OBA" in the cement sector. Lastly, the refined petroleum products sector seems little exposed to a carbon leakage risk.

Figure 8: Leakage-to-reduction ratio in the different sectors (%)

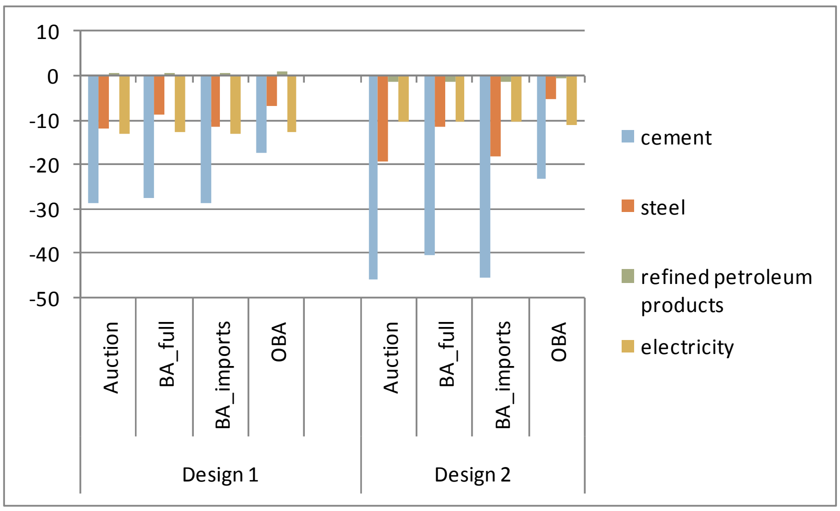


Note: Under the Design 1, the CO_2-tax is USD66 on the figure.

Finally, Figure 9 displays the variations in production levels in Japan relative to the no-policy scenario. The results differ depending on the allocation mode and on the design. While the output-based allocation mode performs relatively well in limiting the decline in Japanese production levels, "Auction" and "BA" induce large losses, in particular under the design 2.

The differences can be important among the sectors. The cement sector is the most impacted whatever the scenario, while the refined petroleum products sector is relatively little affected. The cement sector is very vulnerable to a high allowance price, leading to a better performance in limiting the production loss under of Design 1.

Figure 9: Japanese production level change between the scenario with carbon pricing and the no-policy scenario (%)



Note: Under the Design 1, the CO_2-tax is USD66 on the figure.

5. Summary and Conclusions

When implementing a mandatory ETS the Japanese government will have to define precisely the instrument. This analysis highlights the keyrole of some elements of an ETS.

1. **The inclusion or the exclusion of the electricity sector in the ETS is a political crucial choice.** If the electricity sector is involved in the ETS, its allowance demand will push the allowance price, increasing the constraint on the industrial sectors. At the same time, the inclusion of the electricity sector in the ETS allows releasing the carbon constraint intensity a little for this last sector.
2. The choice whether to integrate the electricity sector leads to **a trade-off between limiting the increase of the electricity price and the industrial product prices.**
3. **The emission reduction examined leads to a high CO_2 tax or to a high allowance price**, comparedto those expected in the EU ETS for 2020.
4. **A BA efficiently limits carbon leakage if it covers imports and exports.** However, if the BA is only on imports, the leakage is about the same as without any BA.
5. **The performance to limit carbon leakage of a BA covering imports and exports and of an OBA isvery close: both lead to a leakage-to-reduction ratioaround 6%.** Without any anti-leakage provision, excluding the electricity sector from the ETS limits a little the carbon leakage from the industrial sectors.
6. **The steel sector is the most exposed to carbon leakage risk.** In this sector, carbon leakage is decreased the most when the electricity sector is in the ETS, with a slightly better performance of the OBA comparedto a full BA. **However, in the cement sector, the carbon leakage stay almost as high as with full auctioning.**
7. **The potential public revenues from the ETS implementation are large.** The largest revenues are obtained if the electricity sector is targeted with a CO_2 tax. Free allocation based on output significantly decreases these revenues.
8. **The ETS implementation leads to a significant production decrease in the steel and cement sectors even with a full BA.** On this point, OBA is the most efficient option to limit the production decrease in the cement and steel sectors. Moreover, the production decrease is limited the most if the electricity is not included in the ETS.

The analysis highlights several important trade-offs for the final choice of the ETS design in Japan. We show that the different possible schemes have differentimpacts on the prices and on the production level in the different sectors. Moreover, the efficiency of the different anti-leakage options depends on the structure of the scheme. Lastly, there is no design which is superior to all other ones. Consequently, the political arbitration will play a particularly important role to decide on the design elements.

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