Political acceptability of emissions trading schemes and interactions with distortionary taxes:

The case of carbon revenues recycling to support renewable energy in the presence of an electricity levy and associated exemption rules

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Abstract

While emissions trading schemes are developed by nations to mitigate their greenhouse gases emissions, behavioral studies have shown that the political and public acceptability of these market-based instruments depends on the way the associated revenues are used. One option that is well considered by the general public is to use them to support renewable energy. We examine the economic consequences of such a recycling method in the case of the European Union. While the EU ETS Directive requires Member States to use at least 50% of the carbon auctions revenues for climate and energy related purposes, the Impact Assessment of the 2030 Climate and Energy Framework suggests one way can be to support electricity generation from renewable energy. With a modeling approach including a detailed disaggregation of EU sectors, we find that using ETS auctions revenues to support electricity generation from renewable sources results in a rise in electricity demand in the whole economy due to the reduced electricity levy that electricity consumers have to pay to support renewable energy in the power sector. This results in a rise of the ETS carbon price. The carbon constraint for the non-ETS sectors is looser as a consequence of the possibility for these sectors to use cheaper abatement opportunities, including through a larger use of electricity. While the ETS sectors generally benefit from electricity levy exemptions, we observe that the combination of these exemptions and of the use of carbon auctions revenues to support RES make them worse off than if carbon revenues are transferred to households. The reason is the rise in electricity and carbon prices as a consequence of the higher electricity demand in the rest of the economy. In aggregate the recycling option analysed here results in a GDP gain due to its impacts on the non-ETS sectors, the reduction of the electricity levy and associated distortionary effects.

Keywords:

Carbon auctions; renewable energy support; electricity levy; emissions trading scheme.

1. INTRODUCTION

Negative environment externalities may be corrected by policy instruments such as subsidies or taxes. Their efficiency respectively depends on the resources used to finance them and on the use made of the corresponding revenues. Pigouvian taxes tend to be more efficient as the associated revenues can be recycled to reduce other taxes (see Ballard and Medema, 1993). Despite this, the general public usually prefers subsidies, as shown for example by Heres et al (2015). There are various reasons for this, one of which being the fact that the cost of the subsidy is less visible for the general public than a tax (Harrison, 2010). The public acceptability of taxes is improved if information is provided on the use made of the corresponding revenues, and, in particular, if these are earmarked for environmental purposes (Kallbekken et al, 2011; Kallbekken and Aasen, 2010).

In the field of climate policy, this is particularly true for political debates regarding carbon pricing[1] vs renewable energy (RE) or innovation support policies. Despite the fact that emissions trading schemes (ETS) are usually considered by policy-makers to reduce emissions

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[1] An overview of carbon pricing instruments developed in the world is provided by Kossoy et al. (2015).

in a cost-efficient manner, cap-and-trades are not always well perceived by the general public. That is visible in the United States where several federal cap-and-trade proposals were discussed, analyzed, e.g by Paltsev et al. (2011), but never adopted. On the contrary, financial support to renewable energy or innovation benefits from a much higher political acceptability. Still, while supporting renewable energy may have various various political objectives (e.g. climate policy, energy independence, competitiveness), it might be rather inefficient with regard to emissions reductions. As an example, Marcantonini and Ellerman (2015) have computed the implicit abatement cost of renewable energy incentives in Germany and found that this might be substantially higher than an ETS price.

Behavioral studies have suggested that the public and political acceptability of carbon markets depends on the design of these schemes and in particular on the way the associated revenues are used. As an example, Vollebergh et al (1997) show that hybrid systems of grandfathering and auctions can improve the political acceptability of carbon pricing. Bristow et al (2010) study the public acceptability of personal carbon trading in comparison with a carbon tax. The authors show that the initial permits allocation and the use made of the carbon revenues are important design features in this regard.

An improvement in the public acceptability of ETS seem to be obtainable by actually using the carbon revenues for climate and energy purposes. One of these purposes can be the support to renewable energy deployment. In a way, this overcomes the debate mentioned above on the ways to correct environmental externalities by combining carbon pricing and subsidies rather than opposing them. The economic impacts of such a recycling choice depends on the preexisting RE policy framework. In particular, if the latter is via the use of an electricity levy, employing the carbon revenues to reduce this tax should result in efficiency gains. The aim of this paper is to analyze the economic consequences of using carbon revenues to support power generation from RE, as a function of the specific characteristics of the preexisting RE policy funding. It extends the literature on environmental taxation in the presence of other taxes (e.g Bovenberg and Goulder, AER, 1996; Norhdaus AER, 1993) to carbon pricing in the form of an ETS, in the presence of a specific distortionary commodity tax - the electricity levy - that applies heterogeneously to the various sectors of the economy.

Given the European experience in terms of carbon pricing and RE support policy, we take the EU as a case study for our analysis. The European Union emissions trading scheme (EU ETS) started in 2005 (EU, 2003). This instrument is the cornerstone of the EU climate and energy policy which was particularly defined by the EU leaders in the 2020 climate and energy package in 2007, and then in the 2030 climate and energy framework in 2014 (EC, 2014a). Together with an objective of a 40% reduction of greenhouse gas (GHG) emissions compared to 1990 levels, this framework also includes a target of 27% of renewable energy sources in energy consumption, and an overall energy savings goal of 27% energy savings compared with the business-as-usual trend. Member States are free to choose the instruments they wish to support RE deployment:[2] feed-in tariffs, premium, green certificates… Since 2013, companies have had to buy an increasing proportion of permits through auctions (EC, 2010). The framework indicates that Member States are free to choose the use they make of carbon auctions

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[2] For recent information on how Member States support renewable electricity, we refer the reader to the RES LEGAL website: www.res-legal.eu.

revenues, but that they have to use at least 50% of the auctions revenues for climate and energy related purposes. Among others, the Impact Assessment of the 2030 framework (EC, 2014b) suggests auctions revenues can be used to support renewable energy. Depending on the way Member States fund their RE policy and given the fact that the electricity sector itself is covered by the ETS, we expect that the use of carbon auctions revenues to subsidize power generation from RE leads to general equilibrium effects that deserve to be examined. In most Member States, RE support is financed by an electricity levy (paid by electricity consumers, including some industries covered by the ETS), while in others (the United Kingdom, Poland and Finland) the funding comes from the general public budget (paid by tax payers). In this empirical context of the EU, the paper examines the economic impacts of such a recycling option on the whole economy and in particular on the various industrial sectors, depending on their energy intensities, the type of renewable energy support used and potentially associated exemption rules. After collecting and combining detailed sectoral level data on the EU industry, we integrate them in the PACE modeling structure and develop the latter to conduct the analysis.

We find that using an electricity levy to reduce RE leads to some slight GDP loss for the economy due to the associated distortion in comparison with public support to RE. In the case an electricity levy is used, we see that recycling auctions revenues to support renewable energy generally benefits the EU economy more than transferring these revenues as a lump-sum rebates to households, as the auctions revenues allows to reduce the electricity levy and the associated distortion. We indeed observe positive impact on the non-ETS sectors that benefit from a reduction in the electricity level. However, if energy intensive sectors are exempted from the levy, their benefit from this exemption is reduced when recycling carbon auctions to support RE due to the increase in energy and carbon prices induced by the electricity demand rise in the rest of the economy.

Section 2 presents the quantitative framework developed and used for the analysis. Section 3 describes the policy simulations considered, Section 4 discusses the results and Section 5 concludes.

2. QUANTITATIVE FRAMEWORK

This section covers the numerical general equilibrium framework employed for the analysis. We first present the data sources used. We explain the work conducted on them to obtain the level of sectoral detail needed for the analysis while ensuring consistency of the whole numerical framework. We then describe the modeling structure and the specific features developed to pursue the analysis.

2.1 Data

To analyze the interactions effects between auctions revenues recycling and electricity levy exemption rules for energy-intensive sectors, we need detailed inputs for these industrials sectors. To do so, we use data from the GTAP 9.1 database (Global Trade Analysis Project) that we disaggregate and complement with inputs from the EU 2016 Reference Scenario (EC, 2016a). The GTAP 9.1 database (Global Trade Analysis Project) provide the most recent consistent accounts of production, consumption, and bilateral trade flows for the reference year 2011. But, despite a rather comprehensive regional and sectoral coverage, this database does not provide sufficient sectoral detail about the energy-intensive industries. We hence apply disaggregation procedures to several energy-intensive sectors covered by the EU Emissions Trading Scheme (EU ETS).[3] We use SplitCom routines (Horridge, 2008) to perform the sectoral disaggregation and refer the readers to Alexeeva-Talebi et al. (2012) for procedural information on this issue.[4] On the other hand, as the representation of the other sectors and regions in GTAP 9.1 is too specific for the purpose of this paper, we aggregate them. The model used for this sector covers 23 regions and 36 sectors (extractives activities, industries covered by the EU ETS, industries not covered by the EU ETS, services). EU regions include France, Germany, Italy, Poland, Spain, the United Kingdom, the other western Member States and the other Eastern Member States (the detailed regional coverage is reported in appendix). The sectoral coverage is presented in Table 1.

For the base year, we derive CO_2 emissions from fossil fuel inputs for the EU regions from the EU 2016 Reference Scenario, figures that we decompose using sectoral shares derived from the GTAP database. We add emissions from industrial processes. To do so, we use the World Input Output Database (WIOD, 2012) which include emission figures with a very detailed breakdown of emission sources, i.e. 20 fossil energy carriers, relevant renewable energy sources and other sources. For each region and sector, we can derive process emissions from the data on emissions from other sources.

For the economic development up to 2030, we use data from both the EU 2016 Reference Scenario and the International Energy Outlook from the US Department of Energy (IEO, 2013).[5] The former is used to calibrate most variables related to the EU regions of the model: energy inputs, prices of energy carriers, economic growth, and carbon prices. We complement these by data from the IEO 2013 in particular for the non-EU regions.

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[3] The following GTAP sectors have been disaggregated: Chemical products, rubber and plastics (into organic chemicals, inorganic chemicals, fertilisers, other chemicals, rubber, plastics); Non-metallic minerals (into cement, glass, ceramics, bricks and tiles, other non-metallic minerals); Iron and steel (into basic production and further processing of iron and steel); Non-ferrous metals (into aluminium and other non-ferrous metals).

[4] The principle of the disaggregation routine is to find shares of production, consumption, trade and the intermediate production structure of the subsector within the aggregate sector. SplitCom then uses these shares to compute respective flows for the new subsectors and balances the input-output structure.

[5] The IEO 2013 provides detailed regional data on total and fuel-specific primary energy consumption and carbon emissions given assumptions on the development of GDP, fossil fuel prices and other factors. The data take population growth and exogenous technical progress into account.

Table 1: Sectoral coverage of the model

Main aggregates	Sectors
Extractive activities	Agriculture, forestry and fishing
	Coal production
	Crude oil extraction
	Natural gas extraction
	Mining, n.e.c.
Industries covered by the EU ETS	Pulp and paper
	Refineries and coke oven production
	Fertiliser production
	Organic chemical production
	Inorganic chemical production
	Cement production
	Bricks and tiles production
	Glass production
	Ceramics production
	Basic iron and steel production
	Further processing of iron and steel
	Aluminium production
	Production of other non-ferrous metals
	Air transport
	Electricity
Industries not covered by the EU ETS	Food production
	Manufacture of textiles, wearing apparel and leather
	Manufacture of wood and wood products
	Other chemicals, rubber, plastics production
	Production of other non-metallic minerals
	Manufacture of electrical and electronic equipment
	Manufacture of machinery and equipment, n.e.c.
	Motor vehicles and parts
	Other transport equipment
	Other manufacturing
	Construction
Other services	Inland transport
	Water transport
	Business services
	Private services
	Public services

2.2 General equilibrium model

The analysis employs the PACE model, a multi-region, multi-sector recursive-dynamic computable general equilibrium (CGE) model of global trade and energy use. Each region in the model includes one representative agent who provides capital, labour and resources to the production sectors. The production structure in each sector is specified using nested constant elasticity of substitution functions. Zero-profit conditions and market clearing conditions follow directly from the assumptions of profit maximization of firms, perfect competition among them, utility maximization of consumers, constant returns to scale in production, and homothecy of consumer preferences. The latter class of conditions determines the most important endogenous variables of the model, i.e. the price of each output good as the unit cost to produce this good. Other endogenous variables include sectoral production levels, emissions, carbon prices and the deployment levels of the primary production factors. Bilateral trade is specified following the Armington approach of product heterogeneity, i.e. domestic and foreign goods are distinguished by origin (Armington, 1969).[6] Böhringer et al. (2009) provide a diagrammatic structure and explain the underlying assumptions about the substitution possibilities in the production process of fossil and non-fossil goods, consumer preferences, CO_2 accounting and the representation of trade links in the model. For the sake of compactness, we point the readers to this publication for more details.

In contrast to the top-down approach which underlies the other sectors of the model, the electricity sector is modelled as a bottom-up type module for the EU regions of the model. It differentiates the following energy carriers: coal, natural gas, oil, nuclear energy and renewable energy sources. By using technology-specific capital inputs based on exogenous data, electricity outputs for each energy source are computed. As in the other sectors, the production structure is based on nested constant elasticity of substitution functions. The resulting price of electricity is then included as an input price for the other model sectors.

2.3 Model development

Three developments were conducted in the model: (i) the introduction of an electricity levy instrument to support RE with revenues from an electricity consumption tax, (ii) the introduction of the possibility for nations to exempt some of their economic sectors from this levy, and (iii) the introduction of the possibility for national governments to use carbon auctions revenues to subsidize power generation from RE.

In the original version of the model, countries reach their renewable energy objectives in the power sector thanks to public support (paid by tax payers). We developed an electricity levy instrument by introducing an endogenous tax on electricity consumption in order for the associated revenues to cover the support needed by each country to reach a specific RE target share in electricity production. We introduced the possibility for countries to exempt some sectors from this levy.

In the model, auctions revenues are by default transferred to households as lump-sum rebates. For the analysis, we introduced the possibility for national governments to transfer these revenues to the electricity sector as a subsidy for production from renewable energy.

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[6] Elasticities in international trade are based on empirical estimates reported in the GTAP 9.1 database.

When carbon auctions revenues are used to support electricity generation from renewable energy, the public support or electricity levy needed to reach the RE target is hence reduced.

3. SCENARIOS

This sections explains how the EU climate and energy policy features required for the analysis are simulated and describes the scenarios considered.

3.1 The EU climate policy and its simulation

We present how the EU emissions objective is simulated in the analysis, both in the sectors covered by the EU ETS and in the other sectors via the effort sharing regulation. We explain how we model the EU ETS characteristics, in particular auctioning. We finally describe how we simulate the renewable energy policies at the EU and Member States level.

The 2030 climate and energy policy framework (EC, 2014a) includes an EU objective of 40% reduction of greenhouse gas (GHG) emissions[7] compared to 1990 levels by 2030. This target is further split in goals for the ETS and non-ETS sectors: the Impact Assessment of the framework (EC, 2014b) suggests that sectors covered by the EU ETS are expected to reduce their GHG emissions by 43% compared to the 2005 level whereas the sectors not covered by the EU ETS have a reduction target of 30% compared to the 2005 level.[8] For the non-ETS sectors (e.g. transport, buildings, agriculture and waste), binding annual greenhouse gas emission targets for Member States are established under the Effort Sharing Directive (ESD) for the period 2013–2020 (EU, 2009) and the Effort Sharing Regulation for the period 2021-2030 (EC, 2016b). Member States are free to choose and design the policy instruments they wish to reach their respective objectives.

In the modeling exercise, full trade of allowances[9] between ETS sectors of all EU Member States is simulated such that the cost efficient allocation of permits is eventually achieved. For the other sectors, given the fact that the ESD is driven by an attempt to equalize costs across member states, we do not fully represent each member state’s target in the simulation, but we introduce carbon trading between these sectors. In the results sections, we hence report the carbon constraint in the non-ETS sectors as a non-ETS carbon price. The 2.2% linear reduction factor for the EU ETS cap is imposed for the time period 2021-2030. In sectors on the carbon

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[7] Energy and non-energy related emissions.

[8] This corresponds to the reduction target of 40% compared to the 1990 level.

[9] In this study, we assume that the respective targets apply to CO_2 emissions.

leakage list,[10] carbon allowances are freely allocated up to sector specific benchmarks.[11] In line with the EU ETS and auctioning regulations, full auctioning[12] is used for the electricity sector, and, for the remaining sectors, 30% of allowances are freely allocated up to sector-specific benchmarks in 2020 (this share is reduced to 0% by 2027, i.e. 2030 in the simulation). A 1% flat rate is applied to the benchmark of the sectors on the carbon leakage list.[13]

In aggregate, for the time period 2021-2030, at least 57% of emissions allowances are auctioned and the rest is given for free.[14]

Regarding renewable energy, the 2030 climate and energy framework includes an overall EU objective of 27% share of renewable energy sources in energy consumption by 2030. In our simulations, this target is reflected at the Member State level by an increase in the share of renewable energy in the electricity sector in line with the potential contribution of the electricity sector to the overall RE share, ie a 45% share of RE in power generation. The respective targets at the member state level are based on the EUCO30 scenario of the European Commission (E3MLab and IIASA, 2016) and presented in Table 2.[15] The targets for the aggregate regions (Rest of Western MS, Rest of Eastern MS) were identified by computing the weighted average with electricity demand.

Table 2: Assumed renewable energy targets in the electricity sector in 2030 based on EUCO30 scenario (in percent of the total power production)

Model region	RE target
France	37.2
Germany	45.6
Italy	51.9
Poland	26.5

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[10] This list includes the following sectors: Refined oil and coal products/ Crude oil extraction/ Cement/ Bricks, tiles and construction products/ Glass/ Ceramics/ Manufacturing of iron and steel/ Aluminium/ Fertilizers and other nitrogen compounds/ Organic chemicals/ Inorganic chemicals/ Paper, pulp and printing products. This list mirrors the carbon leakage list of the European Commission (2014/746/EU, Annex, Commission Decision of 27 October 2014) to the extent possible given the sectoral coverage of the model in comparison to the very detailed (NACE 4 classification) original list.

[11] We model free allocation as an output subsidy allocated to the firms, i.e. firms in a first step buy all of their emission permits and are then given back the value of a specific share of these permits, i.e. the benchmarked emissions.

[12] In our simulations, we do not take into account the fact that eight new Member States make use of derogation under Article 10c of the EU ETS directive, which allows them to issue a decreasing number of free allowances in the electricity sector. Some of these MS will even make use of this option beyond 2020 (http://ec.europa.eu/clima/policies/ets/cap/auctioning/in-dex_en.htm).

[13] This means that, in 2025 and 2030, these sectors respectively receive only 85% and 80% of the respective benchmark allowances (based on 2007/2008 data) for free.

[14] Regarding the structural surplus of allowances which has accumulated since 2014 and is included in the Market Stability Reserve (MSR) that starts in 2019, we assume that the additional allowances from the MSR will not be used before 2030.

[15] This split is purely indicative: Member States will have the possibility to propose national contributions towards the EU RES target in their forthcoming national energy and climate plans.

Spain	68.8
United Kingdom	49.9
Rest of Western MS	62.1
Rest of Eastern MS	36.3

3.2 Scenarios

Six scenarios are considered. They correspond to the combinations of three possible policy features and are presented in Table 3. First, EU Member States are free to choose the type of renewable energy support policy they wish.[16] Most of them, except the United Kingdom, Poland and Finland, finance these support schemes by an electricity levy (paid by electricity consumers). Second, in the countries where an electricity levy apply, some sectors, e.g. energy intensive industries, may be exempted. For this reason, we first consider three scenarios: PUBLIC in which RE support is publicly funded, LEVY in which RE support is financed by an electricity levy paid by all power consumers, and LEVY_ETS_EXEMPT in which RE support is financed by an electricity levy paid by all power consumers except the ETS sectors. Third, Member States are free to choose how to use the ETS auctions revenues. Two ways are considered. One is to transfer them to households as a lump sum. That is the option considered for the PUBLIC, LEVY and LEVY_ETS_EXEMPT scenarios. The alternative option studied here is to use these revenues to support power generation from RE. This is applied in the corresponding PUBLIC_REN, LEVY_REN and LEVY_ETS_EXEMPT_REN scenarios.

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[16] The detail of renewable energy support policies used by European countries is reported in the RES LEGAL website: http://www.res-legal.eu/.

Table 3: Summary of policy scenarios

	RE support funding		
	Public budget	Electricity levy paid by all consumers	Electricity levy paid by all consumers except ETS sectors
Auctions revenues are transferred to households	PUBLIC	LEVY	LEVY_ETS_EXEMPT
Auctions revenues are used to subsidize power production from RE	PUBLIC_REN	LEVY_REN	LEVY_ETS_EXEMPT_REN

In the next section, the results are presented as percentage changes relative to the PUBLIC scenario.

4. RESULTS AND DISCUSSION

In this section, before analysing the impact of recycling auctions revenues to support renewable energy, we first examine the economic effects of using an electricity levy to fund RE support in comparison to using public money.

4.1 Electricity levy versus public support to RE

If RE support is funded via an electricity levy; the aggregate energy demand, as well as the electricity demand is reduced due to a price effect. As electricity consumers have to pay this levy in addition to the electricity price, they tend to reduce their electricity consumption. This is observed in Table 4, which reports the aggregate electricity and energy demand, the carbon price and non-ETS carbon constraint, and GDP for all scenarios for the EU28 in 2030, in comparison to the PUBLIC scenario.

In the scenarios using a levy, the electricity demand is between -2.2 and -4.5% lower than in the PUBLIC scenario; the energy demand is between -0.8 and -1.5 lower. This induces lower ETS carbon price (between -2.2% and -3.9% lower) and non-ETS carbon constraint (between 6.4% and 14.7% lower). We also observe a small GDP loss (-0.1 and -0.2%) when RE support is funded via an electricity levy. We explain this by the fact that the electricity levy applies to a smaller tax base and implies more distortion than funding RE support via the general public budget. This economic activity loss is particularly true for the electricity consumers (households and industries) that have to pay the levy. This can be seen on Figures 1, 2 and 3 that are analyzed with more detail in section 4.2.

In the case when an electricity levy is employed, we note that exempting the ETS sectors induces higher aggregate energy and electricity demands: for example, in the LEVY_ETS_EXEMPT, the electricity demand is 4.1% lower than in the PUBLIC scenario, while it is 4.5% lower in the LEVY scenario. This is understandable as the absence of levy for the ETS sectors makes them better off and encourage them to use more electricity than if they had to pay this contribution. This induces a slight rise in the ETS carbon price: 0.13% in LEVY_ETS_EXEMPT compared to LEVY.

4.2 Using carbon auctions revenues to support RE

The impact of recycling carbon auctions revenues to subsidize renewable energy depends on how this support is financed. If the funding for the latter comes from the general public budget, this recycling option has no impact in our simulation. The reason is that, in our exercise, we assume that the government deficit and surplus are passed to consumers as lump-sum transfers. While in the PUBLIC scenario, households receive the carbon auctions revenues as a lump-sum transfer, in the PUBLIC_REN scenario, carbon auctions revenues are not directly given to households, they are used to support RE, but the induced surplus for the government is reallocated to households, who then see the transfers they receive unchanged.

If RE support is funded via an electricity levy, we expect three mechanisms to take place. First, households do not receive the auction revenues as a lump-sum transfer any more. This should result in a reduction of their aggregate consumption (negative income effect). Second, when auction revenues are directly used to support electricity generation from renewable energy, the electricity levy that households and industries have to pay for their electricity consumption to support power generation from RE is reduced. This results in a positive income effect. For households, this should partly balance the negative income effect mentioned previously. Third, we expect the reduction in the electricity levy to induce a rise in the electricity consumption by industries and households (price effect).

We indeed observe a rise in electricity demand in the whole economy, as can be seen in Table 4. The electricity demand is 2.4% lower in LEVY_REN compared to the PUBLIC scenario while it is 4.5% lower in LEVY. Similarly the electricity demand is reduced by 2.2% in LEVY_ETS_EXEMPT_REN and by 4.1%% in LEVY_ETS_EXEMPT. This directly explains the higher ETS price in the scenarios with the renewable subsidy: 1.5% increase in LEVY_REN compared to LEVY, 1.6% increase in LEVY_ETS_EXEMPT_REN compared to LEVY_ETS_EXEMPT.

Table 4: Carbon price, energy demand and GDP for the EU28 aggregate in 2030.

Indicators	PUBLIC_REN	LEVY	LEVY_REN	LEVY_ETS_EXEMPT	LEVY_ETS_EXEMPT_REN
CO2 price ETS (2010 €)	77.2	74.0	75.2	74.1	75.4
CO2 price non-ETS (2010 €)	163.9	182.8	174.3	187.9	176.8
GDP (% change vs. baseline)	0.0	-0.2	-0.1	-0.2	-0.1
Energy demand (% change vs. baseline)	0.0	-1.5	-0.8	-1.5	-0.8
Electricity demand (% change vs. baseline)	0.0	-4.5	-2.4	-4.1	-2.2
Primary energy consumption (% change vs. baseline)	0.0	-2.5	-1.5	-2.4	-1.4

The sectoral impacts of the recycling options are now presented, first for the non-ETS sectors, then for the ETS sectors.

4.2.a Non-ETS sectors

For the non-ETS sectors, we expect at least two effects to take place. On the one hand, using auction revenues to subsidize RE electricity generation should make the non-ETS sectors better off because the electricity levy they have to pay is reduced. On the other hand, they can be disadvantaged by a possible increase in the energy prices (small electricity price increase due to a larger demand from the whole economy, and subsequent small price increase for some fossil fuels). The final effect is a balance of the two and results in small variations. For example, the *Food and beverage* sector, which is relatively electricity-intensive compared to the other non-ETS sectors (cf. ranking of ETS and non-ETS sectors according to their electricity and energy intensities in appendix), slightly benefits as shown in **Figure 1** below: the change in sectoral output is respectively -0.11 and -0.20 in the LEVY and LEVY_ETS_EXEMPT scenarios in comparison to PUBLIC while it is only -0.03 and -0.07 in LEVY_REN and LEVY_ETS_EXEMPT REN. For

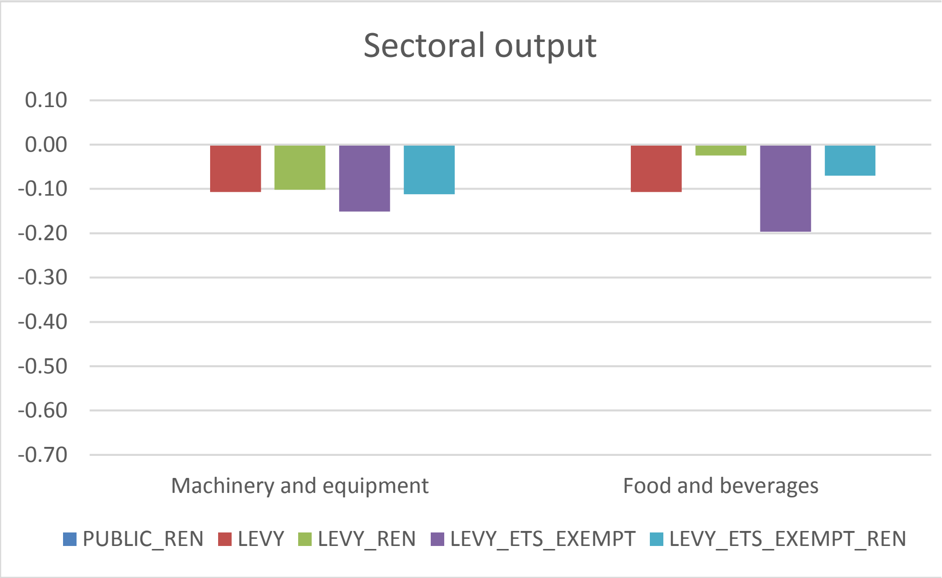

Figure 1: Change in output for two selected non-ETS sectors in 2030 (% change compared to the PUBLIC scenario)

the manufacturing sectors, the impact is minor (for all scenarios, the sectoral output changes compared to the PUBLIC scenario are between -0.11 and -0.15%).

The *Inland Transport* sector benefits from this recycling option (cf. **Figure 2**) due to a demand effect from the non-ETS sectors that have to pay the electricity levy and are better off when the latter is reduced: for example the sectoral output of this sector is reduced by 0.58% in the LEVY_ETS_EXEMPT scenario relative to the PUBLIC scenario, but by 0.30% in the LEVY_ETS_EXEMPT_REN case.

In aggregate, despite the fact that the activity of some non-ETS sectors is higher when auctions revenues are used to support renewable electricity, the non-ETS carbon price is smaller (5.9% reduction in LEVY_ETS_EXEMPT_REN compared to LEVY_ETS_EXEMPT). We suggest that the reduced electricity levy allows these sectors to make use of cheaper abatement opportunities, in particular through a larger use of electricity (3.3% change in electricity demand from all non-ETS sectors in LEVY_ETS_EXEMPT_REN compared to LEVY_ETS_EXEMPT).

4.2.b ETS sectors

The impact of using carbon revenues to support RE on the output of ETS sectors depends on the exemption rules (see **Figure 3** for three selected sectors). If they have to pay the electricity levy, the recycling of the auctions revenues to support electricity production from RE results in a reduction of the levy. This positive income effect makes the ETS sectors better off: -1.35% in aluminium sector output in LEVY _REN compared to the PUBLIC scenario in contrast with -2.3% in LEVY; -0.52% in the sector of iron and steel manufacturing in LEVY_ REN to compare with -0.94% in LEVY. In aggregate, ETS sectors then use 3.4% more electricity than if auctions revenues are transferred to households.

On the contrary, if the ETS sectors are exempted, the use of auction revenues to subsidize renewable electricity generation make them worse off: for the aluminium sector, the output rises by 0.47% in the LEVY_ETS_EXEMPT scenario relative to the PUBLIC scenario, to be compared with 0.14% in LEVY_ETS_EXEMPT_REN: for the sector of iron and steel manufacturing, the respective changes are 0.31% and 0.12%. The reason is that, despite the subsidy to RE electricity, the increased electricity demand in the whole economy results in a higher ETS carbon price and a slight increase in the price of electricity in some countries (for example 3% in France in the scenarios with the subsidy compared to the scenarios without), which results in losses for most ETS sectors.

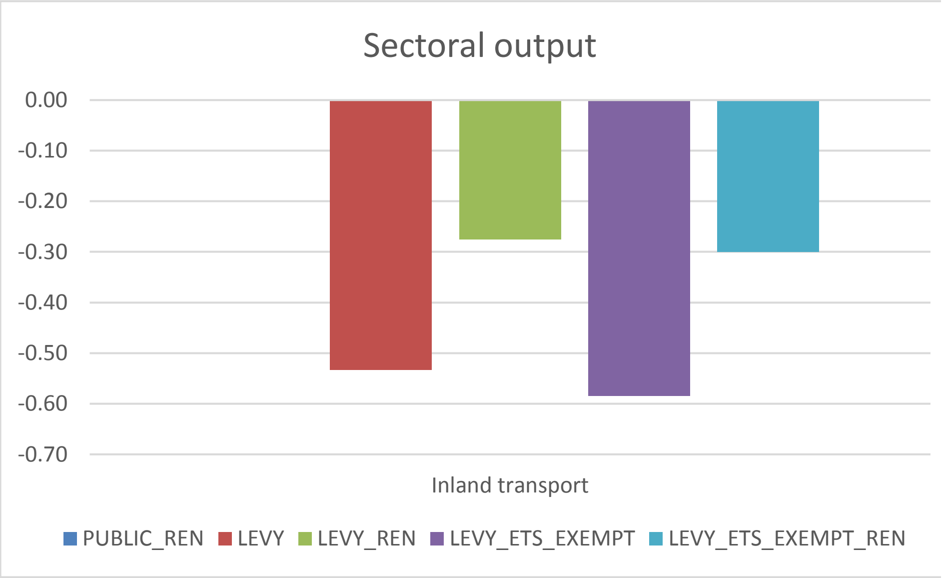

Figure 2: Change in output for Inland transport in 2030 (% change compared to the PUBLIC scenario)

In aggregate for the whole economy, the GDP is slightly better (-0.1% change in LEVY_ETS_EXEMPT_REN relative to PUBLIC, to be compared with -0.2% in LEVY_ETS_EXEMPT). This is explained by the increased output in some non-ETS sectors. Those are not exempted from the levy, but they have a significant use of electricity and benefit when auction revenues are used to support RE electricity. We may explain the improvement in terms of GDP by the reduction of the electricity levy and the associated distortionary effect. Indeed as explained in section 4.1, employing an electricity levy induces a slight GDP loss due to its distortionary effects. These are reduced when the use of auctions revenues to support RE allows a reduction in the levy.

Except for electricity, which is obviously better off when benefiting from a subsidy, the impacts of this auction revenues recycling option on the output of the ETS as well as non-ETS sectors does not result in significant changes in their world market shares (see figures in appendix). We explain this by the fact that the sectoral changes are relatively small. This is an interesting result in the policy context of the Energy Union Package (EC, 2015), in which industrial competitiveness concerns are taken into consideration.

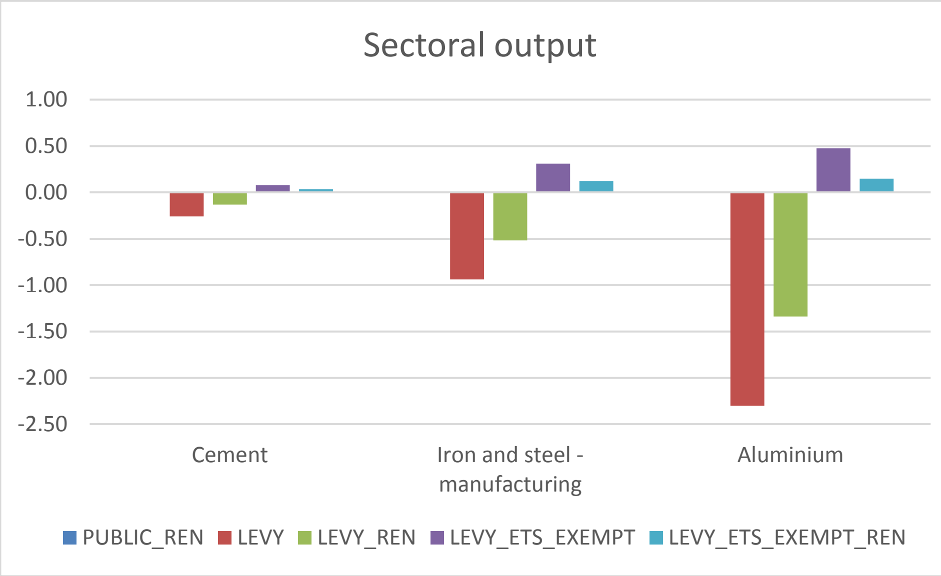

Figure 3: Changes in output of selected sectors in 2030 (% change compared to the PUBLIC scenario)

Besides the analysis of the sectoral impacts on ETS and non-ETS sectors, we observe that, in our simulation, the effect of this carbon revenues recycling method on households is negligible. The reason is that households do not receive the auctions revenues as a lump-sum any more but they benefit from the increase economic activity. In order to fully inform policy makers about the social impacts of such a scheme, the analysis could be complemented by a microsimulation approach comparable to what was conducted by Böhringer et al. (2017).

Regarding the environmental impacts of such scheme, we note that the auctions recycling method does not change the cap of the EU ETS, nor the mitigation objectives in the non-ETS sectors. The only environmental impacts it may have is on co-pollutants via the sectoral output changes described above.

5. CONCLUSIONS

As ETS are being developed by an increasing number of nations as instruments in order to reduce greenhouse gases emissions, behavioral studies have shown that the political and public acceptability of these instrument depends on the use of the associated revenues. A possibility that is well perceived by the general public is to employ them to support renewable energy development.

This analysis aims at examining the economic impact of such a recycling option as a function of the type of RE policy funding and potentially associated sectoral exemption rules. It extends the literature on environmental taxation in the presence of other taxes (e.g Bovenberg and Goulder, AER, 1996; Norhdaus AER, 1993) to carbon pricing in the form of an ETS, in the presence of a specific distortionary commodity tax - the electricity levy - that is heterogeneous among sectors.

The study is conducted on the EU case and takes account of the EU objectives regarding emissions reductions and renewable energy as stated in the 2030 climate and energy framework. The methodology employed uses detailed sectoral data on ETS and non-ETS sectors, data which are gathered and combined to develop the PACE model. The scenarios analyzed include public support to RE, the use of an electricity levy with or without exemptions for the energy intensive sectors, and the associated scenarios in which carbon auctions revenues are recycled to support RE instead of being transferred to households.

In our analysis, public support to renewable energy results in better outcomes for the whole economy than an electricity levy due to the distortion the latter induces and the cost it implies for electricity consumers (households and industries). Only ETS sectors benefit if they are exempted from this levy.

If auctions revenues are used to support RE and reduce the levy, the distortionary effect is diminished and there is an overall GDP improvement. Only the exempted sectors suffer from increased carbon and energy prices. We indeed find that using carbon revenues to subsidize electricity production from renewable energy reduce the electricity levy used by some Member States to support RE, which induces a rise in electricity demand in the whole economy and an associated electricity price (electricity levy excluded) increase. The impact on the output of ETS sectors then depends on the exemption rules. If they have to pay the electricity levy, the recycling of the auctions revenues to support RE results in a positive income effect for them and make them better off. On the contrary, if the ETS sectors are exempted, the use of auction revenues to subsidize renewable electricity generation make them worse off. The reason is that the slight increase in the electricity price, as a consequence of the reduced electricity levy and associated increased electricity demand results in losses for the energy intensive sectors. For the non-ETS sectors, the effect is a balance of two mechanisms: a positive income effect associated with the electricity levy reduction, but a loss induced by the increase in the energy prices. The *Inland Transport* sector benefits from this recycling option due to a demand effect from the non-ETS sectors that have to pay the electricity levy and are better off when the latter is reduced. In terms of carbon constraint, using the auctions revenues to support RE results in a rise in the ETS price as a result of the higher electricity demand, but a reduction of the climate constraint in the non-ETS sectors, which can use more electricity.

Except for electricity, which is better off when benefiting from a subsidy, the impacts of this auction revenues recycling option on the output of the ETS as well as non-ETS sectors does not result in significant changes in their world market shares. We explain this by the fact that the sectoral changes remain relatively small.

The effect of this carbon revenues recycling method on households is negligible. The reason is that households do not receive the auctions revenues as a lump-sum any more but they benefit from the increase economic activity. In order to fully inform policy makers about the social impacts of such a scheme, the analysis could be complemented by a microsimulation approach comparable to what was conducted by Böhringer et al. (2017).

Regarding the environmental impacts, we note that the auctions recycling method does not change the cap of the EU ETS, nor the mitigation objectives in the non-ETS sectors. The only environmental impacts it may have is on co-pollutants via the output changes of industrial sectors.

Our study has interesting policy implications regarding renewable energy support, potentially associated exemption rules and interactions with carbon revenues recycling options. Such a recycling method has no significant impact if there is public support to RE and that government deficits and surplus are passed to households as lump-sum transfers. On the contrary, if an electricity levy is used to finance RE, the reduction of this levy as a consequence of using carbon revenues to subsidize power generation from RE induces a reduction of the distortionary effects of this levy. This results in a GDP improvement. Industrial sectors benefit from the reduction in the levy they have to pay, but exempted sectors suffer some losses due to the aggregate increase in electricity demand and the associated increase in carbon and energy prices.

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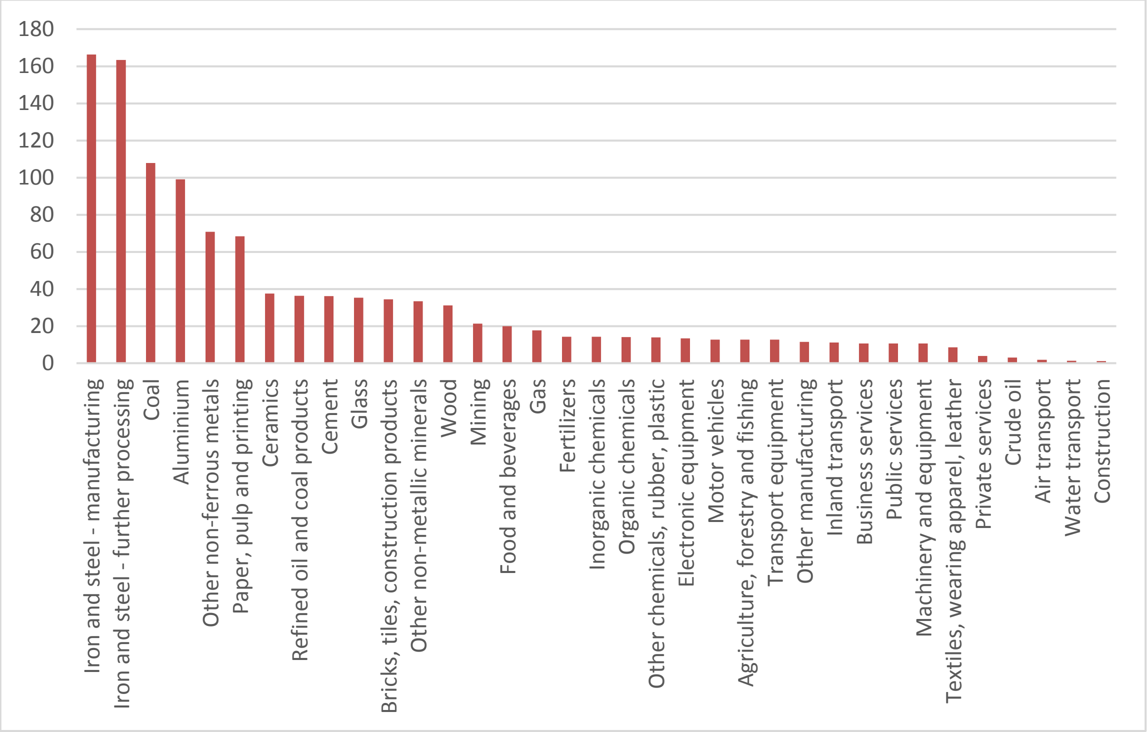
CLIMA, DG ECFIN, DG ENER, DG GROW, DG MOVE, Joint Research Center. The ideas expressed here are those of the authors, who remain solely responsible for errors and omissions.

6. APPENDIX

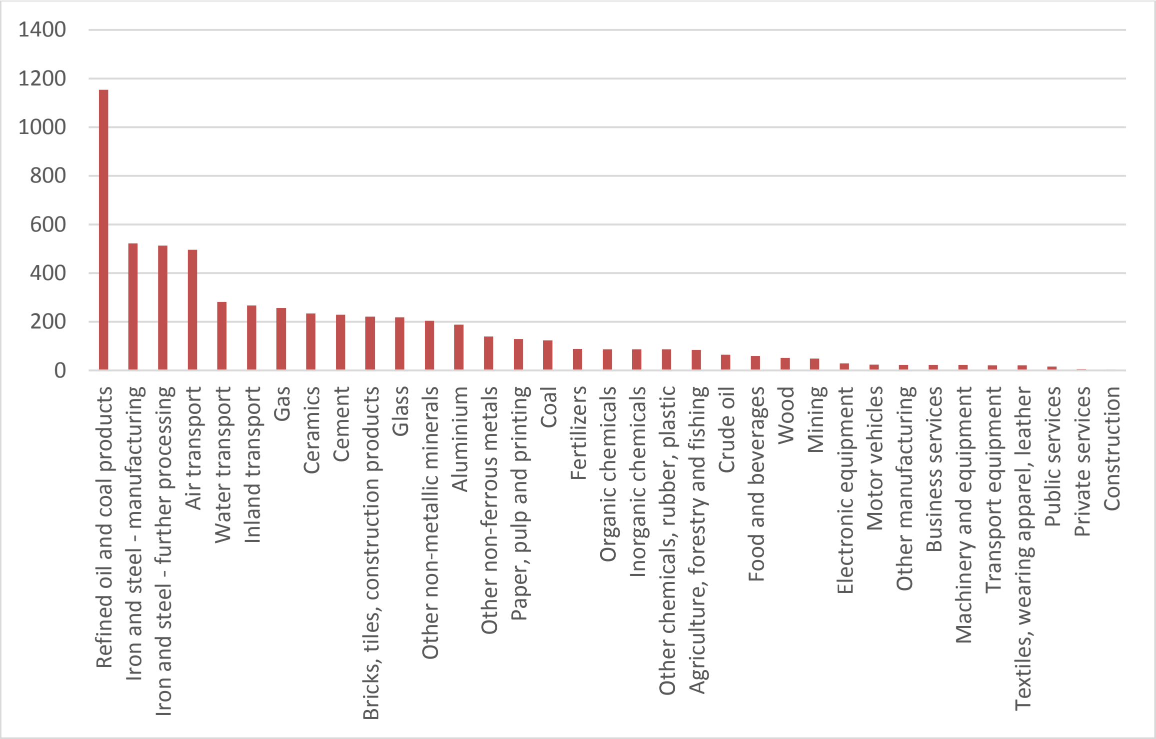
6.1 Regional coverage of the model

Main aggregates	Countries or groups of countries
EU regions	Germany (DEU)
	France (FRA)
	United Kingdom (GBR)
	Spain (ESP)
	Poland (POL)
	Italy (ITA)
	Rest of Western Member States: Denmark, Sweden, Finland, Austria, Belgium, Netherlands, Luxembourg, Ireland, Portugal, Greece, Malta, Cyprus (XWE)
	Rest of Eastern Member States: Czech Republic, Slovakia, Hungary, Slovenia, Bulgaria, Romania, Croatia, Estonia, Latvia, Lithuania (XEE)
Non-EU regions	United States of America (USA)
	Canada (CAN)
	Japan (JPN)
	Russia (RUS)
	Australia (AUS)
	Turkey (TUR)
	Switzerland, Norway, Iceland, Liechtenstein, Ukraine, Belarus, New Zealand (RAX)
	China, incl. Hong Kong, excl. Taiwan (CHN)
	India (IND)
	Brazil (BRA)
	South Korea (KOR)
	Indonesia (IDN)
	Mexico (MEX)
	South Africa (ZAF)
	Rest of the World (ROW)

6.2 Electricity and energy intensities of industrial sectors



Electricity intensity of model sectors (toe/M€) for the baseline scenario in 2010



Energy intensity of model sectors (toe/M€) for the baseline scenario in 2010

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