Gabinete de Estratégia e Estudos
Ministério da Economia, da Inovação e do Desenvolvimento

GEE Papers
Número 21
Julho de 2010

Sectoral and regional impacts of the European Carbon Market in Portugal

Margarita Robaina Alves
Miguel Rodríguez
Catarina Roseta-Palma

Av. da República nº. 79 1050 – 243 Lisboa
Telf: (351) 217998150
Fax: (351) 217998154
Web Site: www.gee.min-economia.pt

ISSN 1647-6212

Sectoral and regional impacts of the European Carbon Market in Portugal

Margarita Robaina Alves
University of Aveiro, GOVCOPP and Department of Economics, Management and Industrial Engineering

Miguel Rodríguez
Facultade Empresariais e Turismo, 32004 Ourense, Spain, Department of Applied Economics, University of Vigo

Catarina Roseta-Palma
ISCTE-Lisbon University Institute, Department of Economics and ERC-UNIDE

Classificação JEL codes: Q48, Q52,R38

Keywords: Regional impact, sectoral impact, tradable CO2 permits, European Carbon Market.

Abstract

Across Europe, CO_2 emission permits represent one of the main policy instruments to comply with the limits established by the European Commission to achieve the goals of the Kyoto Protocol. In this paper we use microdata to address two issues regarding the impact of the European Carbon Market (EU ETS). On the one hand, we analyse the sectoral effects of the EU ETS in Portugal. The main goal is to study the outcomes of this policy in terms of the transactions carried out between sectors, as well as the distributive consequences. On the other hand, we also look at the regional impact. The pre-existing specialization of different regions in the production of different goods and services might lead to an uneven economic impact of the new permit market. In particular, Portuguese data indicate a distribution of revenue from low income to high income regions, or rather, between installations located in those regions. We focus on the first two years of operation of the EU ETS, using data for each one of the 244 Portuguese installations regulated by this market as well as financial data for 80% of these installations

Index

Sectoral and regional impacts of the European Carbon Market in Portugal

Margarita Robaina Alves

GOVCOPP and Department of Economics, Management and Industrial Engineering,

University of Aveiro

Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

Email: mrobaina@ua.pt

Contact author

Miguel Rodríguez

Department of Applied Economics, University of Vigo

Facultade Empresariais e Turismo, 32004 Ourense, Spain

Email: miguel.r@uvigo.es

url: webs.uvigo.es/miguel.r/ and www.rede.uvigo.es

Catarina Roseta-Palma

Department of Economics and ERC-UNIDE, ISCTE-Lisbon University Institute

Av. Forças Armadas, 1629-026 Lisboa, Portugal

Email: catarina.roseta@iscte.pt

1. Introduction

In accordance with the Kyoto Protocol, signed in 1997, the European Union has pledged to reduce the emissions of greenhouse gases (GHG). The European Union Emission Trading System (EU ETS) was established to that effect by Directive 2003/87/CE. An emission permit system is a pollution-control instrument based on requiring pollution sources to hold transferable permits. The regulator issues the desired number of permits and each source designs its own compliance strategy, including sale or purchase of allowances and pollution abatement. The incentives created by this system ensure that each source has enough flexibility to minimize its compliance costs and, as a consequence, the policymaker's environmental goals are achieved cost-effectively, i.e. at the lowest possible cost for the whole economy.

In spite of the desirable theoretical properties of emission permit schemes, the nature of the EU ETS raises a few efficiency and equity concerns. Cost-effectiveness of any environmental regulation requires a full coverage of emitters, especially when non-subject sectors present lower abatement costs (see Böhringer et al, 2006). Also, any unequal treatment of sectors generates distributional consequences. For instance, Kettner et al (2008) provide evidence that Phase I allocations favoured large installations relative to smaller ones. In defence of the EU ETS design, a market limited to main emitters is appealing due to a reduction of administrative and compliance costs. Furthermore, there is no evidence of market power, which if it existed would diminish trading efficiency (Convery and Redmond, 2007).[1]

Another problem is associated with the free allocation of pollution permits by most governments, despite the empirical evidence on the superiority of auctioning. Cramton and Kerr (2002) note that auctioning "allows reduced tax distortions, provides more flexibility in distribution of costs, provides greater incentives for innovation, and reduces the need for politically contentious arguments over the allocation of rents." This is in line with the conclusions of the literature on revenue recycling through distortionary tax reduction (Parry et al. 1999; Fullerton and Metcalf 2001). Environmental instruments aim to correct pre-existing market distortions. Therefore, when they are used to raise revenue (such as with environmental taxes or auctioned permits), other taxes which carry deadweight losses (such as labour or income taxes) can be reduced. This type of "green" fiscal reform could thus allow a reduction of the total tax burden in the economy.

A final point is that regulation falls on installations that in turn are anchored in a physical territory. The specialization of the different regions in the production of different goods and services can lead to different economic impacts of the carbon market from a regional point of view. If there is no proportionality between the regional share of affected installations and population, value added or employment, we can expect important distributional effects between regions, in Europe and even within countries.

Regulations minimising distributive and economic efficiency distortions are necessary. Hence it is important to study both the sectoral and regional impact of the EU ETS inside the different countries involved. However, little attention has been paid to the later in the literature[2]. This article focuses on the Portuguese case, analysing both regional and sectoral EU ETS economic impacts. To this end we use data from 2005 and 2006 for 244 Portuguese installations covered by the EU ETS as well as economic

[1] For a more complete discussion, Convery (2009) reviews the literature on emissions trading in Europe.
[2] The only exception we are familiar with is for the case of Spain (Rodriguez and del Rio, 2008).

data from the "Sistema Anual de Balances Ibéricos" (SABI) database[3]. The regions are shown according to the European NUTS III classification, consisting of 28 regions in continental Portugal and the Autonomous Regions of Madeira and Azores.

The data reveal that: (i) Portuguese carbon emissions permits are extremely concentrated in a small number of installations; (ii) the thermoelectric sector was the only one that had a negative balance, and only in 2005, mainly due to adverse weather conditions; (iii) other sectors appear to have benefited from EU ETS participation, some significantly so; iv) a limited number of regions show a high concentration of regulated emissions, surpluses and deficits. Those results, together with the fact that about 60% of the national emissions remain unregulated by the EU ETS, highlight the necessity of considering the full distributive impacts when analysing policy measures.

The article is made up of seven sections, including this introduction. Section 2 describes the European Union's Emission Trading System, whereas Section 3 focuses on the first Portuguese National Allocation Plan (NAP). Section 4 analyzes the sectoral effects of the European Carbon Market in Portugal, whereas Section 5 discusses its regional effects. The Portuguese NAP for the second period, 2008-2012, is described in Section 6. Finally, some policy implications and the main conclusions are set out in Sections 7 and 8, respectively.

2. The European Union Emission Trading System

The European Union Emission Trading System (EU ETS) was established to that effect by Directive 2003/87/CE. It is based on six fundamental principles: i) it is a "cap-and-trade" system (an overall cap is set, defining the maximum amount of emissions, and sources can buy or sell allowances on the open market at European level); ii) it is focused on CO_2 from large industrial emitters; iii) implementation is taking place in two phases (2005-2007 and 2008-2012) with periodic reviews; iv) emission allowances are decided within national allocation plans; v) it includes a strong compliance framework; vi) the market is EU-wide but taps emission reduction opportunities in the rest of the world through the use of the Clean Development Mechanism and Joint Implementation, and it also provides for links with compatible systems in third countries.

The installations covered by the EU ETS initially received allowances for free from each EU Member State's government, in what is known as "grandfathering". However, since unused permits[4] can be sold, installations are stimulated to invest in emissions reduction even when they are under their "cap" (the grandfathered allocated permits).

Until now, each Member State was able to decide the sum of permits to attribute to the installations regulated by the Directive, following criteria provided by the European Commission. In the two initial phases, a limited number of sectors was included: energy activities (combustion, refineries, coke ovens); iron and steel (production and processing); mineral industries (cement, glass, ceramic products); and pulp

[3] Although 2007 data is available, we do not generally provide it in our analysis because the market collapsed and monetary values were consequently much lower. We do, however, use it occasionally to give a richer picture of developments in Phase I. Moreover, a preliminary analysis of available 2008 data is done in section 5.
[4] Carbon permits in the EU ETS are named European Union Allowances (EUA) and each covers one ton of carbon. Henceforth in the paper we will use the word "permit" when referring to EUA.

and paper. It should be noted that the emissions of the installations covered by the market represent approximately 40% of the total CO_2 EU emissions.

In April 2009, the new energy-climate package was approved[5]. This includes a revision of the EU ETS (Directive 2009/29/EC) which contemplates: (i) an EU-wide target for GHG industrial emissions to achieve a 21% decrease in 2020 compared to 2005 emissions[6]; (ii) an extension of the EU ETS to include two other GHG, nitrous oxide and perfluorocarbons, and to cover other sectors, namely aviation and the petrochemical, ammonia and aluminium sectors; (iii) a greater share (above 50 %) of auctioned permits[7]; (iv) an opt-out possibility for small installations, emitting below 25,000 ton CO_2/year, which show alternative reduction measures. These changes will enter into force in January 2013. The package also contains other provisions, such as national binding targets for renewable-energy use and for non-ETS sectors, in order to reach, respectively, a share of renewables in final energy demand of 20% and an average reduction of 10% in these sectors' GHG emissions, by 2020.

In the first year of trading, which was 2005, 362 Mt (million tonnes) of CO_2 were traded on the market for a sum of €7.2 billion, as well as a large number of futures and options (Point Carbon (2006)). The price of allowances increased more or less steadily to its peak level, in April 2006, of about €30 per tonne CO_2, but fell in May 2006 to under €10 on news that overall emission caps were so generous that in many countries there was no need to reduce emissions. The trading price collapsed to €1.2 in March 2007, declining further to €0.10 in September 2007. Verified emissions, on the other hand, grew in the first phase of the scheme, albeit by less than GDP. For the countries for which data is available (all 27 member states except Romania, Bulgaria and Malta), emissions increased by 1.9% between 2005 and 2007 (European Commission (2008b)).

Phase I is widely believed to have been over-allocated. The number of allowances distributed to installations in 2005 exceeded those installations' emissions by about 176 Mt or 7,7 % of the total EU cap (see Table 1). This could imply that few additional overall emission reductions have been achieved. However, Ellerman and Buchner (2008) emphasize that simply comparing emissions with the cap does not take into account abatement brought about by ETS participation. In their analysis, they compare actual emissions with business-as-usual scenarios to show that abatement might actually explain a significant part of the overall Phase I surplus. At any rate, caps for the second trading period have been lowered 9,5% for the EU as a whole.

Some of the EU15 member states had a net "short" position in 2005[8], notably Spain with the highest deficit (close to 5%). All the EU10 countries, on the other hand, were "long", often significantly so as in the case of the Baltic countries.

5 See http://ec.europa.eu/environment/climat/climate_action.htm
6 And 30% compared to 1990 emissions (see European Commission (2007a))
7 Governments could auction up to 5% of allowances in phase I (2005-2007) and up to 10% in phase II (2008-2012). In phase I, only four out of 25 Member States used auctions at all, and in only one case were auctions fully employed to the 5% limit (see Hepburn et al (2006) and Ellerman and Buchner (2007)).
8 Countries are said to be short (long) if they had emissions greater (smaller) than their allocation so that they are potential buyers (sellers) of allowances from (to) other countries, in order to achieve compliance. The same terminology can be used for sectors.

Table 1- Caps by Member State in 1st and 2nd period of EU ETS (quantities in Mt CO_2)

Member State	*1st period cap*	*2005 verified emissions*	*Deficit (-) or surplus (+) in %*	*Cap allowed 2008-2012*
Austria	33	33,4	-1,2%	30,7
Belgium	62,1	55,58	10,5%	58,5
Bulgaria	42,3	40,6	4,0%	42,3
Cyprus	5,7	5,1	10,5%	5,48
Czech Rep.	97,6	82,5	15,5%	86,8
Denmark	33,5	26,5	20,9%	24,5
Estonia	19	12,62	33,6%	12,72
Finland	45,5	33,1	27,3%	37,6
France	156,5	131,3	16,1%	132,8
Germany	499	474	5,0%	453,1
Greece	74,4	71,3	4,2%	69,1
Hungary	31,3	26	16,9%	26,9
Ireland	22,3	22,4	-0,4%	22,3
Italy	223,1	225,5	-1,1%	195,8
Latvia	4,6	2,9	37,0%	3,43
Lithuania	12,3	6,6	46,3%	8,8
Luxembourg	3,4	2,6	23,5%	2,5
Malta	2,9	1,98	31,7%	2,1
Netherlands	95,3	80,35	15,7%	85,8
Poland	239,1	203,1	15,1%	208,5
Portugal	38,9	36,4	6,4%	34,8
Romania	74,8	70,8	5,3%	75,9
Slovakia	30,5	25,2	17,4%	30,9
Slovenia	8,8	8,7	1,1%	8,3
Spain	174,4	182,9	-4,9%	152,3
Sweden	22,9	19,3	15,7%	22,8
UK	245,3	242,4	1,2%	246,2
Total	**2298,5**	**2122,16**	**7,7%**	**2080,93**

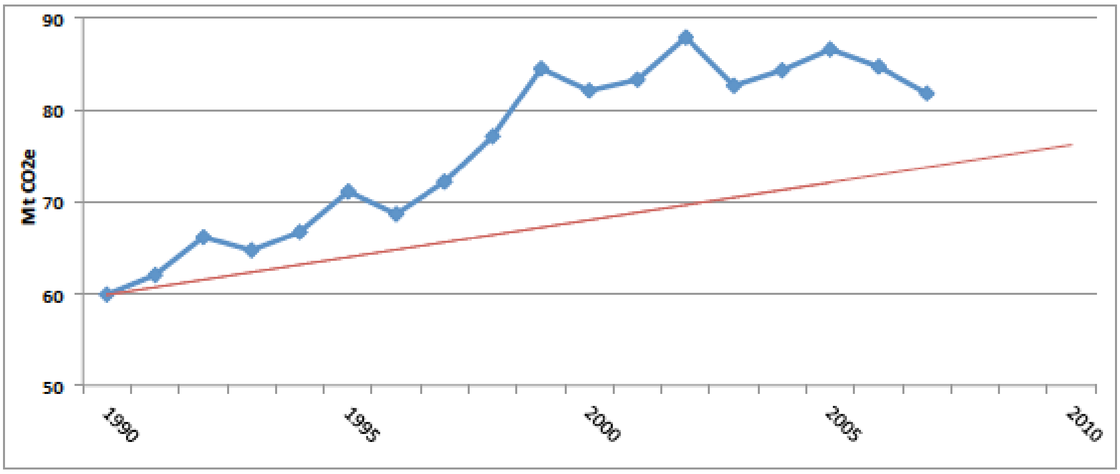
Source: European Commission (2007b); Additional information on which installations are included is given in the source.

Ellerman and Buchner (2007) discuss the disparities among countries for 2005, presenting the gross positions for each one as well as the net ones. They note that the member states which comprise a large part of the potential demand are also important suppliers, indicating that many trades were among installations within each country. They also provide a brief sectoral analysis. It is clear that for the EU as a whole, the Power & Heat sector was the only one to have a short position, while the other industrial sectors were all long, often by large percentages (around 20% for Ceramic, Iron, Steel & Coke, and Pulp & Paper). The underlying reasons for this uneven distribution of permits among sectors appear to have been that other sectors face competition with firms outside the EU and also that abatement options were cheaper in the power sector. As a result, the National Allocation Plans were generous in the number of permits allocated except for the Power & Heat sector. Unsurprisingly, the power sector, which makes up around 60% of EU ETS emissions, represented in 2005 nearly 90% of potential permit demand. It also accounted for some 50% of the potential supply, thus justifying most of the market's activity.

2.1 The first Portuguese National Allocation Plan

The target established by the Directive for Portugal is that during the Kyoto compliance period, 2008-2012, the mean emissions cannot exceed a 27% increase over the emission levels of 1990. Figure 1 illustrates the actual evolution of emissions until 2007 and the linear path to achieving the target in 2010, excluding land use change and forestry (LULUCF). A reference scenario produced in 2006 placed Portugal 12% above the attributed limit and proposed additional measures aimed at sectors that do not participate in the EU ETS, such as transportation, agriculture, commerce and households. The latest official estimates predict an annual deficit of only 5% (2.88 Mt CO2e), to be covered using the Kyoto Protocol mechanisms of flexibility.[9] Emissions show significant annual variability, mainly due to the fluctuations in hydroelectric power generation that are caused primarily by precipitation variability, as discussed in Section 3.

Figure 1: Emissions and linear path to Kyoto target



Source: Agência Portuguesa de Ambiente

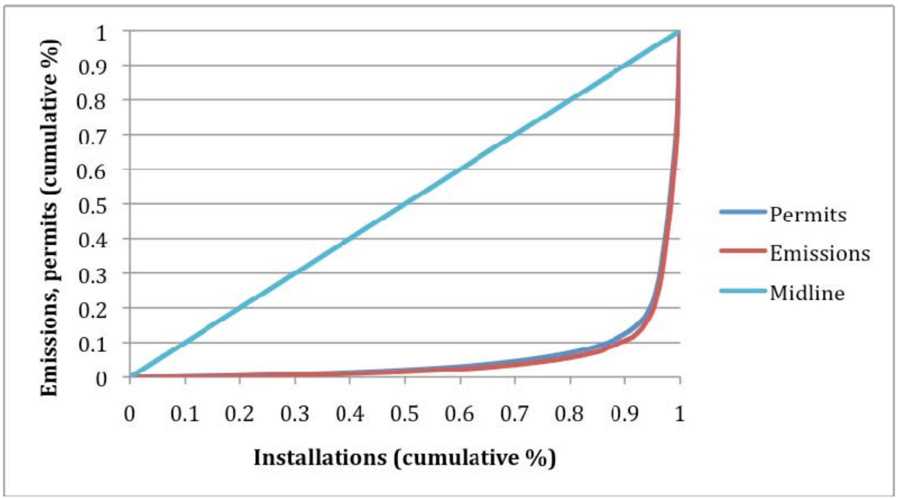
The first Portuguese National Allocation Plan (NAP), covering the period 2005-2007, considered 38,9 Mt of CO_2 per year, of which 36,9 Mt for 244 industrial installations and the remainder left aside for new installations. Mostly, historical emissions were used to distribute permits between sectors and installations. Exceptions were made for new installations and for the sectors of electricity generation and iron and steel, where historical data was seen as inappropriate considering technological potential for emission reduction. Moreover, as in most other EU countries, benchmarking was not used (see Ellerman and Buchner, 2007).

The actual distribution of permits among the 244 installations covered by the EU ETS was based specifically on two criteria: (i) the historical emissions of each one, which had previously been used for the definition of the total permits assigned to each sector and (ii) combustion emissions assuming an "average fuel" for each activity sector. Individual assignments were given out based on the sum of adjusted combustion emissions with historical emissions. Finally, this sum was multiplied by a factor of global adjustment (equivalent to that used for the calculation of the emissions for each sector).

[9] See Comissão para as Alterações Climáticas (2009) Memorando – Estado de Cumprimento do Protocolo de Quioto, in http://www.cumprirquioto.pt/documents/List.action

An outstanding characteristic of the Portuguese NAP, as of many others, is the inclusion of a large number of small installations. Figure 2 ranks the 244 Portuguese installations according to their allocated emissions and reveals the extreme inequality of their size.

Figure 2: Inequality in the distribution of emissions and allocated permits (2005)



Source: Own elaboration using data available in http://ec.europa.eu/environment/ets

We can highlight from the permit allocation that 10% of installations have 90% of emissions permits. Also, two installations jointly have 31.5% of permits, and there are 163 installations classified as "mini" (less than 25000 tons of CO_2), which together account for less than 4% of emissions. Thus it is clear that Portuguese permits are extremely concentrated. This is similar to findings for all EU countries, where Kettner et al (2008) find that the biggest 1,8% of installations account for 50% of emissions. Naturally, regions where these are located will support a large percentage of emission reduction effort.

3. Sectoral effects of the European Carbon Market in Portugal

Based on the final reports of the EU ETS for the years 2005 and 2006, we can analyse the effort made by each sector to reduce CO_2 emissions, and also identify sectors that were harmed by or benefited from the permit distribution. Recall that the Portuguese NAP attributed the equivalent of 36,9 Mt of CO_2 for each year in the first period. In 2005 and 2006 Portuguese installations only emitted 36,4 and 33 Mt respectively, so the country had a surplus that provided potential revenues of approximately 10,4 M € and 58,8 M € for all installations.[10] Table 2 shows the breakdown for the different sectors regulated by the EU ETS in 2005 and 2006. In order to assess the economic implications of the EU ETS, we assumed that the price of each permit negotiated by the Portuguese companies was 21,73 €/t and 15,14 €/t respectively in 2005 and 2006[11]. Negative values indicate potential profit from permit sales and not actual profit, as it unlikely that all surplus permits were actually sold. Moreover, even if all permits had been sold the net benefit of EU ETS participation would need to take into account transaction costs, which tend to be higher

[10] The numbers for 2007 show a further drop in emissions, to 31,2 Mt CO_2.

[11] These are the weighted average prices of permits traded by European companies, calculated from the monthly average prices and the monthly volume of rights (tons of CO_2) interchanged in the European market, using the data in The European Carbon Market Monthly Bulletin published by Caissê des Dépôts (www.caissedesdepots.fr/missionclimat/).

for smaller firms. Still, ETS data indicates that in the first transaction period less than 10% of Portuguese EUA expired worthless (Trotignon and Ellerman, 2008).

Table 2 – Attributed permits, emissions (in Mt) and sectoral costs (in M€) for 2005 and 2006

Sectors	Emissions 2005	Permits	Coverage %	Possible expenses in permit purchase at price 21,73€/ton
Thermoelectric generation	21,91	20,97	95,7	20,50
Ceramic	0,87	1,16	134,4	-6,47
Cement and lime	6,98	7,14	102,2	-3,32
Cogeneration	2,06	2,49	120,7	-9,26
Other Combustion Facilities	0,42	0,54	126,3	-2,42
Iron and steel	0,22	0,31	140,1	-1,92
Pulp and paper	0,31	0,36	115,3	-1,05
Refineries	3,01	3,27	108,5	-5,58
Glass	0,64	0,68	106,4	-0,89
Total	**36,4**	**36,9**	**101,3**	**-10,40**

Sectors	Emissions 2006	Permits	Coverage %	Possible expenses in permit purchase at price 15,14 €/ton
Thermoelectric generation	18,67	20,97	112,3	-34,85
Ceramic	0,81	1,16	142,7	-5,24
Cement and lime	6,86	7,14	104,0	-4,14
Cogeneration	2,06	2,49	120,8	-6,49
Other Combustion Facilities	0,39	0,53	135,2	-2,09
Iron and steel	0,24	0,31	130,3	-1,09
Pulp and paper	0,31	0,36	117,0	-0,80
Refineries	3,02	3,27	108,2	-3,75
Glass	0,64	0,67	104,0	-0,39
Total	**33,0**	**36,9**	**111,8**	**-58,82**

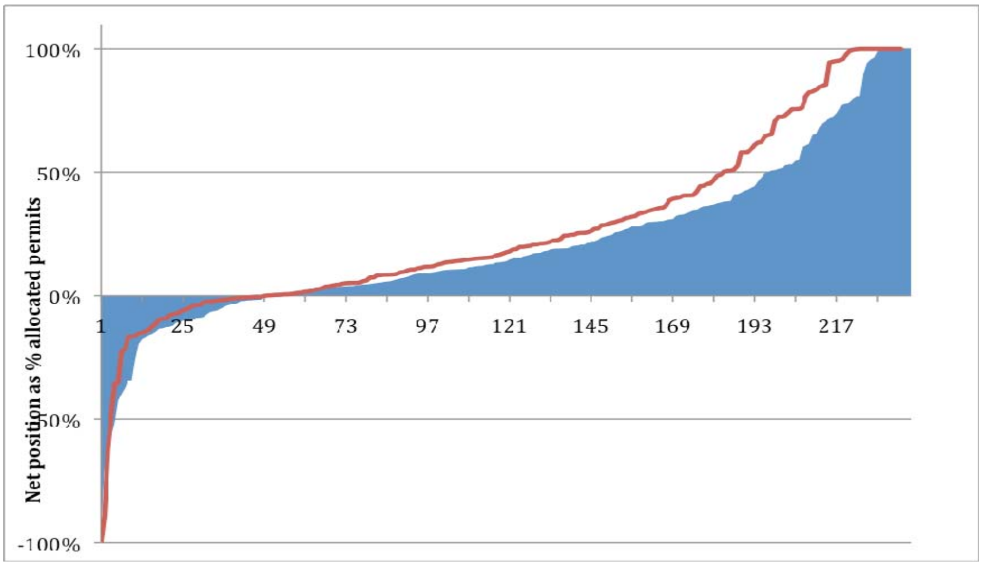
Source: Own elaboration using the data available in http://ec.europa.eu/environment/ets; totals for 2006 exclude 3 installations which were removed, as there were problems with their emissions data

Only thermoelectric plants have a negative balance in 2005, that is, they discharged more emissions than the permits allocated to them (approximately one million tons of CO2 in excess). The assigned permits in that year covered 95.7% of emissions made by this sector, mainly due to a drought that reduced hydroelectricity generation[12]. In the remaining sectors there was a surplus of emission rights for both years, especially so for Ceramic, Iron and Steel, Other Combustion Facilities and Cogeneration. We provide some analysis on the significance for each sector of the extra revenues and costs below.

One important advantage of microdata is that we can perform a detailed analysis of the potential outcome of the carbon market, with individual data for each installation. Figure 3 shows the wide discrepancies in the net positions held by different installations. Obviously, these discrepancies reflect the interaction between permit allocation, abatement activities, and general activity level. The right-hand tail in this figure, with positive 100% positions, refers to installations that had zero carbon emissions despite having positive permit allocations. On the other hand, those with negative 100% positions represent installations that had to cover double their initial allocations[13].

[12] See section 3.1 for a detailed analysis of Thermoelectric generation sector.
[13] Each year had only one installation (not the same one) with a negative position lower than -100%. These were not included in the figure to minimize scale distortions.

Figure 3: Net position as % of allocated permits in 2005 and 2006 (red line)

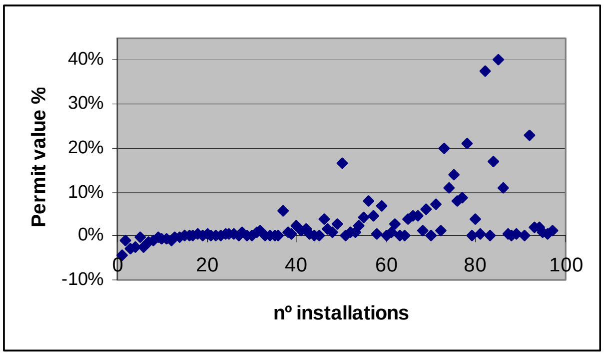
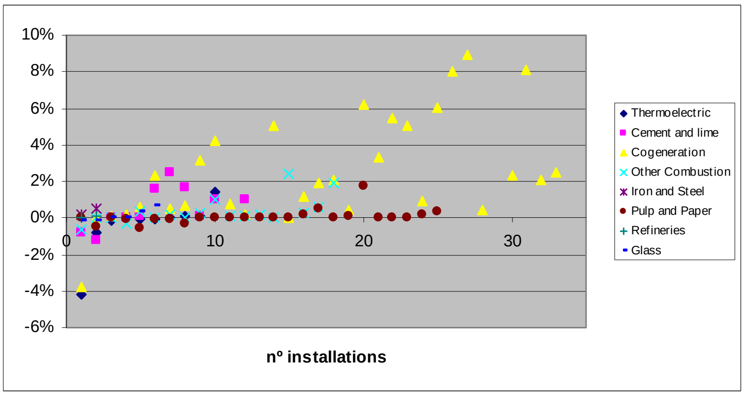
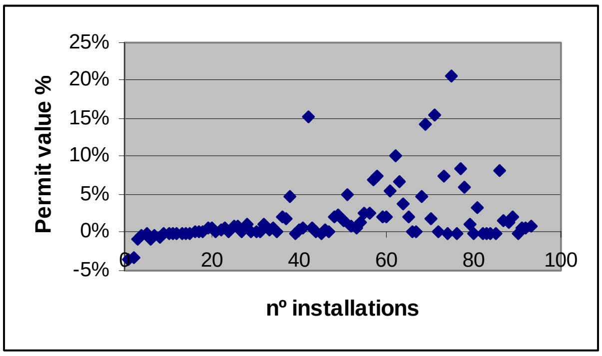
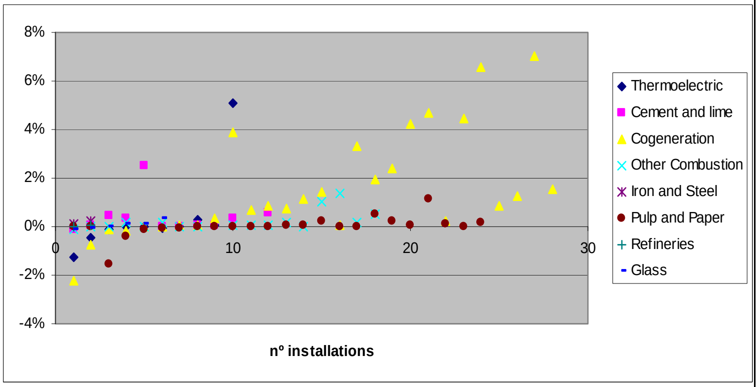


Source: Own elaboration using data available in http://ec.europa.eu/environment/ets

In both 2005 and 2006 around 20% of installations were short and 80% long. Nonetheless, the figure shows that there was a slight shift to better positions in 2006. To assess the economic implications of these positions for each sector's installations, we use the SABI database. This contains general information, as well as the financial accounts, for a large number of Iberian firms. We were able to get financial data for 80% of the EU ETS installations, representing approximately 60% of emissions. Unfortunately, the thermoelectric generation sector has the lowest level of coverage in SABI (34% of emissions). Even so, some interesting conclusions can be presented regarding the possible significance of EU ETS participation for financial accounts. We calculated the potential revenue from permit sales (or cost from permit purchases) for each installation, using average 2005 and 2006 prices as before, as a percentage of that installation's operational revenues (or operational costs). The results are presented in Figure 4. Ceramic is shown separately as it contains a much larger number of installations than other sectors. Note the difference in axis scale between the two years.

Clearly, some installations may have gained significant revenues from participating in the EU ETS, especially in the Ceramic sector where quite a few had permit profits above 5% of their operational revenues. However, these results should be viewed with caution in light of possible transaction cost burdens, since the Ceramic sector is characterized by a large number of small installations. Among the other sectors, Cogeneration was the biggest potential beneficiary, with quite a few installations earning a permit profit between 2 and 10% of revenues. It should also be noted that the proportion of benefits from permit sales was generally higher in 2005, despite the slightly worse volume positions of firms, shown in Figure 3. The price effect thus seems to have been paramount.

Figure 4: Permit Sales (Purchases) as % of Operational Revenue (Cost) [14]

	Ceramic	**Other sectors**
2005		
2006		

Source: Own elaboration using data available in http://ec.europa.eu/environment/ets and SABI data

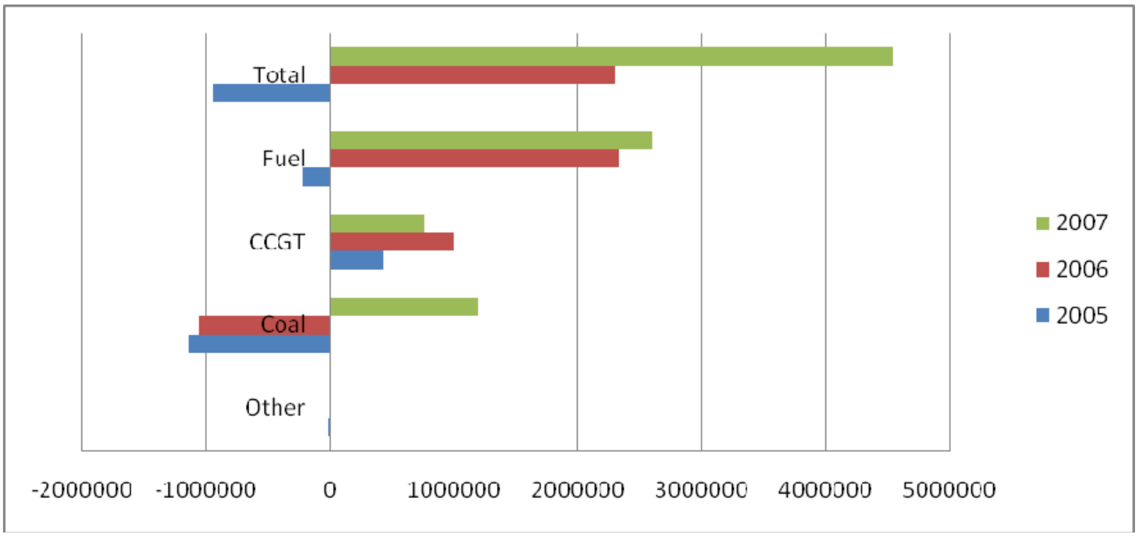
3.1 Thermoelectric Generation Sector

The thermoelectric generation sector deserves a closer analysis because of the bigger effort required of it, the volume of emissions it produces, and also the variability of emissions it shows, depending on the weather patterns that affect hydroelectric production. In Figure 5 we show the 2005, 2006 and 2007 balances of the thermoelectric sector, divided into the sub sectors of Fuel, Combined Cycle Gas Turbine (CCGT), Coal and Other (Biomass+Gasoil).

In 2005, the only “long” facilities had been the ones using CCGT. In spite of this, the strong deficit shown by coal facilities meant that the sector as a whole presented a deficit. On the contrary, in 2006 this sector had a surplus even if coal facilities continued to show a negative balance, whereas all subsectors had surpluses in 2007.

[14] All installations with zero emissions were removed from the sample for this figure, as well as a few outliers (4 with strongly positive permit revenues in 2005 and 1 in 2006).

Figure 5: Thermoelectric Generation Balance



Source: Own elaboration using data from http://www.dgge.pt/

To understand what happened in the period, we need to look at weather factors. The deficit in 2005 can largely be explained by that year's drought. It should be noted that renewable energy sources in Portugal, of which hydroelectric production is the largest by far (over 60% of installed capacity), normally account for a significant part of electricity consumption (between 20% and 40%). In 2005, that value was only 19,2%, with hydropower generation less than half its average value. 2006, on the other hand, was considered an average hydrological year, and hydro production was 124% higher than in 2005. In contrast, 2007 was drier but renewable energy production still increased by 2%, since the slight decrease in hydro was more than offset by the growth in wind power generation. Interestingly, the large sectoral emissions reduction between 2006 and 2007 (12% fewer emissions with only a 3,6% drop in electricity generation) cannot be fully explained by this factor, indicating that there were efficiency gains during the period. [15]

We end this section by noting that wide variations in emissions (hence in permit transactions) should be expected for the power sector whenever renewable sources, especially hydroelectricity, face large variability. For example, Ellerman and Buchner (2007) note that emissions also fluctuate greatly in Denmark, Sweden and Norway, depending on hydroelectricity production in the two latter countries. The effect may or may not show up in the permit prices, depending on weather conditions throughout Europe. Although a couple of studies have looked at the effects of weather on permit prices (Mansanet-Bataller et al (2007), Alberola et al (2008)), they focus on temperatures, which only drive demand, and not precipitation, which may also affect supply.

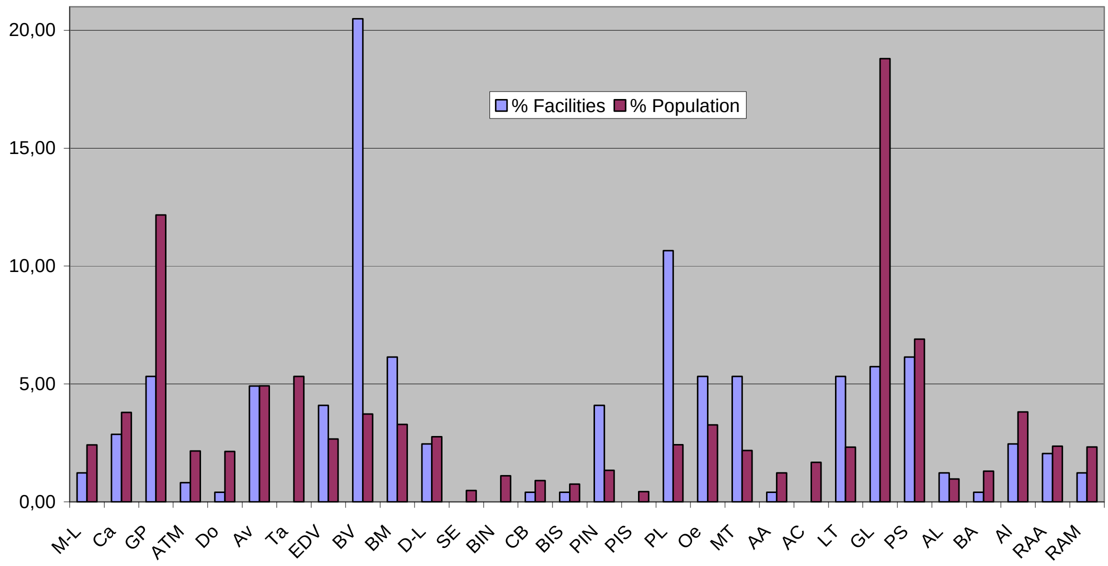
4. Regional effects of the European carbon market in Portugal

Little attention has been paid to the possible impact of EU ETS in regional terms. However, installations are located in a physical territory, and the specialization of the different regions in the production of diverse goods and services can thus lead to dissimilar economic impacts of the carbon market from a regional

[15] Data is from http://www.dgge.pt/

point of view. Figure 6 shows the relative weight of each Portuguese region in the number of installations regulated by the EU ETS and population.

Figure 6. Installations affected by the EU ETS (%) and population (%) by regions (2005)



Source: Own elaboration using data available in http://ec.europa.eu/environment/ets (installations) and INE (population)
See Appendix for full region names

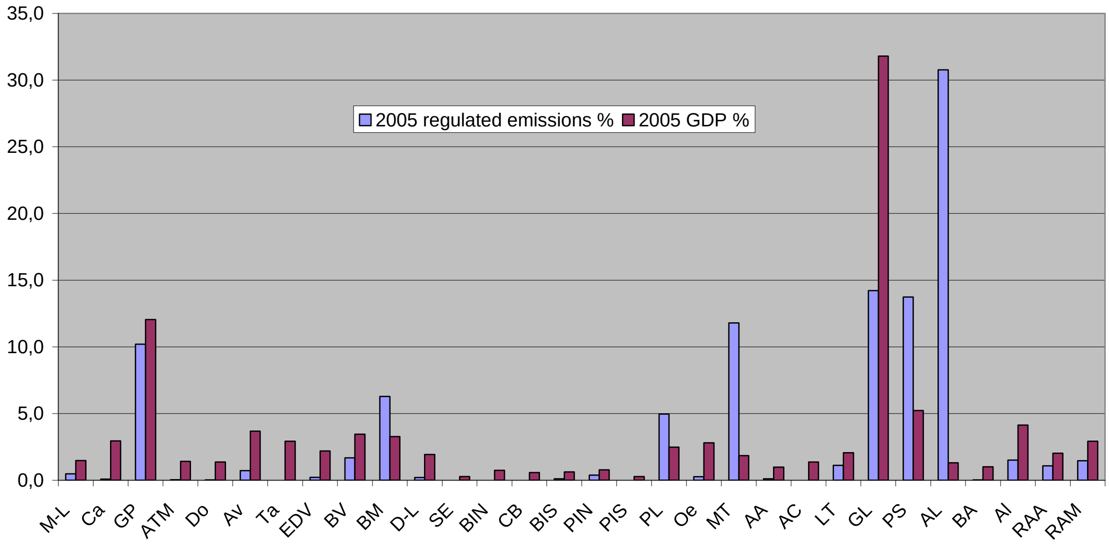
Generally, there is no proportionality between the share of each region in the national population and the share in the number of installations regulated by the EU ETS. For instance, there is one region, B-V, which holds 3,75% of the population and 20.5% of the installations, because in this region there are a large number of small installations; in particular, it has the majority of installations of the Portuguese ceramic sector. In the two major Portuguese cities, Grande Lisboa (GL) and Grande Porto (GP), as expected, the opposite happens: these regions represent 18.8% and 12.2% of the population, respectively, and have only 5.7% and 5.3% of the installations.

We can also trace the relationship between CO_2 emissions and some macroeconomic variables. Figure 7 shows the regional share of allocated permits and national gross value added (GVA) in 2005 (the 2006 data is similar). There are relevant asymmetries in the contribution of each region to both variables and, again, no clear correlation between them.

There are regions whose relative level of emissions largely exceeds their contribution to the national GVA, such as Peninsula de Setúbal (PS), Médio Tejo (MT) and the most evident case, Alentejo Litoral (AL), which contributes with a 32,1% to national emissions and only 1.3% to the GVA. We can also see (and confirm with Table A1 in the Appendix) that 80% of the regulated emissions are made by 5 regions, which together represent 52% of national GVA. As in the sectoral analysis, there is a high concentration of regulated emissions in a limited number of regions.

Clearly, the regional emission levels have a low correlation with GVA (the statistical correlation between variables is equal to 0.42, where the P-value is below 5%).

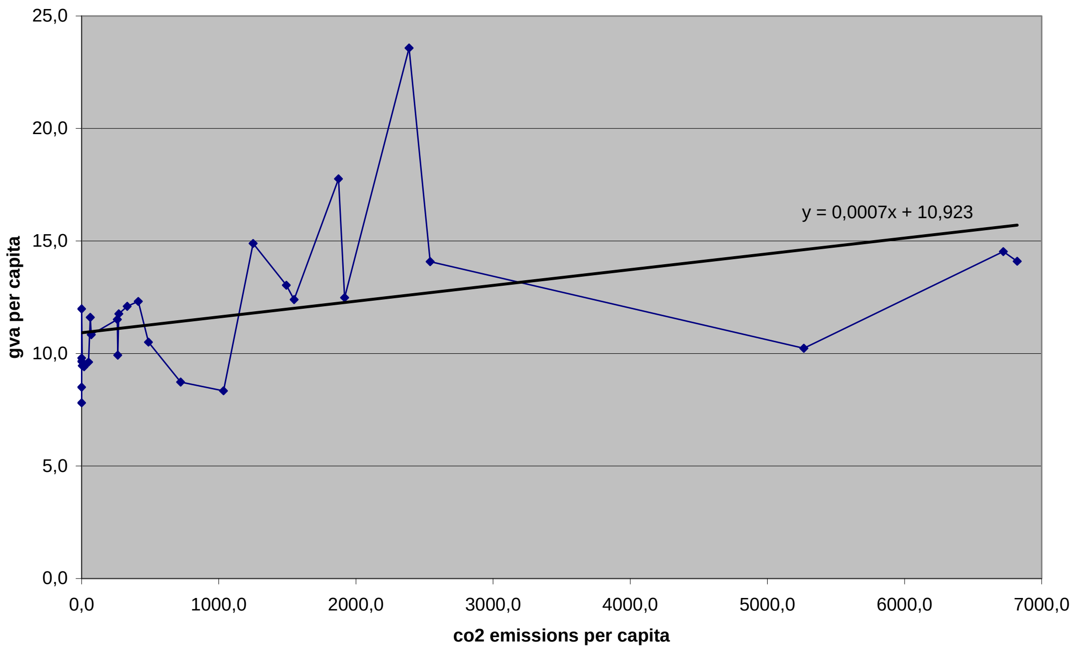
Figure 7. Regulated CO2 Emissions (%) and GVA (%) by regions.in 2005



Source: Own elaboration using CO_2 data available in http://ec.europa.eu/environment/ets and GVA from INE.

This feature can be confirmed by looking at per capita CO_2 emissions (CO_2pc) and per capita GVA (GVApc). Figure 8 shows that there is a weak correlation between GVApc and CO_2pc (the equation in the figure is an OLS estimation).

Figure 8. Per capita GVA (2005) and per capita CO_2 regulated emissions



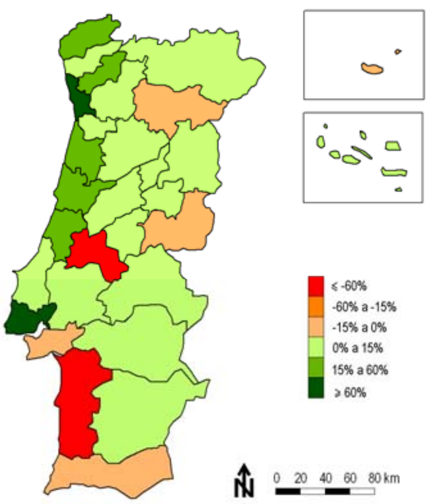
Source: Own elaboration using CO_2 regulated emissions data available in http://ec.europa.eu/environment/ets and GVA and population data in INE.

To better understand the relationship between regional economic activity and CO_2 emissions, it is important to remember that the levels of emissions and allocated permits vary between sectors. Recall that, as shown in Table 3, the largest emitter in the EU ETS is thermoelectric generation. Thus there is a significant correspondence between the regions with the highest level of emissions and the location of thermoelectric plants: Alentejo Litoral (AL), Grande Lisboa (GL), Península de Setúbal (PS), Médio Tejo (MT) and Grande Porto (GP). The high level of emissions in these regions is therefore related with this type of industry and not with general economic activity.

We can now ascertain the direct impact of the EU ETS in regional accounts. In order to do so we have defined an effort index, consisting of the difference between the emission rights attributed to each region (on the basis of installation location) and the actual emissions for 2005 and 2006. A positive difference indicates that the sum of installations located in this region received more permits than they used. The eventual proceeds from selling the surplus may then contribute to increase the regional GVA. Likewise, a negative difference indicates that the installations located in this region had to buy permits and therefore transferred part of its GVA to other regions. Table 3 summarizes these effects. The last two columns shows the permit deficits (-) and surpluses (+) by region. The other columns illustrate the regional deficit or surplus by industry. Although regional GVA includes all economic activity that is physically in each area, it should be noted that not all impacts of an increase or decrease in profits due to EU ETS participation occur necessarily within the same region. In particular, many installations belong to national public companies, whose shareholders are spread among different regions. Nonetheless, we believe it is instructive to analyse the regional concentration of EU ETS direct impacts.

As mentioned in section 2, even though the thermoelectric generation sector presented a deficit in 2005, if we consider 2005 and 2006 together, all sectors had a permit surplus. Yet if we do the same analysis by regions, we see that some regions had a deficit and others a surplus, as shown in Figure 9. Particularly, Alentejo Litoral and Médio Tejo had important deficits (-25% and -10% of total permits, respectively) since the only two Portuguese thermoelectric installations still based on coal are sited there (Sines and Pêgo, respectively). Some other regions presented small deficits (a total of -5.5%) but most had a surplus. It is remarkable that the cities (GL and GP), as well as the next most heavily populated area (PS), had very large surpluses (27%, 34% and 41%, respectively). Thermoelectric installations in these regions had significant surpluses.

Figure 9. Participation (%) of each region on the Portuguese balance of the EU ETS in 2005 and 2006.



Source: own elaboration from Table 3.

Table 3 - Deficit (-) or superavit (+) of emission rights in 2005 and 2006 (t CO_2)

	Thermoelectric generation	Ceramic	Cement and Lime	Cogeneration	Other Combustion facilities	Iron and Steel	Pulp and paper	Refineries	Glass	Total	Total%
Minho-Lima		15268		-141246			2508			**-123.470**	**-2,84**
Cávado		13866			3085		6034			**22.985**	**0,53**
Grande Porto	1291294	12780		70189	13230	45242	-313	56439	-471	**1.488.390**	**34,19**
Alto-Trás-os-Montes		10148								**10.148**	**0,23**
Douro					-3828					**-3.828**	**-0,09**
Ave				109669	72023					**181.692**	**4,17**
Tâmega										**0**	**0,00**
Entre Douro e Vouga		8456		2851	13446		8479			**33.232**	**0,76**
Baixo Vouga		194997		211110	33498		-294			**439.311**	**10,09**
Baixo Mondego		37882	25266	168845			51758		6190	**289.941**	**6,66**
Dão-Lafões	-436	1656		19088	9811		-1060			**29.059**	**0,67**
Serra da Estrela										**0**	**0,00**
Beira Interior Norte										**0**	**0,00**
Cova da Beira		7603								**7.603**	**0,17**
Beira interior Sul							-10047			**-10.047**	**-0,23**
Pinhal Interior Norte		68904		18646			0			**87.550**	**2,01**
Pinhal Interior Sul										**0**	**0,00**
Pinhal Litoral		71342	190650	54420			-397		67923	**383.938**	**8,82**
Oeste		87665								**87.665**	**2,01**
Médio Tejo	-539452	38177		11910			25195			**-464.170**	**-10,66**
Alto Alentejo				1837						**1.837**	**0,04**
Alentejo Central										**0**	**0,00**
Lezíria do Tejo		25491	4075	26760	-6224		3537			**53.639**	**1,23**
Grande Lisboa	1200505		-84500	19298	58552		4908		-7317	**1.191.446**	**27,37**
Península de Setúbal	1173338	11169	269290	177416	48869	114780	8522			**1.803.384**	**41,42**
Alentejo Litoral	-1651747			103519				447905		**-1.100.323**	**-25,27**
Baixo Alentejo		4271								**4.271**	**0,10**
Algarve	-8843	26046	21124							**38.327**	**0,88**
Região Aut. Madeira	-101788									**-101.788**	**-2,34**
Região Aut. Açores	-4279				7269					**2.990**	**0,07**
Total	**1358592**	**635721**	**425905**	**854312**	**249731**	**160022**	**98830**	**504344**	**66325**	**4.353.782**	**100,00**

Source: Own elaboration using data available in http://ec.europa.eu/environment/ets

We can distinguish between the balance of thermoelectric generation and the balance of the remaining industrial sectors. In most regions, the latter had surpluses, as expected. Only the regions of Minho-Lima (M-L), Douro (Do), Beira Interior Sul (BIS) and Grande Lisboa (GL) presented (fairly small) deficits in the remaining industries.

As in section 2, to determine the economic impacts of the EU ETS on regions we will consider a price of 21,73€ and 15,14€ per ton of CO_2 in 2005 and 2006 respectively. Globally, Portugal could have raised revenue of approximately 10 M€ and 58 M€ in those years, as noted earlier. Table 4 illustrates the regional significance of permit costs or benefits.

Table 4. The potential regional costs of the EU ETS (values in thousand euros)

	2005			2006			
Regions	**GVA**	**Permit Cost**	**Cost as % GVA**	**GVA**	**Permit Cost**	**Cost as % GVA**	**Mean cost as % GVA**
Minho-Lima	1.894.649	1116	**0,06%**	1.957.013	1092	**0,06%**	**0,06%**
Grande Porto	15.445.710	-6896	-0,04%	16.203.435	-17730	-0,11%	**-0,08%**
Ave	4.708.421	-1911	-0,04%	4.792.371	-1419	-0,03%	**-0,04%**
Entre Douro e Vouga	2.817.126	-284	-0,01%	2.881.514	-305	-0,01%	**-0,01%**
Baixo Vouga	4.436.423	-4586	-0,10%	4.570.838	-3456	-0,08%	**-0,09%**
Baixo Mondego	4.202.096	-3189	-0,08%	4.342.376	-2168	-0,05%	**-0,06%**
Dão-Lafões	2.482.044	-336	-0,01%	2.552.784	-206	-0,01%	**-0,01%**
Cova da Beira	751.569	-76	-0,01%	764.095	-62	-0,01%	**-0,01%**
Beira interior Sul	801.255	242	**0,03%**	828.595	-17	0,00%	**0,01%**
Pinhal Interior Norte	988.859	-1023	-0,10%	1.017.516	-613	-0,06%	**-0,08%**
Pinhal Litoral	3.190.054	-4596	-0,14%	3.301.249	-2611	-0,08%	**-0,11%**
Oeste	3.591.679	-938	-0,03%	3.721.239	-673	-0,02%	**-0,02%**
Médio Tejo	2.360.368	7481	**0,32%**	2.467.179	2086	**0,08%**	**0,20%**
Lezíria do Tejo	2.641.042	-216	-0,01%	2.705.965	-662	-0,02%	**-0,02%**
Grande Lisboa	40.759.069	-6336	-0,02%	41.845.049	-13624	-0,03%	**-0,02%**
Península de Setúbal	6.704.426	404	**0,01%**	7.072.951	-27584	-0,39%	**-0,20%**
Alentejo Litoral	1.683.540	10058	**0,60%**	1.788.151	9651	**0,54%**	**0,57%**
Região Autónoma Madeira	3.742.764	1109	**0,03%**	3.936.483	768	**0,02%**	**0,02%**
Portugal	**128.362.921**	**-10402**	**-0,01%**	**133.055.128**	**-58398**	**-0,04%**	**-0,03%**

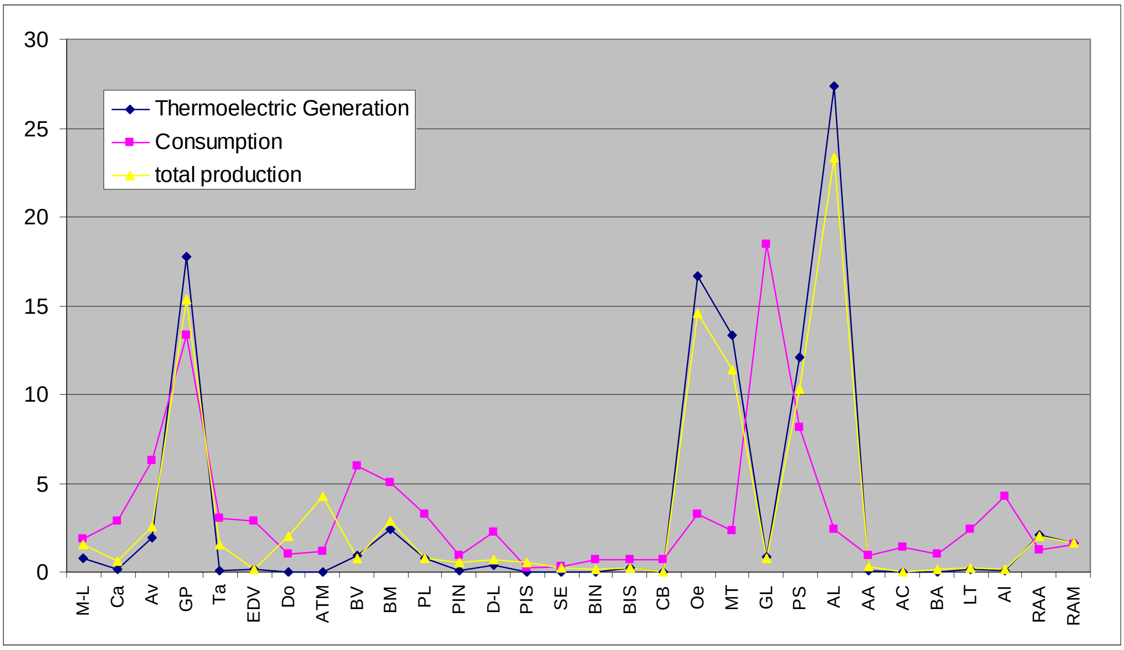
Source: Own elaboration; regions which have no installations, as well as regions where permits costs are below |0,01%| of GVA, are excluded from the Table.

In the 5 regions that present costs (Minho-Lima (M-L), Beira Interior Sul (BIS), Médio Tejo (MT), Alentejo Litoral (AL) and Região Autónoma da Madeira (RAM)) these are not always very significant. The worst cases are Alentejo Litoral (AL) and Médio Tejo (MT) where the costs of the EU ETS reached on average 9,8 million and 4,8 million euros respectively (but note the large variation in the latter). The remaining regions present surpluses, the highest corresponding to the regions of Grande Porto (GP), Península de Setúbal (PS) and Grande Lisboa (GL), with average benefits of 13,6, 12,3 and 9,9 million euros respectively. However, if we analyze the costs and revenues as a percentage of GVA we see that they are generally not very significant. The top loser by far is Alentejo Litoral, where costs represent 0.57% of the GVA, whereas the top winner is now Península de Setúbal, with a 0,2% benefit, and the main cities' gain is not so important (Grande Lisboa, for instance, gained only 0,02% of its GVA).

Since most of the emission reduction effort in Portugal is concentrated on the thermoelectric sector, there is in territorial terms a distortion on the energy-producing regions, which assume a disproportionate responsibility for emission control. On the other hand, the regions that do not produce energy have little responsibility for the reduction, although they contribute for the emissions through the consumption processes. Price pass-through, if allowed, could be a significant distributional factor, but so far that has not been the case, as noted in Section 5.

Figure 10 shows the different values for consumption and production of electricity at the regional level. Both the total production of electricity and the thermoelectric generation alone are shown. Five regions (PS, MT, Oe, GP and AL) represent 87% of Thermoelectric generation, 75% of electricity generation, and 29% of electricity consumption. Together they account for 80% of the CO2 regulated by the EU ETS and 41% of Portuguese population. The most unequal cases are Alentejo Litoral (AL), with 27% of the national thermal electricity generation and only 2.4% of electricity consumption, and Oeste (Oe), with 16% of thermal electricity generation and only 3% of consumption. On the other hand, we have the opposite situation in Grande Lisboa (GL), which has 18% of electricity consumption and only 0.9% of thermal production.

Figure 10. Production and consumption of electricity by regions, as (%) of national total



Source: Own elaboration using data available in Directorate-General for Geology and Energy (DGGE).

5. The second Portuguese National Plan (2008-2012)

Considering the results of the first trading period as well as the difficult path ahead to achieve the established legal targets, it is natural that the second Portuguese National Plan (for the period 2008 and 2012) (NAP II) would contain a permit reduction. Accordingly, the second Plan issued 152,552 million permits (CO_2 equivalent tons), implying an annual value of 30,510 Mt for the period 2008-2012, which is a decrease of about 17%.

Between the first and second NAP there was also a modification in the industries included in the emissions market, in accordance with new EC rules and some national modifications. For period 2008-2012 part of the ceramic industry is excluded, and units of cogeneration and combustion facilities of the chemical sector are included[16]. Considering equivalent installations in both periods, the decrease in attributed permits is 22,4%. Table 5 shows the sectoral distribution of these reductions.

Table 5– Comparison of permit attribution (Mt CO_2) by sectors

Sector /Subsector	**NAP I**	**NAP II (without new entrants 2005/07)**	**NAP II vs NAP I**
Energy Supply	26,8	18,8	-29,7%
Production of electricity	21,0	13,5	-35,5%
Refineries	3,3	3,0	-6,7%
Cogeneration	2,5	2,2	-11,4%
Industry	10,1	9,8	-3,3%
Cement and Lime	7,1	7,0	-1,4%
Ceramic	1,2	1,0	-15,8%
Glass	0,7	0,7	-2,6%
Pulp and Paper	0,4	0,3	-6,9%
Iron and Steel	0,3	0,3	8,4%
Other Combustion facilities	0,5	0,5	-6,5%
Total for existing installations	36,9	28,6	-22,4%
Reserve for new entrants	1,3		
TOTAL	**38,2**		

Source: PNALE II (2008)

The electricity generation sector will once more have to make the largest reduction effort. This could strengthen the conclusions that we reached for the first plan, namely in terms of the higher damage concentration in the regions where these installations are located. The actual cost will depend on hydrological conditions. Moreover, it should also be mentioned that Portuguese electricity prices are mostly regulated and cannot be freely increased. As costs of providing electricity have increased (due to many factors, including the EU ETS), EDP, the main electricity provider, was by the end of 2008 burdened with a debt (the so called "défice tarifário") of around 2 million euros, to be recovered from consumers, with interest, starting in 2010 (Jornal de Negócios, 2008)[17].

The following table is similar to Table 2, since it presents 2008 data for emissions, permits, and potential permit expenses. The only sector that was "short" was, again, thermoelectric generation, while the country's ETS participation as a whole continues to show a surplus.

[16] For more details see NAP II (PNALE II, 2008).

[17] The same problem with cost pass-through is noted for Spain, namely by Oberndorfer(2008), which points out that this may be one of the reasons stock-market values of electricity firms in that country are inversely correlated with permit prices, unlike in other countries. In energy markets without price regulation, on the other hand, results indicate high levels of pass-through, leading to significant windfall profits from EU ETS participation for the power sector (Sijm et al, 2006).

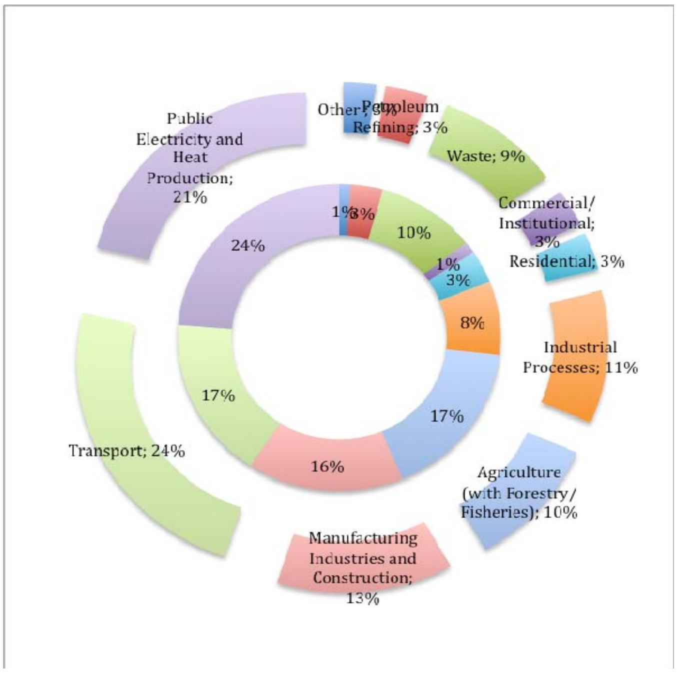
Table 6 – Attributed permits, emissions (in Mt) and sectoral costs (in M€) for 2008

Sectors	Emissions	Permits	Coverage %	Possible expenses in permit purchase at price 18,56 €/ton
Thermoelectric generation	15,78	14,00	88,8	32,93
Ceramic	0,27	0,57	211,2	-5,54
Cement and lime	6,78	7,21	106,3	-7,91
Cogeneration	2,53	3,47	136,9	-17,36
Other Combustion Facilities	0,40	0,54	134,5	-2,56
Iron and steel	0,20	0,34	164,2	-2,43
Pulp and paper	0,34	0,39	113,6	-0,86
Refineries	2,95	3,24	109,7	-5,30
Glass	0,66	0,77	116,5	-2,02
Total	**29,91**	**30,51**	**102,0**	**-11,06**

6. Emission reduction policy analysis

The purpose of this section is to analyse some policy options regarding emissions reductions from both a sectoral and a regional perspective. To this end it is important to look at all sectors, including those outside the EU ETS. Figure 11 contains the weight of each sector in emissions. The largest non-ETS sector is Transport, which accounted for 17% of emissions in 1990 and has since grown to 24%, although other non-ETS sectors are also significant.

Figure 11: Sectoral CO_2 emissions (%) in 1990 (inner) and 2007 (outer)



Source: Own elaboration using data available in EEA, http://dataservice.eea.europa.eu/PivotApp/pivot.aspx?pivotid=475

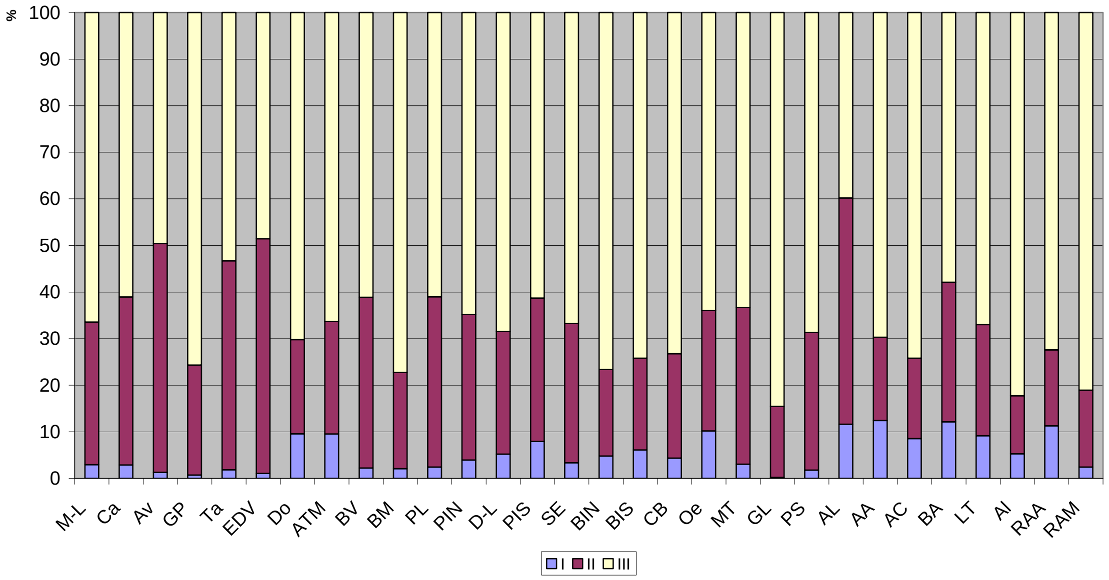
A few European Directives have aimed at improving the performance of uncovered sectors, namely the European Energy Performance in Buildings Directive (EPBD), the Ecodesign Directive, the Biofuels Directive and the Energy Services Directive. Such measures have uncertain effects, however, and their costs cannot easily be calculated. Moreover, the inclusion of additional regulations such as these reduces flexibility and may increase compliance costs.

A recent paper by Simões et al (2008) provides energy and environmental policy scenarios to gauge the impact of different policies on Portuguese CO_2 marginal abatement costs. Theirs is a partial-equilibrium model of the Portuguese energy system which compares abatement costs for different hypothetical values of emission caps, to be achieved in the period 2020-2030. The reference scenario is one where existing policies (such as the ban on nuclear power and the renewable energy goals) continue to be implemented. This scenario is compared to alternative scenarios where emissions reductions are achieved without some of the existing restrictions, ie, with more flexibility. The simulations indicate that the reference scenario has 42-91% higher marginal abatement costs than the scenarios where existing policy restrictions are dropped. It also implies that the full costs of the Portuguese energy system from 2000 to 2030 are 10-13% higher under the current policies than they could be if all reductions were allocated efficiently.

Unfortunately, none of the Simões et al scenarios considers the possibility of emissions trading, as it does not alter abatement costs. However, it does change compliance costs, since high-cost users can purchase permits abroad instead of abating emissions, thus lowering national compliance expenses. Considering the global nature of GHG emissions, country-specific caps are only the starting point to emissions trading schemes and they need not be achieved rigidly. Thus, the authors' estimated costs, assuming that specific emission targets have to be achieved within the national energy system, are higher than necessary.

Considering all sectors of economic activity, we can trace the regional economic implications of the EU ETS more closely. Figure 12 shows the aggregate sectoral composition of GVA in Portuguese regions. The division used here considers three groups of sectors: I (agriculture, hunting and forestry, fisheries and aquiculture), II (industry including energy and construction) and III (services). There are no regional emissions data available to compare EU ETS regional emissions with total regional emissions. Nonetheless, sectors I and III are largely excluded from the emission cap regulations although they account for an important part of national emissions, as shown in Figure 11. Thus a regional analysis of the composition of economic activity can provide some additional insights on the relative imbalance between regional abatement efforts. Figure 12 shows, for instance, that sector III in Grande Lisboa (GL), Grande Porto (GP) and Península de Setúbal (PS), represents 85%, 76% and 69% of economic activity, respectively. These are also the main population centers, which leads us to infer that these three regions could be the main emitters of GHG. Therefore, if sector III and households could be covered by the EU ETS or another emission reduction instrument, these regions could carry the highest burden instead of being the most benefited (as was the case in Table 4).

Figure 9. Sectoral composition of 2006 GVA in % for the Portuguese regions.



Source: Own elaboration using data available in INE

The main conclusion is that the regional effects of the EU ETS during the period 2005-2007, which arise from the specific locations of the main industrial plants covered in the scheme, vary widely, not only because of the uneven stringency of permit allocation among covered sectors, but also because of the different productive specialization of Portuguese regions. The burden of reduction falls on regions which house EU ETS industrial activity, although these may not be the main GHG emitters.

It is true that a system of emissions trading may be unsuitable for most of the uncovered sectors, because the transaction costs of registering and monitoring small emitters would be prohibitive. However, this does not wholly justify the current differentiation in treatment, because other economic instruments could be applicable to these diffuse sectors in order to internalize CO_2 emission costs, like for instance environmental taxes. Theoretically, emission taxes would be capable of achieving targets in a cost-effective manner, by making sure marginal abatement costs are equal for all emitters. They do, nonetheless, impose much higher costs on emitters than grandfathered permits, which were chosen instead as a starting point in EU emission reduction efforts. If further reductions are to be accomplished, other sectors must be covered, preferably by measures that reach all of them equally. Hence the Senior European Commission official, Jos Delbeke, has announced that EU member states must look seriously at introducing carbon taxation to help cut greenhouse gas emissions; 'the taxation debate is not running at EU level because we have chosen a market, but it can run at national level. Indeed it must, because the EU ETS is not going to do everything'[18]. There has been an increased interest in taxation as an additional approach to cutting emissions in several countries[19]. The superiority of green tax reforms for environmental protection (see Parry et al, 1999, or Aldy et al, 2009), joined

[18] "Politics of Climate Change", expert seminars organised by Policy Network at the London School of Economics and Political Science in the latter half of 2008.
[19] The 2009 UK Budget contains a limited environmental tax reform (shift of tax from goods to bads). Denmark has moved in the same direction after the collapse in global oil prices. Fuel taxes and other energy taxes will also be increased in Sweden to help reach its 40% emission reduction target (from 1990'S level) by 2020. A similar debate exists in Ireland (Callan et al., 2009).

with the fact that energy taxes in non-European countries are relatively low, makes them an attractive policy option outside Europe (Sterner, 2007).[20] Market-based climate policies have come increasingly under scrutiny around the world, especially after the 2008 presidential elections in the United States. Nonetheless, this wasn't translated into firm commitments in the United Nations' Copenhagen summit of December 2009, especially due to the objections of China. Climate legislation has meanwhile stalled in the US Senate and in other developed countries (the French government withdrew its proposed carbon tax in March 2010 and Australia shelved its plans for an emissions trading scheme in April 2010).

In Portugal, the current recessionary period provides a difficult background for a discussion of new carbon taxes, in spite of their theoretical advantages. Nonetheless, existing fuel taxes could be further adjusted to reflect emissions in transport, and electricity prices should be allowed to gradually increase to reflect true power-generating costs. Some existing energy policies, such as a reduced VAT rate for energy or diesel fuel tax reductions, can be classified as environmentally harmful subsidies.[21] These should ideally be removed. Ad-hoc partial targets (such as those for renewable power generation), existing or future, should be evaluated taking into account EU ETS carbon prices, allowing their cost-effectiveness to be clearly assessed. This type of economic analysis was not performed to evaluate the National Program for Climate Change (PNAC)[22] nor is it performed in the recent National Action Plan for Renewable Energy (PNAER)[23], which lists a large number of policies, many of which are precisely ad-hoc targets. PNAER contains the mandatory estimates for quantitative policy impacts, but no cost assessment. Finally, our own results also indicate an additional problem that may come about due to strict renewable energy targets, namely because hydroelectricity (as well as, to a lesser extent, wind power) can show significant variability, so that reliance on such energy sources may bring large, and possibly undesirable, fluctuations in compliance costs.

7. Conclusions

This work provided a first analysis of the consequences of the EU ETS at the sectoral and regional level for Portugal. We used data on allocated and verified emissions for all regulated installations for 2005 and 2006, as well as economic data (aggregated and firm-level) to provide context and relevance.

A first set of conclusions deals with the pronounced inequality of the size distribution of Portuguese installations. Portuguese carbon emissions permits are extremely concentrated in a small number of installations. A second set of conclusions refers to the sectoral effects of the EU ETS. Only the thermoelectric plants showed a negative balance in the first phase, and only for year 2005. The results for this sector were shown to be highly dependent on weather conditions, namely precipitation, due to the necessity of replacing

[20] In fact, this motivation might have inspired some recent bills: (i) the Canadian province of British Columbia introduced in 2008 a new carbon tax coupled with reductions to income and business taxes; (ii) there is one proposal in the Major Greenhouse Gas Mitigation Bill in the US 110th Congress (December 3, 2008) for a green tax reform based on an economy wide tax on CO2 content of fossil fuels coupled with payroll tax rebates (see Aldy et al., 2009); (iii) the draft Energy Tax Bill in Taiwan during the year 2007 included alternative green tax reforms (Bor and Huang, 2009).
[21] Valsecchi et al (2009) define an environmentally harmful subsidy as: "A result of a government action that confers an advantage on consumers or producers, in order to supplement their income or lower their costs, but in doing so, discriminates against sound environmental practices."
[22] http://www.apambiente.pt/politicasambiente/AlteracoesClimaticas/PNAC/Paginas/default.aspx
[23] PNAER, preliminary version for public consultation, available in http://www.dgge.pt/, June 2010

lost production from hydroelectricity. Still, most installations in all sectors gained from participating in the EU ETS, with sectors like ceramic and cogeneration receiving considerable additional revenues.

A third set of conclusions deals with the regional impact. As expected, there is a high concentration of regulated emissions in a limited number of regions. Those that specialize on thermoelectricity (in particular, those that have coal based power production) suffered the greatest losses. Even so, these were never higher than 0.6% of regional GVA.

Finally, it should be emphasized that the transport sector, agriculture, households and other services are responsible for a large share of emissions but remain unregulated by the EU ETS. Regions with the greatest share of the tertiary sector in their economic activity are thus benefited (especially because they can often have access to subsidies to improve energy efficiency) in detriment of regions where the activities of the secondary sector predominate, in particular the production of electricity.

The policy implications raised in section 6 calls for a combination of cost-effective instruments: the EU Emission Trading Scheme could be complemented with other mechanisms through a hybrid regulation system, allowing for wide coverage of polluters with reasonable administrative and compliance costs (that is the case in many EU countries and there are several others seriously considering it). This might improve both efficiency and equity of the EU climate change policy, by ensuring that marginal abatement costs tend to equality (so that emissions abatement is done at minimum cost) and by sharing the burden more widely. Also, it could contribute to the new climate change policy agenda around the world both in developed and developing countries.

Future research should focus on a regional-sectoral model of interaction, considering the key sectors, including EU ETS covered and uncovered sectors, or on the use of a General Equilibrium Model for the Portuguese economy that simulates alternative policies. Another important line of work is to provide econometric testing of the relationship between firm-level economic data and emissions (as is done for Germany in Anger and Oberndorfer, 2008).

Acknowledgements

This paper was developed with support from FCT via scholarship SFRH/BD/16726/2004. Part of the work was developed while Catarina Roseta-Palma was visiting researcher at Fundación de Estudios de Economia Aplicada (FEDEA). We also acknowledge the valuable research assistance of Mari Carmen González, and we thank Ricardo Pinheiro Alves for his comments and suggestions.

REFERENCES

Alberola, E., J. Chevalier and B. Chèze (2008) Price Drivers and structural breaks in European carbon prices 2005-2007, Energy Policy, 36, 787-797.

Aldy, J. and Pizer, W. (2009) Issues in Designing U.S. Climate Change Policy, The Energy Journal, 30(3), 179-209.

Anger, N. and U. Oberndorfer (2008) Firm performance and employment in the EU emissions trading scheme: An empirical assessment for Germany, Energy Policy, 36, 12–22.

Böhringer, C., T. Hoffmann and C Manrique-de-Lara-Peñate (2006) The efficiency costs of separating carbon markets under the EU emissions trading scheme: A quantitative assessment for Germany, Energy Economics, 28 (1), 44-61.

Convery, F. (2009) Reflections – The Emerging Literature on Emissions Trading in Europe, Review of Environmental Economics and Policy, 3 (1), 121-137.

Convery, F. and L. Redmond (2007), Market and Price Developments in the European Union Emissions Trading Scheme, Review of Environmental Economics and Policy, 1 (1), 88-111.

Cramton, P. and S. Kerr (2002) Tradeable carbon permit auctions - How and why to auction not grandfather, Energy Policy, 30 (4), 333-345.

Ellerman, A.D. and B.K. Buchner (2007) The European Union Emissions Trading Scheme: Origins, Allocation, and Early Results, Review of Environmental Economics and Policy, 1 (1), 66-87

Ellerman, A.D. and B.K. Buchner (2008) Over-Allocation or Abatement? A Preliminary Analysis of the EU ETS Based on the 2005–06 Emissions Data, Environmental and Resource Economics, 41 (2), 267-287.

European Commission (2007), Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and the Committee of the Regions – Limiting global climate change to 2 degrees Celsius - The way ahead for 2020 and beyond, Brussels, 10 October 2007 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0002:FIN:EN:PDF

European Commission (2007b) Emissions trading: EU-wide cap for 2008-2012 set at 2.08 billion allowances after assessment of national plans for Bulgaria, IP/07/1614, Brussels, 26 October 2007 http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/459&format=HTML&aged=0%3Cuage=EN&guiLanguage=en

European Commission (2008b) Emissions trading: 2007 verified emissions from businesses, IP/08/787, Brussels, 23 May 2008 http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/787&format=HTML&aged=0&language=EN&guiLanguage=en

Fullerton, D. and Metcalf, G.E. (2001), Environmental controls, scarcity rents, and pre-existing distortions, Journal of Public Economics, 80 (2), pp. 249-267.

Hepburn, C., Grubb, M., Neuhoff, K., Matthes, F. and Tse, M. (2006), Auctioning of phase II allowances: how and why?, Climate Policy 6, 137–160.

INE, Portugal (2006), Territorial Portrait of Portugal 2005.

Jornal de Negócios (2008), *Défice tarifário supera os 2 mil milhões de euros em 2008*, published on the 15th December 2008, available at http://www.jornaldenegocios.pt/index.php?template=SHOWNEWS&id=345340

Kettner C., Köppl, A., Schleicher S. and Thenius G. (2008), *Stringency and Distribution in the EU Emissions Trading Scheme –The 2005 Evidence*, Climate Policy 8, 41–61. (some updated values: www.uni-graz.at/vwl2www/Meeting_10_September2007/Thenius_EU-ETS.ppt)

Mansanet-Bataller, M., Pardo, A., Valor, E., (2007) *CO_2 prices, energy and weather*, The Energy Journal, 28, 67–86.

Oberndorfer, U. (2009), *EU Emission Allowances and the stock market: Evidence from the electricity industry*, Ecological Economics, 68, 1116-1126.

Parry, I., Williams, R. and Goulder, L. (1999), *When Can Carbon Abatement Policies Increase Welfare? The Fundamental Role of Distorted Factor Markets*, Journal of Environmental Economics and Management, 37, 52-84.

Plano Nacional de Atribuição de Licenças de Emissão 2008-2012 (PNALE II), available in http://www.dre.pt/pdf1sdip/2008/01/00300/0010600141.PDF

Point Carbon (2006), *Carbon 2006 market survey,* February 2006.

Rodríguez, M. and del Rio, P. (2008), "Sectoral and Regional Impacts of the European Emission Trading Scheme", paper presented at the III AERNA Conference, Palma de Mallorca, Spain.

Sijm, J., K. Neuhoff, Y. Chen (2006) CO2 Cost Pass Through and Windfall Profits in the Power Sector, Climate Policy, 6(1), 49-72.

Simões, S., J. Cleto, P. Fortes, J. Seixas, G. Huppes (2008), Cost of energy and environmental policy in Portuguese CO_2 abatement – scenario analysis to 2020, Energy Policy, 36, 3598-3611.

Sterner, T. (2007) Fuel taxes: An important instrument for climate policy, Energy Policy 35, 3194–3202.

Trotignon, R. and A.D. Ellerman (2008) Compliance Behavior in the EU-ETS: Cross Border Trading, Banking and Borrowing, MIT CEEPR paper 2008-12.

Valsecchi C., ten Brink P., Bassi S., Withana S., Lewis M., Best A., Oosterhuis F., Dias Soares C., Rogers-Ganter H., Kaphengst T. (2009), Environmentally Harmful Subsidies: Identification and Assessment, Final report for the European Commission's DG Environment, November 2009, available in http://ec.europa.eu/environment/enveco/taxation/index.htm

APPENDIX

Table A1: Regional CO_2 regulated Emissions and VAB

Portuguese Regions Nuts III		**CO_2 regulated Emissions ton (average 2005/2006)**	**Regulated Emissions %**	**VAB %**
Minho-Lima	M-L	182013	0,5	1,5
Cavado	Ca	28426	0,1	3,0
Grande Porto	GP	3239134	9,3	12,0
Alto-Trás-os-Montes	ATM	10936	0,0	1,4
Douro	Do	3998	0,0	1,4
Ave	Av	253848	0,7	3,7
Tâmega	Ta	0	0,0	2,9
Entre Douro e Vouga	EDV	74387	0,2	2,2
Baixo Vouga	BV	590515	1,7	3,5
Baixo Mondego	BM	2257925	6,5	3,3
Dão-Lafões	D-L	76735	0,2	1,9
Serra da Estrela	SE	0	0,0	0,3
Beira Interior Norte	BIN	0	0,0	0,7
Cova da Beira	CB	546	0,0	0,6
Beira interior Sul	BIS	31220	0,1	0,6
Pinhal Interior Norte	PIN	142624	0,4	0,8
Pinhal Interior Sul	PIS	0	0,0	0,3
Pinhal Litoral	PL	1792759	5,2	2,5
Oeste	Oe	96261	0,3	2,8
Médio Tejo	MT	4122429	11,9	1,8
Alto Alentejo	AA	40307	0,1	1,0
Alentejo Central	AC	0	0,0	1,4
Lezíria do Tejo	LT	383273	1,1	2,1
Grande Lisboa	GL	4796533	13,8	31,8
Península de Setúbal	PS	4011021	11,6	5,2
Alentejo Litoral	AL	11131160	32,1	1,3
Baixo Alentejo	BA	8191	0,0	1,0
Algarve	Al	517755	1,5	4,1
Região Autónoma da Madeira	RAM	458295	1,3	2,9
Região Autónoma dos Açores	RAA	463588	1,3	2,0
Portugal		34713872	100,0	100,00

Source: Own elaboration using data from INE.
CO_2 Emissions and VAB of 2005

Table A2: Regional regulated CO_2 emissions per VAB and per capita and VAb per capita

Portuguese Regions nuts III	**Regulated Emissions per capita ton (average 2005/2006)**	**VAB per capita 2005 in thousand euros**	**Regulated Emissions per VAB (ton CO_2 per M€)**
Minho-Lima	722,0	8,7	82,7
Cávado	70,0	10,8	6,5
Grande Porto	2541,7	14,1	180,5
Alto-Trás-os-Montes	49,8	9,6	5,2
Douro	18,5	9,4	2,0
Ave	487,6	10,5	46,4
Tâmega	0,0	7,8	0,0
Entre Douro e Vouga	261,3	11,5	22,7
Baixo Vouga	1493,1	13,0	114,6
Baixo Mondego	6720,0	14,5	462,5
Dão-Lafões	264,1	9,9	26,6
Serra da Estrela	0,0	8,5	0,0
Beira Interior Norte	0,0	9,8	0,0
Cova da Beira	5,9	9,5	0,6
Beira interior Sul	413,0	12,3	33,5
Pinhal Interior Norte	1035,0	8,3	124,1
Pinhal Interior Sul	0,0	9,6	0,0
Pinhal Litoral	6821,8	14,1	483,7
Oeste	271,4	11,8	23,1
Médio Tejo	17861,5	11,9	1503,4
Alto Alentejo	333,1	12,1	27,5
Alentejo Central	0,0	12,0	0,0
Lezíria do Tejo	1549,8	12,4	125,0
Grande Lisboa	2388,4	23,6	101,3
Península de Setúbal	5266,6	10,2	515,0
Alentejo Litoral	114283,0	20,1	5693,7
Baixo Alentejo	63,0	11,6	5,4
Algarve	1250,0	14,9	83,9
Região Autónoma da Madeira	1872,9	17,8	105,4
Região Autónoma dos Açores	1918,0	12,5	153,6
Portugal	3290,6	14,1	233,1

Source: Own elaboration using data from INE.