Costs Assessments of European Environmental Policies

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Abstract

The evolution of energy production in the European Union (EU) is going through a big change in recent years: the incidence of traditional fuels is diminishing gradually for increasing renewable energy sources (RES), due to international concerns over climate change and for energy security reasons. This aim of this paper is to construct a simulation model that identifies and estimates costs that may arise for a community of negotiating countries from opportunistic behavior of some country when defining environmental policies. In this paper, the model is applied specifically to the new 2030 Framework for Climate and Energy Policies (COM(2014) 0015) (EC, 2014) on the promotion of RES that commits EU governments to a common goal to increase the share of RES in final consumption to 27% by 2030. Costs faced by EU countries to achieve the RES target are different due to their endowment heterogeneity, the availability of RES, the diffusion process of cost improvements and the different instruments to support the development of the RES technologies. Given the still undefined participation agreement to reach the new overall RES target by 2030, we want to assess the potential cost penalty induced by free riding behavior. This could stem from some EU country, which avoids complying with the RES Directive. Our policy simulation exercise shows that costs increase more that proportionally with the non-participating country size, measured with GDP and CO_2 emissions. Furthermore, we provide a model to analytically assess the likelihood each EU country may have to behave opportunistically within the negotiation process of the new proposal on EU RES targets (COM(2014) 0015).

Keywords: Simulation model; Renewable energy; Cost function; Opportunistic behavior.

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1. Introduction

Climate change has become the main pillar of EU policies aimed at accelerating the transition towards sustainable development, a future with low emission of greenhouse gases. The development of multi-disciplinary and multi-dimensional strategies by EU institutions to face climate change has occurred and is still evolving within a particularly complex system. Indeed the evolution of energy consumption in the EU especially in the electricity sector, linked to concerns about climate change and energy security, offers important opportunities for the development of RES.

We analyze the two main instruments of the EU Climate change policy, namely the target setup to 2020 and the new target setup to 2030. The Renewable Energy Directive on the promotion of the use of RES (2009/28/EC) (EC, 2009) has committed EU member states to reach 20% share of RES in the EU energy consumption by 2020 and it has set national RES targets for all EU member states by implementing the National Renewable Energy Action Plans[1]. In particular, member states adopted National Renewable Energy Action Plans with binding goals for heating and cooling, electricity and transport biofuels from renewables; it remains up to EU member states to decide on the mix of contributions from these sectors to reach their national targets, choosing the means that best suit their national circumstances.

The new EU proposal for 2030 has set several targets within the 2030 Framework for climate and energy policies (COM (2014) 0015) (EC, 2014), to make the EU energy system more competitive, secure and sustainable[2]. We focus on the new RES target, based on a more market-oriented approach, which is set at 27% for the EU as a whole by 2030. Thus, the EU abandons the policy of setting binding national targets[3]. We deem that this makes the need for a new round of negotiation and cooperation within the EU extremely important. EU member states will enjoy some flexibility on how to transform their energy system. This is certainly an important and controversial point

[1] The allocation of different national target rests on a flat rate approach adjusted for the GDP of each country. System of incentives and support for RES are quite costly and recovery times are long. Indeed the EU RES directives 2001/77/EC, 2003/30/EC and 2009/28/EC oblige member states to introduce support schemes to RES technologies to allow RES enter the commercial market and to become competitive in the long term with respect to fossil fuel technologies (Klessmann et al., 2010).

[2] These targets are related to GHG reduction, RES increase, increase in energy efficiency, reform of the EU emissions trading system etc. More specifically, the EC has established a 40% reduction in GHG emissions compared to 1990 levels, to be achieved through action at the national level.

[3] We have considered the case of RES' goal but our simulation model can be applied to other environmental goals to estimate costs that may arise for a community of negotiating countries from opportunistic behaviour of some country when defining environmental policies.

since the new communication does not contain any mandatory target for individual nations in terms of RES, nor it discusses the implications in terms of additional costs for the European citizens. Indeed, according to recent estimates, investments resulting from RES target of reaching 30% in final consumption by 2030 are estimated to range between € 73 billion and € 90 billion per year (European Investment Bank, 2013; Held et al., 2014; Resch et al., 2014). We consider investment costs as the direct costs for reaching the RES targets by 2030, while the indirect ones as the reputation costs of not achieving the 2030 EU target and the climate change issues are not considered in our paper.

The new approach of the COM 2014(0015) policy is radically different from the Directive 2009/28/EC RES policy which imposes precise RES national targets in 2020. On the contrary, the new EU RES policy imposes a common target to be achieved all together. This raises an immediate question: can a macro entity, such as the EU be successful in defining and then achieving a common target if its constituents are not subject to some binding constraint? We reckon that possible opportunistic participation to environmental agreements may arise from the gain that each country can get. Climate change is a global problem and each country believes to get only small benefits compared to her effort. The results of recent negotiations confirms that countries individually are primarily concerned about potential economic disadvantages arising from financing of RES.

The maximization of national welfare can lead to unilateral actions at the expenses of the European community, i.e. European electricity consumers. Whether a coalition is stable or not it also depends on the opportunities available in a bargaining situation of collaborate for the mutual well-being. As demonstrated by past negotiations, an agreement with full participation of all parties involved is difficult to obtain. What most often happens in reality is that some countries act unilaterally to maximize their own welfare (Kemfert, 2004). Indeed, achievement of full cooperation in an agreement with such EU principles, with reference to RES, is relatively difficult when the underlying game poses a dilemma for players. Notwithstanding the fact that cooperation is socially optimal, it is often the case that a number of players will have the temptation of stealing away from the game, still enjoying the benefits without having to bear the costs of implementing RES technologies (Lessmann and Edenhofer, 2011). Thus, we find evidence in most of the literature that the behavior of nations is characterized by some opportunism in both the formation and implementation of environmental policies.

The aim of this paper is to construct a simulation model, which is able to identify and estimate costs that may arise because of potential opportunistic behavior of some country, in the process of negotiation and definition of environmental policies. In our model, we use as a starting point the available national data of the 2020 RES targets and we simulate the results for the new EU environmental policy by 2030, which has to be achieved at the EU aggregate level. More specifically, we assume that there is an indirect relation between CO_2 emission reduction and RES development[4] (see among others Gerlagh and Van der Zwaan, 2006; Panwar et al., 2011). More generally, the failure of meeting a given RES policy does not necessarily have negative consequences, if there is a compensatory effect of a more aggressive decarbonization policy. In this sense, we assume that there is a linkage between the opportunity cost of achieving a RES target and that of achieving a CO_2 target. This is an interesting issue, because the total cost of a given RES is also a function of the mix of different RES technologies, which have different unit costs. However, in this paper we do not explore this issue further.

Although the RES Directive does not impose costs on other countries within the EU if countries fail to meet RES targets, according to Nordhaus (2015), opportunistic behavior of countries in environmental agreements is always possible, requiring the implementation of sanctioning mechanisms, as it is the case of the EU legislation. Such sanction mechanisms have been applied to Poland and Cyprus as a daily penalty imposed by the European Commission (€133,228.80 and €11,404.80 for Poland and Cyprus respectively, EC, 2013).

In this framework, we estimate the potential additional costs suffered by all other EU countries. We want to clarify that we refer to the opportunity cost that is faced by the abiding countries as a consequence of the behavior of the reneging country. We acknowledge that the Renewable Directive has no mechanism for imposing to other countries the burden resulting from the failure of some to meet their targets. However, if the overall target has to be met, in principle, the remaining countries have to make up for the non-participating ones, upgrading their effort, and this has a cost. Alternatively, the remaining countries give up the goal of achieving the original target for the whole EU. In this case, the remaining countries abide to their original commitment but they incur in a loss of not achieving the overall climate change policy target and this has a cost, too[5].

This is crucially dependent on the fact that the marginal cost to deploy RES is a convex increasing function (Nordhaus, 2009). In fact, starting with any given efficient RES allocation among EU countries, consider a country reneging on its share. If the remaining countries have to make up the difference, they will have to increase their quantity and therefore their cost will increase. In our analysis, we assume that RES marginal costs rise if some EU member countries renege on their targets. The relevant novelty of our model is that we empirically estimate the increasing marginal

[4] For a given level of electricity generation, if an additional KWh generated by RES displaces a KWh generated by traditional fossil sources, the result is an additional reduction in CO_2 emissions.

[5] We are grateful to an anonymous referee for raising this point.

cost function and therefore we provide empirical evidence of the convexity of marginal costs. The degree of convexity of the marginal cost of abatement is related to the opportunistic behavior of some participants.

We take into account explicitly the relationship between costs for implementing different RES technologies, i.e. photovoltaic (P), wind (W) and biomass (B) technologies, and costs arising from less than full participation. In our model, the non-participation in the agreement to reach the RES target can be partial or total. The analysis is conducted using an empirically estimated functional model, which captures the endogenous feedback from the environmental policy to the overall macroeconomic equilibrium, capable of measuring the non-participation costs.

Empirical results yield a precise measure of the cost imposed by some non-participating country to all others. These costs increase more than proportionately with the non-participating country size expressed in terms CO_2 emissions and provide an analytical base to assess the likelihood that each country may have to attempt to behave opportunistically within the negotiation process of the new proposals on EU RES targets. The amount of CO_2 emitted by a country expresses indirectly also the size of GDP, given the positive relationship shown by most of the literature between CO2 emissions and GDP (Soytas et al., 2007; Selden and Song, 1994; Tucker, 1995).

The paper proceeds as follows. Section 2 provides a review of the literature. Section 3 describes the model. Section 4 provides data and Section 5 presents results and discussions. Section 6 concludes the paper.

2. Literature review

The EU sees itself as a pioneer in climate protection policies and RES technologies implementation. Indeed, the EU is the only region that, to date has embarked on binding targets to 2020 in relation to pollution and RES (Böhringer et al., 2009). Despite this, the EU can also experience problems in achieving goals related to cooperation and negotiation between EU countries. The development of RES still faces barriers of various kinds. The energy produced from RES is quite expensive compared to traditional sources; without financial support, RES technologies are limited by their financial cost to enter the commercial market. From an economic point of view, the public policy of intervention in relation to the RES is justified by the fact that the effects of learning by doing generates spillovers benefiting the market (Reichenbach and Requate, 2012). Spillovers are positive externalities that added to the negative externalities represented by pollution lead to a reduction in the supply of technologies based on fossil fuels and an increase of RES technologies (Helm and Schöttner, 2008).

Many environmental policies share the features that when many countries are involved in international agreements it is possible that some of them do not actually participate (Cremer and Gahvari, 2002; Kolstad, 2000; Stavins, 1995). Barrett (1994) finds that partial participation and compliance in climate change agreements is due to the lack of incentives. In order to understand how to increase participation, the author examines positive and negative incentives for participation. It turns out that positive incentives, that are market-based instruments, can reduce costs overall but are less likely to be effective in promoting participation. There is need for negative incentives, such as reciprocal measures, sanctions and trade restrictions together with positive incentives to stimulate cooperation. If incentives are not successfully implemented then the likelihood to reach full participation is reduced.

According to Helm (2008), climate change is an issue so intractable because the basic conditions for an agreement and compliance with the agreement itself are absent. For instance, proper allocation of responsibilities of existing stocks of carbon in the atmosphere; some countries may benefit from climate change and, however, its effects vary from one country to another; there are powerful and multidimensional incentives to free riding.

Klessmann et al. (2010) reviews flexibility mechanisms and cooperation introduced by RES directive (2009/28/EC) to enable member states that have a low potential for RES or have high costs of implementation of the RES to partially fulfill their own binding targets in other EU countries that have rather more potential production or lower costs relative to RES technologies. The three mechanisms are statistical transfer, joint projects and joint support scheme. Statistical transfer refer to the RES that have already been produced in a EU member state and that are partly virtually transferred to the statistics of the EU member state showing a deficit. Joint projects are projects related to RES used for electricity or for heating and cooling projects, developed under an agreement among two or more EU member states. A member state may provide financial support for a project for the development of RES in another member state and then consider some of this energy produced in its RES binding national target. Joint support schemes open up the possibility that the EU member countries have to combine their own support schemes to RES in the electricity and heating and cooling sectors to achieve their own targets. Clearly, the EU member states will make use of these cooperation mechanisms only if economic, environmental and social costs benefits outweigh costs and risks. The authors argue that, by referring to the documents predictions of the EU member states themselves, most countries prefer to rely on their national support schemes to reach the target, that is to say, they want to enjoy at national level of benefits arising from their efforts to implement RES technologies.

In the literature, there have not been analytical studies on the design of cooperation mechanisms within the European directive on RES. Muñoz et al. (2007) propose a methodology for the harmonization of support mechanisms for RES in the EU based on a feed-in law with a modular and transparent premium for producers of RES electricity. The premium considers costs of the technology, some of the grid services, the political incentives and national priorities. The authors show that the feed-in laws are an effective and efficient way to increase RES electricity production and achieve the EU's RES objectives.

Klessmann et al. (2013) describe policy options to reduce project costs of RES and then consumer costs of reaching the 2020 goals. Regarding the policy options to reduce the costs of the projects for the investors, the authors propose to reduce the required investment costs, to improve the regulatory framework, to increase research and development activities and to reduce the cost of capital by reducing project risks. In order to lower consumer costs, the authors discuss possible options for policy makers, as adjusting the financial support level to RES generation costs and attempt to introduce some form of European cooperation for optimized resource exploitation. Finally, they identify the main options that at the macroeconomic level might reduce RES technologies costs that are the adjustment of support mechanisms for both RES and fossil fuel technologies through increased cooperation among EU member states.

3. Model formulation

In order to simulate the effects of environmental policies, we construct a coherent model, which incorporates endogenous feedbacks from the economic activity to the environmental sector. To this end, we reckon that the RES Directive (2009/28/EC) (EC, 2009) imposes to EU member countries specifics targets[6] in terms of RES, which are the result of a political negotiation. This process leads to the recognition that Climate change policies have significant costs, which are constituted by both direct investment and indirect policy-driven costs. The first type of costs is related to new equipment and other infrastructure investments necessary to achieve the desired quantitative targets. The second type of costs is the result of the policy formation process itself. In fact, the level of the target set by the policy decision process is, without any doubt, related to the amount of resources

[6] The extent to which each RES technology could be adopted compared to other options is uncertain because of the differences in technology costs and RES potentials. Cost uncertainty is partly relates to the learning by doing effects: if investment costs do not decrease as fast as expected, total costs for RES deployment by 2020 0r by 2030 might be higher than expected. Therefore, there is considerable uncertainty over the use of RES technologies in the future. Changes to the assumptions we have made according to the RES Directive (2009/28/EC) (EC, 2009) and COM 2014 (0015) could have an important impact on our results. We assume the RES technologies implementation process is in line with the RES Directive (EC, 2009).

required by an increasing function. This is so due to the general principle of increasing marginal costs, which characterizes any economic activity. Thus, the more ambitious is the target, the more costly is the policy to be implemented. We focus on learning by doing effects using one factor, i.e. production, as the driver for RES cost reductions over time, assuming away strategic roll out. We have considered that research and development activities play an important role in the early stages of development, while learning by doing and then production is more important as the technology matures[7].

In addition, we also take into account that it is plausible that this complex negotiation process may be characterized by some opportunistic behavior, that is, each country could try to negotiate a lower assignment in order to save costs, public land usage, and political opposition such as the NIMBY (not in my back yard) syndrome (Van Der Horst, 2007). Obviously, a lower assignment gained by one country (or sub-coalition of countries) must result into a higher target assignment to the remaining countries, in order to allow a full compliance of the total EU target. In the extreme case, if a country refuses to comply with her overall assigned target, there results the classical case of free riding, simply because the burden of the Climate Change Policy will rest on the shoulders of the remaining countries.

With these considerations in mind, we propose a simple simulation tool which is conceived as a module to enrich the modelling the macroeconomic interaction of the income formation with the government intervention. The theoretical feature of our model can be captured by considering a general equilibrium set of equations, representing income equilibrium, emission generation and government balance equations:

$$Y = A(Y) + (G-T) \tag{1}$$

$$Z = f\,(Y) \tag{2}$$

$$T = T(Y, Z) \tag{3}$$

Conceptually, in this simple scheme, the macroeconomic equilibrium condition is defined in eq. (1), where it is stated the equilibrium between supply *Y*, the endogenous aggregate demand *A(Y)* and the

[7] Notice that the RES price is strongly related also to demand fluctuations, which could in turn depend on public incentives. Indeed, RES will be competitive in the energy market when the production cost is similar to the electricity price (Movilla et al., 2013). Failure to meet targets in one country could reduce demand and therefore the market price, benefitting other countries. In any case, in our paper we do not take into account this issue given the modest European share in world RES demand, which is not likely to affect the world price.

government budget constraint (G-T, expenditures minus taxes). The amount of emissions Z is defined as a function of economic activity Y in eq. (2) (Kolstad, 2000). The required public resources, which come through taxation T, are a function of economic activity Y and specifically of the emission level Z in eq. (3).

The novelty of our approach is that we recognize a crucial feature of climate change policies negotiation processes, namely the existence of the cost imposed by one country to all the others, when she attempts to reduce her participation burden. We model explicitly this cost, which modifies and enriches the simple conceptual macro model described above. In fact, there exists a cost of this political process which is not only a function of the exogenous political preferences but it is also a function of the emission level Z and becomes an additional factor be included into the level of taxation T. Thus, our model provides a policy simulation tool, which can be incorporated into large macro models, in order to capture this important feature of endogenous channel of interaction between policy targets and costs.

We assume the existence of a cost function, convex and differentiable, which represents the necessary usage of monetary resources to implement an additional abatement of the CO_2 emissions (Bollino and Micheli, 2014). The assumption of convexity is crucial to explain the rising costs that eventually non-complete participation imposes to the others, because it implies rising marginal costs. We also assume that technologies are the same all throughout the EU member countries, but that costs are differentiated by types of RES and by regions, for several reasons (as discussed in detail in the empirical section).

The arguments of the cost function are defined in terms of units of CO_2 emissions (millions of tons) for a country i, associated with a specific RES technology j deployment. C_{ij} is the monetary total cost, Z_{ij} is the total amount of CO_2 emissions associated with the total economic activities of the country, g_j is the emission reduction rate and α_j is a fixed parameter, $\alpha_j > 0$, capturing the convexity of the cost function, with $i = 1,\dots n$ regions and j = *P (photovoltaic), W (wind), B (biomass)*. We assume that the deployment of a specific RES technology j is equivalent to the emission reduction activity, represented by the parameter g_j.

We define as λ_j ($\lambda_j < 1$) the share of EU emissions corresponding to the fraction of countries that fully participate to the climate policy target, deploying the specific RES t
echnology j.

Formally, we define the cost function as:

$$C_{ij} = g_j^{\alpha j} Z_{ij} \quad (4)$$

Summing over the i countries, we obtain the total cost for all EU member countries when they fully participate to the climate policy target, for each RES technology deployment:

$$C_j = [\Sigma C_{ij}] = g_j^{\alpha j} [\Sigma Z_{ij}] = g_j^{\alpha j} Z_j \tag{5}$$

We can use the total cost function (5) to define the cost of participating countries, when only a subset of countries, for $i = 1, ... p$, decide to fully comply with the assigned targets. In this case the share of participating countries is $\lambda_j = [\Sigma_p Z_{ij}] / [\Sigma_n Z_{ij}]$. In this case, we can define C_{pj} as the cost for the participants:

$$C_{pj} = g_{pj}^{\alpha j} Z_{pj} \tag{6}$$

and accordingly we can define $g_{pj} = g_j/\lambda_j$ and $Z_{pj} = \lambda_j Z_j$, yielding by substitution into eqs. (5) and (6):

$$C_{pj} = g_j^{\alpha j} Z_j \lambda_j^{1-\alpha j} \tag{7}$$

Thus, we have obtained analytical expressions to compute the total cost of both full and incomplete participation, C_j and C_{pj}, respectively eqs. (5) and (7), from which we can define the penalty factor imposed by non-participants to participants:

$$S_j = C_{pj} / C_j = \lambda_j^{-(\alpha j-1)} \tag{8}$$

where S_j is the penalty factor borne by all remaining participants because some countries do not participate to the agreement, for a given total RES target.

Notice that this penalty, which measures the extra cost necessary to respect fully the target when the group of participants shrinks, due to the opportunistic behavior of some participants, crucially depends on the parameter α_j, which denotes the degree of convexity of the marginal cost of abatement. If marginal costs are constant, then (α_j-1) equals zero and the penalty factor vanishes. On the contrary, with positive (α_j-1), the marginal cost of abating emissions rises, making the non-participation costly for the remaining countries.

4. Data

We use official data of the EU for GDP, the CO_2 emission and the RES developments targets defined in the Climate package for the year 2020[8]. We have taken also into consideration the new EU Communication of March 2014 (COM(2014) 0015). We have constructed an original set of data to estimate the Levelized Cost of Energy (LCOE)[9] for RES' production resulting from P, W and B in 97 regions of the EU at the NUTS level 1 (NUTS classification is taken from the Regio-database by Regulation (EC, 2003) No. 1059/2003 and Eurostat (2010)). The LCOE is constructed taking into account regional differences in solar radiation, wind regimes, land productivity as well as country specific factors, such as labor costs, building regulations and national differences in legislations, bureaucratic impediments and financial conditions. With this procedure we are able to geo-locate, for the 97 regions listed in NUTS level 1.RES' production which is characterized by geographical features. In other words, we take into account the specific regional productivity conditions, so that, for instance, the same P panel, over the same lifetime, generates a lower LCOE when installed in a southern region, because it enjoys a longer solar radiation period in each year.

We use the LCOE computed in each region to measure the marginal cost of each technology at the EU level, for 288 observations in total. We estimate the marginal cost parameter $(\alpha_j - 1)$ for each technology at the EU level, defining a specific logarithmic cost function[10] for each technology (Table 1). Notice the high significance of the coefficients, showing that empirically the cost function is convex. In particular, the convexity parameter of the marginal cost function, $(\alpha_j - 1)$ of each technology is 0.58 for P; 0.96 for W and 1.63 for B. This pattern is an interesting empirical result, which demonstrates the importance of our geographical breakdown in order to take into account the structural differences for each technology.

Table 1. Estimated marginal cost function parameter for RES generation.

	No obs.	**R Squared**	**Estimated (a-1)**	**Constant**
P	97	0.90	0.58	-1.38
W	97	0.69	0.96	-3.17
B	94	0.40	1.63	-3.89
Total	288	0.71	1.61	-4.43

Note: all coefficient are significant at 1%
Source: our calculation from Eurostat (2013)

[8] In order to use homogeneous data, we refer to the EU 27, because homogenized data for Croatia are not available.
[9] We compute the LCOE in €/kWh assuming, over a standard lifetime period of the equipment, that the energy is generated according to the most efficient available technologies and equipment for P, W and B.
[10] We differentiate the cost function of eq. (5) and take logs: $log(C_j)' = \alpha_0 + (\alpha_j - 1)\ log(g_j)$ in order to estimate econometrically the marginal cost parameter $(\alpha_j - 1)$.

The empirical estimation of the cost function is the operational base, which allows computing the penalty factors imposed by some non-participating countries to all others. Intuitively, when a country reduces her effort, all other countries have to increase their efforts more than proportionally, in order to pursue the common targets of the climate change policy.

In order to appreciate the importance of the hypothetical reneging country, we report the share of each country in the total EU RES target in Table 2. The country list is shown in Column 1. The country shares for each technology (P, W, B) are reported in Column 2, 3 and 4 and the country shares for total RES target are reported in Column 5. For instance, consider Austria, which contributes only 0.37% of the total EU PV target; 0.96% of W target; 2.60% of the B target. Consequently, the Austrian share of EU target is 1.27% and the share of all other countries is 98.73%.

Table 2. EU member states share in EU target RES electricity generation in 2020.

Non-participating Country	P share of non participating country (%)	W share of non participating country (%)	B share of non participating country (%)	Total RES share of non participating country (%)
Austria	0.37	0.96	2.60	1.27
Belgium	1.37	2.08	5.47	2.79
Bulgaria	0.54	0.45	0.29	0.42
Cyprus	0.37	0.10	0.08	0.12
Czech Republic	2.07	0.30	1.88	0.86
Denmark	0.00	2.33	3.62	2.37
Estonia	0.00	0.31	0.20	0.25
Finland	0.00	1.21	7.20	2.46
France	7.09	11.52	7.68	10.15
Germany	49.63	20.79	14.83	22.57
Greece	3.47	3.34	0.21	2.63
Hungary	0.10	0.31	1.53	0.57
Ireland	0.02	3.95	1.40	2.93
Italy	11.57	3.98	7.27	5.57
Latvia	0.00	0.18	0.37	0.20
Lithuania	0.02	0.25	0.46	0.27
Luxembourg	0.10	0.05	0.11	0.07
Malta	0.05	0.05	0.05	0.05
Netherlands	0.68	6.45	6.82	5.90
Poland	0.00	3.03	5.81	3.34
Portugal	1.77	2.91	1.70	2.50
Romania	0.38	1.67	1.11	1.40
Slovakia	0.36	0.11	0.48	0.22
Slovenia	0.17	0.04	0.18	0.08
Spain	17.17	15.58	4.22	13.13
Sweden	0.00	2.49	9.52	3.84
United Kingdom	2.69	15.58	14.91	14.01

Source: our calculation from Eurostat (2013)

Notice that Germany alone has the highest total share, about 23%, due to the considerable incentive policies[11], and that the big five EU countries (Germany, UK, France, Italy and Spain amount about 66% of the total). In addition, considering P, notice that only three countries, Germany, Spain and Italy make up almost 78% of the total EU target.

We consider the relative importance of each country in terms of her share of RES. This is a measure of country's maximum potential free riding behavior, which is given by the share of the EU target that the non-participating the country does not take in charge. Obviously, the cost of the remaining share has to be redistributed among all other countries. For instance, if Austria would decide to withdraw from the EU policy commitment, given that her share is 1.27%, all other countries would have to pick up the cost to implement the remaining 98.73% of the target.

5. Results and discussions

We use our model as a policy simulation tool in order to assess the cost penalty induced by potential free riding behavior on behalf of some country, which avoids complying with the targets of RES Directive. We compute using eq. (8) the ratio of the cost of achieving a policy with partial participation with respect to the cost with full EU participation (Table 3). Given the convexity of cost function for each technology, we obtain that this ratio increases more than proportionately with the respect to the non-participating country's share.

We report the country list in Column 1. We compute the cost penalty imposed by each non-participating country for each technology in Columns 2, 3 and 4 and the total cost penalty in Column 5. In other words, we simulate that each country reneges her participation, imposing an hypothetical extra-burden on the remaining (n-1) countries, because these have to update their share in order to meet the target and make up for that of the reneging country. Notice that, in principle, if one country fails to meet the target of a specific technology, there is no reason why another country has to do more of that technology. Anyway, our baseline simulations assume the energy mix projections for RES electricity of each country, as outlined in the NREAPs. Columns 2, 3 and 4 of Table 3 show calculations separately for each source. For instance, if a country does not

[11] Indeed, the incentive system and the German legislation have certainly played a key role in RES development. In particular, since 2000, the German legislation has further refined its regulatory model introducing a differential tariff system to encourage the development of P. Differentiated tariffs are an important tool to guide the development of markets. Indeed, German installed capacity of P is almost half of that of the EU as a whole. The RES industry has shown that with a stable and clear regulatory framework it is possible to overcome the challenges that the energy transition arises, finding appropriate solutions, with an innovation that proceeds more quickly than in other sectors. Currently RES are an economic engine for Germany also from the point of view of employment and are part of a comprehensive view for transition, i.e. the so called "Energiewende" (Beveridge and Kern, 2013).

produce the amount of P stated in the NREAP, the Column 2 shows the cost suffered from the other countries to make up the EU P target. Column 4 shows the same cost computation when a country renege her mix of RES stated in NREAP[12]. We also report the cost share of each country in the total EU RES target, in Column 6, which we interpret as a measure of the potential benefit for the non-participating country, in the sense that the country could save resources by not investing in her share. Then, we compute the ratio of benefit accruing to the non-participating country to the cost imposed to all other countries, in Column 7. This is a measure of how much a country could save by non-participating to the EU target with respect to the extra cost that she imposes on all others. If this ratio is less than one, this means that the country could have a strong temptation to behave opportunistically but certainly, this leaves no margin for potential compensating negotiations with the other small countries.

In other words, we identify two types of potential opportunistic behavior, elaborating further the lines of Nordhaus (2015) discussion of the climate club formation. The first (ratio less than one) is the behavior of a country, which uses a subtle approach to negotiation, asking for a "discount" in the assigned target, knowing that the others would be prepared to concede it, because in the end it is in their interest to do so. The second (ratio above one) is the aggressive behavior of a country, which acts reneging explicitly the cooperative attitude and simply refuses to abide to an assigned target. Finally, we report the share of CO_2 emissions of each country in column 8.

Notice that there are several interesting considerations, which emerge from the empirical computations of our model. Firstly, as expected, Germany is the most important country in the EU RES policy framework. An hypothetical withdrawal of Germany would impose an additional cost of 28.8% on all others (col. 5). The cost share borne by Germany accounts for about 48% of total EU cost of the RES policy (col. 6) although her share of total EU emissions is 19% (col. 8). Secondly, this is very different form the UK, which contributes to almost 13% of the emissions but has a cost share of about 7% of the total EU. These differences are obviously due to the different composition by technologies. Germany relies heavily on P, which is more costly, while the UK relies relatively more on W (mostly onshore W that is more cost effective than offshore W) and B (imported), which are less costly.

[12] We defer to future research the implementation of a model of simultaneous costs minimization among the sources, which would also allow to investigate the relationship between increased RES and decarbonization targets.

Table 3. Estimates of the penalty from limiting participation in the EU RES policies by 2020.

Non-participating Country	P cost penalty for other EU participants (%)	W cost penalty for other EU participants (%)	B cost penalty for other EU participants (%)	Total RES cost penalty for other EU participants (%)	Total RES benefits for non participating country (%)	Ratio Benefits/Costs	Country share of CO_2 emissions
Austria	0.21	0.93	4.39	1.65	0.63	0.38	1.75
Belgium	0.80	2.04	9.60	3.65	4.61	1.26	3.41
Bulgaria	0.32	0.43	0.48	0.43	1.24	2.87	1.36
Cyprus	0.22	0.10	0.13	0.12	0.17	1.46	0.21
Czech Republic	1.22	0.29	3.14	1.05	4.21	4.02	2.24
Denmark	0.00	2.29	6.20	2.94	0.35	0.12	1.38
Estonia	0.00	0.29	0.32	0.27	0.10	0.36	0.52
Finland	0.00	1.18	12.96	3.76	0.43	0.12	1.43
France	4.36	12.47	13.90	11.91	7.91	0.66	9.75
Germany	48.85	25.07	29.90	28.79	47.82	1.66	19.49
Greece	2.07	3.32	0.34	2.49	2.05	0.82	2.37
Hungary	0.06	0.30	2.55	0.79	0.18	0.23	1.30
Ireland	0.01	3.94	2.32	3.14	1.95	0.62	0.96
Italy	7.39	3.98	13.10	6.45	6.16	0.95	10.45
Latvia	0.00	0.17	0.60	0.25	0.07	0.28	0.39
Lithuania	0.01	0.24	0.76	0.33	0.14	0.42	0.42
Luxembourg	0.06	0.05	0.18	0.08	0.04	0.51	0.31
Malta	0.03	0.05	0.08	0.05	0.03	0.58	0.18
Netherlands	0.40	6.61	12.21	7.22	1.15	0.16	6.57
Poland	0.00	3.00	10.25	4.34	0.92	0.21	8.00
Portugal	1.04	2.87	2.84	2.66	0.94	0.35	1.22
Romania	0.22	1.63	1.84	1.53	0.46	0.30	2.42
Slovakia	0.21	0.11	0.79	0.28	0.33	1.20	0.91
Slovenia	0.10	0.04	0.29	0.10	0.07	0.66	0.26
Spain	11.54	17.65	7.28	14.59	10.19	0.70	8.31
Sweden	0.00	2.45	17.71	5.70	0.95	0.17	1.41
United Kingdom	1.59	17.65	30.10	18.76	6.90	0.37	12.95

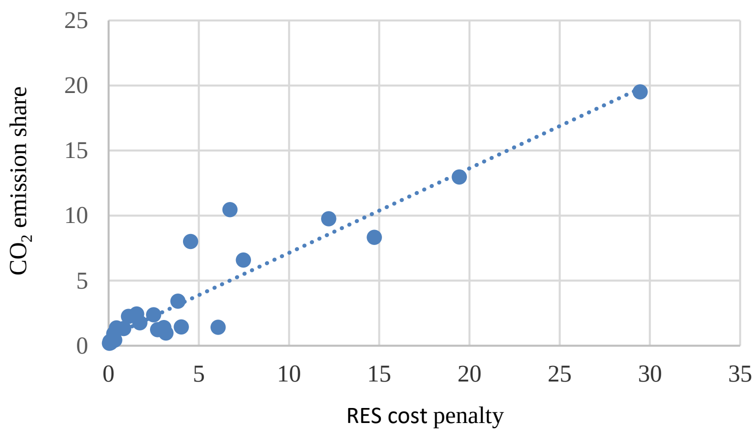
Source: our calculation from Eurostat (2013)

Thirdly, turning the attention to the penalty cost computations, we explain the logic of our model by using the case of Austria as an example. We consider the hypothetical case in which Austria withdraws from participation to the EU target. This action would impose to all others an (undesired) increase in their cost of about 1.6% (col. 5). However, if a country like France or Spain decides to non-participate, the cost penalty associated to this partial participation for all other would be either 12% or 15%, respectively. Notice also that our model allows assessing the penalty cost in case of partial participation to specific technologies. For instance, if a country like Italy withdraws from her commitment to B development, the extra cost imposed to all others is about 13% (Col. 4), but if Italy does so for W, the extra cost for all others is only 4% (Col. 5). A quite different picture emerges in the case of UK. If UK withdraws from her commitment to B development, the extra cost imposed to all others is a relevant 30.1%, but if UK does so for P, the extra cost for all others is only 1.6%. This fact highlights the importance of the analysis for each technology, because the mix is different for each country. There are only few countries that impose to all others a penalty above 5%: Germany, as already noted, with 28%; then there are: UK 19%, Spain 15%, France 11%, Netherlands 7% and Italy 6%.

Moreover, notice that these effects are non-linear and therefore cannot be simply added. To show this last point, notice the last three rows of Table 3, where we report computations for some hypothetical group of countries whose "size" is expressed in terms of CO_2 emissions. Indeed, we take into account the contribution to CO_2 emissions of EU member countries; our empirical findings show there is heterogeneity among them. They are the smallest 11 countries, the three large Mediterranean countries (France, Italy and Spain) and the Big 5 Group (Germany, UK, France, Italy and Spain). It is immediately clear that the cost imposed by these groups taken together is different from the sum of the individual effects. Thus, the smallest country group would impose a penalty of 4.49% to the remaining countries, The Mediterranean group would impose a 22% penalty, while in the hypothetical case of withdrawal on behalf of the Big 5 Countries all the others would have to bear a 85% cost increase.

Notice that the penalty imposed to other participants is an increasing function of the country's importance in terms of CO_2 emissions, as shows in Figure 1.

Figure 1. Total RES Cost penalty and CO_2 emission share



Source: Table 3

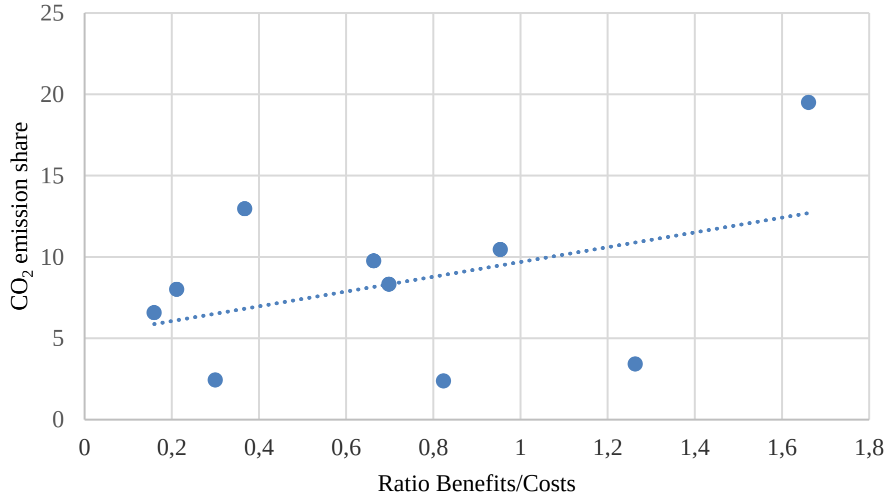
We stress that this is because the cost function is convex. This constitutes a novel result in the literature, which stems from the empirical estimation of the cost function for the EU regions.

The analysis of the ratio benefits/costs (Col. 7) shows an interesting pattern. There is only one large country with a ratio greater than one: Germany with a ratio equal to 1.66, while the other are Czech Republic, 4.02, Cyprus 1.46, Belgium 1.26, Slovakia 1.20, while the majority of countries show a ratio less than one. This means that Germany is the only large country, which could potentially behave aggressively in the negotiation process. The majority of the countries could have a potential temptation to negotiate opportunistically their share of the common EU target, showing a discount bargaining attitude. This consideration reinforces the need for implementing a stringent and cohesive process, inclusive of a definite sanction mechanism, to define the ambitious target shares for the new 2030 horizon.

Notice that the ratio of benefits to costs does not show a definite pattern, but if we distinguish two groups of countries, according to the emission share, a new pattern emerges. In fact, this ratio is positively correlated with the CO_2 emission share for the group of 10 large countries, which account for 84% of total emissions (Figure 2), but it is negatively correlated with the same variable for the group of 11 small countries, which account for 6% of total emissions (Figure 3). This pattern shows that the opportunistic incentive when negotiating common EU targets decreases with size for large countries, or else that large countries have an increasing incentive to adopt responsible behaviors towards common EU targets. On the contrary, the temptation to behave opportunistically appears to be potentially higher, the smaller the size of the country for the group of small countries.

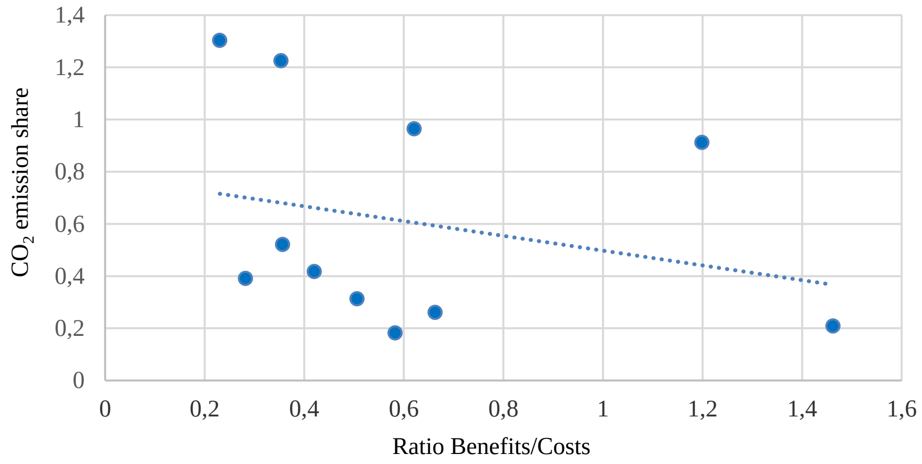
In conclusion, we highlight that we provide a measure of the cost of not meeting RES as the extra cost that has to be borne by the remaining countries. We express this penalty as a percentage of the total cost of the target, not in absolute terms. To express this in absolute terms, there is need for an estimate of the monetary cost of the required investment. There is a large variance in projected EU investment estimates, which range between 73 and 90 billion euro per year to achieve the 2030 targets (European Investment Bank, 2013; Held et al., 2014; Resch et al., 2014). According to these figures, we deem that each percentage point of our estimated penalty cost is worth in the EU between 0.7 and 0.9 billion euro per year. In addition, we point out that our analysis is useful for the EU policy-making. We take into account that it is plausible that the new complex negotiation process for the 2030 target may spur some opportunistic behavior, i.e. each country could try to declare the intention to negotiate a lower assignment in order to save costs, public land usage and political opposition. Obviously, a lower assignment gained by one country (or sub-coalition of countries) must result into a higher target assignment to the remaining countries, in order to allow a full compliance of the total EU target. In the extreme case, if a country refuses to comply with her overall assigned target, there results the classical case of free riding because the burden of the RES Directive will rest on the shoulders of the remaining countries. In terms of policy design, besides a sanction mechanism, our analysis shows that there is probably need for reinforcing social norms and conventions to induce maximum cooperation toward the common goals of EU Environmental policy.

Figure 2. Ratio Benefits/Costs and CO_2 emission share - Large Countries



Source: Table 3 – Countries are the largest in terms of CO_2 emission, accounting for 84% of total emission in the EU.

Figure 3. Ratio Benefits/Costs and CO_2 emission share – Small Countries



Source: Table 3 – Countries are the smallest in terms of CO_2 emission, accounting for 6% of total emission in the EU.

6. Conclusions

This paper has estimated potential extra costs may arise when some EU countries do not participate or partially participate to the environmental agreement, i.e. the RES Directive 2009/28/EC, on the promotion and use of RES. This approach might be useful for EU policy makers in the light of the new and important RES goals proposed by the 2030 Framework for Climate and Energy Policies Package (COM 2014(0015)). Indeed, the EU abandons national targets for an overall EU target of 27% of RES by 2030. With the implementation of the COM 2014(0015) there might be problems regarding cooperation to achieve RES' goal: when member states differ from each other with respect to costs and benefits of implementing RES, some of them might find affordable to free ride.

The motivation of our analysis are the claim more and more challenging to increase the use of RES over the last years, the required support from governments for this expansion and the possibility to behave opportunistically by EU member countries. Costs to reach RES' targets vary among EU countries given both the heterogeneity of countries themselves and different instruments used by governments to implement RES in the energy portfolio mix. These costs may be higher if not all EU countries undertake to comply with the agreement. We specify that we consider the opportunity cost imposed by the non-participating country to the others.

We construct a simulation model that identifies and estimates costs that may arise because of potential opportunistic behavior of some country in the process of negotiation and definition of environmental policies. The model incorporates endogenous feedbacks from the economic activity to the environmental sector. We apply the model to RES countries in the context of the Directive 2009/28/EC on the promotion of RES.

RES Directive has significant costs for EU countries, which are constituted by both direct investment and indirect policy-driven costs, such as costs of new equipment, infrastructure investments necessary to achieve the desired quantitative targets and costs that result from the policy formation process itself. In fact, the level of the target set by the policy decision process is, without any doubt, related to the amount of resources required by an increasing function. The more ambitious is the target, the more costly is the policy to be implemented.

Let us stress that we refer to the opportunity cost that each country has to face. Therefore, reneging behavior of some country will impose a cost on all other countries in order to meet the overall RES target. In fact, in case the remaining countries want to achieve the original target, they will have to make up for the missing one. Alternatively, if the overall target remains unfulfilled, the remaining countries will incur in the cost of having reached a lesser target, which is the opportunity cost of sustaining the extra-burden to reach the original target. The future of the EU environmental policy, which therefore includes RES development, has to be seen in the wider context of the pursuit of environmental objectives in a coordinated and mutually compatible way, otherwise EU development will be environmentally unsustainable. This requires a strong involvement by EU countries and then greater accountability for actions which might harm the environment by the EU member countries themselves.

The analysis is based on a data set with 288 observations to estimate the LCOE for RES' production resulting from P, W and B technologies at EU level. We use our model as a policy simulation tool to assess the cost penalty induced by potential free riding behavior on behalf of some country, which avoids complying with the targets of RES Directive. We compute the ratio of the cost of achieving a policy with partial participation with respect to the cost with full EU participation.

Given the convexity of the cost function of each technology, we obtain that this ratio increases more than proportionally with respect to the non-participating country's share. Indeed, we find that costs imposed by some non-participating country increase more than proportionately with the non-participating country size expressed in terms CO_2 emissions. We provide an analytical base to assess the likelihood that each country may have to attempt to behave opportunistically within the negotiation process of the new proposals on EU RES targets (the amount of CO_2 emitted by a country is an implicit measure of the size of GDP). For instance, the cost share borne by Germany accounts for about 48% of total EU cost of the RES policy although her share of total EU CO_2 emissions is 19%. This result is very different form the UK, which contributes to almost 13% of the total EU CO_2 emissions but it has a cost share of about 7% of the total EU. These differences are due to the different composition of RES technologies, so that a country as Germany that relies heavily on P, pays more than the UK that relies relatively more on less costly RES as W and B.

Furthermore, we compute the ratio of benefit/costs accruing to the non-participating country to the cost imposed on all other EU countries in order to assess the incentive for a hypothetical non-cooperative behavior. From our calculation, the majority of countries show a ratio less than one, i.e. the majority of the countries could have a potential temptation to negotiate opportunistically their share of the common EU target.

These results might be useful in terms of policy implications in helping to cast appropriate incentive schemes to avoid free riding and to enhance the effectiveness of continuing new proposals design, raising the RES bar even more for 2030, 2050 and beyond.

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