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The reform of the European Energy Tax Directive: exploring potential economic impacts in the EU27

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Abstract:

The aim of this study is to analyze the effect that the Energy Tax Directive reform proposed in 2011 would have, if implemented, on the level of prices in the different sectors of the 27 countries of the European Union. We apply a multiregional and multisectoral model of trade flows that takes into account all the intersectoral and intercountry interdependences in the production processes. Using the World Input-Output Database we perform two different simulations. The first one considers the tax changes proposed by the reform; the second one shows the impact the reform would have entailed if it were applied also to sectors belonging to the European Trade System. The main finding of the first simulation shows that the new energy tax regime would have had a low economic cost in terms of impact on prices (less than 1% in all the countries). So, the concerns about competitiveness do not find empirical support in our results, suggesting the need for further analyses to find out the reasons that caused the failure of a reform that was an important step to introduce a taxation explicitly linked to CO_2 emissions. The second simulation, however, leads to strongly different results, pointing out the relevance of maintaining significant economic incentives to reduce carbon emissions for the European Trade System sectors, by improving the emission market performance or by applying carbon taxation also to these sectors.

Keywords: Environmental Taxation; European Energy Tax; European Trade System; Price Impact; Multiregional Input-Output Model; World Input-Output Database (WIOD).

JEL classification codes: C67, D57, H23, Q48, Q53.

1. Introduction

Policy instruments aimed at reducing emissions are widely recognized as a necessary intervention to mitigate the impact risks related to atmospheric contamination and climate change. Through policy interventions, legislators try to reduce polluting behaviors and to encourage a more respectful conduct and more efficient technologies. There are several tools for emission control, many of which use economic mechanisms to influence the existing patterns of production and consumption. These instruments, generally classified in price-mechanisms and quantity-mechanisms, should minimize abatement costs by creating an incentive to develop alternative technologies or to use alternative energy products.

In Europe, although each country has the legal competency to regulate emissions, the European Union (EU) takes part in this process too. One of the instruments implemented at European level is the minimum energy tax on the use of energy products, currently ruled through the Energy Tax Directive (ETD).

In 2011, the European Commission (EC) proposed a new version of the current ETD in order to strengthen its effectiveness, but the European Parliament blocked the process in 2012 and the reform was not accepted. The political process that leads to the implementation or, as in this case, the renewal of a policy instrument is often slow and difficult due to the complexities involved. The 2011 ETD reform was a political reform inherently difficult to be achieved that aroused the reaction of various interest groups. Such reform, which sought to rebalance the current treatment of different energy products used by different sectors, would have affected many economic agents and many countries that have different priorities regarding the climate change policy.

However, it is equally clear that, given the environmental objectives that the EU has set itself, and given the difficulties that the carbon market is facing, the 2011 ETD reform could have been a very moderate but useful step forwards the policy on climate change. This is the main reason that led us to ask what economic impact it would have if approved. As far as we know, there are almost no studies on the potential economic implications of the 2011 ETD reform, although such analyses could bring some evidence to the debate. Barker et al. (1993) and Manne and Richels (1993) analyzed the previous proposal of the Commission to renew the ETD in 1992, but there are no similar studies regarding the recent one. This paper tries to fill this lack.

Following the idea of Nguyen (2008) who examines the impact on prices of the Vietnamese program to increase taxes on electricity, we analyze the potential effect on prices that the implementation of the EU tax energy reform would cause on the different sectors and EU countries. We use a multiregional and multisectoral database with intermediate inputs that allows us to consider international trade flows within the EU and with the rest of the world. The results of our simulation are an interesting starting point to answer a simple question: would the reform imply a strong economic impact on costs and prices?

To contextualize the analysis, the following subsections describe the main economic instruments for emission control implemented in the EU so far (1.1) and the energy tax reform proposed by the EC in 2011 (1.2). Section 2 presents the methodology and database. Results are presented in section 3, which will be discussed afterwards in section 4. Section 5 concludes and gives some policy implications of this research.

1.1. Energy tax and emission trading: current status

Looking at different policies that can be used to reduce CO_2 emissions, two main market instruments exist: carbon (or energy) taxes and carbon emission trading.[1] Energy taxes try to affect the emission quantity by increasing the price of energy products. The emission trading is a "cap and trade" system that fixes a total amount of CO_2 emission allowances that are distributed among economic agents who can either use or trade them, letting the market determine their price and final distribution. In particular, the EU has implemented both instruments, approving the ETD and introducing an Emission Trading System (ETS).

Energy taxes are not a recent phenomenon in Europe; European countries have been using them for nearly ninety years, although initially the aim was only to raise revenues and to reduce oil imports.[2] It was during the 1980s when some European countries started thinking on the energy taxes

[1] Compared with non-market instruments, market instruments imply efficiency gains because the marginal cost of emitting an unit of CO_2 is the same for all emitters (Tietenberg and Lewis, 1984) resulting in a cost-efficient reduction of total emissions.
[2] See Hasselknippe and Christiansen (2003), Speck (2008), Weisbach (2011) for a history of energy taxes in Europe.

as an instrument for emission control. In 1992, the EC presented the first proposal (European Commission, 1992) that reflected strong environmental concerns, recommending a tax on the use of energy products that explicitly referred to the CO_2 emissions content. However, this ambitious plan found the opposition of some countries and the text that was actually approved by the Council in the same year was much more modest (European Council, 1992); it was mainly focused on regulating the minimum harmonized taxation on mineral oils and natural gas by imposing relevant rates only for motor fuels. Since then, the EC has started a slow and difficult process aimed at enlarging the scope of this instrument to more energy products, strengthening its climate change policy, and harmonizing the legislation among the Member States of the EU. The unanimity rule for fiscal decisions in the EU was the main obstacle to approve the subsequent attempts of the EC in 1995 and 1997 (European Commission, 1995, 1997).

Anyway, this process led to the adoption of the current regulation approved in 2003. The current 2003 ETD constitutes an important improvement compared to the 1992 legislation: it widens the scope of the energy taxation to other energy products, and it increases the minimum rates that countries must take into account when enacting their national implementation.[3] Nonetheless, despite the important achievements reached with the 2003 ETD, its environmental targets are still limited. Indeed, considering the dependence and intensity in the use of energy products for some industries and the impact of taxation in terms of competitiveness, the 2003 ETD proposes a complex system of reductions and exemptions that has been denounced as a factor that might reduce the environmental effectiveness of this type of taxes (Ekins and Speck, 1999). Moreover, in the current directive there are other elements that could suggest the need for a legislative renewal: in particular, the absence of a signal that clearly reflects CO_2 emissions and the energy content of the products, the absence of incentives to develop markets for alternative energies, and the absence of coordination with the European ETS approved afterwards (European Commission, 2011).

All these difficulties of setting a carbon tax raised the need for alternative emission control tools. The process to create a European emission trading mechanism did not start before the late 1990s influenced by the international context. In 1997, despite the initial opposition of Europe, within the Kyoto protocol negotiations "flexible mechanisms" for emission control such as the emissions trading

[3] Moreover, the 2003 ETD distinguishes between motor fuels and other uses of energy products and between business and non-business activities.

between countries were introduced. In this context, in 1998 the EC proposed to create an internal ETS focused on individual companies (European Commission, 1998); the emission market, defined as one of the EU's flagship of the climate change project (Vlachou, 2014), was finally approved in 2003 (European Parliament and Council, 2003) and was launched in 2005.[4] Since the allowances were basically distributed for free considering historical emission grandfathering, the most part of them were given to large installations belonging to energy-intensive sectors. Practically, the main activities that enter the ETS mechanism are energy activities (such as combustion installations, mineral oil refineries and coke ovens), production and processing of ferrous metals (such us metal ore and production of pig iron), activities from mineral industry (such as installation for the production of cement, glass and ceramic product), and other industries as industrial plants for the production of pulp from timber and paper. Aviation was included in the ETS in 2012 but, due to international conflicts, initially it was only applied to internal flights in Europe.

A first learning phase of the European ETS (2005-2007) was followed by a second stage (2008-2012) that corresponded to the Kyoto protocol commitment period, and now the market is in its third phase (2013-2020). Although a major revision approved in 2009 tried to strengthen the system (European Parliament and Council, 2009), the mechanism is now under many criticisms (see Branger et al., 2013). One of the weakest points of this is the volatility of allowance price over time, which has been much lower than expected during the last years (see Figure 1). Without a credible and significant price signal both in the short and in the long term, it is not possible to create an incentive for firms to invest in low carbon technologies.

[FIGURE 1 HERE]

1.2. The 2011 ETD reform proposal

In 2011 the EC proposed a new version of the European ETD (European Commission, 2011). The main aim of the new proposal was to increase the effectiveness of this tool through the implementation of three main changes (see Tables 1 and 2). First, the proposal fixed higher minimum

[4] Meanwhile, in 2004 it was approved that enterprises of the EU could obtain carbon credits from investments in other countries in order to accomplish the limits established by the ETS allowances. The two mechanisms, implemented by the Kyoto protocol, were the so-called "clean development mechanism" (CDM) and the "joint implementation" (JI) (European Parliament and Council, 2004).

rates in an attempt to strengthen the incentive for energy efficiency and to cause a shift toward less polluting production and consumption patterns. Second, as in the 1992 proposal, existing energy taxes were split into two components that, taken together, would determine the overall rate at which a product is taxed. One component was based on the energy content, which was different depending on the use of energy products. The other component was specifically linked to CO_2 emissions.[5] The aim of this novelty was twofold. On the one hand, an explicit carbon tax component would be introduced in order to underline the climate change policy. On the other hand, it tried to establish a comprehensive and consistent signal of the CO_2 allowance price in order to complement the European ETS; indeed, the plants affected by the ETS would have only been affected by the energy component and not by the CO_2 component to avoid a double burden. Finally, the new text also tried to restructure and simplify reductions and exemptions, limiting them to the energy taxation based on the energy content and removing unjustified subsidies for certain fossil fuels, such as diesel and coal.

[TABLE 1 HERE]

[TABLE 2 HERE]

Nonetheless, in May 2012 the process of updating stopped; the EC's proposal was not supported by the European Parliament and the 2003 directive continues in force. The main worry seemed to be the effect of such proposal on competitiveness caused by the induced increase in prices. In particular, the concern was about sectors that would be mainly affected given the intensive use of energy products (Euractiv, 2012). Conversely, the advocates of the reform argued that the impact of the environmental tax reform, for example on diesel prices, has been overestimated since today tax rates are higher than the new minima proposed in the majority of the EU countries.[6]

[5] In practical terms, for energy products that are not used as motor fuels the energy component was very low in comparison with the CO_2 component.

[6] Astrud Lulling, the Parliament's report lecturer, referred to direct negative social impact from higher prices for coal, natural gas, heating oil and diesel oil. Three major European automobile manufacturer associations (ANFIA for Italy, CCFA for France and VDA for Germany) have issued a joint statement calling on the European Parliament and the Council to disassociate them from the proposed increase in taxation diesel. On the other hand, Algirdas Semeta, commissioner for taxation and customs, said that the impact on diesel prices has been overestimated. Moreover he stressed that diesel use is a major concern for the EC because of the European dependence from import, which causes prices variations stronger that the prices variation the reform would imply. See National Association of the Automotive Industry et al. (2011), Euractiv (2012), Greenreport (2012), Reuters (2013).

2. Material and methods

2.1. Method

Today's products and services are no longer produced within a single country; instead, they are made in global supply chains. A multicountry and multisectoral model is needed to take into account all these country-to-country interdependencies in the production processes.

We consider a world economy consisting of *c* countries. Each country is composed of *n* sectors, which produce one single product (x_i^r) that might be used (either at home or abroad) by other sectors as intermediate input $\left(x_{ij}^{rs}\right)$ or consumed or invested as final product by final user categories such as households and the government $\left(f_i^{rs}\right)$, although household consumption is the most important part of the final use. These monetary transactions are represented by $x_i^r = \sum_{j=1}^{n}\sum_{s=1}^{c} x_{ij}^{rs} + \sum_{s=1}^{c} f_i^{rs}$, where x_{ij}^{rs} indicates the monetary value of goods and services from industry *i* in country *r* that are used as intermediate input in industry *j* in country *s*, and f_i^{rs} indicates the deliveries in monetary units from industry *i* in country *r* to final users (mainly households) in country *s*. The technology of this world economy is be represented by $\mathbf{A}$, whose elements are $a_{ij}^{rs} = \frac{x_{ij}^{rs}}{x_j^s}$.[7]

Final users (mainly consumers) are at the end of the global supply chains and are the ultimate users of all production. Hence, if producers pass on their production costs to the buyers of their products, the final users (consumers) will bear the full burden. In that case, the accounting expression will be $x_j^s = \sum_{i=1}^{n}\sum_{r=1}^{c} x_{ij}^{rs} + v_j^s$, where now the monetary value of product *j* produced in country *s* is equal to total cost of its production, that is, the cost of intermediate inputs x_{ij}^{rs} plus the value added v_j^s.

An equivalent expression in matrix terms becomes $\mathbf{x}' = \mathbf{i}'\mathbf{X} + \mathbf{v}'$, being $\mathbf{i}$ a column vector of one's of appropriate dimension. Substituting $\mathbf{X} = \mathbf{A}\hat{\mathbf{x}}$ and post-multiplying by $\hat{\mathbf{x}}^{-1}$, the cost of inputs per

[7] Matrices are indicated by bold, upright capital letters; vectors by bold, upright lower case letters; and scalars by italicized lower case letters. Vectors are columns by definition, so that row vectors are obtained by transposition, indicated by a prime. A circumflex indicates a diagonal matrix with the elements of any vector on its diagonal and all other entries equal to zero.

unit of output is given by $\mathbf{p'x} = \mathbf{p'A} + \mathbf{w'}$, where $\mathbf{w}$ represents the value added per unit of output and $\mathbf{p}$ is the price vector in which each price is indexed and equal to 1. This expression leads to $\mathbf{p'} = \mathbf{w'}(\mathbf{I} - \mathbf{A})^{-1} = \mathbf{w'L}$, which indicates that changes in primary inputs prices lead to changes in sectoral unit cost and, therefore, to output prices. Whenever an additional cost per unit value of output $\mathbf{t}$ is added, the new price will be defined by $\tilde{\mathbf{p}}' = (\mathbf{w'} + \mathbf{t'})\mathbf{L}$. This model implies that any additional cost is totally passed on final prices and there is not substitution of any kind. Thus, we are calculating, in fact, the maximum effect on prices of such additional cost.

The main advantage of this model is that it permits to simulate the effects of a policy change, such as the implementation of a new energy tax or the increasing of energy tax rates, taking into account not only the effect on each sector due to its use of energy products at home, but also the indirect effect caused by the increase of the price of all the other inputs produced in different countries but used at home. Taking into account that our analysis is on a taxation change affecting at the same time several countries with important trade relationships, the convenience of a multicountry model is even clearer.

For the analysis of the impact on countries, we summarize all the potential price changes into a synthetic measure that will allow us to compare the total effects of the energy tax reform among different countries. Considering only the household consumption, the main component of final demand, we compare the cost of the basket of goods that characterizes households' consumption before the implementation of the new energy tax with the cost of the same basket after the reform. However, the EU energy tax reform not only affects the use of energy products by sectors, but it also applies to energy products consumed directly by households. This price index is defined by *W* as:

$$W = \frac{\sum_{i=1}^{n} \tilde{p}_i q_i + \sum_{e=1}^{m} t_e q_e}{\sum_{i=1}^{n} p_i q_i} \qquad [1]$$

Being q_i the monetary value of goods and services *i* consumed by households, p_i the initial price of the commodity *i*, $\tilde{p}_i$ the new price after the proposal implementation, t_e the tax variation of each energy product *e* applied to households' consumption, and q_e the monetary value of each energy product consumed by households.

It should also be stressed that the potential negative economic effects might be even lower than this index *W* suggests. First, because the model assumes that there is not technical change. Second, the Laspeyres-type price index computed does not consider that consumers could react to the price variation changing the relative consumption of different goods and services (which is, in fact, the main environmental objective of carbon taxation!). Finally, this analysis does not take into account that the new energy tax revenues could be used to decrease other taxes or to increase public expenses or to reduce public debt, generating in this way a positive effect not considered here.

A final remark about the computation of the new cost $\mathbf{t}$ is needed. Since our analysis considers the increased taxation as an additional production cost, it is necessary to work out what is the additional tax per unit of product that each sector would have faced if the reform proposal was implemented. Indeed, it is necessary to know, for every sector, the consumption of the different energy products per unit of output and the additional taxation on every energy product. So, vector $\mathbf{t}$ has been computed as $\mathbf{t} = (\mathbf{D} \circ \mathbf{R})\mathbf{i}$, where $\mathbf{D}$ is the matrix of energy use coefficients, $\mathbf{R}$ is the matrix of tax rates variations, and $\circ$ is the element-wise product of matrices $\mathbf{D}$ and $\mathbf{R}$. In particular, $\mathbf{D}$ is obtained considering the energy flows from energy-producing sectors to all sectors (matrix $\mathbf{E}$) and the output produced by each sector $\mathbf{D} = \mathbf{E}\hat{\mathbf{x}}^{-1}$.

2.2. Database and database transformation

Three main information sources have been used for this analysis: economic information about the intersectoral transactions inside each country and between countries, information about the energy use by sectors and by households, and information on current and new tax rates proposed by the European 2011 ETD reform.

Regarding the economic information, we use the multiregional input-output tables from the World Input-Output Database (WIOD) (Timmer, 2012; WIOD, 2012a). This database offers time series from 1995-2011 about intersectoral transactions of 35 sectors and 59 products; its geographic area refers to 41 countries: 27 EU counties, 13 other major countries in the world, and all the remaining countries aggregated in a single "rest of the world" region.[8] In particular, we use the world input-output table at current prices and international supply and use tables for the year 2008.

For energy use, we use information from the environmental accounts of the WIOD for the year 2008 (WIOD, 2012b), in particular, the "Emission relevant energy use" tables. These data, which include energy flows in physical terms (terajoules, TJ) related to 26 energy products,[9] are derived from the gross energy use but excluding the non-energy use and the inputs for transformation into energy products.[10] The economic and energy information refers to 2008 due to data availability.

As regards energy taxation, it is necessary to know the current regime applied in the EU countries, and what changes the implementation of the EC proposal in 2011 would cause. Regarding the current environmental taxation regime, two sources of information are used: the "Taxes in Europe" database from the EC (European Commission, 2014), and the updating to 2013 of the tax regimes implemented in the EU countries for the main energy products (European Commission, 2013). Regarding the new regime, the European Commission (2011) document describes the 2011 EC's proposal.

Given the use of different sources and given the number of energy products, sectors, and countries considered, it is necessary to carry out some data transformations in order to have a coherent database.

Firstly, concerning the classification of energy products two main differences exist between the energy products taxed through the European ETD and those energy products available in the environmental accounts of the WIOD. On the one hand, the ETD regime distinguishes between products used as motor fuel and products used for heating,[11] but this distinction does not exist in WIOD database. On the other hand, there is no a strict correspondence between the energy product classifications in the WIOD and in the ETD. For all these reasons, when necessary, data were integrated and transformed using additional information from the International Energy Agency -one of

[8] Croatia, member of EU from 2013, is not included in the analysis since WIOD covers the EU27. The 13 other countries are: Australia, Brazil, Canada, China, Indonesia, India, Japan, Korea, Mexico, Russia, Turkey, Taiwan, and Unites States.

[9] The 26 energy products are further classified into six groups as following: coal (hard coal and derivatives, lignite and derivatives, coke); crude and feedstock (crude oil and feedstock); petroleum products (diesel oil for road transport, motor gasoline, jet fuel, light fuel oil, heavy fuel oil, naphtha, other petroleum products); gases (natural gas, derived gas); renewable and wastes (industrial and municipal waste, bio-gasoline including hydrated ethanol, bio-diesel, bio-gas, other combustible renewable); electricity and heat (electricity, heat, nuclear, hydroelectric, geothermal, solar, wind power, other sources).

[10] As defined in Genty et al. (2012), the non-energy use is the use of energy products as chemical feedstock (e.g. naphtha for plastic production), asphalt, lubricants, and solvents.

[11] The same tax rates are applied to heating use and to industrial use of energy products. For simplicity in the text we refer to heating use, although data refer to both categories.

the primary source used to compile the environmental accounts of the WIOD-, and from the database Odyssee (Odyssee-Mure, 2014). After all these transformations, nine uses of energy products are finally analyzed: gasoline (motor fuel), diesel (motor fuel), LFO, LPG (motor fuel), LPG (heating), natural gas (heating), HFO (heating), coal and coke (heating), and electricity. A detailed description of these transformations is shown in Appendix A (Tables A.1, A. 2 and A.3)).

Secondly, as regards tax variation, the matrix **R** containing the variation in rates is filled in, considering in column the nine energy products analyzed, and in row 35 sectors for the 41 countries. The rate variation is assumed to be zero for all the non-EU, as well as, for those sectors in the EU countries that have a current rate higher than the new minimum proposed by the 2011 ETD reform.[12] Moreover, as it is summarized in Appendix B (Tables B.1 and B.2), some sectors are treated in specific way in the new proposal. In particular we highlight three cases. For instance, to "Electricity, gas and water supply" and "Air transport", sectors already belonging to ETS and hence exempted from the tax component related to CO_2 emissions, it is also applied an exemption for the energy content component, so that the tax variation is equal to zero.[13] Another example is "Agriculture", whose increase in taxation is especially greater because the reform tries to reduce favored treatments of the past (i.e. the elimination of previous exemptions for the energy tax component related to emissions). Finally, the reform also eliminates the favored treatment for the commercial use of diesel: its enforcement would therefore cause a greater tax variation for the sector "Inland transport".[14]

3. Results

A simply descriptive analysis of the current level of taxation, the new tax rates proposed by the reform and the intensity of energy consumption in each country could shed some light on impact that the 2011 ETD reform would have had on costs and prices of the EU27 countries. However, such a

[12] This seems to be a realistic assumption: if a country is already charging rates higher than the current minima proposed, there would be no reason for the proposal to cause an increase or a decrease in present rates. Anyway, this assumption could be changed in order to see what happens if other assumptions were implemented, for instance, that countries decided to lower the fiscal pressure at the minimum level required by the directive.

[13] Electricity is exempted because the most of products used by this sector are transformed in electricity. Air and water transport are exempted because they are regulated by international agreements.

[14] The commercial use of energy products is defined by the current directive as the use for "the carriage of goods and the carriage of passengers" (European Council, 2003). In particular, countries that are currently applying this reduction are Belgium Hungary, Italy, Spain, and Slovenia.

partial analysis will not give a full insight into the effects on prices as it will not be taking into account the existing interactions between different sectors from different countries, which are crucial nowadays.

Table 3 shows the total effect (direct and indirect) on sectoral prices that the minimal rates proposed by the 2011 ETD reform would have had in the countries of the EU27. According to our estimation, the most remarkable aspect is that only the 5% of sectors (47 out of 945) would present a price increase higher than 0.50%. Obviously, in some cases small changes in prices could potentially cause important shifts in the origin and destination of traded goods and services. Then, to establish a threshold to determine if a price increase is weak (or not) is not evident at all and it might have a strong conventional component. Following Mongelli et al. (2010) we take 0.50% as a threshold and, for ease of reading, in Table 3 we mark cells with a higher value in grey. Moreover, following the proposal of Nguyen (2008) who compares his results with the inflation level of Vietnam, we also consider the threshold of 2% in the analysis of our results since the European Central Bank defined the price stability target for the EU as a variation of a year-on-year increase in the Harmonized Index of Consumer Prices (HICP) below this 2%.[15]

Despite the country analyzed, 18 sectors would have a price variation lower than 0.50% due to the exceptions of the ETD reform, because they are already included in the ETS, or because their use of energy products is very low. These 18 sectors are: "Pulp and paper" (7)[16], "Coke and refined petroleum" (8), "Other non-metallic minerals" (11), "Basic metals" (12), "Machinery" (13), "Electrical and optical equipment" (14), "Transport equipment" (15), "Electricity, gas and water supply" (17), "Construction" (18), "Retail trade" (21), "Hotels and restaurants" (22), "Water transport" (24), "Air transport" (25), "Financial intermediation" (28), "Real estate" (29), "Renting and other business activities" (30), "Public administration and defense" (31), and "Private household with employed persons" (35). Sectors more affected by the reform across most EU Members States would be "Mining and quarrying" (2), "Chemicals and chemical products" (9), and "Inland transport" (23). But even for these sectors the total impact on prices would be higher than 2% in only three countries: "Inland Transport" (23) in Bulgaria (3.36%), "Mining and quarrying" (2) in Czech Republic (2.62%), and "Chemicals and chemical products" (9) in Romania (2.19%).

[15] See https://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.en.html

[16] The number in parenthesis after a sector's name refers to sectors' number in Table 3.

[TABLE 3 HERE]

A detailed analysis by country, sector and energy product[17] reveals that there are two energy products -gasoline and electricity- for which countries are already applying tax rates that are generally higher than the minimum rates proposed by the reform and, in consequence, the reform would not actually cause an increase on prices.

As regards LPG, LFO and HFO, the analysis reveals that the quantity embodied in the production of goods is not relevant enough to affect prices significantly. Regarding LPG, the two countries that use it most intensively are France and United Kingdom: in France, the 36% of the industrial use of LPG corresponds to “Chemicals” (9), while in United Kingdom the main users of LPG are “Food” (3) (11%), “Chemicals” (9) (19%), and “Construction” (18) (20%). Anyway the price variation of these sectors never exceeds the 0.50%. As regards LFO, generally the main user is the sector of “Agriculture” (1); in this case the total price variation is greater than the 0.50% in five countries: United Kingdom (0.96%), Luxemburg (0.73%), Belgium (0.68%), Latvia (0.61%), and Poland (0.54%). Finally, as regards HFO, this energy product is basically used by the sector “Water transport” (24), which is regulated through international agreements and hence exempted by the ETD (and it would remain exempted also if the reform were applied). Spain is the country that uses more intensively HFO, the 34% of the industrial use of this energy product is consumed by “Electricity” (17), another of the sectors totally exempted by the ETD, which explains the non-existent increase on prices in this country.

The energy products that could cause higher impacts on prices in some countries are coal and coke, natural gas, and diesel. In particular, for coal and coke, the sectors mainly affected would be “Mining and quarrying” (2), and “Chemicals” (9). The main change that would influence “Mining and quarrying” (2) is the increased tax rate on coal and coke (in particular for Belgium, Bulgaria, Czech Republic, Germany, Estonia, United Kingdom, Poland, Romania, and Slovakia); anyway the price growth never exceeds the 2%, with the exception of “Mining and quarrying” (2) in Czech Republic. Although Poland, Germany, and France use coal and coke intensively and we would expect a higher price impact, the main sectors involved in these countries are partially or totally exempted for their

[17] Detailed results are available under request.

inclusion in the ETS; these sectors are “Other non-metallic mineral” (11), “Basic metals and fabricated metals” (12), and “Electricity” (17). For natural gas, the main sector affected would be “Chemicals” (9) in Bulgaria and Romania, but also in this case the price increase is lower than 2%. For United Kingdom and Spain -the countries that most intensively use natural gas-, the price increase for “Chemicals” (9) would be 0.33% and 0.59%, respectively. Finally, the increase in diesel taxation would basically regard “Inland transport” (23), in this case the price increase would be greater than 0.50% in 12 countries (Belgium, Bulgaria, Greece, Hungary, Lithuania, Luxemburg, Latvia, Poland, Portugal, Romania, Slovak Republic, and Slovenia) but only in the case of Bulgaria this increase would exceed the 2%.

All the previous results show that the ETD reform, if implemented, would have had different effects depending on sectors and countries. Even though many interest groups or lobbies might intervene in any political proposal, the ultimate agents that should approve (or not) the proposal are the political representatives of each country. The ETD reform should be approved by unanimity (see section 1.1) and thus, a global indicator of the effects on each country would be particularly relevant from the political point of view.

Taking into account the importance of countries in the decision of political processes, we now focus our analysis on the potential impact on prices for each country. A Laspeyres-type price index, as the computed by expression [1], summarizes all the price changes by country in an indicator of potential and maximum impact on consumers taking into account not only the effects on sectors but also the direct effect of taxation on energy products directly consumed by households. The second column of Table 4 shows the results for all the EU27 countries placing on the top of the table the countries less affected.

[TABLE 4 HERE]

As Table 4 shows, our model estimates that the average effect on consumer prices for the EU27 countries would be 0.22%, which represents approximately one tenth of the price stability target for the EU27. For 24 countries the price index variation is lower than 0.50%. However, it is important to emphasize the great differences between countries, whose price index variations range from 0.02% to 0.71%; the coefficient of variation of the price index of the EU27 is equal to 0.89. The countries less affected would be Finland, Denmark, Sweden, Netherland, and Austria; mainly because they already apply rates that are generally higher than the minimum rates proposed by the 2011 ETD reform. In contrast the countries most affected would be Poland and Bulgaria, characterized by lower energy tax rates and by using more intensively the energy products more taxed, especially coal. Thus, even though the economic effects are moderate in any country, it is worth noting a difference between the negligible effects in some EU countries (mainly Nordic countries) and the more important effect for Eastern Europe countries.

Besides the price index variation, a proper way to quantify whether these changes in the consumer price indexes could be considered relevant or not is to compare the price index variation in relative terms with respect to the 2011 HICP for each country. This information is included in columns third and fourth of Table 4. Our results show that the increase in consumer prices would be a maximum of one fifth of the HICP in the case of Bulgaria; in other six countries (Czech Republic, Latvia, Hungary, Lithuania, Luxemburg, and Poland) it would exceed one tenth of the respective HICP.

All in all, the differences between countries are important to explain the conflicts that the different proposals on EU energy/carbon taxation have provoked since the early 1990s. The most ambitious initiatives -as the one in 1992- failed due to the opposition of some governments. Nowadays, the difficulties to advance in environmental taxation are even higher in the EU28 and, probably, a compensation mechanism for countries more affected should be considered.

4. Discussion

There are two main characteristics of the ETD reform that, taken together, basically drive the results of our analysis: the way in which the rates are calculated as a sum of two different components, and the specific treatment for sectors belonging to the ETS.

As previously described, the ETD reform established minimum energy tax rates resulting from two different components. One component was linked to carbon emission content and it did not depend on the different purposes the energy products are used for (20 €/CO_2 ton). The second component was linked to the energy content, and it was much lower for energy products used as heating or for industrial uses (0.15 €/GJ), higher for energy products used as motor fuels (9.6 €/GJ).

As regards sectors already belonging to the ETS, the plants participating to the emission market would only be affected by the (very low) energy component and not by the CO_2 component to avoid "double burden". In this way the reform tried to create a consistent system of emission control, considering both instruments in force, the energy tax and the ETS mechanism, and introducing a similar incentive to non-ETS and ETS sectors: all the sectors would pay the energy component, the non-ETS sectors would also pay the carbon component while the ETS sectors would take the allowances price into account when deciding to emit more or less CO_2.

Given the already high energy tax rates implemented in several EU countries –and on motor fuels in all the countries-, and given the exemption of the ETS sectors to the tax related to CO_2 emissions, the main finding of our analysis is that the new energy tax regime would have a really low impact on prices, and this impact would regard few sectors in few countries. Although the proposal might not have a strong capability to change the production structure in order to reduce environmental pressures, it was an important step to introduce a taxation explicitly linked to CO_2 emission, so explicitly shaped by environmental concerns.

Anyway, the reform was rejected. Considering our analysis, the reasons of this rejection are not so clear. However, it is important to bear in mind at least three possible reasons that our analysis is not taking into account. The first one has institutional nature: in the EU all the decisions on taxation requires the unanimity and this is very difficult to achieve. The second one is that the effects of a change in energy taxation affects very differently –even though in any case moderately- different sectors and countries. Last but not least, we should not underestimate the influence of some particular economic interests in political decisions -for instance the interests connected with coal sector or the industry of gasoline and diesel- even though they might have low weight in terms of total GDP or labor force.

Moreover, considering that the reform tried to coordinate energy tax and ETS, the discussion could go even farther. It would be interesting to know whether it would be appropriate to exclude from the ETD reform the ETS sectors, given the poor results shown by the ETS mechanism so far, as can be seen in Figure 1. Indeed, to establish a similar incentive for firms affected by the ETS and for firms affected by the energy tax, it would require to forecast with certain accuracy the CO_2 emission price established through the market, while, as we have seen, the EU CO_2 market has been characterized by a great instability and very low prices, much lower than the reference value considered by the 2011 reform (20€/TnCO_2).[18] There are different policy options to reach a consistent price signal and to create a significant incentive to emission reduction, although all of them are politically very difficult to be adopted. A possibility already analyzed in literature (Branger et al. 2013, Wood and Jotzo 2011) would be to establish some mechanism of price floor. Interestingly, Wood and Jotzo (2011) specifically propose an extra-fee (or tax) on carbon emitted, which suggests that the two instruments (emission mechanism and tax) do not necessarily exclude each other.

In a way, considering the failure of ETS, it is questionable if the carbon taxation on ETS sectors should be considered as a substitute or a complement of the allowances market. For this reason, we simulate a different scenario to see what would happen if the 2011 ETD reform proposal did not exempt the ETS sectors from the 20€/Tn CO_2 tax component. This is an extreme framework that can be justified only if we suppose that the ETS market is suppressed, or it collapses to insignificant prices, or alternatively if the political target is assumed to be 20€/Tn CO_2 as a floor price (to add to the uncertain allowance price). The potential impact on prices reveals the importance of maintaining a relevant carbon price incentive for the ETS sectors and it can serve as a point of reference for evaluating more moderate proposals.[19]

As expected, this second simulation leads to strongly different results.[20] The main change would affect the electricity sector. In particular, for some eastern countries such as Estonia, Bulgaria, Poland, and Czech Republic, the imposition of the new taxation to the ETS sectors would imply an increase in the price of electricity equal to 24.30%, 21.06%, 11.78% and 8.36% respectively. This is because

[18] According to a 2012 EU Report (European Commission, 2012) several factors –mainly the economic downturn and the acquisition of cheap credits in carbon markets linked to CDM and JI Kyoto mechanisms– caused a great surplus of allowances and a dramatic reduction of prices. The situation did not change in 2013 when the price was typically around 4€/TnCO2 or even lower; in the first months of 2014 the prices has been situated between 4.5 and 7€/TnCO2. The 2012 EU Report considered the supply-demand imbalance as a structural problem and several meetings are currently debating different ways to avoid the price collapse and the ETS failure.

[19] As in the previous analysis, the model not only assumes that taxes are completely translated into prices but it also assumes that there are not technical changes neither. This last assumption is particularly unrealistic when –as it is now the case– the relative prices changes considerably. Regarding the electricity sector, it is considered as any other ETS sector affected by the new minima taxes: although the most part of countries are now applying specific taxes on electricity and they could react to the new minima reducing these taxes, we have not taken this possible reaction into account.

[20] Detailed results are available under request.

these countries are highly dependent on coal and coke for electricity production. The most interesting result is that in comparison with the first scenario, in this second scenario the effect would not be limited to few sectors, but spread in several sectors of the economy. While the reform proposed in 2011 would cause a price increase greater than 0.50% for only the 5% of the total of sectors/countries considered, a tax also imposed to the ETS sectors would significantly affect roughly the 16% of the total sectors/countries considered.

Table 5 shows results by country. The second column of Table 5 displays the price index variation for the EU27 countries including the ETS sectors sorted in increasing order. When considering the ETS sectors, the price increase would rise, on average, from 0.22% (Table 4) to 0.65%. The countries less affected would be more or less the same but including France, probably due to the relative weight of nuclear power;[21] and the most affected would also be Poland and Bulgaria. In this case the price index variation would be greater than 0.50% for 15 EU countries. The great differences between countries still persist (values ranges from 0.12% to 1.91%) although, they are lower than before (the coefficient of variation of the price index for the EU27 countries is now 0.69). The third and fourth columns of Table 5 show the 2011 HICP and its relation with the price index variation for each country. In this case, the values are higher than in Table 4: only in three countries the increase in consumer prices would be lower than one tenth (Sweden, Austria, and France). In any case, however, the price increase would exceed the annual inflation.

[TABLE 5 HERE]

The results of this second simulation are not realistic: they merely represent a hypothetical scenario. In this case, it should be considered how the demand for final goods and intermediate goods would react given the increase in prices that this scenario would lead. In any case, it seems interesting to include these results in the discussion to reinvigorate the debate on the potential of an energy tax, which seems to be effective as a political tool of emission control, and an alternative to the emission trading mechanism. Taking into account that the effects would have been much more important in all the countries, this result not only shows the complexity of introducing a general carbon tax, it also

[21] Taking into account the environmental risks of nuclear power, it could be argued that a European reform of energy tax should also introduce a specific tax on nuclear electricity. In fact the 1992 and 1995 European proposal for a CO_2 tax reform also introduced taxation for nuclear power (even though less than the fossil fuel taxation). Moreover, Padilla and Roca (2004) proposed that a new European CO_2 tax should be complemented by a high taxation for nuclear power.

shows how difficult it is to adopt effective measures of emission reduction and effective tools to foster a proper performance of the emission market.

5. Conclusions and policy implications

The analysis we have proposed is focused on the European ETD, an environmental taxation applied to energy products used by industrial sectors and by households. More specifically, in 2011 the EC proposed a renewal of the existing ETD, but in 2012 the proposal did not find the approval of the Parliament and the taxation in force is still the previous directive approved in 2003. The Parliament's main concerns regarded the possible effect of the proposal on prices and the negative impact on competitiveness.

Given this framework, the aim of this analysis was to estimate what potential economic effect the reform could have had on prices in the EU27 countries if implemented. We carried out a multiregional and multisectoral analysis and we used one of the latest available world input-output table: the one provided by the WIOD that offers information about the economic flows of 41 countries and 35 sectors.

The main finding of our first simulation was that the new energy tax regime would not have had a strong and wide impact on prices: the tax increase would have caused a price variation greater than 0.50% only for few sectors in few countries; expressing the price changes through a consumer price index, the effect of the reform would have been even weaker. Due to the characteristics of the model and the price index used these results are, indeed, the maximum effect on prices since there is not any substitution of any kind. Besides, these results were basically driven by the fact that the reform would have tried to coordinate energy taxation with ETS keeping sectors already belonging to the ETS exempted from the main component of taxation. Indeed, applying the reform also to ETS sectors, as in our second simulation, the results were strongly different showing a more relevant and wider impact on prices.

The results of this paper entail three main policy implications. The first one is that the concerns about an important impact of the 2011 ETD reform on competitiveness and prices do not find empirical support in our results. The rejection of the reform may have been driven by other factors, such as the fear of feeding the long and deep economic crisis, or the belief of some countries that taxation matters should remain an exclusive competence of each State Member. Moreover, the shortage of studies on economic impact of the 2011 ETD reform might have led to unreasonably exaggerate this impact. This work aims at reducing this lack by using a world database, which is essential to take into account inter and intra-sectoral interdependences in the global supply chain.

Second, our outcomes also show that the impacts would have been different for different sectors and different countries. Thus, even when the aggregated economic impact was very weak, particular interests could have been significantly affected and they could have had important political influence. For some of the reform opponents, for instance, the attempt proposed by the 2011 ETD reform to balance the tax treatment of different energy products such as gasoline and diesel would have gone against previous policies aimed at fostering the research and use of diesel engines. While it is clearly necessary to take into account sectors or countries likely to be particularly affected by the reform and it might also be desirable to provide some compensation mechanism for them, it is equally true that development policies should not go against other European targets such as emission control.

The third issue is the relationship between the two main instruments for emission control put in place by the EU: energy taxation and ETS. Although avoiding a double burden is aimed at reducing distortions in the choices of economic agents, it is questionable whether the carbon taxation on ETS sectors should be considered as a substitute or a complement of the allowances market given the weaknesses of ETS's incentives nowadays. If we consider that the (potential) economic impact on prices is an indicator of the (potential) environmental impact, our results suggest the relevance of maintaining significant economic incentives to reduce carbon emissions, introducing in the ETS mechanisms to keep emission market price higher or applying carbon taxation also to these sectors.

The ETS has been defined as one of the EU's flagship climate change project; to strengthen this instrument a future increase in the proportion of allowances auctioned is planned. However, the ETS has not been able to work properly due to the low prices of allowances. Perhaps it would be useful to consider alternatives, such as introducing a general European CO_2 tax –in the line proposed in the 1990s- or introducing other effective mechanisms to keep allowances prices higher. In the light of our analysis, the failure of the 2011 ETD reform does not seem in line with the role that the EU has set for itself with respect to climate change and emission control.

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Appendices

Appendix A. Energy data transformations

[TABLE A.1. HERE]

[TABLE A.2. HERE]

[TABLE A.3. HERE]

Appendix B. Tax variation matrix compiling

[TABLE B.1. HERE]

[TABLE B.2. HERE]

Table(s)

Table 1. The 2003 ETD and the 2011 ETD reform proposal

<table>
<tr><th colspan="2">ETD (2003)</th></tr>
<tr><td>Energy products</td><td>Petrol, gas oil, kerosene, liquefied petroleum gas, natural gas, heavy fuel oil, coal and coke, electricity.</td></tr>
<tr><td>Scope</td><td>The directive fixes minima for mineral oils as well as for coal, gas, and electricity. These products are taxed only if burnt, and are levied with different rates depending on their uses (motor fuels, heating, industrial use). They are not under the directive scope when they are used as raw materials, in chemical reductions or in electrolytic or metallurgical processes.</td></tr>
<tr><th colspan="2">ETD (2003) and ETD reform proposal (2011): main changes</th></tr>
<tr><th>2003</th><th>2011</th></tr>
<tr><td>The taxable base for mineral oils is the volume while for coal, gas and electricity is the energy content</td><td>The tax rate is calculated according to CO_2 emissions content (20€/ton) and energy content (9.6€/GJ if products are used as fuels, 0.15€/GJ if products are used for heating).</td></tr>
<tr><td>Minimum rate are fixed (see Table 2).</td><td>Higher minimum rate are proposed (see Table 2).</td></tr>
<tr><td>Member States are allowed to differentiate between commercial and non-commercial diesel and provide for a lower rate on commercial diesel.</td><td rowspan="3">It is not allowed any exemption or reduction below the minima related to the CO_2 emissions content.</td></tr>
<tr><td>Member States can reduce tax rates if businesses are energy intensive.</td></tr>
<tr><td>Member States can reduce tax rates up to exemption for the agricultural sector.</td></tr>
</table>

Source: own elaboration.

Table 2. Comparison between the current minima rates established by the 2003 ETD and the minima rates proposed by the 2011 ETD reform proposal

	Current minima	Minima proposed in ETD reform		
		Energy content	**CO_2 emissions**	**Total**
Motor fuels		**(9.6 €/GJ)**	**(20 €/ton)**	
Petrol (€ per 1000 l)	359	314	46	360
Gas oil (€ per 1000 l)	330	337.9	52.1	390
Kerosene (€ per 1000 l)	330	340.6	50.9	392
LPG (€ per 1000 kg)	125	442	58	500
Natural gas (€ per GJ)	2.6	9.6	1.1	10.7
Heating fuels and motor fuels for industrial use		**(0.15 €/GJ)**	**(20 €/ton)**	**Total**
Gas oil (€ per 1000 l)	21	5.28	52.1	57.37
Heavy fuel oil (€ per 1000 kg)	15	6	61.84	67.84
Kerosene (€ per 1000 l)	0	5.32	51	56.3
LPG (€ per 1000 kg)	0	6.9	58	64.86
Natural gas (€ per GJ)	0.15	0.15	1.12	1.27
Coal and coke (€ per GJ)	0.15	0.15	1.89	2.04
Electricity				
Electricity (€ per MWh)	0.5	0.54	--	0.54

Source: European Commission (2011).

Table 3. Total effect on prices of the minima rates proposed by the 2011 ETD reform (percentages variations)

	Sector	AUT	BEL	BGR	CYP	CZE	DEU	DNK	ESP	EST	FIN	FRA
1	Agriculture, Hunting, Forestry and Fishing	0.02	0.68	0.45	0.33	0.11	0.03	0.03	0.34	0.06	0.03	0.08
2	Mining and Quarrying	0.03	0.66	0.53	0.08	2.62	1.70	0.01	0.41	0.73	0.02	0.48
3	Food, Beverages and Tobacco	0.03	0.24	0.69	0.10	0.21	0.06	0.03	0.34	0.13	0.02	0.14
4	Textiles and Textile Products	0.04	0.21	0.68	0.06	0.20	0.05	0.03	0.30	0.08	0.02	0.09
5	Leather, Leather and Footwear	0.03	0.14	0.79	0.07	0.07	0.03	0.02	0.26	0.21	0.01	0.07
6	Wood and Products of Wood and Cork	0.03	0.21	0.64	0.05	0.12	0.05	0.02	0.23	0.07	0.02	0.07
7	Pulp, Paper, Printing and Publishing	0.03	0.09	0.36	0.02	0.06	0.02	0.01	0.13	0.03	0.02	0.03
8	Coke, Refined Petroleum and Nuclear Fuel	0.09	0.07	0.09	0.00	0.08	0.07	0.02	0.03	0.08	0.02	0.04
9	Chemicals and Chemical Products	0.05	0.40	1.53	0.08	0.99	0.09	0.02	0.59	0.32	0.03	0.24
10	Rubber and Plastics	0.05	0.27	0.54	0.08	0.14	0.04	0.03	0.47	0.05	0.02	0.11
11	Other Non-Metallic Mineral	0.04	0.11	0.34	0.03	0.16	0.08	0.02	0.16	0.08	0.02	0.05
12	Basic Metals and Fabricated Metal	0.03	0.08	0.31	0.03	0.11	0.03	0.02	0.11	0.03	0.02	0.03
13	Machinery, Nec	0.03	0.07	0.40	0.07	0.11	0.02	0.02	0.14	0.07	0.01	0.04
14	Electrical and Optical Equipment	0.02	0.11	0.32	0.06	0.05	0.02	0.02	0.15	0.03	0.01	0.04
15	Transport Equipment	0.03	0.11	0.28	0.08	0.10	0.03	0.02	0.15	0.04	0.01	0.05
16	Manufacturing, Nec; Recycling	0.03	0.23	0.52	0.05	0.08	0.03	0.02	0.19	0.08	0.01	0.08
17	Electricity, Gas and Water Supply	0.03	0.04	0.20	0.00	0.21	0.04	0.02	0.04	0.10	0.01	0.02
18	Construction	0.03	0.08	0.37	0.05	0.11	0.03	0.02	0.09	0.06	0.01	0.03
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	0.02	0.16	0.53	0.03	0.08	0.03	0.01	0.12	0.02	0.01	0.03
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	0.02	0.14	0.63	0.06	0.08	0.01	0.01	0.16	0.03	0.01	0.03
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	0.01	0.10	0.46	0.05	0.09	0.02	0.01	0.13	0.02	0.00	0.03
22	Hotels and Restaurants	0.01	0.14	0.49	0.09	0.11	0.03	0.01	0.11	0.04	0.01	0.06
23	Inland Transport	0.04	1.24	3.36	0.03	0.07	0.02	0.02	1.13	0.02	0.01	0.02
24	Water Transport	0.02	0.11	0.25	0.07	0.06	0.02	0.04	0.13	0.03	0.01	0.02
25	Air Transport	0.03	0.09	0.24	0.06	0.05	0.03	0.03	0.09	0.04	0.01	0.02
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	0.02	0.18	1.01	0.06	0.06	0.02	0.01	0.37	0.05	0.01	0.03
27	Post and Telecommunications	0.01	0.08	0.53	0.08	0.05	0.01	0.01	0.09	0.01	0.01	0.04
28	Financial Intermediation	0.01	0.05	0.16	0.02	0.05	0.01	0.00	0.04	0.01	0.00	0.02
29	Real Estate Activities	0.01	0.03	0.19	0.01	0.12	0.00	0.00	0.03	0.03	0.00	0.01
30	Renting of M&Eq and Other Business Activities	0.01	0.09	0.20	0.03	0.06	0.01	0.01	0.08	0.02	0.01	0.02
31	Public Admin and Defense; Compulsory Social Security	0.01	0.07	0.38	0.04	0.09	0.01	0.01	0.10	0.03	0.01	0.10
32	Education	0.01	0.05	0.50	0.01	0.15	0.01	0.00	0.07	0.02	0.00	0.04
33	Health and Social Work	0.02	0.07	0.53	0.06	0.12	0.02	0.01	0.09	0.02	0.01	0.03
34	Other Community, Social and Personal Services	0.01	0.12	0.50	0.05	0.13	0.01	0.01	0.12	0.02	0.01	0.05
35	Private Households with Employed Persons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: own elaboration.

Note: For ease of reading, cells in grey mean sectors with a price variation higher than 0.50%.

EU27 countries: AUT: Austria; BEL: Belgium; BGR: Bulgaria; CYP: Cyprus; CZE: Czech Republic; DEU: Germany; DNK: Denmark; ESP: Spain; EST: Estonia; FIN: Finland; FRA: France; GBR: United Kingdom; GRC: Greece; HUN: Hungary; IRL: Ireland; ITA: Italy; LTU: Lithuania; LUX: Luxemburg; LVA: Latvia; MLT: Malta; NLD: Netherland; POL: Poland; PRT: Portugal; ROM: Romania; SVK: Slovak Republic; SVN: Slovenia; SWE: Sweden.

Table 3. (continuation) Total effect on prices of the minima rates proposed by the 2011 ETD reform (percentages variations)

	Sector	GBR	GRC	HUN	IRL	ITA	LTU	LUX	LVA	MLT	NLD	POL
1	Agriculture, Hunting, Forestry and Fishing	0.96	0.04	0.16	0.12	0.32	0.34	0.73	0.61	0.04	0.34	0.54
2	Mining and Quarrying	0.66	0.07	0.13	0.09	0.23	0.17	0.30	0.39	0.03	0.01	0.80
3	Food, Beverages and Tobacco	0.32	0.07	0.25	0.06	0.13	0.33	0.33	0.35	0.04	0.06	0.43
4	Textiles and Textile Products	0.30	0.08	0.11	0.04	0.08	0.28	0.34	0.28	0.04	0.03	0.20
5	Leather, Leather and Footwear	0.15	0.08	0.11	0.02	0.05	0.40	0.00	0.21	0.04	0.02	0.24
6	Wood and Products of Wood and Cork	0.15	0.09	0.15	0.05	0.04	0.44	0.13	0.30	0.04	0.02	0.42
7	Pulp, Paper, Printing and Publishing	0.06	0.04	0.06	0.02	0.03	0.11	0.09	0.07	0.03	0.02	0.14
8	Coke, Refined Petroleum and Nuclear Fuel	0.25	0.01	0.08	0.07	0.02	0.09	0.00	0.08	0.08	0.06	0.19
9	Chemicals and Chemical Products	0.33	0.16	0.24	0.03	0.14	0.20	0.35	0.30	0.07	0.05	0.74
10	Rubber and Plastics	0.15	0.08	0.14	0.04	0.06	0.10	0.25	0.14	0.05	0.05	0.24
11	Other Non-Metallic Mineral	0.03	0.04	0.09	0.04	0.04	0.06	0.11	0.10	0.03	0.04	0.14
12	Basic Metals and Fabricated Metal	0.07	0.04	0.06	0.04	0.03	0.08	0.08	0.06	0.02	0.02	0.14
13	Machinery, Nec	0.10	0.05	0.09	0.03	0.06	0.18	0.21	0.11	0.03	0.02	0.15
14	Electrical and Optical Equipment	0.06	0.06	0.05	0.02	0.06	0.15	0.21	0.12	0.03	0.02	0.14
15	Transport Equipment	0.10	0.05	0.07	0.02	0.04	0.15	0.17	0.15	0.02	0.03	0.15
16	Manufacturing, Nec; Recycling	0.10	0.09	0.10	0.09	0.04	0.19	0.55	0.19	0.03	0.02	0.21
17	Electricity, Gas and Water Supply	0.11	0.02	0.05	0.03	0.02	0.05	0.16	0.06	0.05	0.03	0.18
18	Construction	0.05	0.06	0.09	0.02	0.03	0.19	0.23	0.17	0.03	0.02	0.13
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	0.03	0.08	0.07	0.01	0.05	0.17	0.33	0.13	0.02	0.02	0.11
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	0.03	0.09	0.14	0.02	0.04	0.12	0.17	0.15	0.03	0.01	0.17
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	0.05	0.08	0.15	0.02	0.07	0.19	0.27	0.21	0.02	0.01	0.15
22	Hotels and Restaurants	0.10	0.04	0.18	0.02	0.08	0.24	0.42	0.21	0.03	0.02	0.18
23	Inland Transport	0.02	1.35	0.82	0.02	0.05	0.76	0.79	0.84	0.14	0.01	1.16
24	Water Transport	0.02	0.05	0.07	0.02	0.04	0.07	0.11	0.10	0.03	0.02	0.19
25	Air Transport	0.02	0.06	0.10	0.02	0.03	0.16	0.08	0.10	0.04	0.03	0.21
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	0.02	0.32	0.11	0.02	0.04	0.21	0.16	0.25	0.02	0.01	0.58
27	Post and Telecommunications	0.04	0.07	0.08	0.01	0.04	0.16	0.08	0.14	0.02	0.01	0.10
28	Financial Intermediation	0.02	0.02	0.06	0.01	0.02	0.08	0.05	0.05	0.02	0.01	0.09
29	Real Estate Activities	0.01	0.01	0.07	0.01	0.01	0.18	0.04	0.15	0.02	0.01	0.14
30	Renting of M&Eq and Other Business Activities	0.02	0.06	0.07	0.01	0.04	0.15	0.19	0.11	0.02	0.01	0.15
31	Public Admin and Defense; Compulsory Social Security	0.04	0.04	0.11	0.01	0.04	0.14	0.24	0.13	0.02	0.01	0.12
32	Education	0.03	0.03	0.11	0.01	0.02	0.28	0.26	0.18	0.02	0.00	0.10
33	Health and Social Work	0.06	0.06	0.13	0.02	0.04	0.25	0.31	0.20	0.03	0.01	0.12
34	Other Community, Social and Personal Services	0.03	0.04	0.12	0.01	0.05	0.19	0.27	0.18	0.03	0.01	0.19
35	Private Households with Employed Persons	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: own elaboration.

Note: For ease of reading, cells in grey mean sectors with a price variation higher than 0.50%.

EU27 countries: AUT: Austria; BEL: Belgium; BGR: Bulgaria; CYP: Cyprus; CZE: Czech Republic; DEU: Germany; DNK: Denmark; ESP: Spain; EST: Estonia; FIN: Finland; FRA: France; GBR: United Kingdom; GRC: Greece; HUN: Hungary; IRL: Ireland; ITA: Italy; LTU: Lithuania; LUX: Luxemburg; LVA: Latvia; MLT: Malta; NLD: Netherland; POL: Poland; PRT: Portugal; ROM: Romania; SVK: Slovak Republic; SVN: Slovenia; SWE: Sweden.

Table 3. (continuation) Total effect on prices of the minima rates proposed by the 2011 ETD reform (percentages variations)

	Sector	PRT	ROM	SVK	SVN	SWE
1	Agriculture, Hunting, Forestry and Fishing	0.09	0.17	0.08	0.03	0.01
2	Mining and Quarrying	0.21	1.90	1.63	0.14	0.01
3	Food, Beverages and Tobacco	0.21	0.20	0.19	0.09	0.02
4	Textiles and Textile Products	0.56	0.27	0.12	0.08	0.03
5	Leather, Leather and Footwear	0.19	0.25	0.13	0.06	0.02
6	Wood and Products of Wood and Cork	0.17	0.23	0.09	0.06	0.03
7	Pulp, Paper, Printing and Publishing	0.10	0.09	0.09	0.05	0.02
8	Coke, Refined Petroleum and Nuclear Fuel	0.01	0.27	0.07	0.04	0.03
9	Chemicals and Chemical Products	0.28	2.19	0.43	0.09	0.03
10	Rubber and Plastics	0.17	0.28	0.16	0.08	0.04
11	Other Non-Metallic Mineral	0.12	0.21	0.14	0.07	0.03
12	Basic Metals and Fabricated Metal	0.08	0.25	0.12	0.04	0.02
13	Machinery, Nec	0.12	0.25	0.08	0.05	0.02
14	Electrical and Optical Equipment	0.10	0.19	0.06	0.05	0.02
15	Transport Equipment	0.10	0.16	0.07	0.05	0.02
16	Manufacturing, Nec; Recycling	0.16	0.38	0.09	0.05	0.02
17	Electricity, Gas and Water Supply	0.04	0.28	0.09	0.04	0.01
18	Construction	0.11	0.14	0.06	0.05	0.02
19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel	0.10	0.25	0.07	0.05	0.01
20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles	0.14	0.10	0.06	0.04	0.01
21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods	0.14	0.12	0.11	0.03	0.01
22	Hotels and Restaurants	0.11	0.15	0.21	0.03	0.01
23	Inland Transport	1.68	0.53	0.53	0.89	0.02
24	Water Transport	0.10	0.11	0.07	0.02	0.02
25	Air Transport	0.10	0.09	0.09	0.02	0.02
26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies	0.25	0.30	0.18	0.11	0.05
27	Post and Telecommunications	0.06	0.12	0.08	0.02	0.01
28	Financial Intermediation	0.04	0.13	0.05	0.01	0.00
29	Real Estate Activities	0.02	0.10	0.15	0.01	0.01
30	Renting of M&Eq and Other Business Activities	0.09	0.16	0.06	0.02	0.01
31	Public Admin and Defense; Compulsory Social Security	0.11	0.10	0.11	0.01	0.01
32	Education	0.07	0.13	0.19	0.02	0.01
33	Health and Social Work	0.12	0.23	0.22	0.03	0.01
34	Other Community, Social and Personal Services	0.12	0.16	0.25	0.02	0.01
35	Private Households with Employed Persons	0.00	0.00	0.00	0.00	0.00

Source: own elaboration.

Note: For ease of reading, cells in grey mean sectors with a price variation higher than 0.50%.

EU27 countries: AUT: Austria; BEL: Belgium; BGR: Bulgaria; CYP: Cyprus; CZE: Czech Republic; DEU: Germany; DNK: Denmark; ESP: Spain; EST: Estonia; FIN: Finland; FRA: France; GBR: United Kingdom; GRC: Greece; HUN: Hungary; IRL: Ireland; ITA: Italy; LTU: Lithuania; LUX: Luxemburg; LVA: Latvia; MLT: Malta; NLD: Netherland; POL: Poland; PRT: Portugal; ROM: Romania; SVK: Slovak Republic; SVN: Slovenia; SWE: Sweden.

Table 4. Price index change for the EU27 countries (in percentage)

Country	Price index variation (1)	HICP 2011[a] (2)	Ratio (1)/(2)
Finland	0.02	3.3	0.01
Denmark	0.02	2.7	0.01
Sweden	0.03	1.4	0.02
Netherland	0.03	2.5	0.01
Austria	0.03	3.6	0.01
Germany	0.04	2.5	0.02
Cyprus	0.07	3.5	0.02
Slovenia	0.07	2.1	0.03
Malta	0.08	2.5	0.03
Greece	0.08	3.1	0.03
Italy	0.08	2.9	0.03
Estonia	0.09	5.1	0.02
Ireland	0.10	1.2	0.08
France	0.13	2.3	0.06
Portugal	0.20	3.6	0.06
United Kingdom	0.24	4.5	0.05
Slovak Republic	0.28	4.1	0.07
Spain	0.29	3.1	0.09
Belgium	0.29	3.4	0.09
Czech Republic	0.30	2.1	0.14
Romania	0.39	5.8	0.07
Latvia	0.42	4.2	0.10
Hungary	0.42	3.9	0.11
Lithuania	0.43	4.1	0.10
Luxemburg	0.59	3.7	0.16
Poland	0.61	3.9	0.16
Bulgaria	0.71	3.4	0.21
Mean[b]	**0.22**		
Coefficient of variation[c]	**0.89**		

Source: own elaboration.

[a] HICP stands for Harmonized Index of Consumer Prices (data available at http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&language=en&pcode=tec00118&tableSelection=1&footnotes=yes&labeling=labels&plugin=1)

[b] Mean is the arithmetic mean.

[c] Coefficient of variation is the ratio between the standard deviation and the mean.

Table 5. Price index change for the EU27 countries including ETS sectors (in percentage)

Country	Price index variation (1)	HICP 2011[(a)] (2)	Ratio (1)/(2)
Sweden	0.12	1.4	0.09
Austria	0.19	3.6	0.05
France	0.22	2.3	0.09
Netherland	0.27	2.5	0.11
Denmark	0.29	2.7	0.11
Italy	0.30	2.9	0.10
Finland	0.33	3.3	0.10
Germany	0.34	2.5	0.14
Ireland	0.35	1.2	0.29
Slovenia	0.44	2.1	0.21
Portugal	0.47	3.6	0.13
Spain	0.49	3.1	0.16
Greece	0.51	3.1	0.16
Belgium	0.51	3.4	0.15
United Kingdom	0.52	4.5	0.12
Cyprus	0.54	3.5	0.16
Malta	0.60	2.5	0.24
Slovak Republic	0.67	4.1	0.16
Latvia	0.72	4.2	0.17
Lithuania	0.72	4.1	0.18
Luxemburg	0.73	3.7	0.20
Hungary	0.87	3.9	0.22
Romania	0.92	5.8	0.16
Czech Republic	1.28	2.1	0.61
Estonia	1.53	5.1	0.30
Poland	1.60	3.9	0.41
Bulgaria	1.91	3.4	0.56
Mean[(b)]	**0.65**		
Coefficient of variation[(c)]	**0.69**		

Source: own elaboration.

[(a)] HICP stands for Harmonized Index of Consumer Prices (data available at http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&language=en&pcode=tec00118&tableSelection=1&footnotes=yes&labeling=labels&plugin=1)

[(b)] Mean is the arithmetic mean.

[(c)] Coefficient of variation is the ratio between the standard deviation and the mean.

Table A.1. Main transformations applied

Products
The main products that are taxed through the ETD are: petrol used as motor fuel; gas oil, kerosene, liquefied petroleum gas (LPG) and natural gas used as motor fuel as well as for heating; heavy fuel oil (HFO) and coal and coke used for heating; finally electricity. Biofuels are currently taxed but an option of fully exemption exists, and they would remain exempt under the reform. Nuclear fuels are not energy products for the purposes of the directive. For some of these products a correspondence exists between the ETD classification and the classification used in the WIOD database.
Product selection
Three uses - kerosene used as motor fuel, kerosene used for industrial use and heating, and natural gas used as motor fuel -are excluded from the analysis for the following reasons. As regards kerosene, it is used as motor fuel basically by the aviation sector that is exempted from the energy component of the tax for competitiveness reasons and is exempted from the CO2 component of taxation because it is an ETS sector. As regards kerosene used as heating, when consumption is relevant, households rather than economic sectors basically use it. Finally, as regards natural gas used as motor fuel, it is not considered in the analysis because the IEA considers the amount consumed in most countries (except for Bulgaria, France, Germany, Italy, Sweden) as irrelevant, assigning to data (IEA, 2012a) a value equal to zero.
LPG
As regards LPG, two transformations are needed. Since in WIOD LPG is classified in the category "Other petroleum products" along with other nine energy products (the products classified in the "Other petroleum products" category are LPG, bitumen, ethane, lubricants, non-specified oil products, other kerosene, paraffin waxes, petroleum coke, refinery gas, white spirit.), it is necessary to desegregate the WIOD category into the different components. This is done using IEA energy balances information that have been used for computing the WIOD category "other petroleum products" (IEA, 2012a). Then, it is necessary to distinguish between LPG used as motor fuel and LPG used for heating. Also in this case the additional information used comes from IEA energy balances: in IEA data (IEA, 2012a) there is a final consumption flow named "road" that records fuels used in road vehicles. For LPG, as for gas oil and petrol, this flow has been split and allocated to all NACE sectors and private consumption in WIOD. Following the same procedure, explained in Genty et al. (2012), it is possible to desegregate, for each WIOD sector, the share of LPG classified in IEA as "road", and consider this component as LPG used as motor fuel, while the remaining share of LPG is considered as used for heating. This transformation requires additional information from IEA prices (IEA, 2012b) and from the database Odyssee (Odyssee-Mure, 2014).
Coal and coke
The different WIOD products "coal" and "coke" are aggregated in a single product as in the ETD. Table A.2 summarizes the correspondences between ETD and WIOD products and the transformation needed.
Conversion factors
It is necessary to convert WIOD energy data in units coherent with the ETD: in the ETD rates on different products are expressed in euro related to different volumetric measures. In particular: rates on petrol, gas oil and kerosene are expressed in euro per 1000 liters, rates on LPG are expressed in euro per 1000 kilograms, rates on natural gas, coal and coke are expressed in euro per gigajoule. On the other hand, WIOD energy use tables are expressed in their energy content (TJ). They have indeed to be conveniently transformed with the ETD (see Table A.3).

Source: own elaboration.

Table A.2. Correspondence between ETD and WIOD energy products classification

ETD product	WIOD product	Transformation
Petrol (motor fuel)	Gasoline	None
Gas oil (motor fuel)	Diesel	None
Gas oil (heating)	Light fuel oil-LFO	None
Kerosene (motor fuel)	Jet fuel	Excluded
Kerosene (heating)	Other kerosene	Excluded
LPG (motor fuel)	Other petroleum products	Desegregated
LPG (heating)	Other petroleum products	Desegregated
Natural gas (motor fuel)	Natural gas	None
Natural gas (heating)	Natural gas	Excluded
Heavy fuel oil-HFO (heating)	Heavy fuel oil-HFO	None
Coal and coke	Coal	Aggregated
Coal and coke	Coke	Aggregated
Electricity	Electricity	None

Source: own elaboration.

Table A.3. Conversion factors

WIOD Energy Product	WIOD Units	ETD Units	Net Calorific Value (NCV, GJ/1000 kg) Density (D, Kg/m^3) Conversion factor (CF, GJ/1000 kg)	Transformation from WIOD to ETD Units
Gasoline (motor fuel)	TJ	1000 kg	CF=NCV= 32.8	Data in 1000 kg=TJ x 1000/32.8
Diesel (motor fuel)	TJ	1000 l	NCV =42.3; D=832; CF=NCV x D/1000=35.2	Data in 1000 l=TJ x 1000/35.2
LFO (heating)	TJ	1000 l	NCV=42.3; D =832; CF=NCV x D/1000=35.2	Data in 1000 l=TJ x 1000/35.2
LPG (motor fuel)	TJ	1000 kg	CF=NCV (GJ/1000 kg)= 46	Data in 1000 kg=TJ x 1000/46
LPG (heating)	TJ	1000 kg	CF=NCV (GJ/1000 kg)= 46	Data in 1000 kg=TJ x 1000/46
Natural gas (heating)	TJ	GJ		Data in GJ=TJ x 1000
HFO (heating)	TJ	1000 kg	CF=NCV (GJ/1000 kg)= 40	Data in 1000 kg=TJ x 1000/40
Coal-coke (heating)	TJ	GJ		Data in GJ=TJ x 1000
Electricity	TJ	MWh	CF=NCV (GJ/MWh)= 3.6	Data in MWh= TJ x 1000/3.6

Source: own elaboration from European Commission (2011).

Table B.1. Correspondence between economic activities subject to the ETS and WIOD sectors

Economic activities	**WIOD sector**
Energy activities	
Combustion installations with a rated thermal input exceeding 20 MW (except hazardous or municipal waste installations)	Electricity, Gas and Water Supply
Mineral oil refineries	Coke, Refined Petroleum and Nuclear Fuel
Coke ovens	
Production and processing of ferrous metals	Basic Metals and Fabricated Metal
Metal ore (including sulfide ore) roasting or sintering installations	
Installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2,5 tons per hour	
Mineral industry	
Installations for the production of cement clinker in rotary kilns with a production capacity exceeding 500 tons per day or lime in rotary kilns with a production capacity exceeding 50 tons per day or in other furnaces with a production capacity exceeding 50 tons per day	
Installations for the manufacture of glass including glass fiber with a melting capacity exceeding 20 tons per day	
Installations for the manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain, with a production capacity exceeding 75 tons per day, and/or with a kiln capacity exceeding 4 m3 and with a setting density per kiln exceeding 300 kg/m3	
Other activities	Pulp, Paper, Paper , Printing and Publishing
Industrial plants for the production of	
(a) pulp from timber or other fibrous materials	
(b) paper and board with a production capacity exceeding 20 tons per day	
Aviation	Air Transport
Flights which depart from or arrive in an aerodrome situated in the territory of a Member State to which the Treaty applies	

Source: own elaboration from European Parliament and Council (2003, 2008).

Table B.2. Specific treatment for some sectors

WIOD sector	**New minima applied (for all energy product)**
Agriculture, Hunting, Forestry and Fishing	Component related to CO^2 emissions
Pulp, Paper, Paper , Printing and Publishing	Component related to energy content
Coke, Refined Petroleum and Nuclear Fuel	Component related to energy content
Other Non-Metallic Mineral	Zero
Basic Metals and Fabricated Metal	Component related to energy content
Electricity, Gas and Water Supply	Zero
Inland Transport	Component related to CO^2 emissions (only for gas oil)
Water Transport	Zero
Air Transport	Zero

Source: own elaboration.

Figure(s)

Figure 1. EU ETS: Average of daily closing price, 2008 – 2014

Source: own elaboration from Sendeco (2014).