PAPER

Title: Carbon inequality impacts of lifestyles and its recent evolution by income distribution in EU countries

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Abstract: The raising awareness on the current and future consequences of climate change has leaded to different international commitments aimed to ensure a sustainable development as the United Nations Framework Convention on Climate Change (UNFCCC), and especially the recent Paris Agreement (PA). These agreements have reflected the concern of how to reduce GHG emissions and the requirement of organization of all countries to get the aim of environmental improvements. They also provide a guide for the implementation of transformation processes towards sustainable goals. The European Union (EU) sets key targets related to cut emissions and improve energy efficient through a set of binding legislation for all production sectors and citizens.

The environmental impacts from different agents are analysed by many researchers. In last year, researchers have pointed households as an element that have an important role in environmental impacts. Production and consumption patterns in each country drive atmospheric emissions embodied throughout production chain, thus being a key element of climate policy as sustainable pathways can contribute to reduce emissions. Not only production is the cause of global warming, direct and indirect emissions by households make an important change in environment. Disparities in income distribution and lifestyles between and within each country entails a different starting point for each country to reach their objectives.

In this context, we explore carbon implications of the current production and consumption patterns using an environmentally extended multiregional and multisectoral input-output model for all the EU Member States, plus the rest countries of the world, for 56 industry sectors. In particular, we evaluate the different household consumption patterns of the countries and how they are distributed from 2000 to 2015 using five income categories. Additionally, we propose two possible scenarios and make a comparation between their results.

Keywords: households, consumption, emissions, lifestyles, impacts
JEL codes: Q51

Carbon inequality impacts of lifestyles and its recent evolution by income distribution in EU countries

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1. Introduction

The raising awareness on the current and future consequences of climate change has leaded to different international commitments aimed to ensure a sustainable development as the United Nations Framework Convention on Climate Change (UNFCCC, 2015), and especially the recent Paris Agreement (PA). Specifically, the UNFCCC adopted a set of goals to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda. This agenda includes 17 goals of sustainable development such as no poverty, affordable and clean energy, sustainable cities and communities, responsible consumption and production, and climate action, among others. These goals have to be compatible with other deals stablished in the Paris Agreement (UNFCCC, 2016), which sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2°C. These agreements have reflected the concern of how to reduce GHG emissions and the requirement of organization of all countries to get the aim of environmental improvements. They also provide a guide for the implementation of transformation processes towards sustainable goals.

In this context, the European Union (EU) is an outgrowth of a multinational organization which includes countries with different characteristics, income inequality, wealth disparity, fiscal policies and so on, while having common objectives, such as climate change mitigation, that lead them to understand and adapt policies involving them all. Each Member State plays a role in economic systems through both production and demand side, which has thus significant influence on the environment. Moreover, consumption patterns and lifestyles in each country drive atmospheric emissions embodied throughout production chain, thus being a key element of climate policy as changes in demand both national and international level can contribute to reduce emissions. Recent studies in the literature have shown worrying consumption and production patterns related to the environment. On the one hand, it is shown that wealthier countries consume and import intensive products in emissions that are produced in developing countries with low efficiency technologies to then produce and export high-value products (see Davis and Caldeira, 2010; Hertwich and Peters, 2010; Peters et al. 2011; Feng et al. 2013, Fernández-González et al. 2014). On the other hand, increasing income leads to increasing carbon footprints and makes global targets for mitigating greenhouse gases more difficult to achieve (Hubacek et al., 2017[8]). However, previous researches also show that a high-income level produces a greater number of emissions because of the energetic use and consumption of goods and services by people. However, this increase could be not proportional as luxury consumption produces less impacts than the goods that satisfy basic needs (Girod et al., 2010).

Therefore, production is not the only cause of global warming, but direct and indirect emissions by households make an important change in environment. Disparities in income distribution and lifestyles between and within each country entails a different starting point for each country to reach their objectives.

In this context, we explore carbon implications of the current production and consumption patterns using an environmentally extended multiregional and multisectoral input-output model for all the EU Member States, plus the rest countries of the world, for 26 industry sectors. In particular, we evaluate the different household consumption patterns of the countries and how they are distributed from 2000 to 2015 using five income categories. We also address a structural decomposition analysis (SDA) to analyse the key components in the evolution of CO_2 emissions, by country and household. Additionally, we simulate two possible scenarios to assess the economy-wide impacts of a sustainable path towards a greater equity and lower emissions.

The paper is organized as follows. Section 2 describe a brief review of previous findings from the literature in this topic. Section 3 presents the methodology used. Section 4 describe the main results obtained and some reflections concludes the paper is Section 5.

2. A brief review of the previous literature

The environmental impacts from different agents have been analysed by many researchers previously in the literature. In last years, previous works have pointed households as a key element that have an important role in environmental impacts. Production and consumption patterns in each country drive atmospheric emissions embodied throughout production chain, thus being a key element of climate policy as sustainable pathways can contribute to reduce emissions.

Since seventies, a great interest of studying direct and indirect pollution has emerged. Households pollute in a direct way through of electricity, heating or driving. Moreover, they produce an indirect pollution because the production of the goods and services that they use, also produce pollution. However, consumption basket can be different by household, depending on the kind of household, so the impact in the environment can be different.

We can find some interesting facts in the previous literature. In Munksgaard et al. (2000), they address a structural decomposition analysis for the Danish economy from 1966 to 1992. They also use an input-output model to evaluate the factors that affect to CO_2 emissions (direct and indirect) of households. They find that direct emissions are bigger than indirect, but they follow different tendencies. Inside of private consumption, they highlight the relevance of transport use, recreation and entertainment.

In Kerkhof et al. (2009), they evaluate the relations between household expenditure and environmental impacts. They made their research for Netherlands by 2000 using an input-output environmental extended model. They found that the environmental impact is bigger in high-income households. They observe also that there are differences in consumption patterns. For example, households with high expenditure levels spend their money on “gasoline”, “cars” or “holidays, camp and weekend recreation” while households with low expenditures levels spend their money in other issues, such as “food” or “house”. In other words, they found that the demand for basic goods is more important in low-income households, while luxury goods are more relevant in high income households.

In Duarte et al. (2016), authors evaluate the impacts of changes in the energy, transport and diet, using different consumption pattern of Spanish economy by income level. They suggest that reductions in carbon dioxide, methane and sulphide dioxide, could be compatible with increases of income and reductions of unemployment. They also show that emissions’ reductions are bigger in electricity and gas activity in lower income households. The public transport is pointed as the most efficient option in environmental terms.

3. Methodology and data

We develop a multiregional input-output (MRIO) model for the years 1999,2005, 2010 and 2015 for the European Union that has 26 sectors and 29 regions (28 EU Member States, plus the rest of the world) obtained from EORA database that provides multiregional input-output database with environmental accounts for 189 countries, see Lenzen et al. (2012) and (2013). Additionally, the expenditure structure of consumption is obtained from Eurostat, by income’s quintile for years (Eurostat, 2010).

The model is extended in two ways. First, an environmental extended model that allow us to analyse the emissions of productive sectors and households that are joined to production and consumption process. Second, the final demand of households of all different European countries has been extended to disaggregate in five income quintiles.

The use of the input-output analysis allows us to evaluate the effects on emissions of different income level.

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{y}$$

This equation shows the balance in MRIO model with m countries and n industries, where the vector **x** mxn is the total product (gross production). We named as **A**= $\left(a_{ij}^{rs}\right)$

to the technique coeficient matrix, whose element a_{ij}^{rs} signs the quantity of intermediate inputs i of country r that are needed to produce an unit of the product j in country s. We named as $\mathbf{Y} = (\mathbf{y}^{rs}) = (y_i^{rs})$ to the matrix (mxn)xm of total final demand, whose elements y_i^{rs} show the demand of product i of country r to satisfy the final demand of country s, where $\mathbf{y}^{rs}$ is the vector nx1 of goods from r incluided in final demand of s. Finally, we denominated $\mathbf{y} = (y_i^r) = (\sum_s y_i^{rs})$ to the vector mxn of final world demand.

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{y} = \mathbf{L}\mathbf{y}$$

The Leontief's inverse allows us to link the production with the demand, so we can evaluate, for each demand, what is the total production of world economy, that is generated directly and indirectly to satisfy the final demand of a sector in a country.

Then, we extend the model environmentally by including a row vector of direct pollution coefficients **c** with elements crj = Crj / xrj, which represents the pollution that is generated in each country and sector by unit production of each sector. In addition, we consider final demand of each country, so we get a matrix **Ω** ((mxn)x(mxn)):

$$\boldsymbol{\Omega} = \left(\omega_{\mathrm{ij}}^{rs}\right) = \widehat{\mathbf{c}\mathbf{L}\boldsymbol{Y}} = \begin{pmatrix} \boldsymbol{\Omega}_{11} & \boldsymbol{\Omega}_{12} & . & . & \boldsymbol{\Omega}_{1\mathrm{m}} \\ \boldsymbol{\Omega}_{21} & \boldsymbol{\Omega}_{22} & . & . & \boldsymbol{\Omega}_{2\mathrm{m}} \\ . & . & . & . & . \\ \boldsymbol{\Omega}_{\mathrm{r}1} & . & \boldsymbol{\Omega}_{\mathrm{rs}} & . & \boldsymbol{\Omega}_{\mathrm{rm}} \\ . & . & . & . & . \\ \boldsymbol{\Omega}_{\mathrm{m}1} & \boldsymbol{\Omega}_{\mathrm{m}2} & . & . & \boldsymbol{\Omega}_{\mathrm{mm}} \end{pmatrix}$$

$$= \begin{pmatrix} \hat{\boldsymbol{\lambda}}_1 & \mathbf{0} & . & . & \mathbf{0} \\ \mathbf{0} & \hat{\boldsymbol{\lambda}}_2 & . & . & \mathbf{0} \\ . & . & . & . & . \\ . & . & . & \hat{\boldsymbol{\lambda}}_r & . \\ . & . & . & . & . \\ \mathbf{0} & \mathbf{0} & . & . & \hat{\boldsymbol{\lambda}}_m \end{pmatrix} \begin{pmatrix} \boldsymbol{y}_{11} & \boldsymbol{y}_{12} & . & . & \boldsymbol{y}_{1m} \\ . & \boldsymbol{y}_{22} & . & . & . \\ . & . & . & . & . \\ . & . & . & \boldsymbol{y}_{rs} & . \\ . & . & . & . & . \\ \boldsymbol{y}_{m1} & \boldsymbol{y}_{m2} & . & . & \boldsymbol{y}_{mm} \end{pmatrix}$$

where $\boldsymbol{\lambda}_{rj} = \sum_{i,s} \boldsymbol{c}_i^s \boldsymbol{\alpha}_{ij}^{sr}$ and ω_{ij}^{rs} is all the pollution that is generated in sector *i* in country *r* that is needed directly and indirectly to satisfy final demand of sector *j* in country *s*.

The values of λ represent "pollution values", in other words, the direct and indirect pollution, which is incorporated by unit of final demand. These values are a representation of technology (production and pollution), because they mix the information that is contained in Leontief's inverse, and the information of emissions by production unit (intensity emissions). These values allow us to analysis final demand in terms of the pollution that is contained in itself.

On the other side, if we only consider final household demand, we have direct and indirect pollution incorporated in this final demand:

$$\begin{pmatrix} G_{11} & G_{12} & . & . & G_{1m} \\ . & G_{22} & . & . & . \\ . & . & . & . & . \\ . & . & . & G_{rs} & . \\ . & . & . & . & . \\ G_{m1} & G_{m2} & . & . & G_{mm} \end{pmatrix}$$

That is to say:

$$\Omega^g = \begin{pmatrix} \widehat{\lambda}_1 & 0 & . & . & 0 \\ 0 & \widehat{\lambda}_2 & . & . & 0 \\ . & . & . & . & . \\ . & . & . & \widehat{\lambda}_r & . \\ . & . & . & . & . \\ 0 & 0 & . & . & \widehat{\lambda}_m \end{pmatrix} \begin{pmatrix} G_{11} & G_{12} & . & . & G_{1m} \\ . & G_{22} & . & . & . \\ . & . & . & . & . \\ . & . & . & G_{rs} & . \\ . & . & . & . & . \\ G_{m1} & G_{m2} & . & . & G_{mm} \end{pmatrix}$$

In this research, we focus in final demands of European Union's countries (m=1…28), and specially, in the distribution of them depending on income level.

Additionally, as commented, we address a structural decomposition analysis. This methodology is an important macroeconomic technique, that allows to distinguish direct and indirect components of sectorial changes through similar process of accounting of growth with the techniques of I-O analysis. SDA analysis allows to decompose, in two different periods of time, the effects of a macroeconomic variable in different elements.

We decompose in four effects:

-H is the matrix, which represents consumption patterns by income level for each country:

$$\boldsymbol{H} = \{H_{ij}\} = \left\{\frac{G_{ij}}{\sum_{i=1}^{n} G_{ij}}\right\} \; where \; i = 1, \dots n; j = 1, \dots, h$$

-D is a diagonal matrix which collects the distribution of the expenditure between the different kinds of households by income level for each country of European Union. This allows us to approximate to income's distribution:

$$\mathbf{D}=\{D_j\} = \left\{\frac{\sum_i G_{ij}}{\sum_i \sum_j G_{ij}}\right\} \; siendo \; i = 1, \dots n; j = 1, \dots, h$$

-T is the scalar factor, which represents the sum of total expenditure of all households by each country:

$$T = \sum_i \sum_j G_{ij}$$

In this way, we can get the matrix with the pollution's values λ by 2000:

$$\boldsymbol{\Omega}_{\mathbf{0}}^{\boldsymbol{g}} = \hat{\boldsymbol{\lambda}}_{\mathbf{0}} \boldsymbol{H}_{\mathbf{0}} \widehat{\boldsymbol{D}}_{\mathbf{0}} T_0$$

And by 2015:

$$\boldsymbol{\Omega}_{\mathbf{1}}^{\boldsymbol{g}} = \hat{\boldsymbol{\lambda}}_{\mathbf{1}} \boldsymbol{H}_{\mathbf{1}} \widehat{\boldsymbol{D}}_{\mathbf{1}} T_1$$

We use the Polar Solution which is known in this literature as one of the most appropriate solution. In this way, we have the following solutions:

1) $$\Delta \boldsymbol{\Omega}^{\boldsymbol{g}} = \Delta \hat{\boldsymbol{\lambda}} \boldsymbol{H}_{\mathbf{0}} \widehat{\boldsymbol{D}}_{\mathbf{0}} T_0 + \hat{\boldsymbol{\lambda}}_{\mathbf{1}} \Delta \boldsymbol{H} \widehat{\boldsymbol{D}}_{\mathbf{0}} T_0 + \hat{\boldsymbol{\lambda}}_{\mathbf{1}} \boldsymbol{H}_{\mathbf{1}} \Delta \widehat{\boldsymbol{D}} T_0 + \hat{\boldsymbol{\lambda}}_{\mathbf{1}} \boldsymbol{H}_{\mathbf{1}} \widehat{\boldsymbol{D}}_{\mathbf{1}} \Delta T$$

2) $$\Delta \boldsymbol{\Omega}^{\boldsymbol{g}} = \Delta \hat{\boldsymbol{\lambda}} \boldsymbol{H}_{\mathbf{1}} \widehat{\boldsymbol{D}}_{\mathbf{1}} T_1 + \hat{\boldsymbol{\lambda}}_{\mathbf{0}} \Delta \boldsymbol{H} \widehat{\boldsymbol{D}}_{\mathbf{1}} T_1 + \hat{\boldsymbol{\lambda}}_{\mathbf{0}} \boldsymbol{H}_{\mathbf{0}} \Delta \widehat{\boldsymbol{D}} T_1 + \hat{\boldsymbol{\lambda}}_{\mathbf{0}} \boldsymbol{H}_{\mathbf{0}} \widehat{\boldsymbol{D}}_{\mathbf{0}} \Delta T$$

Finally, and the average of the two solutions:

$$\Delta\Omega^{g} = \frac{(I_1+I_2)}{2} + \frac{(P_1+P_2)}{2} + \frac{(R_1+R_2)}{2} + \frac{(T_1+T_2)}{2}$$, where

$$\frac{(\boldsymbol{I_1} + \boldsymbol{I_2})}{2} = \boldsymbol{I}$$

$$\frac{(\boldsymbol{P_1} + \boldsymbol{P_2})}{2} = \boldsymbol{P}$$

$$\frac{(\boldsymbol{R_1} + \boldsymbol{R_2})}{2} = \boldsymbol{R}$$

$$\frac{(\boldsymbol{T_1} + \boldsymbol{T_2})}{2} = \boldsymbol{T}$$

4. Results

4.1. Descriptive Analysis of Consumption Patterns

First, we analyse consumption patterns for each country of European Union by income level for years 1999, 2005, 2010 and 2015. The largest sectoral consumption results are shown in Table 1 for all countries. We can see that for the lowest income level households, “Public Administration” sector is the most relevant in some countries as Romania (75%), Poland (68.75%) or Latvia (33.33%). We can also highlight the importance of “Foods and Beverages” sector in Cyprus with the 30.08% of total consumption. On the contrary, in the highest income level, we find that “Wood and Paper” and “Financial Services” sectors are the most important sectors. For example, in Italy, “Wood and Paper” represents 58.9%; and “Financial Services” represents the 62.76% in Sweden.

Table 1. Most important sectors of first and fifth quintile in % of total consumption of each sector

First Quintile	Second Quintile	Third Quintile	Fourth Quintile	Fifth Quintile
Public Administration Romania 75% Poland 68.75% Latvia 33.33%	**Others** Denmark 31.58% Croatia 27.87%	**Public Administration** Latvia 55% Croatia 25.89%	**Maintenance and Repair** Germany 26.25% Bulgaria 25.93%	**Wood and Paper** Italy 58.9% Bulgaria 41.48% Estonia 39.98%
Foods and Beverages Cyprus 30.08%	**Agriculture** Greece 22.70% Latvia 22.45%	**Metal Products** Cyprus 25.65% Ireland 23.14%	**Transport** Estonia 25.70% Romania 26.06%	**Financial Services** Sweden 62.76% Portugal 57.14%

Table 2 presents sectoral results by income level for the whole economy of the EU. In this analysis, we find some premises that are observed in the literature. For example, as expected, sectors related with food decrease their weight as income increases. The same is observed in the case of "Electricity, Gas and Water". On the other hand, sectors such as "Transport" and "Wood and Paper" increase their role when income increases, as we can find in the literature. As example, "Wood and Paper" has a weight of 30.75% as average of European Union, as we can see in ***Table 2***.

Table 2. European Union's average of each sector by each income quintile for the total consumption of each sector.

	First Quintile	Second Quintile	Third Quintile	Fourth Quintile	Fifth Quintile
Agriculture	0.2384	0.2174	0.2008	0.1830	0.1515
Fishing	0.2384	0.2174	0.2008	0.1830	0.1515
Mining and Quarrying	0.2384	0.2174	0.2008	0.1830	0.1515
Food & Beverages	0.2399	0.2181	0.2021	0.1855	0.1545
Textiles and Wearing Apparel	0.1617	0.1793	0.1983	0.2165	0.2443
Wood and Paper	0.1218	0.1598	0.1888	0.2221	0.3075
Petroleum, Chemical and Non-Metallic Mineral Products	0.1641	0.1817	0.2015	0.2124	0.2402
Metal Products	0.1553	0.1827	0.2099	0.2215	0.2305

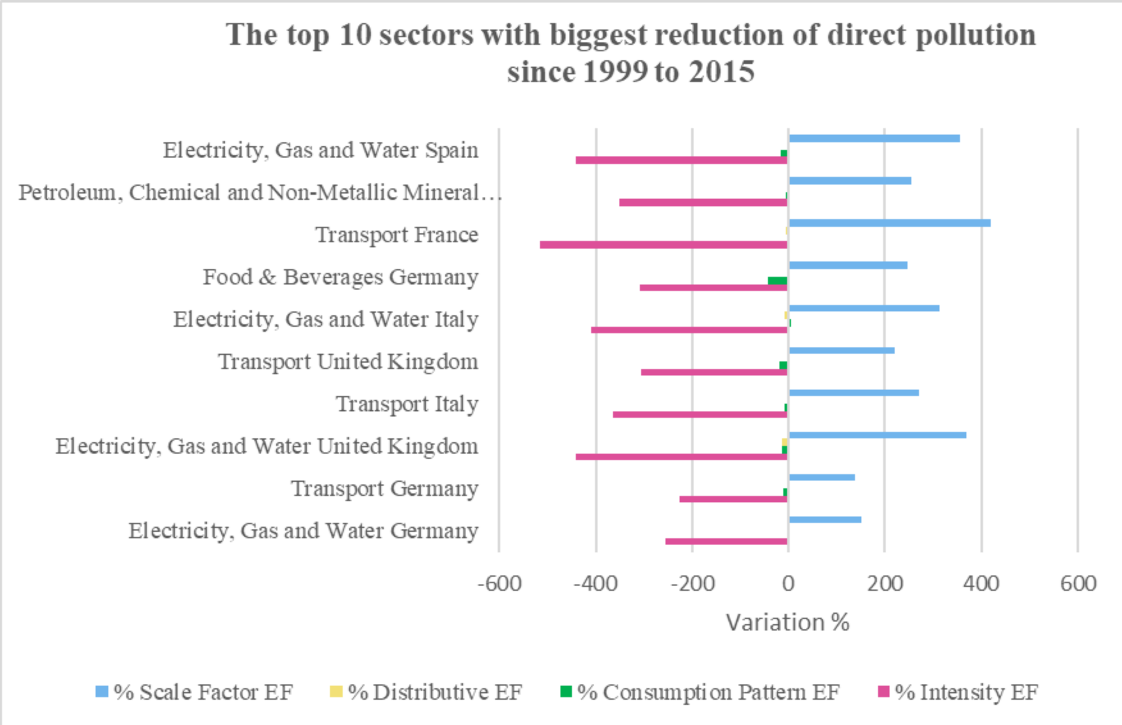
Electrical and Machinery	0.1632	0.1895	0.2079	0.2141	0.2253
Transport Equipment	0.1307	0.1675	0.1985	0.2316	0.2717
Other Manufacturing	0.1553	0.1827	0.2099	0.2215	0.2305
Recycling	0.2038	0.1981	0.1925	0.1898	0.2159
Electricity, Gas and Water	0.2405	0.2200	0.2011	0.1817	0.1567
Construction	0.2335	0.2139	0.1954	0.1823	0.1749
Maintenance and Repair	0.1670	0.1817	0.2022	0.2124	0.2368
Wholesale Trade	0.2116	0.2066	0.2029	0.1972	0.1816
Retail Trade	0.2116	0.2066	0.2029	0.1972	0.1816
Hotels and Restraurants	0.1538	0.1662	0.1886	0.2211	0.2702
Transport	0.1307	0.1675	0.1985	0.2316	0.2717
Post and Telecommunications	0.2116	0.2066	0.2029	0.1972	0.1816
Finacial Intermediation and Business Activities	0.1353	0.1413	0.1814	0.2236	0.3183
Public Administration	0.1950	0.2059	0.1857	0.1918	0.2216
Education, Health and Other Services	0.1956	0.1989	0.1987	0.1966	0.2102
Private Households	0.1670	0.1864	0.2011	0.2153	0.2302
Others	0.1770	0.1889	0.1814	0.1981	0.2545
Re-export & Re-import	0.1770	0.1889	0.1814	0.1981	0.2545

Direct Pollution and Embodied Analysis of European Union

Direct emissions Analysis (production perspective)

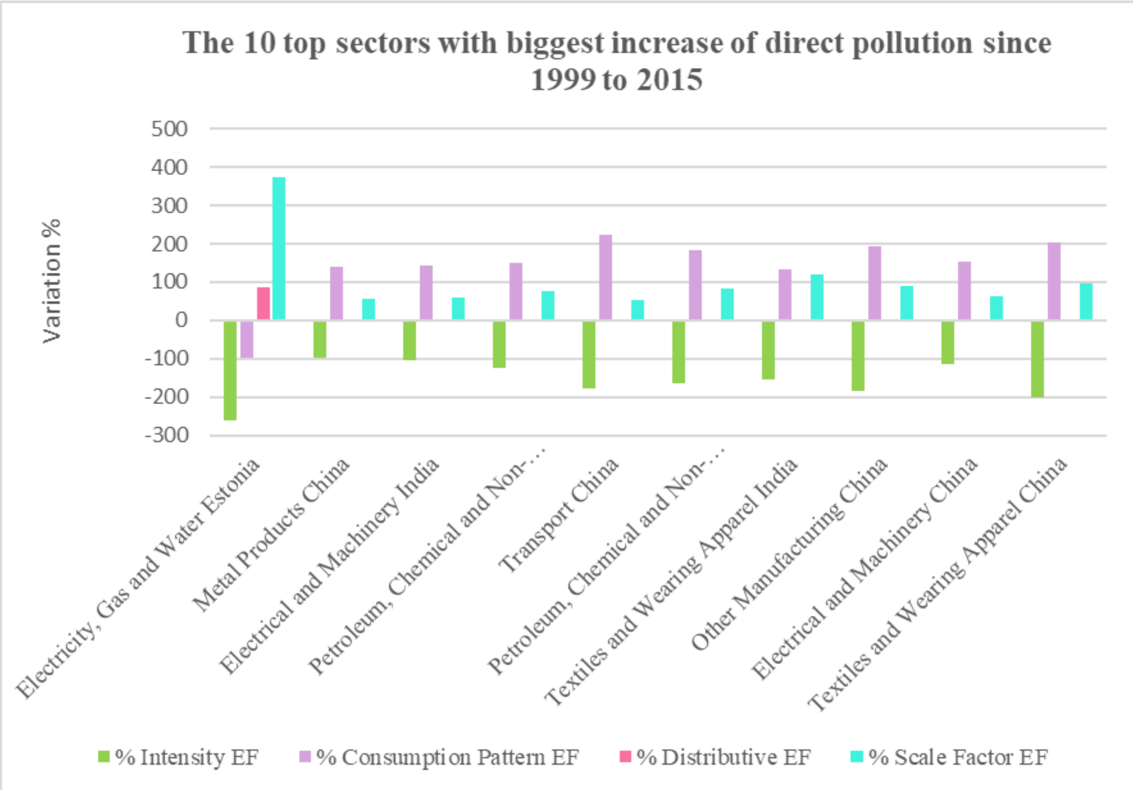
First of all, we consider direct emissions as emissions associated to households consumption. On the one hand, “Transport” was the sector with the greatest reduction of emissions in most of the countries, as we can see in ***Figure 1***. When we study the case of “Transport”, we can see that this reduction is due to the intensity effect and the distributive effect. In this way, for example, we can see that the largest relevance of the intensity effect to achieve this reduction. The fall in emissions from “Electricity, Gas and Water” sector was also remarkable. In this case, it was also important the reduction that we can find in the intensity effect, maybe because of an improvement in technology. In United Kingdom, the consumption pattern effect was also remarkable in “Electricity, Gas and Water”. In France, we could also see that “Petroleum, Chemical and Non-Metallic Mineral Products” had an important reduction of their direct emissions, where, again, intensity effect was the main factor in causing this decrease.

Figure 1. The top 10 sectors with biggest reduction of direct pollution since 1999 to 2015.



On the other hand, consumption pattern effect and intensity effect were very important to determinate the sectors with the biggest increases of direct emissions. It could be highlighted the relevance of "Textile Sector" from China and India, and "Petroleum, Chemistry and Non-Metallic Mineral Materials", as we can see in ***Figure 2***. This could be due to a big growth that both countries had experimented in nineties. It made that middle class had more relevance than in the past, and with the growth of the population of those countries, they made that consumption increased.

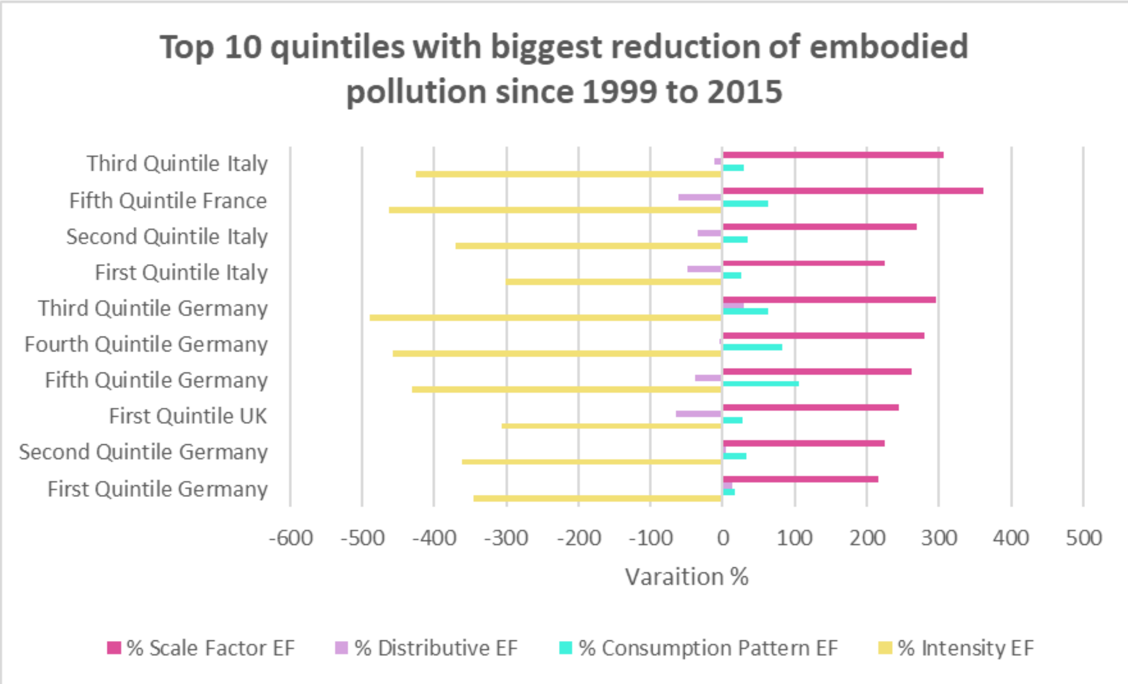
Figure 2. The top 10 sectors with the biggest increase of direct pollution since 1999 to 2015.



Embodied Pollution Analysis

We've considered embodied pollution as the pollution that is inside of all the process to the products that are consumed by households. Then, we find that all the quintiles that belonged to Germany, were the less pollutant (Figure 3**)**. It was because of intensity effect, especially in the case of high-income and middle-high-income level. In the case of fifth quintile, it was also due to a decrease of distributive effect. In United Kingdom, the reductions were because of intensity effect, while in Italy, first and second quintile reduced their emissions due to a reduction in their distributive effect.

Figure 3. Top 10 quintiles with the biggest reduction of embodied pollution since 1999 to 2015



On the contrary, we found that in Estonia and Romania appear the most pollutant sectors In the case of Romania, which was the country that presented the biggest increase of emissions, the sector that had had a strong increase of their emissions associated to households' demand, was "Wholesale Trade" (almost an increase of 26% respect of its initial value) and "Education, Health and Other Services" (20.35%). In the first increase, we can see a strong reduction of intensity effect and a big increase in scale factor effect. On the other side, as we can see in ***Table 3***, "Private Households" had the biggest reduction, with an important reduction of its intensity effect and of its consumption pattern effect.

Table 3. Change in total effect of embodied emissions in Romania for each sector in % since 1999 to 2015.

Sectors	Variation Total Effect	Sectors	Variation Total Effect
Wholesale Trade	25.90%	**Hotels and Restraurants**	-1.28%
Education, Health and Other Services	20.35%	**Wood and Paper**	-2.94%
Textiles and Wearing Apparel	18.60%	**Construction**	-3.44%
Agriculture	18.53%	**Transport Equipment**	-4.97%

Post and Telecommunications	16.10%	**Maintenance and Repair**	-5.14%
Retail Trade	12.07%	**Mining and Quarrying**	-5.83%
Petroleum, Chemical and Non-Metallic Mineral Products	11.63%	**Metal Products**	-6.51%
Other Manufacturing	11.58%	**Public Administration**	-14.30%
Transport	9.33%	**Electricity. Gas and Water**	-29.13%
Finacial Intermediation and Business Activities	7.59%	**Fishing**	-41.58%
Electrical and Machinery	5.21%	**Recycling**	-50.31%
Re-export & Re-import	2.64%	**Others**	-76.20%
Food & Beverages	0.06%	**Private Households**	-87.90%

When we analysed the case of Spain, we can see that "Metal Product" was the most pollutant, due to consumption patterns effect. On the other hand, "Private Households" was the less pollutant sector because of intensity effect.

Other relevant results

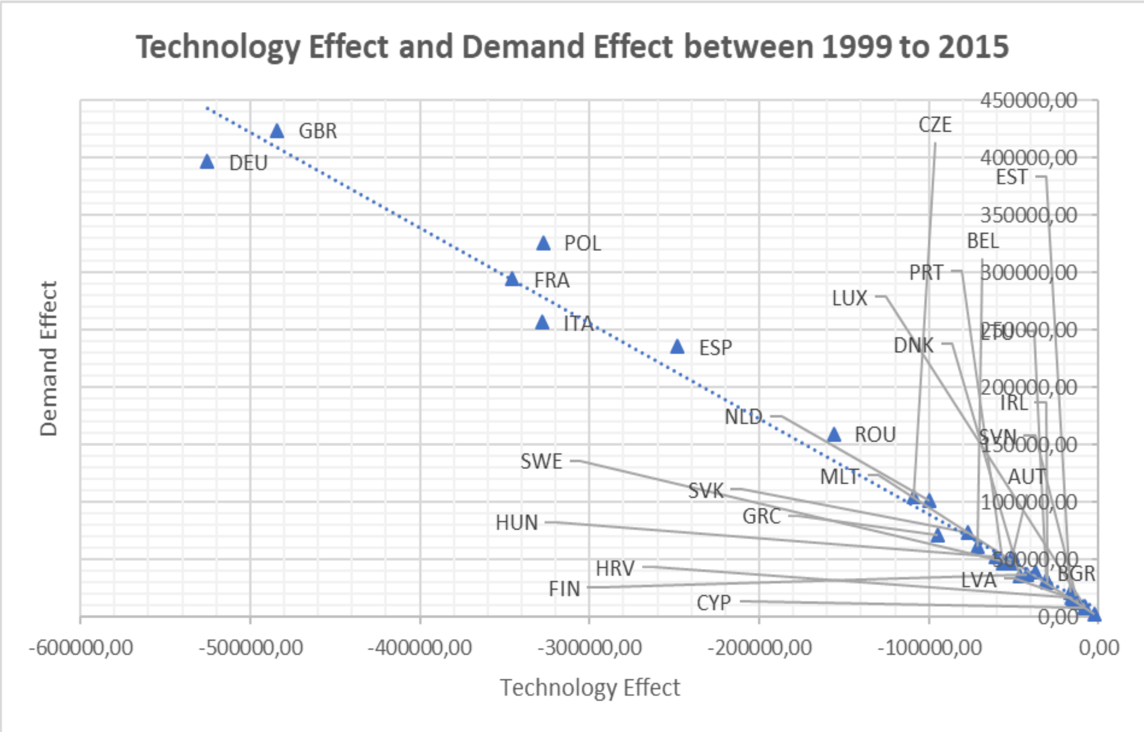
We've carried out a structural decomposition analysis, and we find the following results. Greece was the country with the biggest reduction of pollution associated to households' final demand (23.22 %), following by Denmark (21.80%). On the contrary, Estonia with almost 50%, was the most pollutant, in total terms. It was following by Luxembourg (26.02%) as we can see in ***Table 4***.

Table 4. The biggest reductions and increases of pollution in the European Union between 1999 to 2015

Countries with the biggest reduction	**Countries with the biggest increase**
Greece 23.22% Denmark 21.80% Hungry 19.38% Germany 18.97%	Estonia 52.48% Luxembourg 26.02%

We can see a relationship between demand effect and technologic effect in ***Figure 3.*** In this way, a bigger demand effect involves a lower intensity effect. In other words, a technologic improvement produces a reduction in the emissions by product. In this case, we can observe that the biggest reduction of technology effect, as the biggest increase of demand effect, took place in United Kingdom and in Germany. However, in both of them, the technology effect was so strong that it could overcome a positive effect of demand. So, finally it allowed to get a reduction in total effect of emissions. In the case of Spain, we can see that technology effect achieved a reduction of 250.000 Gg/thousands of $ leading to a reduction in total effect, in spite of the increase of demand effect (235.000 Gg/thousands of $).

Figure 3. Technology effect and demand effect between 1999 to 2015



4.2 Scenarios proposed

We proposed two possible scenarios. The first scenario studies the impacts of improvements in equity by reducing people from extremes groups. The second scenario analyses the effects of changes in the consumption pattern of households, through a reduction of transport use.

In the first, we analyse the effects of a greater distributive equity that could achieve after a fiscal policy that would lead to reduce expenditure in 30% of extremes households (low-income households and high-income households). The remaining consumption reduced is distributed in the middle-income groups. This allows us to approximate to the effects of a redistribution policy.

Table 5 shows the percentage of income in each income group after our simulation. Environmental results are shown in

Table 6.

Table 5. Income redistribution among different quintiles

	First Quintile	Second Quintile	Third Quintile	Fourth Quintile	Fifth Quintile
BELGIUM	-30.00%	18.35%	18.35%	18.35%	-30.00%
BULGARIA	-30.00%	25.33%	25.33%	25.33%	-30.00%
CZECH REPUBLIC	-30.00%	18.87%	18.87%	18.87%	-30.00%
DENMARK	-30.00%	18.86%	18.86%	18.86%	-30.00%
GERMANY	-30.00%	19.08%	19.08%	19.08%	-30.00%
ESTONIA	-30.00%	17.87%	17.87%	17.87%	-30.00%
IRELAND	-30.00%	18.43%	18.43%	18.43%	-30.00%
GREECE	-30.00%	23.90%	23.90%	23.90%	-30.00%
SPAIN	-30.00%	19.89%	19.89%	19.89%	-30.00%
FRANCE	-30.00%	19.29%	19.29%	19.29%	-30.00%
CROATIA	-30.00%	19.14%	19.14%	19.14%	-30.00%
ITALY	-30.00%	20.65%	20.65%	20.65%	-30.00%
CYPRUS	-30.00%	16.01%	16.01%	16.01%	-30.00%
LATVIA	-30.00%	18.72%	18.72%	18.72%	-30.00%
LITHUANIA	-30.00%	18.98%	18.98%	18.98%	-30.00%
LUXEMBOURG	-30.00%	18.56%	18.56%	18.56%	-30.00%
HUNGARY	-30.00%	19.13%	19.13%	19.13%	-30.00%
MALTA	-30.00%	19.19%	19.19%	19.19%	-30.00%
NETHERLANDS	-30.00%	19.06%	19.06%	19.06%	-30.00%
AUSTRIA	-30.00%	18.92%	18.92%	18.92%	-30.00%
POLAND	-30.00%	18.85%	18.85%	18.85%	-30.00%
PORTUGAL	-30.00%	19.97%	19.97%	19.97%	-30.00%
ROMANIA	-30.00%	19.69%	19.69%	19.69%	-30.00%
SLOVENIA	-30.00%	18.78%	18.78%	18.78%	-30.00%
SLOVAKIA	-30.00%	18.46%	18.46%	18.46%	-30.00%
FINLAND	-30.00%	18.80%	18.80%	18.80%	-30.00%
SWEDEN	-30.00%	18.03%	18.03%	18.03%	-30.00%
UNITED KINGDOM	-30.00%	18.22%	18.22%	18.22%	-30.00%

We can see that this type of polices could have a positive impact in countries like Italy, Estonia and Hungary, who present a bigger reduction in total emissions. On the contrary, we could find larger increases in countries like Greece, Bulgaria and Luxembourg**.** However, these reductions are lower than 1% in comparison with the baseline.

Table 6. Final change after reduction of 30% in extreme quintiles.

COUNTRIES	TOTAL	COUNTRIES	TOTAL
BELGIUM	-0.59%	**LITHUANIA**	-0.32%
BULGARIA	0.20%	**LUXEMBOURG**	0.04%
CZECH REPUBLIC	-0.56%	**HUNGARY**	-0.85%
DENMARK	-0.46%	**MALTA**	-0.58%
GERMANY	-0.59%	**NETHERLANDS**	-0.54%
ESTONIA	-0.93%	**AUSTRIA**	-0.30%
IRELAND	-0.42%	**POLAND**	-0.44%
GREECE	0.48%	**PORTUGAL**	-0.32%
SPAIN	-0.35%	**ROMANIA**	-0.73%
FRANCE	-0.68%	**SLOVENIA**	-0.65%
CROATIA	-0.86%	**SLOVAKIA**	-0.48%
ITALY	-0.95%	**FINLAND**	-0.19%
CYPRUS	-0.74%	**SWEDEN**	-0.35%
LATVIA	-0.49%	**UNITED KINGDOM**	-0.13%

In Spain, we could see that "Transport" sector was very important because of its reductions in first and fifth quintile (see ***Table 7***). However, that reduction was notable to beat the increase of emissions that were produced by the rest of quintiles in front of that new income distribution.

Table 7. Variation in Spanish "Transport" because of Scenario 1.

	First Quintile	Second Quintile	Third Quintile	Fourth Quintile	Fifth Quintile	Direct Total
Variation in Gg/thousands $	-1335.81	1044.85	1074.71	1233.92	-1891.15	126,52
Variation in %	-1055.77	825.81	849.41	975.24	-1494.69	

. Scenario 2 addresses a reduction of 60% of transport use. The aim of that politic is to reduce the emissions that this sector generates. In this way, as it is mentioned in the literature, the biggest reduction is expected in the fifth quintile. The new consumption structure is presented in

Table 8.

Table 8. Changes in each quintile due to transport's reduction.

	First Quintile	Second Quintile	Third Quintile	Fourth Quintile	Fifth Quintile
BELGIUM	-4.18%	-6.26%	-5.95%	-7.56%	-7.74%
BULGARIA	-1.89%	-3.89%	-5.84%	-7.78%	-7.31%
CZECH REPUBLIC	-1.41%	-2.69%	-3.84%	-4.89%	-5.95%
DENMARK	-1.52%	-2.00%	-2.45%	-2.87%	-3.20%
GERMANY	-3.52%	-4.88%	-5.22%	-6.35%	-7.60%
ESTONIA	-0.28%	-1.03%	-2.16%	-3.13%	-3.32%
IRELAND	-6.01%	-8.46%	-8.73%	-9.80%	-10.57%
GREECE	-5.26%	-6.70%	-7.49%	-9.40%	-10.54%
SPAIN	-5.87%	-6.82%	-6.98%	-7.84%	-7.83%
FRANCE	-6.06%	-7.69%	-8.59%	-9.40%	-9.33%
CROATIA	-4.31%	-5.37%	-7.88%	-8.04%	-7.62%
ITALY	-5.63%	-6.32%	-6.80%	-6.82%	-9.88%
CYPRUS	-5.48%	-5.37%	-6.52%	-5.80%	-6.66%
LATVIA	-1.94%	-3.73%	-5.31%	-6.43%	-8.30%
LITHUANIA	-2.32%	-3.38%	-3.99%	-4.51%	-6.53%
LUXEMBOURG	-9.12%	-8.99%	-9.16%	-10.81%	-9.13%
HUNGARY	-2.41%	-2.51%	-4.17%	-5.40%	-6.80%
MALTA	-5.54%	-6.11%	-7.26%	-7.75%	-9.05%
NETHERLANDS	-3.16%	-3.96%	-5.09%	-5.98%	-7.47%
AUSTRIA	-7.61%	-10.53%	-10.17%	-10.98%	-11.49%
POLAND	-2.69%	-3.15%	-3.99%	-4.89%	-5.85%
PORTUGAL	-5.01%	-6.89%	-8.16%	-8.51%	-8.69%
ROMANIA	-1.97%	-3.10%	-4.37%	-6.24%	-7.16%
SLOVENIA	-3.30%	-4.23%	-5.60%	-6.23%	-7.27%
SLOVAKIA	-2.58%	-4.21%	-5.94%	-6.56%	-8.20%
FINLAND	-5.42%	-6.35%	-6.42%	-6.47%	-7.72%
SWEDEN	-6.62%	-8.03%	-7.06%	-7.50%	-7.36%
UNITED KINGDOM	-5.48%	-7.16%	-8.31%	-9.53%	-10.39%

In all the countries, we can see that the biggest reduction in the majority of countries occurs in the fifth quintile (exception in Luxemburg, where we could find the same decrease in the first and fifth quintile). Results from this scenario are shown by country in Table 9. The biggest reduction could be observed in Austria with a reduction of

10.22% in comparison with the baseline, while it could be lower in Estonia where we could find the smallest reduction, with a change of 1.85%.

Table 9. Total change in each country because of transport's reduction

COUNTRIES	TOTAL	COUNTRIES	TOTAL
BELGIUM	-6.35%	**LITHUANIA**	-4.21%
BULGARIA	-5.65%	**LUXEMBOURG**	-9.44%
CZECH REPUBLIC	-3.70%	**HUNGARY**	-4.41%
DENMARK	-2.42%	**MALTA**	-7.23%
GERMANY	-5.54%	**NETHERLANDS**	-5.16%
ESTONIA	-1.85%	**AUSTRIA**	-10.22%
IRELAND	-8.75%	**POLAND**	-4.17%
GREECE	-7.96%	**PORTUGAL**	-7.53%
SPAIN	-7.10%	**ROMANIA**	-4.90%
FRANCE	-8.21%	**SLOVENIA**	-5.33%
CROATIA	-6.80%	**SLOVAKIA**	-5.53%
ITALY	-7.24%	**FINLAND**	-6.52%
CYPRUS	-5.96%	**SWEDEN**	-7.32%
LATVIA	-5.15%	**UNITED KINGDOM**	-8.29%

In Spain, we could see that "Food and Beverages" and "Hotels and Restaurants" sectors had increased their emissions, as we see in ***Table 10***.

Table 10. Top sector with biggest increase due to Scenario 2

	First Quintile	Second Quintile	Third Quintile	Fourth Quintile	Fifth Quintile	Direct Total
Transport Equipment	11,10	15,94	15,08	19,68	16,29	78,10
Textiles and Wearing Apparel	17,50	22,65	22,51	27,00	22,38	112,04
Retail Trade	32,45	38,32	33,12	35,21	23,74	162,85
Wholesale Trade	33,39	39,42	34,08	36,23	24,43	167,54
Education, Health and Other Services	25,79	37,31	39,02	42,56	40,46	185,15
Finacial Intermediation and Business Activities	43,52	26,47	48,72	55,36	112,76	286,82
Petroleum, Chemical and Non-Metallic Mineral Products	61,22	74,48	68,54	77,88	63,46	345,58
Hotels and Restraurants	43,08	71,20	78,26	102,37	95,21	390,12
Food & Beverages	87,14	94,82	79,20	84,92	58,42	404,50
Electricity, Gas and Water	125,95	140,14	122,08	128,96	98,71	615,84

5. CONCLUSIONS

The world is in an inflexion point because of the consequences of climate change. It is not just our way of producing, if not that our way of consuming too. Both of them, generate emissions that have their effect in the atmosphere, living beings, and, in consequence, in our health too. For this reason, it's necessary that we focus on both sides to try to reduce our emissions.

As we mentioned before, different income levels of households as lifestyles produce different levels of emissions. This is very relevant, because we need to take this into account in the moment when we propose a new politic. Following that, we have to considerer that consumption patterns of European Union countries are also different between them, and, in consequence, their emissions too. In this way, we found that the biggest reductions of emissions, in the period that has been analysed, were in countries of the Centre of Europe, while the biggest increases were in East Europe.

In our research, we found some premises that are claimed in the literature. For example, we can see that sectors related to food and "Electricity, Gas and Water" are more important in first quintile, in other words, in low-income households. On the contrary, as income increase, "Transport" or "Wood and Paper" are more relevant.

In this research, we proposed two possible scenarios for a sustainable path. However, we got small changes in comparison with the initial situation. The second scenario has had a bigger impact than the first. Nevertheless, demand policies are not enough. We need to combine demand politics with technological measures, as shown our results.

Finally, according our results, in the future, we could make technological policies and analyse the rebound effects of the politics. In addition, we could try to analyse price/expenditure elasticities and draw conclusions about that.

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