Impact Analysis of Tax Policy on Prices and Greenhouse Gas Emissions in Europe

Karmen Marguč
Echo, d.o.o., Slovenia

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Europe, emissions, energy taxes, energy market

Abstract

Producers and consumers are facing with higher taxes on energy, prescribed by European system for taxation of emissions. The positive effect of such taxes should be more effective energy use among European Union members, as well as lower rate of greenhouse gas emissions, what will slowly lead to presupposed Kyoto protocol demands. Not many empirical studies were carried out concerning the field of taxes on emissions in Europe. Most of them were based on theory, which propose political guidelines for such taxations in order to reduce greenhouse gas emissions.

Present article will analyze relation between greenhouse gas emissions and implicit energy tax rates with a purpose to examine the following hypothesis: on one hand, the impact of higher taxes on lower amount of emissions and on the other hand a relation between energy taxes and the following dependent variables: electricity and gas prices in households and industries and energy intensity in 27 European Union members for the period from 2001 to 2010.

Results show that we cannot confirm a relation between higher energy tax rates and amount of emissions, but we can confirm that higher energy taxes have influence on lower energy consumption and have influence on higher prices of natural gas in households and industries as well as on electricity prices in European Union members' households for the period from 2001 to 2010. Present research shows a part of Kuznets curve researches, which presupposes the influence of economy growth on the environment.

1 Introduction

In 1997, adopting the Kyoto Protocol, almost 200 countries participated to the first initiative of the international community to moderate the global warming (UNFCCC, 1998). Countries have agreed on unequal share of measures, which will contribute to 5% lower GHG concentration till 2012, in comparison with the year 1990. Important initiative of European Union is introduction of energy taxes and slightly higher prices of gas and electricity that will contribute to lower energy use and consequently to reduction of GHG emissions.

In the year 2011 a new tax scheme was presented in order to reduce fossil fuels consumption, which release more GHG emissions in the atmosphere, and to increase request for renewable sources (Council Directive 2003/96/EC). Results of econometric analyses (COMETR project) show that GHG emissions have reduced for approximately 3.1% in six European Union members in the period from 1990 to 2004. Success can be scored in Finland; emissions have reduced for 5.9%, which is a consequence of lower common fuel use (Andersen-Skou, 2010). The Netherlands (1996) and Slovenia (1997) have followed the guidelines mentioned above, few years later, in the late nineties Germany (1998) and Great Britain (2000) joined as well.

It is difficult to predict how higher energy tax rates, impact GHG emissions, energy use and GDP. Some researches show that introducing energy tax has an influence on higher gas and electricity prices in households and industries. The latter should be a consequence of more expensive production and supply operations which are assessed and also influence the consumers (Queensland Government, 2011). It is evident that European Commission intend to increase energy prices till 2030, which is a consequence of smart electricity network investments and improved technology that will assure more effective production, distribution and keeping of energy.

There are not many researches concerning the impact of energy tax on higher prices of electricity and gas. Therefore the purpose of this article is, besides empirical research of relation between GHG emissions and energy tax, to study correlation between energy tax and independent variables such as energy intensity, electricity and gas prices for households and industries in 27 European Union members for the period from 2001 to 2010.

Aims of the research are the following:

- Examination of the existing literature concerning influence of tax on energy and GHG emissions, to examine intensity of the electricity and prices of gas and electricity among European Union members.
- analysis of GHG emissions and energy taxes on one hand, and energy intensity, gas and electricity prices on the other hand, namely for EU 27 countries for the period from 2001 to 2010
- to prove or deny presupposed hypotheses
- Introduction of the key guidelines of imposing energy taxes in EU-27.

The study introduces the frame for forming such economy development, which will have a positive effect on environment as well as on development and competitive position of European Union members. The research supplements with a research of carbon dioxide emissions and energy use in developing countries and will all together represent data in the field of Kuznets curve.

2 Literature review and presupposed hypotheses

Transition of EU members to so called low carbon economy is reflecting in some indicators. In spite of all that, many countries stay in carbon intensive economies, which is a consequence of economy crisis. European Commission accedes to energy tax scheme in order to develop a simulation model of the economy, presupposed by various scenarios of emissions trading and its influence on economy growth and development of EU members (see Huntington and Weyant, 2002). In the beginning of implementing energy tax, Hoeller and Coppel (1992) maintained that energy tax, which includes carbon dioxide emissions tax, directly influence carbon dioxide emissions.

Various researches show that costs of imposing taxes on energy, with a purpose to fight against global warming, are dependent on existing prices of energy. Countries with higher prices of energy can demand higher absolute tax in comparison with those who have lower prices, for achieving measures and are therefore more effective (see Hoeller and Coppel, 1992).

Prices of marginal costs, which are a consequence of released emissions, are inter alia connected with prices of electricity and gas. After liberalization of the energy sector, have gas as well as electricity become goods which are traded every day, therefore there are present inconsistencies of prices. However, some questions about the relation between carbon prices or emissions still remain (see Eurostat, 2013a). While coal is worlds market commodity, which's dynamics is dependent on permission of carbon emissions in Europe (the largest consumers of coal are USA and China), dynamics of gas is more dependent on energy use (for example Great Britain, where electricity works create around 40% of electricity) (WBCSD, 2012).

Researches, studied in a frame of existing literature about gas prices, electricity and their connection with tax rate, are mostly based on theory or practice with distinctively specific orientation. Regarding the issue, of how to form the guidelines for reduction of GHG, I believe that relations between various policies of prices and energy use including influence on the concentration of GHG emissions should be studied.

2.1 Greenhouse gas emissions

In 2009 greenhouse gas emissions were 17.4% below the rates from 1990 in EU-27- net reduction was 974 million tons of CO_2 equivalent. Concentrations have decreased mostly in nineties, when emissions drop for 0.69% per year. After that period the amount of emissions have started to grow in the beginning of the year 2000, but changed in 2004 when there was a drop of GHG emissions till 2009. Reduction of emissions, which was reached during the period of 2000 and 2008, should be the result of more effective energy use and reflects the use of fuels with less carbon, according to European Commission. Due to lower carbon intensity, emissions drop irrespective of greater energy use and transportation. Likewise, less pollution with emissions is a reflection of responsible act in the field of agricultural sector, a bit less is a consequence of the usage of renewable sources (Queensland Government, 2011). On the other hand International Energy Agency attributes large reduction of emissions to economic crisis, because carbon dioxide emissions, concerning the energy, have increased in 2010 (IEA, 2011).

Despite the reduction of emissions till 2009, EU will struggle with difficulties to achieve the goals they set; reduction of GHG emissions for 80-95%, in comparison with the year 1990, till the year 2050. Nineteen European Union members have already achieved presupposed Kyoto protocol demands, namely EU-15 members have in the year 2009 decreased GHG emissions for approximately 12.7%; however emissions increased in other countries. Spain reached in 2009 the greatest level of emissions (27%). Some other countries reached similar level of emissions: Portugal (24%), Greece (14%) and Ireland (12%). The opposite trend was evident in Estonia (-60%), Latvia (-58%), Lithuania (-56%), Bulgaria (-55%) and Romania (-53%). In the year 2009, some of the countries which were on the list of the greatest causer of emissions manage to reduce them: Germany (for 25%), Great Britain (for 27%) and France (for 10%) regarding the base year. On the other hand Italy increased emissions for 5%. Despite the facts above it was evident that emissions all together drop in European Union countries between the year 2008 and 2009, what was partially the cause of economic crisis, which influence energy sectors and cement manufacturing (European Commission, 2012). GHG emissions in EU-27 for the year 2009 regarding 1990 are shown in figure 1.

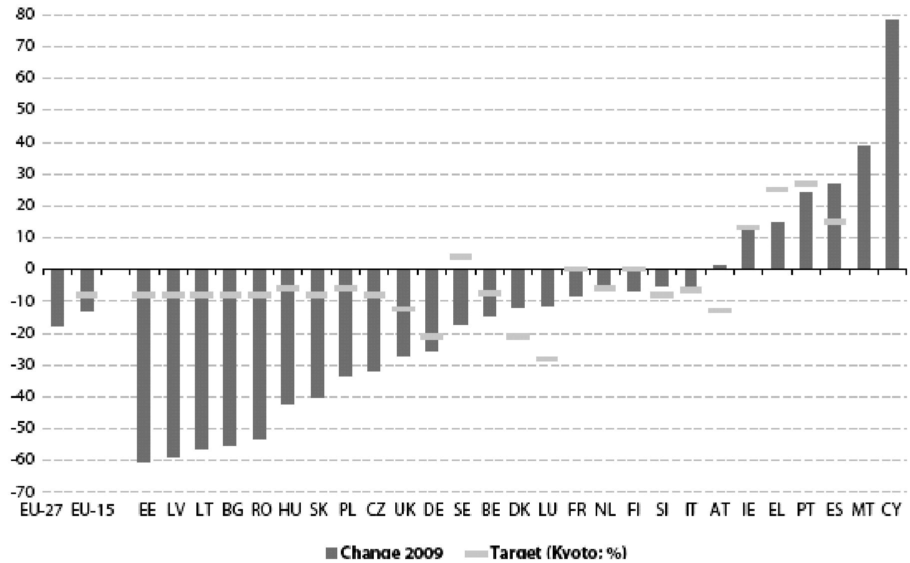

Figure 1: Changes of GHG emissions in EU-27 in the year 2009, regarding the base year 1990 (European Commission, 2012).

2.2 Implicit tax rate on energy use

Implicit tax rate on energy is an indicator of sustainable development, according to which, energy price should include all external costs arising from energy use. Such price will enable investment decisions and subject act, which consequently means the possibility to achieve sustainable development. The disadvantage of this indicator is the weight of "green" and fossil energy. Usually, stimulating the use of renewable sources leads to lower tax, which means that country with greater use of renewable sources has lower implicit tax rate on energy than country that mainly uses fossil fuels (UMAR, 2009). Indicator is comparable to EU members, which is why it will be used in a relation to GHG emissions, energy and gas prices.

Data concerning the tax rate on energy are available on Eurostat website, and are defined as a relation between energy tax and final energy consumption, i.e. implicit tax rate on energy. Petrol, oil, fuel oil and natural gas are usually assessed with such taxes. For the analytical purpose CO_2 tax is placed in the category of energy tax. According to other energy taxes for statistical purpose, CO_2 tax cannot be studied separately from these taxes (Council Directive, 2009).

Between the year 2000 and 2009 in EU-27 there was an evident trend of implicit tax rate drop (5.6%) per energy use (abr. ITR). The drop indicates less efficient energy tax according to potential tax base. The trend mentioned above, contradicts the guidelines of sustainable development in EU, which supports changes in the taxation of employees and energy use. In the period of 2000 and 2009 average ITR amounts to 28.8 EUR per toe in Romania and 291.4 toe in Germany. An ITR in most EU members was in the year 2000 low, but absolutely and relatively increased in 2009. ITR dropped only in the countries where the initial rate was higher. In Romania where ITR was 58.2 EUR/toe in year 2000 and decreased till 2009, reached the lowest rate 26.6 EUR/toe (Eurostat).

Most of the taxes on energy are taxed as a nominal amount per consumption unit; therefore inflation has influence on reduction of tax subscription, if taxes are not regularly adapted. As such, energy tax should decrease the need for energy use and increase the prices of energy. Therefore the increase of tax rate should decrease energy use and also GHG emissions. The relation between GHG emissions and energy use will be defined as a hypothesis H1.

H1: Higher implicit energy tax rate among EU members has an influence on lower concentrations of GHG.

Energy use is also influenced by electricity and gas prices; therefore the relation between energy use, electricity and gas prices in households and industries for EU-27 will be studied.

2.3 Energy intensity

Energy use has a great impact on the environment. Total energy intensity is a factor, which shows total energy intensity counted up as quotient of total energy intensity and GDP for single calendar year. It is expressed in toe/mio EUR (ARSO, 2009). In 2007, EU-25 needed 165 toe of primary energy, what is 3.7% less than a year before. Energy intensity is lower due to improved energy effectiveness, evaluation of energy use, economy and energy effectiveness (SURS, 2009). Comparison of intensity in 2007, counted up from GDP in standard purchasing power, shows that there are big differences in intensities of economies among EU members. The most energy effective country is Ireland, which uses almost three times less energy for the same GDP as Bulgaria does (ARSO, 2009). We have to take into consideration the fact, that higher GDP per capita, means lower energy intensity as seen in the case of Ireland and vice versa.

EU has in 2006 set the goal which leads to greater energy effectiveness and lower energy intensity. Action plan for energy effectiveness: EU will in 2020 save 20% in total of energy use. In order to achieve the goal, there are measures present in all the sectors of total use and transformations. Besides that, in April 2006 Directive 2006/32/ES was adopted, which contains the segments of effective total energy use and energy service, covers all the sectors of total use, with an exception of companies which are included in greenhouse gas emissions trading and to a certain degree also aviation industry, shipping and armed forces. Directive demands to set the goal which dictates that EU members should save 9% of baseline energy (average between the period from 2001-2005) in nine years (2008-2016). In order to achieve the goals, each EU member prepared an action plan for energy effectiveness for the period from 2008 to 2016 (Eurostat, 2013a).

2.4 Electricity and gas prices in households and industries

The indicator of energy price shows total prices of fuel, which reflect basic prices of fuel including all the tributes. Prices for the electricity energy are expressed in EUR/kWh, for natural gas in EUR/GJ, and for liquid fuels in EUR/l. Prices for electricity energy and natural gas show final prices of energy for typical groups of industrial and household customers (ARSO, 2012).

Usage of energy affects its production. The connection is not ambivalent concerning the country, because the opening of electricity market can assure electricity from whichever power station in Europe. The data concerning electricity energy use is a good indicator of burdening the environment with its production. Absolute level of prices and their movement have a great impact on total use of energy and have also an impact on the changes concerning versatile fuels request. The growth of prices is an initiative to reduce energy use by consumers, what consequently means less pollution. Relative changes of the energy prices, which can be interchanged from one to another, have an influence on the switch of fuels (ARSO, 2012).

The prices of electricity in medium large households for the second half of 2011 were the highest in Denmark, Germany and Cyprus. The lowest prices were present in Bulgaria, Estonia and Romania. In Denmark, price of electricity amounted to 0,298 EUR/kWh and were three times higher than in Bulgaria (0.087EUR/kWh). An average price in EU-27, regarding national consumption in 2010 for households, amounted to 0.184 EUR/kWh (Eurostat, 2012). The prices of electricity in industrial sector for the second half of 2010 were the highest on Cyprus, Malta and in Italy. An average price in EU-27 (determined, regarding national consumption in 2010 for industrial sector) amounted to 0.112 EUR/kWh (Eurostat, 2013b).

Gas prices have the most increased in Germany, in comparison with other EU members, namely for more than an average in EU-15. On one hand, the latter is a consequence of basic price rise, regarding average price in EU-15 and on the other hand because of higher taxation. In 1999 tax was almost the same as the rates in other EU-15, but now they are higher for about 80%. Basic gas prices and tax rates for EU-27 are seen in figure 4 (Verduin and Huurman, 2007). The lowest gas prices in households for 2011 were evident in Romania, Estonia and Latvia. The price of natural gas for households in Sweden amounts to (0.117 EUR/kWh) and was four times higher than in Romania (0.028 EUR/kWh). An average price in EU-27 (the price is determined regarding the national use in 2010 for households) is 0.064 EUR/kWh. The relative tax contribution was the lowest in Great Britain's households (4.8%). The greatest price rise among EU members in the second half year of 2010 and 2011 was evident in Great Britain (27%), Luxemburg (22%) and Belgium (21%) (Eurostat, 2013b).

Prices of gas in industries have mostly increased during second half year of 2011 in Denmark and Sweden (see figure 2). The lowest prices are evident in Romania, Great Britain and Estonia. An average price (determined regarding national consumption in 2010 for industrial sector) amounts to 0.038 EUR/kWh (Eurostat, 2013b).

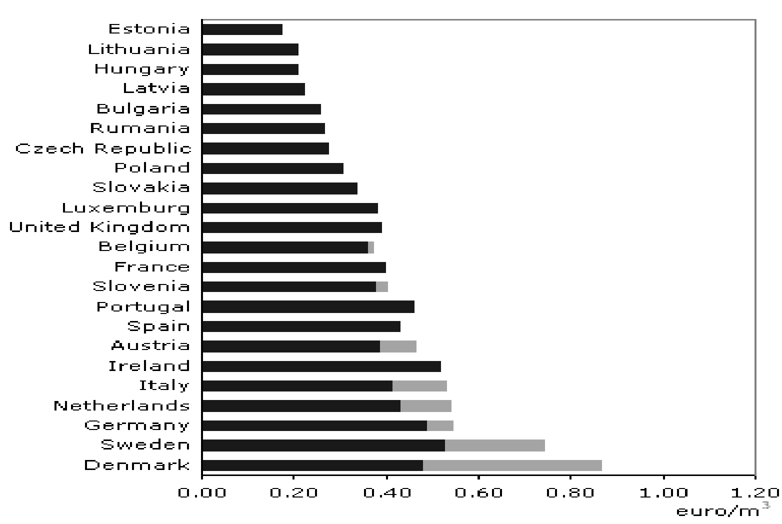

Figure 2: Basic gas price and tax for EU-27 on 1. January 2007 (Verduin and Huurman, 2007)

With a purpose to examine, whether implicit tax rate (dependent variable) is influenced by independent variables such as energy intensity, price of gas in industries and households, price of electricity in industries and households, the econometric research will be carried out in order to prove or deny H2.

H2: Implicit tax level is influenced by energy intensity, prices of gas in industries and households and prices of electricity in industries and households.

Hypotheses H1 and H2 are verified with the regression analysis and verification of regression sample 1 for hypothesis H1 and sample 2 for hypothesis H2.
Sample1: $EMIS = ß_1 + ß_2 * ITR + u$
Sample 2: $ITR = ß_1 + ß_2 * EI + ß_3 * PGI + ß_4 * PGH + ß_5 * PEI + ß_5 * PEH + u$

3 Sample and methodology

In the empirical research 27 European Union countries for the period from 2001 to 2010 were studied. Data were acquired from Eurostat website database. The following variables with specific marks were formed in order to test the hypotheses.

Hypothesis H1 will study the relation between greenhouse gas emissions and implicit tax rate of EU members for the period from 2001 to 2010 based on the following variables:
Dependent variable: greenhouse gas emissions (GHG), which mainly result from toxic gas emissions, such as CO_2.

Independent variable: implicit tax rate on energy (ITR) defined as quotient between total tax revenue from energy taxes and total energy use in single country. The variable is expressed in EUR tons per oil equivalent (EUR/TOE).

Hypothesis H2 studies the relation between implicit tax rate on energy and dependent variables: energy intensity, prices of electricity and gas in industries and households in EU members for the period from 2001 to 2010.

Independent variables:

Energy intensity (EI) that presents a relation between quantities of energy (total energy use) and GDP is expressed in constant prices (toe/mio EUR). Prices of natural gas in industry represent (PGI) are defined in a certain manner: an average price in EUR per GJ without taxes is defined regarding the first half of a year for the medium large industrial consumers (between 10.000 and 100.000 GJ). Until 2007, prices referred to the status of medium large consumers with an annual consumption of 41.860 GJ in 1st January every year.

Prices of gas in households (PGH) represent prices of natural gas for the final consumers. They are defined as an average national price in EUR per GJ, without taxes for the first half of a year in medium large households (between 20 and 200 GJ per year). Until 2007, prices referred to the status of medium large households with an annual consumption of 83.70 GJ.

Prices of electricity in industry (PEI) are defined as an annual national price in EUR per kWh without taxes for the first semester in every year, considering large industrial consumers with an annual consumption between 500 and 2000 kWh. Until 2007, prices referred to the status of medium large consumers with an annual consumption of 2.000 mWh in 1st January every year. Prices of electricity in households (PEH) represent the prices of electricity for the final consumers. For the households, the prices are defined as an average national price in EUR per kWh without taxes for the first semester of every year, considering medium large industrial consumers with an annual consumption between 2.500 and 5.000 kWh. Until 2007, prices referred to the status of medium large industrial companies with an annual consumption of 3.500 mWh.

Microsoft Excel was used to collect the data and Gretl32 was used to analyze and describe the statistical data. Afterwards, scatter plots were made and the outliers for the variables were searched. The regression analysis was used to check relations between single variables of both samples. A robust model was used to do the comparison between OLS and HAC model. Relation between variables is represented with scatter plots. In order to prove or deny the hypothesis multiple linear regressions is used. Results are presented as images and tables.

4 Results of the empirical research

The sample of EU-27 for the period from 2001 to 2010 did not contain the data for all researched years. Mostly the data for the year 2010 was missing; therefore we used data from the previous year. The extent of all the units is 270; they were acquired from the Eurostat's Statistics Database (2012). The following variables are described: greenhouse gas emissions, implicit tax rate on energy, energy intensity, prices of natural gas in industry and households and prices of electricity in industry and households.

4.1 Relations between the variables

Scatter plots are made for all the studied variables, in order to check hypotheses H1 and H2. The correlation between level of implicit tax rate and GHG emissions is positive, which was not presupposed when setting the hypothesis. All the independent variables PGI, PGH, PEI and PEH variables are in positive relation with ITR (for example see figure 3). The correlation coefficient of PEI and ITR is close to zero. The relation between ITR and EI variable is negative.

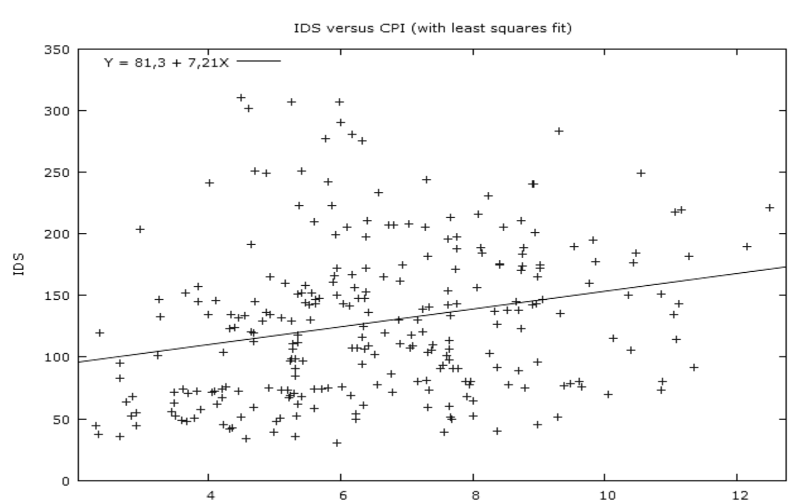

Figure 3: Scatter plots for ITR and PEI variables

4.4 Multiple linear regression

The null hypothesis presupposes that there is no relation between GHG and ITR variables for the period from 2001 to 2010. Also, the alternative hypothesis is set in order to present inequality between variables. The variables are checked with a following formula:

$GHG_{it} = ß_1 + ß_2 ITR_{it} + e_{it}$ $\quad i = 1, 2, \ldots, 27; \; t = 1, 2, \ldots, 10$

$H_0: ß_2 = 0$

$H_1: ß_2 \neq 0$

$\hat{}GHG = 4,05e{+}04 + 1,13e{+}03 * ITR$			
t	$(1,260)$	$(5,039)$	
p	$(0,009)$	$(0,000)$	
$n = 269$	$R^2 = 0,087$	$Adj\ R^2 = 0,083$	$se = 230290,5$

Figure 4: model of combined data (GHG and ITR variables)

According to data we can conclude, that energy tax rate is in a positive relation with amount of released GHG emissions. Statistically significant difference is below 1% what consequently means that the differences are not the case of coincidence, but a result of certain systematic process. A standard error amount to 0.087, the influence of tax rate on emissions is in a range between 2042.82 and 2492.86 with the best estimation of 1.130.

The result is statistically significant. According to data, we estimate that the partial regression coefficient is equal to 1130 what means that emissions in kt increase approximately for 1130 kt, if the tax rate increases for 1 percent point. A model for combining data explains 87% of the variance. P value of Whit's test amounts to 0,000 what means that the significance variance is homogeneous. Similar was presupposed for ITR, PGI, PGH, PEI, PEH and EI variables. The null hypothesis presupposes that there is no relation between ITR variable and independent PGI, PGH, PEI, PEH and EI variables.

$ITR_{it} = ß_1 + ß_2 EI_{it} + ß_3 PGI_{it} + ß_4 PGH_{it} + ß_5 PEI_{it} + ß_6 PEH_{it} + e_{it}$

$i = 1, 2, \ldots, 27; \; t = 1, 2, \ldots, 10$

$H_0: \quad ß_2 = 0$

$ß_3 = 0$

$ß_4 = 0$

$ß_5 = 0$

$ß_6 = 0$

H1: At least one of the assumptions is not valid.

Figure 5 shows a model of combined data (ITR, PGI, PGH, PEI, PEH and EI variables).

$$\hat{ITR} = 148 + 0{,}0771*EI + 2{,}76*PGI - 632*PGH + 438*PEI - 0{,}129*PEH$$

t	(8,714)	(0,041)	(2,083)	(-3,473)	(2,627)	(-8,372)
p	(0,000)	(0,037)	(0,038)	(0,000)	(0,009)	(0,000)
	n = 269	R^2 = 0,403	Adj R^2 = 0,391	*se* = 62,51		

Figure 5: Model of combined data (ITR, PGI, PGH, PEI and EI variables)

The growth of PGI, PGH and PEH is in a positive relation with ITR, while PEI and EI variables are in a negative correlation. The significance for PEI, PEH and EI variables amounts bellow 0.01, for PGH variable between 1 and 1.5% and for PGI above 10%. The null hypothesis is denied and the result is statistically significant. Based on the data collected, we estimate that natural gas prices in industry (EUR/GJ) increase for 0.0077 EUR/GJ if the tax rate for emissions increase for 1 percent point. Prices of the electricity in industries decrease for 0.063EUR/kWh, while prices in households increase for 0.044EUR/kWh if the tax rate increases for 1 percent point. When the tax rate increases for 1 percent point, energy intensity decreases for 129toe mio/EUR. Coefficient of determination amounts to 40.3% of variance. P-value of Whit's test amounts to 0.157, what shows that there is no significance. Variance is heterogeneous. Breusch-Pagan's test amounts to 0.533 the values of Hausman's test are 0.683, what show that there is no significance. Based on the results we can accept the null hypothesis and conclude that the variance is positive. The test of multicollinearity shows no difficulties in colinearity.

5 Discussions and conclusions

The statistical research of multiple linear regression and scatter plots do not prove presupposed hypothesis H1.

H1: Higher implicit level of energy tax rate among EU members, have an effect on lower concentrations of GHG.

Therefore we can conclude that higher energy tax rate does not have an influence on the reduction of GHG emissions in Europe. Regarding the latter, tax on emissions does not directly affect the reduction of emissions, but has an influence on lower energy use; therefore it would be recommendable to compare GHG emissions and energy use. The result of studied relation between implicit tax rate and energy intensity shows a positive correlation or in other words, when the tax rate is higher, energy use decrease, therefore it would be recommendable to answer the question whether lower energy use has an influence on lower GHG emissions in Europe.

Hypothesis H2 was proven on the basis of model for combining data with a statistical reliability. According to the data we estimate, that prices of gas and electricity in industries and households increase, if the implicit tax rate increases for 1 percent point, while prices for electricity in industries as well as electricity intensity decrease, if the tax rate increase for 1 percent point.

Based on the findings we can prove theoretical and empirical researches in the field of energy tax rate and energy prices; in this case natural gas in industrial sector and households, prices of energy in households, which are more expensive, if energy tax rate increases. We have also confirmed that higher tax rate and probably the higher prices of energy too, have an influence on lower energy use in EU-27. Interesting would be also to investigate, why energy prices in industry decrease in the case of higher energy tax rate.

6 Research limitations and direction for further research

The rate of tax on energy, which would optimal influence the reduction of GHG emissions as well as the reduction of global emissions, is difficult to solve. In the following researches more emphasis is going to be put on ethics, economy and ecology.

In order to meet the aims of European directives, accuracy and analysis of ethical elements according to the developed country is needed. On the basis of suchlike research, it will be possible to define discount rate of the future costs of global climate change, which represents the basis for determining taxes and prices of energy that cause the highest concentrations of GHG emissions. Only in such a way, it is possible to acquire an adequate tax rate and carbon cost, which will be based on ethical, environmental and economic elements.

While, the paper analyses only EU members, due to the limited data and critical aspect of tax and cost of energy, I believe that analysis for countries all over the world (if the data is available) is needed in order to solve the problem concerning GHG. The following researches need to be based on sustainable research, which will vary from country to country regarding the stage of development of the country. Therefore it would be necessary to check whether there is a negative relation between GHG and tax rates.

Problem concerning the appropriate tax rate and its effect on reduction of GHG emissions is difficult to solve as well as the problem concerning global reduction of emissions. In the future more effort in environmental, economic and ethic factors is needed in order to form the regulations against sudden global climate changes.

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