ENVIRONMENTAL EFFICIENCY OF STEEL INDUSTRY IN VISEGRAD FOUR COUNTRIES: A PANEL DATA APPROACH

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Abstract

European Union authorities effort to make the industrial companies to decrease the amount of CO_2 emissions produced. The main instrument of the EU environmental policy is emissions allowances trading. The main goal of this paper is to analyze the impact of the EU Emissions Trading Scheme (EU ETS) on the environmental efficiency in the national steel sectors. We define the efficiency as a share of CO_2 emissions released on the amount of steel products manufactured. The analysis is performed on the data of Visegrad Four (V4) countries. The results of the panel data analysis and the single regression proved the statistical significance of the emissions allowances allocated to each sector for free on the environmental efficiency.

Keywords: Emissions allowances, EU ETS, Visegrad countries, environmental efficiency, panel data

1. INTRODUCTION

Nowadays, the environment and its protection is frequently discussed topic as well as the mutual relationships between the environment and industry. On the one hand, the heavy industry is expected to have a substantial negative ecological impact. But, on the other hand, the policy-makers effort to make the industrial companies to decrease the pollution by using several legislative constraints. Such constraints are supposed to affect the efficiency in production processes of companies. The less pollution the less impact of those constraints. In the case of the EU, the main legislative constraint is the EU ETS system of carbon dioxide emissions trading whose aim is to decrease the amount of emissions produced by the participating companies.

In this contribution, factors of environmental efficiency are investigated. In particular, the aim is to assess the impact of the Emissions trading system on steel sectors of the Czech Republic, Slovakia, Poland and Hungary (i.e. Visegrad Four countries). There are more reasons for choosing the steel sector. Firstly it is one of the core sectors of heavy industry with a long tradition in the V4 countries. Secondly, it belongs to the sectors of the so called "carbon leakage" group, i.e. group of industries with particularly high amount of carbon dioxide emissions expected, see [1].

The current state of art analysis shows that this study is quite innovative. Many performed researches are focused on economic consequences of the emissions trading e.g. impact on product prices (see [2] or [3]) or impact on windfall profits of companies (see [4]). Most of those studies are devoted to energy sectors and the results are, said with exaggeration, very similar - the EU ETS has/can have a substantial effect on production prices as well as on profit of companies. Authors of [5] or [6] designed the optimization model regarding the impacts of the EU ETS on steel companies. The author of this paper have also presented similar research, but using the methods of multi criteria decision making PROMETHEE (see [7]) and Data envelopment analysis (see [8]). A very useful analysis has been presented by [9]. There, the impact of the EU ETS on companies using the analysis of firm level data has been investigated. The results have proved that, generally speaking, regardless the sector of industry, the EU ETS has the impact on companies and it can force them to reduce the emissions. However, that study has been done during the Phase II of the EU ETS and many changes in conditions and rules of the system have been carried out since that time.

Many different mathematical models and approaches have been used in the studies mentioned above. The most frequently used are different methods of econometric analysis (e.g. GARCH model) or mathematical programming (e.g. DEA methods, stochastic programming etc.). The interesting idea was to use some principles of the project management, see [10]. In this paper, the panel data (as in the case of [11]) and simple regression is used.

2. THE MODEL DESIGN

This chapter is split into two parts. The first one provides a list of variables/factors involved in the model together with the data sources. The second part is devoted to the structure of the model and also to the method used for the analysis.

2.1. The data

Due to the fact that all data on emissions are available only with annual periodicity, the analysis can be performed using the annual observations only. All the data have been aggregated from the Carbon Market Data database (available at www.carbonmarketdata.com) or the EUROSTAT database (available at http://ec.europa.eu/eurostat/data/database). Based on studies of [5], [9] and [11], following variables are considered in our model:

- *Production* - a total production of steel industry aggregated for one country, expressed in tons (source: the Carbon Market Data database)
- *Emissions* - a number of CO_2 emissions released per 1 ton of a product on average (source: the Carbon Market Data database).
- *Allowances* - a number of emissions allowances granted to companies in a sector for free, aggregated for one country expressed in pcs (source: the Carbon Market Data database). The grandfathering of allowances has often become the target of criticism. In the past, the free allowances caused not only lower costs of companies but also large windfall profits.
- *GDP* - Gross domestic product at market prices (chain linked volumes to 2010, million euro, source: EUROSTAT) divided by total population (measured on 1st January, source: EUROSTAT). An increase in GDP (i.e. the economic growth) implies the increase in the industrial activity and thereby in the demand for emissions allowances and in number of emissions produced. We assume that higher economic growth and increase in the industry demand can support investments in this field and helps also to develop new "cleaner" technologies. The economic growth makes the "cleaner" technologies more accessible for companies.
- *IR* - the 3-month money market interest rate (source: EUROSTAT). The new and "cleaner" technologies are much easier available when lower interest rates.

Except of the variables mentioned above, also other factors have been investigated like price of emissions allowances, net taxes, an amount of work in the steel industry, structure of the sector, wages in the steel industry or changes. But, none of those factors have been proved to be statistically significant.

2.2. The model

As we are investigating the impact of the EU Emissions Trading Scheme (EU ETS) on the environmental efficiency in the national steel sectors, firstly, we have to decide how to measure this environmental efficiency (1). We define this efficiency for country *i* at time *t* as a ratio of CO_2 emissions released per total production expressed in tons. This definition allows us to compare the environmental efficiency for different countries. The weak point of this is that the growth of effectiveness implies the growth of emissions produced per ton of production, hence practically the non-effectiveness. Thus the results should be interpreted carefully.

The time series of GDP, Effectiveness and Allowances were expressed in their growth rates due to its non-stationarity, see (2), (3) and (4). Because of a short length of the time series, the time series of Effectiveness could be considered as stationary. However, following the rules of the EU ETS system, amount of Allowances allocated to companies for free decreases by 5pp year by year. This should put pressure on companies' Effectiveness. A short term interest rate is transformed into its difference by (5).

$$Effectivness_{it} = Emissions_{it}/Production_{it} \tag{1}$$

$$growth\_effectivness_{it} = (Effectivness_{it} - Effectivness_{it-1})/Effectivness_{it-1} \tag{2}$$

$$growth\_allowances_{it} = (Allowances_{it} - Allowances_{it-1})/Allowances_{it-1} \tag{3}$$

$$growth\_gdp_{it} = (GDP_{it} - GDP_{it-1})/GDP_{it-1} \tag{4}$$

$$diff\_ir_{it} = IR_{it} - IR_{it-1} \tag{5}$$

We have estimated the regression model (M1) on the panel data, the simple ordinary least square (OLS) model with and without a constant term (M2) and (M3), respectively:

$$growth\_effectivness_{it} = \beta_0 + \beta_1 growth\_allowances_{it} + \beta_2 growth\_gdp_{it} + \beta_3 diff\_ir_{it} + u_{it}^P + \varepsilon_{it}^P \tag{M1}$$

$$growth\_effectivness_{it} = \beta_0 + \beta_1 growth\_allowances_{it} + \beta_2 growth\_gdp_{it} + \beta_3 diff\_ir_{it} + \varepsilon_{it}^P \tag{M2}$$

$$growth\_effectivness_{it} = \beta_1 growth\_allowances_{it} + \beta_2 growth\_gdp_{it} + \beta_3 diff\_ir_{it} + \varepsilon_{it}^P \tag{M3}$$

where $\beta_0, \beta_1, \beta_2, \beta_3$ are the model parameters, u_{it}^P expresses a between-entity error and ε_{it}^P within-entity error in the panel data regression and ε_{it} stands for the error term of OLS regression. All the error terms are assumed to be a white noise (i.e. non-correlated random variables with zero expected value and constant variance across the time).

3. THE RESULTS OF ESTIMATIONS

Firstly, we present the *Effectiveness* and its growth in each country in **Figure 1**. Each observation is depicted by the dot; the line connects the mean values of each country. We can observe that the lowest value (hence the "cleanest" one) production is achieved in Slovakia, the worst one in Hungary. The mean value of the growth of effectiveness is negative in the case of the Czech Republic (-0.019) and Slovakia (-0.011) which means that both countries have been decreasing their emissions per ton in time. In Poland, a value of this measure is negative but very close to zero, meanwhile in Hungary it is positive (0.011) implying the positive growth of emissions per ton of production in time. Based on the used data, we can conclude that the Czech Republic and Slovakia are also the countries with the lowest short term interest rate, thus the conditions for investment into "cleaner" technologies are better.

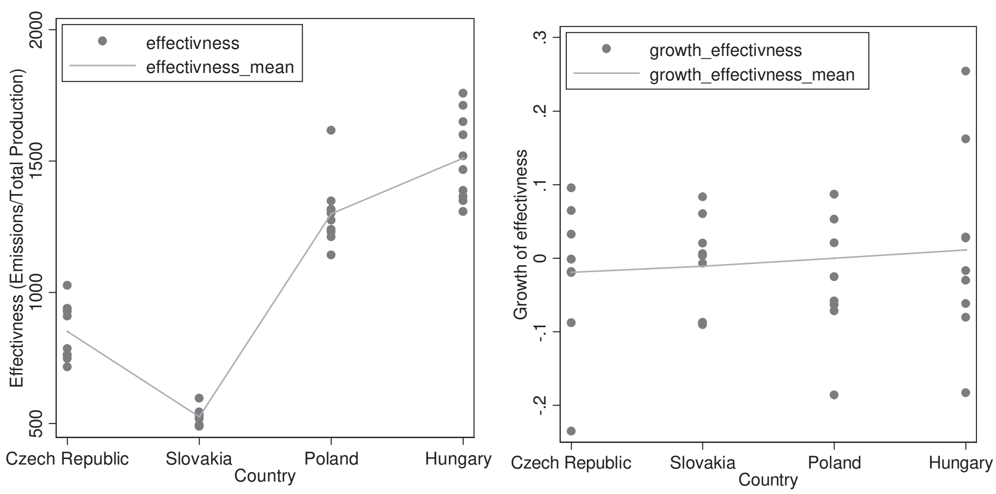

Figure 1 The effectiveness and its growth in V4 countries

The model was estimated with respect to panel character of the data by panel data approach with fixed and random effects. Hausman test (in [13]) rejected fixed effects in the model on the 5 % level of significance. However, the Breusch-Pagan Lagrange multiplier test (in [13]) did not reject the hypothesis that variances across entities (countries) are zero at 5 % level of significance, thus there is no need to take the panel effect into account).

Table 1 The estimation results

Variable	Random-effects GLS regression (M1)	OLS regression (M2)	OLS regression (M3)
growth_allowances	-0.232 (0.135) 0.085	-0.232 (0.135) 0.095	-0.269 (0.126) 0.041
growth_gdp	-1.090 (0.452) 0.016	-1.090 (0.452) 0.022	-0.877 (0.366) 0.022
diff_ir	0.024 (0.013) 0.060	0.024 (0.013) 0.069	0.021 (0.012) 0.095
constant	0.017 (0.021) 0.416	0.017 (0.021) 0.422	-
Observations	36	36	36
R^2		0.248	0.234
Adjusted R^2		0.178	0.165

The estimation by simple OLS regression has been done. As the constant term β_0 was not significant in both models even at the 10 % level of significance, the OLS estimation of the model without constant term has been done. The results of GLS regression with random effects and both OLS regressions are presented in **Table 1**. We have decided to present the results from all three models to show that the obtained results with and without controlling for panel effects are very similar. The OLS regression gives us the same estimations of the model parameters and their standard errors, but the *p*-values are different. According to the tests (following [13], [14] and [15]), the presence of multicollinearity, autocorrelation and also heteroscedasticity was rejected at the 5 % level of significance. At the same level of significance, we have rejected to omit additional explanatory variables. Hence, there was no need for robust or cluster estimations and simple OLS estimations were done. Because the time series for each country are short we could not estimate the same model for each country separately. All explanatory variables are significant at the 10 % level of significance. The Wald test for panel regression (in [13]) and *F*-test for OLS regression (in [14] and [15]) rejected the hypothesis that all the model parameters of explanatory variables are zero at the 5 % level of significance.

As we can see in **Table 1**, the estimation of β_1 representing the impact of growth of allowances on the growth of effectiveness is negative and around -0.23. This result suggests that the decrease in growth of allowances should imply the increase of growth of effectiveness. As the effectiveness is defined as the amount of emissions produced per ton of production, the speeding up the reduction of allowances allocated to companies can lead to increase in the growth of emissions produced per ton. Hence, the allocation of allowances and its policy can make a metal production to be environmental friendly more difficult.

The negative parameter of the growth of GDP per capita (around -1, see **Table 1**) signalizes that the increase in growth of GDP (mainly in the case of economic expansions) would have a negative effect on the growth of "effectiveness", e.g. slowing down the growth of emissions produced per ton of metal production. If we take into consideration that during the times of expansion the demand for production is growing, an increase in production would be accompanied by new higher investments and launching new technologies, targeting also the reduction of emissions, probably. On the contrary, the slowing down of GDP growth, observed generally in periods of contraction, should speed up the growth of emissions per ton of production.

The estimation of the parameter by the difference in interest rates is of value around 0.02. This implies that the decrease in interest rate would lead to increase in growth and also in "effectiveness" (e.g. the decrease in a growth of emissions produced per ton of metal production). The short term interest rate is the key factor for investment, hence with lower interest rate, the firm could reach lower costs on launching the new and more environmental friendly technologies.

4. CONCLUSIONS

The main goal of this paper was to evaluate the impact of the allocated allowances on the effectiveness in the metal production. The estimations from the panel data and OLS regressions of Visegrad four countries confirmed that the increase in growth of the GDP and decrease in interest rate lead to slowing down the growth of emissions per a ton of production in metal industry. However, the reduction in growth of allocated allowances would, in the line with the estimation results, support the increase in growth of emissions produced per ton of production (effectiveness). Hence, the tight allowance policy can lead not only to encourage companies to purchase environmental-friendlier technologies, but on the other hand it can also burden their investments because of the fact that their financial and economic situation cab get worse, unfortunately.

However, there are at least two main facts which has to be considered. Firstly, the data source for estimation is limited. The analysis has been performed on Visegrad four countries only and the time series for all countries were very short. In addition, the data from 2005 to 2014 were influenced by the economic crisis. Secondly, all EU ETS system's stakeholders still find their optimal behavior and strategy because emissions trading is still quite a new tool and its rules were not constant in the past.

Because of the above mentioned reasons, we definitely propose a deeper analysis of the impact of allowances on the production in metal industry. Also, the panel can be extended by more countries. This analysis will be the scope of our future work.

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