

ECONOMETRIC ANALYSIS OF INFLUENCING FACTORS OF EU EMISSION ALLOWANCES

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lucie.chytilova@vsb.cz***Abstract**

The aim of this paper is to analyze factors which influence the European Union Allowances spot prices. This involves also the strength of the dependency. Factors which were explored were as follows, prices of oil, gas, coal representing the most important sources for heavy industry and then other emission allowances types (like CERs). The method which was used for the mentioned analysis is the linear regression analysis. The research confirmed that the strongest relationship can be found between EUAs and CERs. Prices of coal and gas have the less influence on European emission permits price and price of oil even did not show the significant effect.

Keywords: regression analysis, EU ETS, allowances, EUA, CER

1. INTRODUCTION

The aim of this paper is to find out the strength of the influence of chosen factors on EUA permits' price development. EUA permit is a security which is used within the EU ETS (European Union Emissions trading system). The EU ETS was launched in 2004 and it covers all European companies with the combustion exceeding 420 MW capacity from following fields: electricity, coke, iron, steel, cement, lime, glass, ceramics, brick, tile, refinery, paper and pulp industries and aviation [1]. The principle of this system is that each tonne of CO₂ released to the atmosphere must be covered by one emission permit. This fact makes this article necessary for companies' production. The system is designed as a cap-and-trade system so the essential measure of the system is a price of allowances. Since the beginning of the EU ETS, it suffered from the over-allocation of permits. Because of too high amounts of free allocated permits to companies during the first two periods of the system (2004-2012), a factor of deficit did not occur for the vast majority of participating companies [2]. The lower price of permit the lower impact of the system on amount of released emissions and that of course leads to its lower efficiency. There were many attempts to increase emission prices artificially by legislative shocks - p. e. reduction of national allocation plans during the first and second period of the EU ETS (2004-2012), inclusion of aviation companies into the system by [3] in 2009), launching the new potential source where to purchase the allowances - emission auctions (2012), back loading (the removal of a part of total permits amount from secondary markets and auctions, 2013) or decreasing an amount of free allocated permits each year for companies (by [4], valid since 2013). Accept of the mentioned legislative shocks many of systematic factors exist.

The paper is organized as follows. After this introduction, the Chapter 2 is focused on the current state of researched area is outlined. The Chapter 3 devotes to the selection and description of influencing factors included in the analysis of this paper. Chapter 4 describes a brief review of applied method - the regression analysis. The key part of the paper is Chapter 5 where research hypotheses are set and then the regression analysis is used to assess the influence of chosen factors on emission permits and its strength. Stated hypotheses are then evaluated and results are discussed also in the same chapter. The final conclusion summarizes obtained results and it proposes possible future extensions of this study.

2. CURRENT STATE OF THE RESEARCHED AREA

Many researches have been already performed on topic of emission prices since the beginning of the EU ETS system. Some of them were focused on prices analysis and prediction. For these purposes were used both parametric and non-parametric methods - here can be mentioned for example [5] or [6] using the GARCH method or [7] or [8] using the ARIMA method and its variants. The result of these mentioned studies concluded that the prices of emission permits are nearly unpredictable with very frequent volatile price movements especially in the longer term. Unlike those researches, the aim of this paper is not to make the prediction of time series but just the find out some any important explanatory factors and their explanatory power. This research should be beneficial for companies which need to know factors influencing the permits price during a time period for which an amount of free allocated allowances is received - that means during the one year. Moreover the latest daily data will be used for the analyses.

3. A SELECTION AND DESCRIPTION OF EXPLANATORY FACTORS

A summary of the most important factors was presented p.e. by [2]. For purposes of this paper were chosen only the factors were daily data are available in order to find out which factors affect the emission price during one single stage of the EU ETS which is set at one year. Because of this reason the fuel prices and prices of alternative (non-European) permit are tested (in accordance with [2]).

With increasing price of fuels, increase of allowances price can be also expected. The reason is an emerging pressure on energy price growth [6] and [9]. The most widely used fuel types in a heavy industry are coal and oil (and they are also sources of high amount of released emissions by manufacturing process. The fuels which analyzed within this research are coal, oil and gas.

The main type of emission allowance introduced specially for the EU ETS system is the EUA (European Union Allowance). Accept of this main type, also allowances from some other emission trading systems can be used within the EU ETS - concretely the most used is CER (Certified Emission Reduction) presented within the worldwide system under the Kyoto protocol. It can be expected that influencing factors of emission price for all emission trading schemes are very similar. For this reason the positive relationship between EUAs and CERs is awaited.

4. A BRIEF REVIEW OF THE REGRESSION ANALYSIS

The regression analysis is a statistical tool for the investigation of relationships between variables. The usual goals of regression are prediction or control. Regression analysis gives an information about relationship between the chosen explained variable (denoted as Y) by filling in values for the explanatory variables (X) in an equation estimated from data. Regression analysis also offers a measure of the probable accuracy of its predictions. The use of regression analysis for control implies that it could be manipulated with one or more explanatory variables with the aim of changing the value of the explained variable.

The multiple regression model combines an equation relating the explained variable Y (a.k.a. the dependant variable) to a set of predictors (a.k.a. independent variables) X_1, X_2, \dots, X_k with a collection of supporting assumptions. The equation of the model describing n observation is

$$Y_t = \beta_0 + \beta_1 X_{1t} + \dots + \beta_k X_{kt} + u_t, \quad (1)$$

where β_i are the regression coefficients and u_t are random errors known as residua. Each independent variable X_i and dependent variable Y could be also involved in model in form of logarithm or difference.

The optimal multiple regression model describes a utopian data generating process. The more actual data resemble observations from such an optimal process the more reliable statistical results obtained (such as confidence or prediction intervals).

In addition to the assumed equation (1), the assumptions that complete this multiple regression model are following:

1. the independent variables X_1, X_2, \dots, X_k are non stochastic;
2. the random errors are normally distributed, i.e. $u_t \sim N(0; \sigma^2)$, that is the normality of residues;
3. the mean of random errors u_t is zero, i.e. $E(u_t) = 0$;
4. the variance of random errors u_t is constant, i.e. $Var(u_t) = \sigma^2$, that is the homoscedasticity;
5. the random errors u_t are uncorrelated, i.e. $Cov(u_i; u_j) = 0$ for $i \neq j$, that means that model is not autocorrelated;
6. independent variables X_1, X_2, \dots, X_k are collinear, i.e. there is no multicollinearity.

5. ANALYSIS OF INFLUENCE FACTORS OF EUA PRICE

This paper tries to model the relationship between the dependent variable - EUA and the independent variables – CER, oil, coal and gas. The data consisted of 1279 daily measurements between the years 2010 - 2013. All data come from the SendeCO2 European market (sendeco2.com).

5.1 The determination of hypotheses

As it was written in the introduction of the paper, the goal of the analysis is to find the dependency relationship between EUA price and price of chosen fuels (coal, oil and gas) and of alternative CER allowances. This relationship is expressed by equation (2).

$$EUA_t = \beta_0 + \beta_1 CER_t + \beta_2 oil_t + \beta_3 coal_t + \beta_4 gas_t + u_t \quad (2)$$

where β_i are the regression coefficients for each independent variable and u_t stands for random errors.

The analysis is also looking at the relationship between the dependent variable EUA and each independent variable. These relationships are taken from the economical interpretation and they are also shown in Figure 1.

On the basis of specified aim of the paper, research hypotheses can be determined. Figure 1 is showing plots of dependent and four independent variables. These scatter graphs help to specify relationships more precisely. These relationships are as follows $H_1: EUA = f^+(CER)$, $H_2: EUA = f^-(oil)$, $H_3: EUA = f^+(coal)$, $H_4: EUA = f^+(gas)$, where + sign means the positive dependency. It means that if the dependent variable EUA increases then the independent variables CER, gas and coal increase too. On the contrary, if EUA price decreases, a price of oil increases.

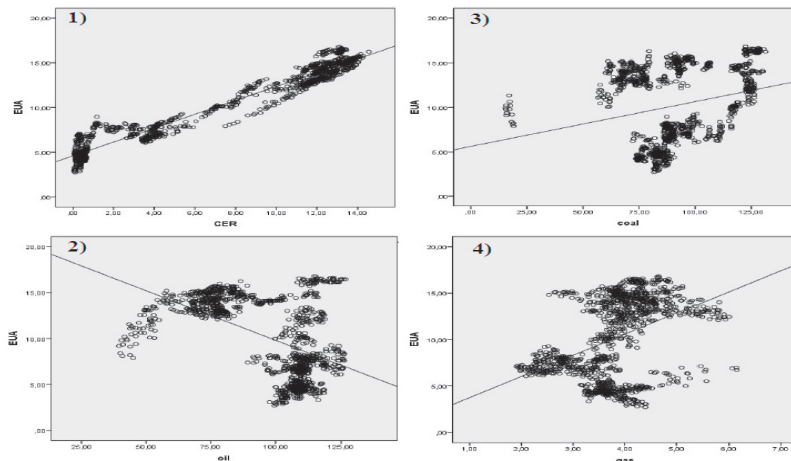


Fig. 1 The relationship of EUA and each independent variable (1. CER, 2. oil, 3. coal, 4. gas)

Table 1 Descriptive Statistics of input data

	N	Minimum	Maximum	Mean	Std. Deviation
EUA	1279	2.70	16.80	10.2031	4.19793
CER	1279	0.07	14.55	7.2377	5.27486
Oil	1279	39.54	126.65	96.3899	19.87725
Gas	1279	1.91	6.15	3.8343	0.76133
Coal	1279	15.50	131.25	90.9075	20.21181

Before the regression analysis began all involved time-series were analyzed. If it was necessary the time-series can be gently modified. At first, the descriptive statistics were examined (see Table 1). It is seen that there exist large differences between maximum and minimum. Also the standard deviation is large in all-time series. So there should be expected problems with stationary of these time series. This was also improved by testing the stationary by line graphs. Neither time series could be considered as stationary. However for further calculations were applied these time-series with the assumption that the regression analysis could be problematic. Furthermore, the analysis of remote and extreme outliers was done. Extreme outliers may make problems with calculation of regression analysis in further analyses. Extreme outliers were found only in time-series of coal and gas. These extreme values were removed and replaced by an average value of the particular time-series. The last preliminary analysis before the regression analysis was a correlation analysis between the dependent variable EUA and independent variable and the relationships between all independent variables. The correlation matrix is shown in the Table 2. The correlation matrix shows that the relationship between the dependent value EUA and all independent values are statistically significant at 5% significant level (as there are two ** next to the number). The strongest relationship is between EUA and CER. The value of coefficient is equal to 0.974. This means that CER contributes most to the explanatory of variable EUA. The price of coal is the less contributed value. The value is the weakest and it is equal to 0.243. Also the relationship between all independent values is shown in the correlation matrix. There is also no problem. Coefficients for these variables should be as smallest as possible and should not exceed a value of 0.8. All coefficients are in this case smaller then 0.8. It can be assumed that the model will not have problem with multicollinearity.

Table 2 Correlation matrix

	EUA	CER	Oil	Gas	Coal
EUA	1	0.974**	-0.511**	0.413**	0.243**
CER	0.974**	1	-0.615**	0.414**	0.138**
Oil	-0.511**	-0.615**	1	-0.353**	0.594**
Gas	0.413**	0.414**	-0.353**	1	-0.014
Coal	0.243**	0.138**	0.594**	-0.014	1

5.2 Regression analysis

The regression analysis of the model given by the equation (4.1) was performed by using the SPSS 21 software. The first estimation is shown by the equation (4.2)

$$EUA_t = 1.028 + 0.805CER_t + 0.019oil_t + 0.149coal_t + 0.01gas_t + u_t \quad (3)$$

All regression coefficients are statistically significant at the significance level 0.05. This was verified using the t-test for all the independent variables. Then, statistical significance of the whole model was tested by F-test (also on the level 0.05). The results of the F-test showed that the model is well specified, so there is no need to add other explanatory variables or to modify the model.

The coefficient of determination (R^2) indicates how well data points fit a statistical model. In this model the coefficient of determination is equal to 0.963. Simply, 96.3% of the dependent variable EUA is explained by the model (3). The econometric verification of the model was performed as well – all six conditions for using the regression analysis mentioned in the Chapter 4 were tested.

Autocorrelation was tested by using the graphical tests and Durbin-Watson test. Graphical analysis using the scatter chart showed positive autocorrelation. For another graphical analysis were used ACF and PACF graphs. According to the PACF chart the autocorrelation of the 1st order was identified. This result was confirmed also by the Durbin-Watson test (DW coefficient equal to 0.055). Authors tried to decrease this autocorrelation by several methods – by adding the trend, by adding the delayed dependent variable EUA and by using the Cochran-Orcutt method. But all mentioned attempts to reduce the autocorrelation was either unsuccessful it was accompanied also by a large decline of the R^2 coefficient. That is the reason why it was considered that no additional transformations in order to reduce the autocorrelation were done. Therefore, the unchanged model was further analyzed. However, for future needs is important to keep in mind that the estimation of the regression coefficients could be unbiased and with no minimum variance. That means that they could be distorted. Also the statistical verification of individual variables and whole model could be inaccurate.

The heteroscedasticity was tested by both - graphical analysis (scatter graphs of squared residua) and White's test. Both variants have demonstrated that there is a quadratic heteroscedasticity in the model. The weighted least-squares method was applied to decrease the undesirable heteroscedasticity but the result was similar to attempts to remove an autocorrelation – a heteroscedasticity persisted and the R^2 coefficient dropped.

Multicollinearity was tested with help of correlation matrix (see Table 2). All relationships between independent variables have Pearson's coefficient smaller than 0.8 so it can be said that there is no problem with multicollinearity between independent variables.

Last of all, normality of residues was tested. The graphic methods – Q-Q plots, P-P-plot and histograms gave satisfactory results which were also support by using the Kolmogorov-Smirnov test.

5.3 Results and their discussion

The result of the regression analysis is model (4.2), which describes the relationship between dependent variable (EUA price) and independent variables (CER, oil, coal and gas prices). The high coefficient of determination indicates the high suitability of the model. The problems of the model are especially revealed autocorrelation and heteroscedasticity which can lead to lower accuracy of determined model coefficients. Because of the fact that results of the model are not further used for predictions, mentioned problems are acceptable. Furthermore, there were not indicated any problem with normality and multicollinearity.

Three of four hypotheses were confirmed (positive dependency between EUA price and prices CER, coal and gas). On the contrary, positive influence of oil price on EUA price was not proved.

CONCLUSION

The performed research confirmed results of existing studies that European emission permits price is influenced by fuel prices influence the as well as by CER type of allowances. The surprising result is that not all the fossil sources of energy have a significant effect – as it was proven for the case of oil. Exhibited dependency was also supported by using the daily data for all variables and these data were up-to-date as much as possible. Because of the high EUA price volatility and many other affecting factors including also a both legislative and external market shocks, the designed model is not too suitable to do some predictions, especially predictions for a longer period.

The study can be further extended by adding other explanatory factors or by prolonging examined time-series. Another possibility could be the distinguishing between the several types of financial instruments (accept of included spots derivatives can be analyzed). It is also possible to use any other method of dependency testing.

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