MANAGEMENT OF EMISSIONS PERMITS: THREATS OF THE EUROPEAN EMISSIONS TRADING SYSTEM

Frantisek Zapletal, Jan Ministr, Petr Řeháček

Abstract: *Since the beginning of the millennium, heavy industrial companies in the EU must face the threat related to duty of emissions trading. The aim of this paper is to assess an impact of selected indicators of the emissions trading system (EU ETS) – number of grandfathered permits (allowances) to a company for free and emissions price for different type of permits. That is enabled by the parameterization and sensitivity analysis of the simple linear programming model which maximizes the total profit margin of the company. Analyses in this paper are performed using the data of one real iron and steel producing company in the Czech Republic. The influence of the chosen factors is explored for the second and the available part of the third trading phase of the EU ETS.*

Keywords: *EU ETS; risk management; European Union Allowance; linear programming*

JEL Classification: *C44, C61.*

Introduction

The aim of this paper is to analyze an influence of selected factors of the European emissions trading system (EU ETS) on profit of participating companies. Companies must face many constraints on their production. Except of traditional economical and legislative restrictions, European industrial companies are also affected by legislative constraints protecting the environment. Thus, decision-making on production of these companies is influenced by environmental factors headed by carbon emissions trading. All analyses will be performed for companies of so called carbon leakage sector. This sector involves selected industrial branches where an amount of emissions released to the atmosphere is extra large. This sector was established by (Directive EU, 2009). It is not necessary to involve also other companies to analysis of influence of an amount of freely allocated permits by the EU because these remaining installations either do not currently get any such free allowances or at least it will be so in very short term. An influence of emission permit price is the same for both carbon leakage company and non-carbon leakage company. All the analysis is performed using data of one Czech steel company. The steel sector is also involved in the carbon leakage sector, see (Directive EU, 2009).

Emissions trading within the European Union is a frequent object of many researches but most of them have analysed EU ETS' factors only as a whole (e.g. system efficiency analysis, econometrical analysis for forecasting the price of allowances etc.) and only few of them investigate their influence on companies. Some optimization models maximizing companies' outputs with respect to the EU ETS have been already designed, see e.g. (Rong and Landhelma, 2007; Tang and Song, 2012; Zapletal and Němec, 2012; Zapletal, 2014; Zhang and Xu, 2013). One of them (Zhang and Xu, 2013) is also used for analyses in this paper. The main benefit of this paper is the complex assessment of the EU ETS' influencing factors for the whole EU ETS system's lifetime till September 2014 (more recent data are not available for free).

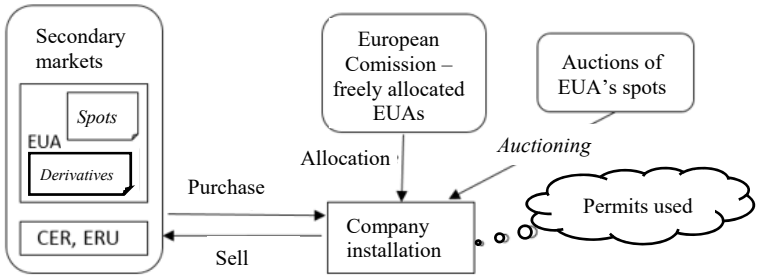
The paper is organized as follows. After this short introduction, Chapter 1 containing basic principles of the EU ETS system follows. Legislative background and links between the system and companies are presented there briefly. Chapter 2 consists of the optimization model design and basic data on researched parameters of the EU ETS and their descriptive statistics. Results of the performed analysis and their critical discussion can be found in the Chapter 3. Finally, the paper is ended by conclusions and suggestions for future possible research topics related with this paper.

1 Emissions trading Scheme of the EU (EU ETS)

The EU ETS is the main tool of the EU's environmental policy which has been established in 2005 by (Directive EU, 2003). The core idea of the system is that each ton of the CO_2 released to the atmosphere by a company must be covered by one emission permit. That means that increase in production leads to increase in profit but, on the other hand, it will also cause an increase in need of emission allowances and thus increase in costs. Currently, the EU ETS involves more than 12 000 industrial installations inside the EU. A lifetime of the EU ETS is divided into phases – phase 1 (2005-2007), phase 2 (3018-2012) and current phase 3 (2013-2020). Conditions of emissions trading have been changing gradually, see e.g. (Zapletal and Moravcová, 2013).

Emission permit flows between a company and its environment are illustrated in Fig. 1.

Fig. 1: Emission permit flows between a company and its environment



Source: authors

In Fig. 1, it can be seen that three possible sources of allowances exist for companies. The main source for companies from the already mentioned carbon leakage sector is a flow of freely allocated permits by the European Commission. Other two flows are common for all the companies in the EU ETS – additional permits can be purchased either on a secondary market or via emissions auctions for a market price. On the other hand, only one possibility to sell unused permits is accessible for all the companies – secondary market where permits are traded. All flows mentioned above refer to two main conditions affecting companies – market price of allowances and an amount of allowances granted to companies for free. These two parameters of the system are analysed further.

Allowances of the EUA type (European Union Allowance) in the form of a spot are the basic and the most traded financial instrument of the EU ETS system. Above that, derivatives of EUAs also exist, but they are of interest rather for speculators on the financial market. Except of EUA's, companies can also use allowances which have their origin in the Kyoto worldwide emissions trading system – CER's (Certified Emission

Reduction). These CER's are highly beneficial for European companies because their price is much cheaper than in case of EUAs. The EU has come with 10% quota for using CER's by European companies to prevent companies from over-using CER's which would lead to EUA's price drop, see (Directive EU, 2003).

The secondary market has been allowed to use since the very beginning of the EU ETS system in 2005. It consists of many stock exchanges all around Europe (e.g. SendeCO2 in Spain, EEX in Germany, ICE in Great Britain etc.). Analysis of EUA allowance price dependency among various stock exchanges was performed in (Zapletal and Moravcová, 2013) Almost perfect correlation (with the correlation coefficient greater than 99%) was proven there. That is why only prices from one chosen stock exchange (SendeCO2) where used for the analysis in this paper because this stock exchange (as one of few) enables also CER's trading.

Emissions auction is a new channel for purchasing the permits launched in 2013 (Directive EU, 2009). The reason for this change was the fact that conditions for allowances allocation had been changed for the third phase of the EU ETS system. The already mentioned research (Zapletal and Moravcová, 2013) proved that almost perfect correlation between prices at auctions and prices on the secondary market exists (with correlation coefficient exceeding 99%). That is why a possibility of emissions auctioning is not included in following analyses.

2 Optimization model and input data

In this chapter, the optimization model together with input data from the EU ETS system on allowance prices for further analyses are presented.

2.1 Optimization model maximizing the total profit of a company

The following deterministic optimization model is an aggregation of the models presented in (Zapletal and Němec, 2012) and (Zapletal, 2014). The model is deterministic like the one in (Zapletal and Němec, 2012), on the other hand it enables using the CER type of allowances like the one in (Zapletal, 2014).

Model presumptions are as follows:

- all the model parameters are considered to be deterministic;
- model is static, for only one period;
- decision is made at the beginning of the period and it cannot be changed further;
- the company always chooses a possibility of using the greatest possible amount of CER's (i.e. 10%) to cover its emissions.

The last presumption is supported by the fact that EUA's have never been cheaper than CER's so far. Currently, CER's are more than fifty times cheaper.

$$\max_{\boldsymbol{x},\boldsymbol{y}}\{\boldsymbol{m}^T\boldsymbol{y} + (r - 0.9 \cdot \boldsymbol{e}^T\boldsymbol{x}) \cdot p^{EUA} - 0.1 \cdot \boldsymbol{e}^T\boldsymbol{x} \cdot p^{CER} - c\},$$

$$\text{s. t.} \quad \boldsymbol{y} = (\mathbf{E} - \mathbf{A})\boldsymbol{x},$$
$$\boldsymbol{d}^c \leq \boldsymbol{y} \leq \boldsymbol{d}^e,$$
$$\boldsymbol{x} \leq \boldsymbol{v},$$
$$\boldsymbol{x} \geq 0, \boldsymbol{y} \geq 0,$$

where:

$\boldsymbol{y} \in \mathrm{R}^n$ is a vector of product sales;
$\boldsymbol{x} \in \mathrm{R}^n$ is a vector of company's production;
$\boldsymbol{e} \in \mathrm{R}^n$ is a vector of carbon coefficients indicating an amount of CO2 released by production of a one unit of a particular product;
p^{EUA} is a price of the EUA allowance type;
p^{CER} is a price of the CER allowance type;
r is an amount of emissions permits granted to company for free;
$\boldsymbol{m} \in \mathrm{R}^n$ is a vector of company's margins;
c stands for total fixed costs of a company;
$\mathbf{E} \in \mathrm{R}^{n \times n}$ is a unit matrix;
$\mathbf{A} \in \mathrm{R}^{n \times n}$ is a matrix of technical emissions coefficients of a production;
$\boldsymbol{d}^c \in \mathrm{R}^n$ is a vector of lower bounds for sales (given by already signed contracts);
$\boldsymbol{d}^e \in \mathrm{R}^n$ is a vector of expected demands for the investigated period;
$\boldsymbol{v} \in \mathrm{R}^n$ is a vector of company's production capacities.

The reduction of model variables would be possible by substituting of *y* by *x* (in accordance with the first model constraint). The provided form was chosen in order to keep the clarity of the model. Fixed cost (*c*) is not dependent on any model variable and thus it does not affect the result of optimization. Therefore, it would be possible to optimize the model excluding *c* and then to decrease the optimal value by the value of fixed costs in the end.

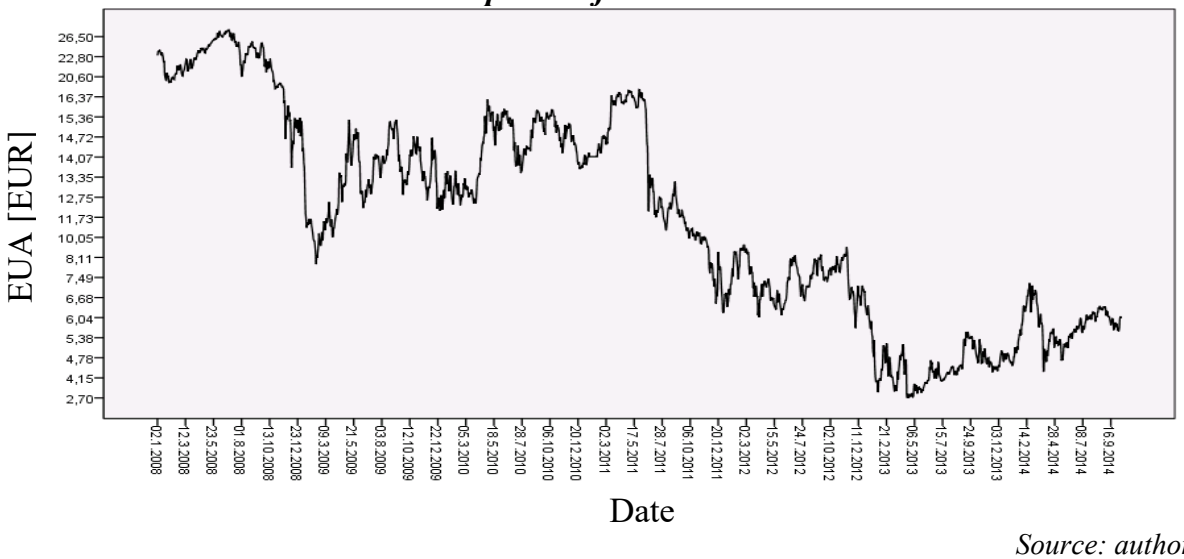
2.2 Input data for analyses

To be able to perform the analysis declared in the introduction of this paper, many data are required like the data of some real industrial company on its production and data related with the EU ETS system (amounts of freely allocated allowances and allowance prices). Fig. 2 and Fig. 3 show a development of EUA's and CER's, respectively. In Fig. 4, it can be seen a development of amounts of allowances granted for free to the modelled company from the beginning of the EU ETS system (2005) till the end of the third phase of the system (in 2020). Basic descriptive statistics of the data sets mentioned above can be found in Tabs 1a-1c and 2. Many changes in EU ETS' conditions were realised between the second and the third phase so these statistics are also shown separately for these periods (the second phase is shown in Tab. 1b and the third phase in Tab. 1c). All the data were aggregated from the Spanish stock exchange SendeCO2[1]. Data on amounts of freely allocated allowances were gained from the CarbonMarketData database[2].

[1] Sendeco2.com

[2] www.carbonmarketdata.com

Fig. 2: EUA price development on the SendeCO2 stock exchange in the second and third phase of the EU ETS



Source: authors

Fig. 3: CER price development on the SendeCO2 stock exchange in the second and third phase of the EU ETS

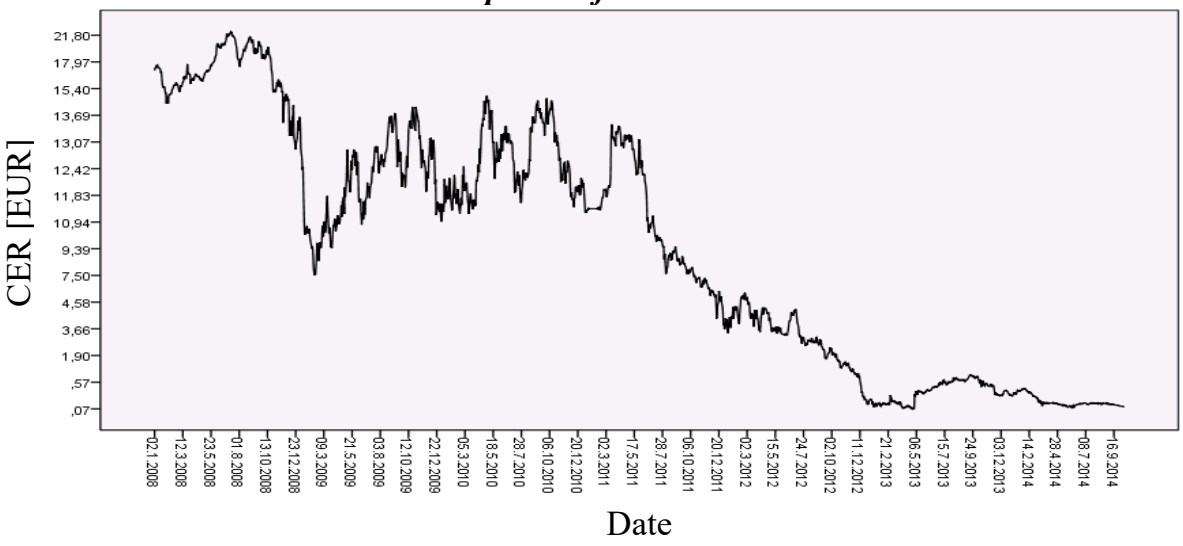


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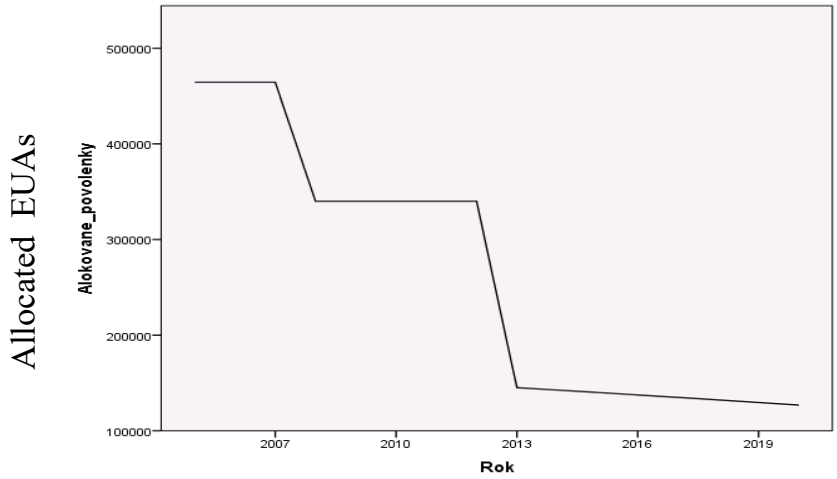
Fig. 4: Development of freely allocated amount of EUAs to the modelled company (2005-2014)



Source: authors

The main difference between prices and these amounts is the fact that amounts are determined directly by the central authority and prices are determined by the market. That is why data till the end of the third phase of the EU ETS are already known.

All the outputs mentioned above were processed using the SPSS 22 software.

The data on the modelled company were provided by one steel company in the Czech Republic. This company requires to be kept in anonymity because of the data privacy. However, this fact does not influence results of the analysis.

Tab. 1a: Descriptive statistics of allowance prices in the second and third EU ETS phases

	Observations	Range	Min	Max	Mean	Standard deviation
EUA	1721	25.60	2.70	28.3	11.57	5.965
CER	1721	22.53	0.07	22.6	8.16	6.412

Source: authors

Tab. 2b: Descriptive statistics of allowance prices in the second EU ETS phase

	Observations	Range	Min	Max	Mean	Standard deviation
EUA	1266	22.57	5.73	28.3	13.92	5.206
CER	1266	22.45	0.15	22.6	10.98	5.074

Source: authors

Tab. 3c: Descriptive statistics of allowance prices in the third EU ETS phase

	Observations	Range	Min	Max	Mean	Standard deviation
EUA	455	4.42	2.70	7.12	5.02	0.904
CER	455	0.65	0.07	0.72	0.31	0.181

Source: authors

Tab. 2: Descriptive statistics of amounts of allowances granted to the modelled company for free

	Observation	Min	Max	Mean	Standard dev.
Granted EUA	16	12688	46450	261386.2	136764.008

Source: authors

3 Model verification and sensitivity analysis

Results of the optimization are shown in Tab. 3. It can be seen that the modelled company is currently in loss of about 4 mil. EUR where about 10% of this loss is caused by the emissions trading. These results correspond to values of input parameters current in September 2014 (EUA price equals to 6.2 EUR, CER price equals to 0.56 EUR and 145,098 permits granted to the company for free.

Now, sensitivity analyses of obtained results will be performed when the input data change in a range of historical data shown in Tabs. 1a-1c and 2.

A sensitivity analysis was performed using the parametrization in the MS Excel 2013 software.

Tab. 3: Results of the steel company's profit optimization

		V1	V2	V3	V4	V5
[tons]	Production	431451.3	576840.5	665365.6	120000	30000
[tons]	Sales	0	12000	620545.6	120000	30000
[EUR]	Objective function optimum:		-4013185	Costs induced by allowances:		-406903
[EUR]	Optimal value excluding fixed costs:			47638910.05		

Source: authors

As mentioned above, conditions of the EU ETS system have been changing very quickly during its phases which influenced a development of both analysed parameters – price of emissions permits and amounts of freely allocated permits to companies. That is why these factors are both analysed further for each phase individually and for the second and third phase together.

Figures 6a-8 show the results of the optimization. All these figures contain the visualization of dependency of optimal profit ("%UF" curve) and costs given by emissions trading on a change of chosen parameter (value ranges of parameters were determined on the base of value range from previous periods. In order to keep higher clarity of the figures, values of dependent variables are given in percentage change in comparison with the current state (the current state is indicated by dotted vertical lines). Mean values of probability distributions (μ) of explanatory variables are indicated by dashed vertical lines. Borders of blue rectangles correspond to bounds of intervals $[\mu - \sigma; \mu + \sigma]$, where σ stands for a standard deviation.

Figures 6a-6c show an influence of changes in EUA prices (Fig. 6a for values of parameters according to the variation range in the second and third EU ETS phase together, Fig. 6b for values of the second phase only and Fig. 6c of the third phase only).

Figures 7a-7c present an influence of changes in CER prices (Fig. 7a for values of parameters according to the variation range in the second and third EU ETS phase together, Fig. 7b for values of the second phase only and Fig. 7c of the third phase only). Finally, Fig. 8 demonstrates an influence of freely allocated allowances to the modelled company on the profit of this company.

Fig. 6a: Influence of EUA prices in the second and third EU ETS phase on chosen measures of the modelled company

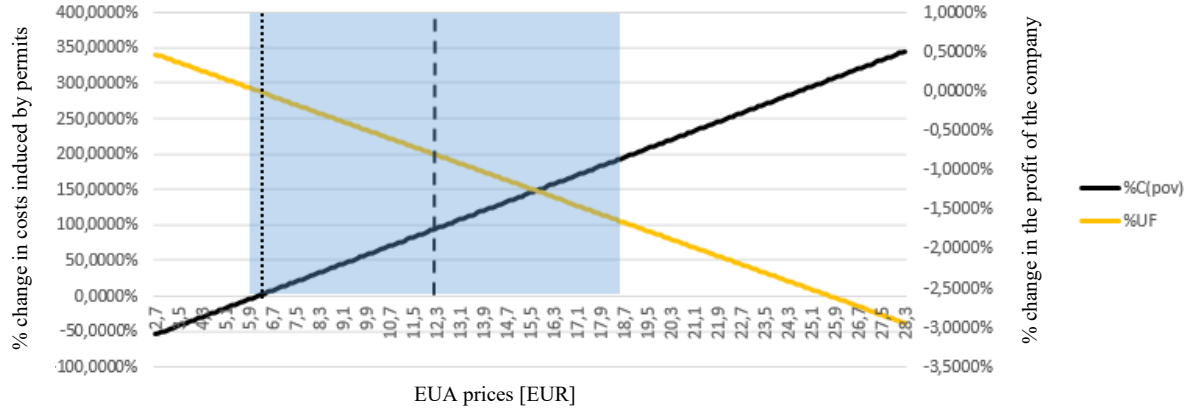


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Fig. 6b: Influence of EUA prices in the second EU ETS phase on chosen measures of the modelled company

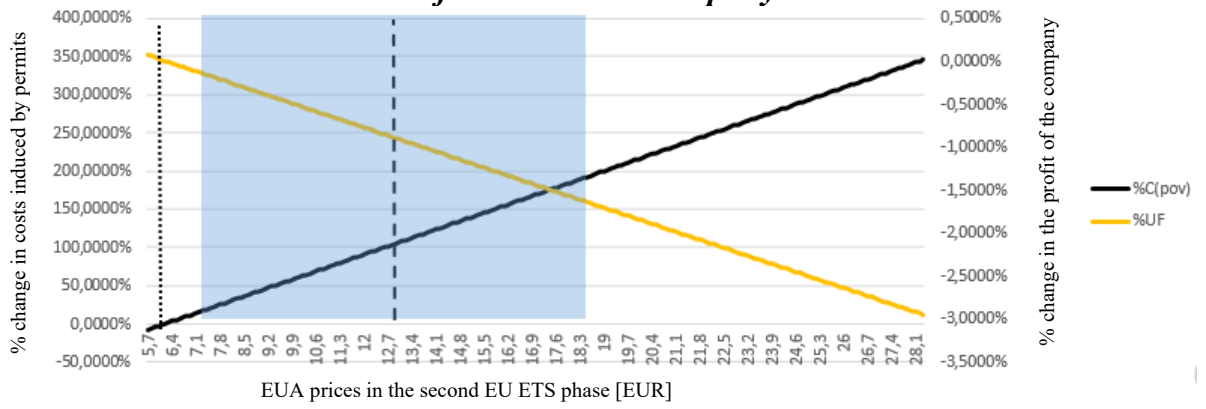

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Fig. 6c: Influence of EUA prices in the third EU ETS phase on chosen measures of the modelled company

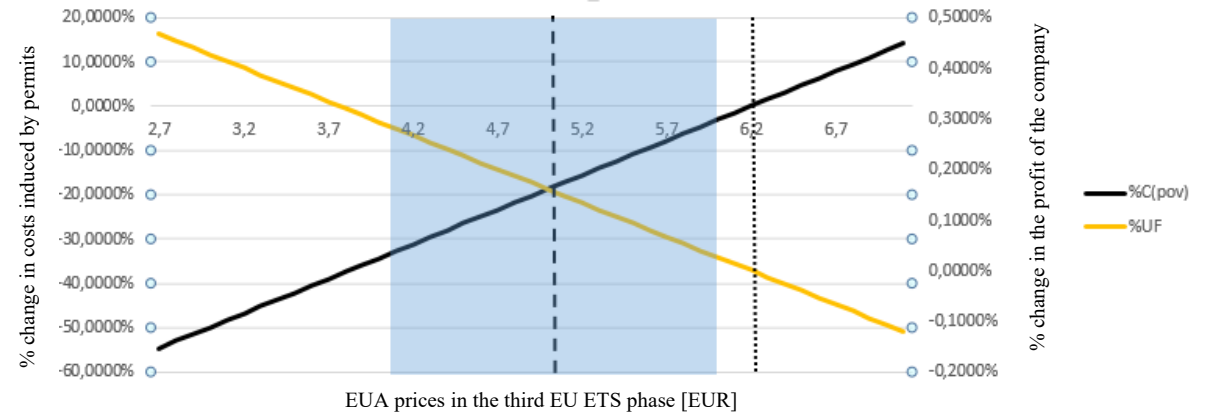

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Fig. 7a: Influence of CER prices in the second and third EU ETS phase on chosen measures of the modelled company

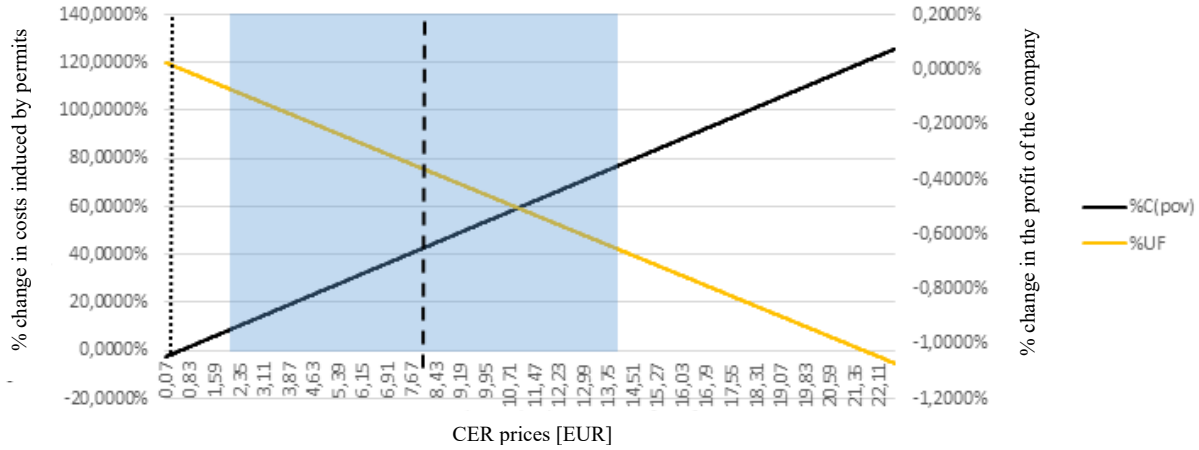

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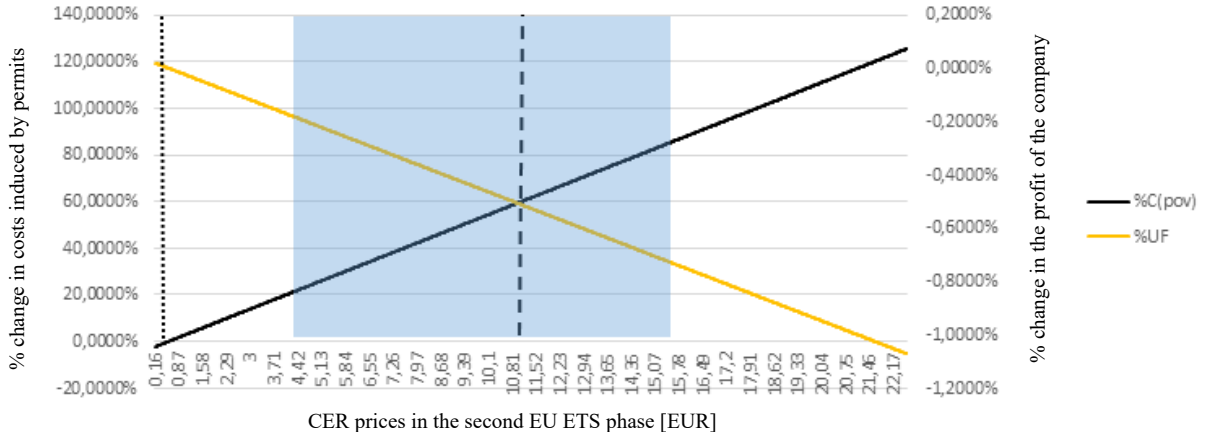
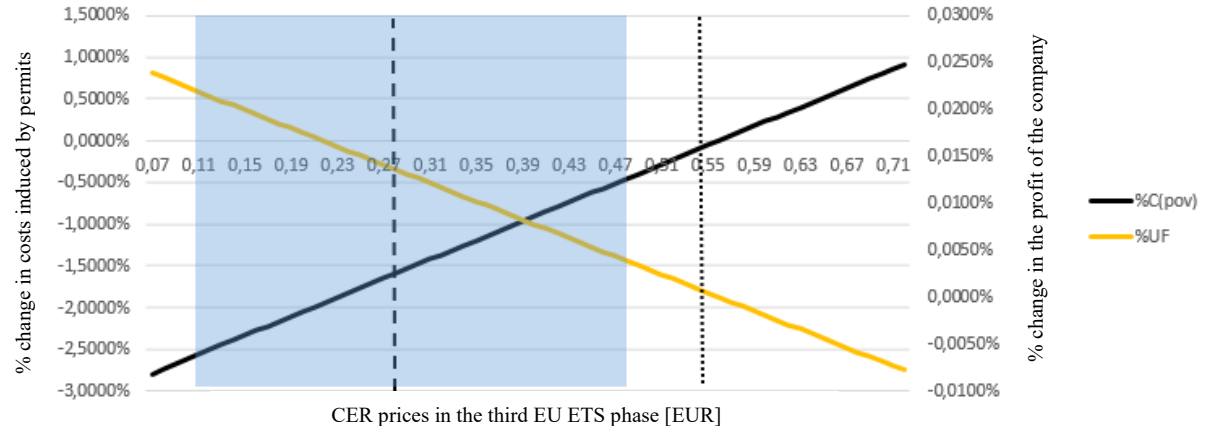
Fig. 7b: Influence of CER prices in the second EU ETS phase on chosen measures of the modelled company



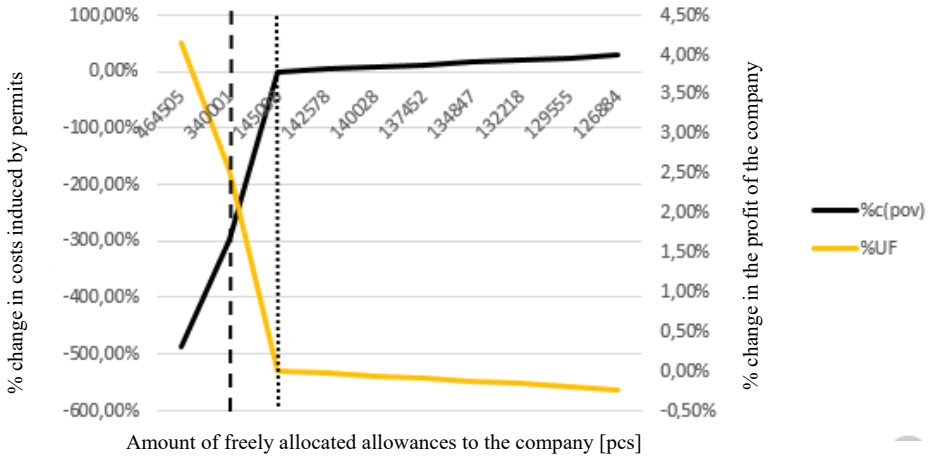
Source: authors

Fig. 7c: Influence of CER prices in the third EU ETS phase on chosen measures of the modelled company



Source: authors

Fig. 8: An influence of the free allocated amount of allowances on selected measures of the modelled company



Source: authors

Figures 6a-8 demonstrate the dynamics of allowance prices' development. Analysis of individual EU ETS phases showed that current EUA and CER prices do not lie nearer than the standard deviation from the mean value (they lie out of blue rectangles in the figures above). In comparison with the second phase, current prices are lower, and in comparison with the whole third phase, prices are higher, on the contrary. This fact emphasises a need of further analysis of potential allowance prices' impacts on companies.

The analysis showed that a potential influence of EUA's is greater than in the case of CER's. An impact of EUA prices from both EU ETS phases on company's profit (without fixed costs) lies in [-3; 0.46]% in comparison with the current state. The same analysis but only taking variation range of values from the third EU ETS phase specified a shorter interval [-0.12; 0.46]%. An influence of EUA prices on costs induced by emissions trading can be expressed by the interval [-54; 345]% while taking into account values from both phases and by the interval [-57; 345]% for values only from the third phase. In financial terms, EUA prices can affect the profit by [-1,404; 222] thousand of EUR for values from both EU ETS phases and by [-57; 222] thousand of EUR for values from the third EU ETS phase only.

An influence of CER prices is weaker in comparison with EUA prices, especially due to the legislative restriction in the form of 10% limit for European companies which was already mentioned. Percentage change of company's profit (excluding fixed costs) in comparison with the current state taking into account values from both the second and third EU ETS phases lies in [-1.07; 0.024]%. The same analysis but only taking variation range of values from the third EU ETS phase specified a shorter interval [-0.078; 0.024]%. An influence of CER prices on costs induced by emissions trading can be expressed by the interval [-2.79; 125.56]% while taking into account values from both phases and by the interval [-2.79; 0.912]% for values only from the third phase. In financial terms, EUA prices can affect the profit by [-510; 11] thousand of EUR for

values from both EU ETS phases and by [3.8; 11] thousand of EUR for values from the third EU ETS phase only.

The last analyzed factor was an amount of freely allocated permits and it turned out to be the most influencing EU ETS system's parameter. The data collected for all available years were used (that means the data for the period 2005-2020). It was discovered that the involved variation range can cause the change in profit between [-0.24; 4.16]% (that means in [-112.9; 1980.3] thousand of EUR) considering no other changes. An influence of the same factor on costs induced by emissions trading lies in [- 487.7; 27.8]% or [-112.9; 1980.3] thousand of EUR, respectively.

Although an amount of freely allocated permits was identified as the most influencing factor for companies, another important fact should be taken into account. Too large amounts of allowances were granted to companies especially in the first EU ETS phase. Corresponding potential great increase in company's profit and decrease in costs induced by the emissions trading are caused by these high values for the first EU ETS phase. However, values of amounts are already known till the end of the third trading phase (till 2020) and these values are going to decrease slightly for each following year. That is the reason why emission prices can be considered as a greater threat for companies than freely allocated EUA amounts. Due to the fact that allocated amounts are known in advance, companies can adjust their decisions on production and investments also in advance. But emissions prices are very difficult to predict. Presented risks could be also investigated by some specialised risk assessing methods in the frame of risk management like the FMEA method, see e.g. (Řeháček, 2011).

Conclusion

The aim of this paper was to analyze a power of influence of selected EU ETS factors on companies. In particular, an influence of CER and EUA permit prices and amount of freely allocated permits has been investigated. The sensitivity analysis has been performed using the data of one steel company in the Czech Republic. Very similar effect for the whole steel sector and for other sectors listed in the carbon leakage group within the EU can also be expected. All three analyzed factors had a higher impact in the second EU ETS phase than in the third one. Currently, the weakest influence on companies can be observed for CER permit price, especially due to its low mean value, low volatility and because of legislative restriction of CER's use for European companies. An amount of freely allocated permits is the most influencing factor whose advantage is the fact that its values are known in advance. Therefore, EUA permit price is considered to be the most important factor for companies which are influenced by the high uncertainty. According to the historical EUA prices in the third EU ETS phase, an increase in costs induced by the emissions trading up to 14% can come. On the other hand, these costs can also be decreased down to 54% under the effect of EUA prices and down to 2.8% under the effect of CER prices.

The presented research can be extended further for example by involving also non-carbon-leakage companies. Statistical dependencies between particular factors could be also included into the analysis to make the results more precise.

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