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Impact of CO_2 emissions reduction on firms' financial performance

Bakalářská práce

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Prohlášení

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2. Souhlasím s tím, aby práce byla zpřístupněna veřenosti pro účely výzkumu a studia.

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Tomáš Brzobohatý

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Abstract

The objective of this work is to investigate the relation between firms' economic and environmental performance with focus on CO_2 emissions of Czech firms included in the 1st Phase of European Union Emissions Trading Scheme. I review the literature concerning the link between local pollutants that firms emit and firms' revenues, costs and profits. Later, I discuss whether hypothesis verified on local pollutants are valid also for CO_2. To reveal the impact of CO_2 reduction on firms' costs, I decompose CO_2 emissions reduction into several effects, from which reduction of energy consumption is the most important. Special attention is given also to EU Emissions Trading Scheme that is specific to CO_2 and determines the impact of CO_2 reduction on revenues. In empirical models, I test the hypothesis derived in the theoretical part on the dataset of 125 Czech firms that covers firms' CO_2 emissions, their revenues, costs, profits and other characteristics. I find out that introduction of EU ETS did not encourage significant investments into CO_2 emissions reduction. Uncertainty of development of carbon market after 2007 did not enable to predict potential future revenues from sold allowances and three years time horizon was too short for calculations of return on investments. Companies that invested into CO_2 reduction despite these uncertainties experienced a negative impact on their financial performance. Drop in the price of allowances on the carbon market in 2006 caused that they received less revenues from saved allowances than they expected.

Keywords

Envirinmental protection, CO_2 emissions, firms, financial performance, market with emissions allowances, EU ETS, Czech republic

Abstrakt

Cílem této práce je analýza vztahů mezi ekonomickými výsledky firem a jejich působením na životní prostředí, zejména emisemi CO_2. V první části uvádím přehled literatury zabývající se vzájemným působením finančních výsledků firem a množstvím lokálních polutantů, které vypouštějí. Dále zkoumám, zda závěry odvozené pro vztah mezi emisemi místních polutantů a finančními výsledky firem platí také pro emise CO_2. K analýze vlivu snížení emisí na náklady firem podrobněji zpracovávám dekompozici procesů, jež vedou ke snižování CO_2 emisí. Z nich jako nejefektivnější vyhodnocuji investice vedoucí ke snížení spotřeby energií. Detailněji se zabývám také systémem obchodování s emisními povolenkami, který v případě dobře fungujícího trhu přináší firmám snižující emise nové příjmy a vytváří tak další podnět ke snižování emisí. V empirické části testuji teoreticky odvozené hypotézy na datech 125 českých firem, která zahrnují jejich příjmy, náklady, zisky a další charakteristiky. Zjišťuji, že zavedení systému obchodování s emisními povolenkami nepodnítilo významnější investice do snižování emisí. Důvodem byla zejména nejistota firem týkající se vývoje regulace emisí CO_2 emisí po roce 2007, která neumožňovala firmám odhadnout návratnost investic do snižování emisí. Firmy, které i přesto emise snižovaly, na systému nevydělaly. Naopak, kvůli velkému poklesu ceny povolenek na trhu v roce 2006 získaly za nevyužité povolenky daleko méně peněz než předpokládaly a jejich celková ziskovost se snížila.

Klíčová slova

Ochrana životního prostředí, emise CO_2, firmy, finanční výsledky, trh s emisními povolenkami, EU ETS, Česká republika

Poděkování

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Všechny chyby a omyly jsou pak jen mé vlastní.

Contents

1. Introduction

In the last few years global warming has become one of the most discussed topics in our society. Politicians of many industrial countries are committing to binding limits on emitted CO_2 to slowdown the whole process. As a consequence, companies have to adjust to new rules of game in order to reach the emissions target. This adjustment is the field of interest of economists. Many questions appear. How costly is the emissions reduction? Does it not harm country‘s economy and competitiveness? Does it not restrict free market competition? Who should set the emissions limits? Which industries and companies are affected by the regulations? Which kind of regulation is the most efficient? Why do not companies reduce their emissions voluntary? Or do they? What is the impact of CO_2 reduction on their financial performance?

The answers on these questions are not easy to find, scholarly discussion requires deep understanding of the problem. Sometimes the debate turns more into philosophical level with interventionists on the hand and *laissez faire* advocates on the other hand. I would like to avoid this ideological bias in my work and asses the problem of emissions reduction from the neutral position. As the questions that I mentioned cover really broad topics I restrict myself just to last ones that I could also test empirically. Why do not companies reduce their emissions voluntary? Or do they? What is the impact of CO_2 reduction on their financial performance?

To answer these questions, I firstly discuss the literature on relation between companies' economic and environmental performance in *chapter 2*. I investigate how the pollution reduction reflects in companies' revenues, costs and profits. I also analyze whether profitable companies are more likely to reduce emissions. Majority of the authors consider local pollutants as the environmental performance and not greenhouse gases. Because the characteristics and also impacts of these two kinds of pollutants are very different I cannot automatically assume that the hypotheses tested for local pollutants hold also for CO_2. Therefore, in *chapter 3* I compare impacts of CO_2 and local pollutants and investigate how much they are related. I analyze decomposition of CO_2 reduction into more details, because knowledge of processes that lead to CO_2 reduction is crucial when investigating its impact on companies' costs.

When comparing the impact of both groups of pollutants on revenues, I analyze the influence of EU Emissions Trading Scheme introduction in *chapter 4*. I ask to which extend the system with traded allowances generates additional revenues for companies that reduced their CO_2 emissions. In order to answer this question, I discuss the national allocation plans of the 1st Phase of EU ETS and development of carbon market. Finally, I conclude whether carbon market can reward companies that reduced their CO_2 emissions.

C*hapter 5* includes description of the dataset of 125 companies included in my empirical work. In *chapter 6* I describe six models. In these models I test hypotheses derived in theoretical part. Firstly, I test the impact of emissions reduction on revenues costs and profits in the year when reduction took place and than the impact on revenues and costs in the following year. I compare both models and their expected outcome. In models, not only variables describing financial and environmental performance are included, but also other companies' characteristics like industry, ownership, environmental management system iso or size of assets. In last model, I investigate which kinds of firms are more likely to invest in emissions reduction, to be more precise I analyze whether more profitable companies reduce their emissions more. Finally, I try to find out causality between firms' environmental and financial performance.

Results of the models are summarized and discussed in the *chapter 7*. Last *chapter 8* concludes the results and my entire work.

2. Relations between companies' financial and environmental performance

2.1 Overview of environmental regulation

Since 1990s, there have been written numerous papers concerning relations of companies' economic and environmental performance. With increasing awareness of environmental protection in the recent decades, also demand for economic solution and interest of economists itself in these issues have risen. They wanted to investigate popular perception that both economic growth and cleaner environment cannot be reached at the same time. In the past, most economists and politicians were convinced that any company never reduced its impact on environment voluntary, because it would in any case result in an increase in its costs which would be undesirable (I will come back to this assertion later and more in details). Thus, it seemed that the only way how to tackle pollution was to introduce binding limits (emissions standards) on the level of emissions or other kind of regulation. These measures forced companies to use the end-of-pipe technology, like particulate filter or flue gas desulphurization. These tools significantly restricted the level of pollution (which was their goal) but, at the same time, they induced additional costs for the factory related with the purchase, installation and maintenance. No pronounced benefits for company were evident (if we do not consider the improvement of the image among customers). But if all the companies from particular industry had to introduce this restriction compulsory, there would be no advantage for any company against its competitors stemming from better image. The only benefit may be the improvement of image of whole industry which may be reflected in its overall sales. But still, introduction of end-of-pipe technologies rather confirmed the original hypothesis, that companies do not benefit from reducing its impact on environment and therefore, they will not undertake it voluntary.

Later on, although the reduction of some pollutants per unit of output was reached (e.g. SO_2, NO_X), the growing economy has caused further increase in overall emissions that outweighed the intensity reduction. The production was cleaner already, but there was a need to stop the increase of overall emissions. End-of-pipe technologies were already applied, so it was necessary to find another way to emissions reduction which would require changes in production process itself. It was proved that binding limits did not worked very efficiently any more and evoke huge costs. Economists tended to the use of

economic measures instead, like taxes or allowances. It was shown that these measures can reach pollution abatement at lower costs, giving companies more flexibility with respect to the ways how they will reach the reduction.

End-of-pipe solutions were already depleted, so companies were forced to change their production process. At the beginning they were rather reluctant, they could change production process earlier instead of end-of-pipe, but it would be accompanied by too big changes with high costs and uncertain results so companies preferred easier end-of-pipe technologies. But later on, changes of production process seemed to be necessary so companies finally undertook this cuts. The result was surprising, although companies invested significant amount of money at the beginning, the production process became often easier and even cheaper, so many companies have observed additional savings. In the long run, the investment in cleaner technology has become profitable. „The philosophy of pollution prevention holds that pollution is a sign of inefficiency within manufacturing process and waste is a non-recoverable cost**“** (Shrivastava P., Hart S. (1992): Greening organizations, p. 185-189, *Academy of Management Best Paper Proceeding*). Higher level of waste is highly correlated with high amount of raw materials, which is of course costly. So installing a better technology leads not only to lower level of pollution, but also it improves utilization of materials and resources and thus increases the overall productivity and efficiency in production process (Schmidheiny, 1992).

It is also proved, that in early stages of pollution abatement, there is a great deal of „low hanging fruit“, abatement which is caused by easy and cheap material and structural changes that lead to high emissions reduction for low costs (Rooney, 1993). If the company is in later stages of pollution abatement efforts, further reduction is increasingly difficult and thus costs of abatement per one unit of pollution are becoming more expensive because reduction requires substantial changes of production technologies (Frosch and Gallopoulos, 1989).

The question is why companies did not invest in cleaner technologies earlier, without state intervention if it would be profitable for them. Was it just their ignorance, aversion to undertake any change or was there any rational reason which daunted them to

undertake this investment? I looked for the reasons in the literature and I will present a brief overview of my findings.

There are in general two approaches to investigated relation between economic and environmental performance. The first asserts that environmental performance influences economic performance and researches influence of the environmental measures that company has taken on its financial performance. Generally, the impact does not evince immediately, there is a lag of approximately 1, 2 or even more years. In the year of implementation, the financial performance is likely to be deteriorating, due to the investment costs. The lag has also further causes. Firstly, it takes time to renegotiate supply and waste disposal contracts, sometimes entire restructuring is required (White et al, 1993).
We must however, take into account, that these costs are fixed and that in quite close time horizon, the investment generates cuts in operating expenses.

2.2 Environmental incentive approach

The first approach was the field of interest of Stuart L. Hart and Guatam Ahuja in their paper „Does it pay to be green?“. They tested several hypothesis concerning financial consequences of pollution abatement measures on the sample of 127 companies listed among S&P 500. They found out that emissions reduction improves company's return on sales (ROS) and return on assets (ROA) one and two years after the reduction took place. The best improvement of return on equity was observed third year after reduction. In this case, the effect is distorted by changes in capital structure which might not be linked with pollution abatement. Research also confirmed the hypothesis of Rooney and Heart, confirming that reduction brings higher profits to high polluters in comparison with low polluters. However, as the research was done with data from years 1989 – 1992, it is possible that today's results would differ significantly. We can assume that environmental performance of companies has improved, so according to the above mentioned hypothesis, a decrease in operating costs stemming from pollution reduction would not be so pronounced.

Stanley J. Feldman, Peter A. Soyka, and Paul Ameer investigated the relation between environmental management system introduction on the one hand and economic performance on the other hand. In their paper „Does improving a firm's environmental management system and environmental performance result in a higher stock price?". They focused on the impact on the value of the firm at the stock exchange. They investigated companies form Standard & Poor's and found out that improvement in both environmental performance and environmental management system decreases the environmental risks of the company. This decrease results in a decrease of overall costs of capital which is reflected in higher stock price, which can generate even 5% increase.

Paper from Klaus Rennings, Michael Schröder and Andreas Ziegler „The Economic Performance of European Stock Corporations. Does Sustainability Matter?" concentrates on a very similar field, it evaluates the impact on the share value of the company. Contrary to Feldman, Soyka and Ameer, authors focused not only on impacts of environmental performance but also on impacts of social performance. The research shows diverse effects. While better environmental performance leads to higher price of the shares, social does not. They analyzed data from approximately 300 leading European companies in years 1996-2001 and thus conducted one of the first researches of this kind on non-US firms. Advantage of this study is that it uses more variables as an indicator of environmental performance than information about hazardous accidents from Toxic Release Inventory (TRI) as some other papers do. Unfortunately, due to lack of data, they did not analyze data in the time series and therefore could not involve time lags.

Study from Dietrich Earnhart and Lubomír Lízal "Does Better Environmental Performance Affect Revenues, Costs, or Both? Evidence From a Transition Economy" includes two unusual figures. Firstly, contrary to other researches on relation between environmental and economic performance, it does not use market value of the company nor overall profits as indicators of financial performance. Authors occupy with profits, but in contrast to other studies, they separate revenues and costs and investigate both variables, not only their sum (profits). Such approach provides us with more detailed insight what occurs in the company, decomposition of profits on revenues and costs extend our knowledge of effects that lead to improved/deteriorated financial performance of the company.

The dataset of this study was also extraordinary. It is probably the first study that focuses on analyses of environmental and financial performance in the transition economy, particularly Czech Republic between years 1996 and 1998[1]. Companies were in very different position than those in developed market economies and their environmental performance was in general very poor. It was a time of increased pressure leading to the pollution reduction, both from public and state authorities. Czech Republic had to comply strict environmental rules in their path to the EU accession. For these reasons, significant pollution reduction took place and provided interesting data to be analyzed.

Authors revealed that pollution reduction leads to both lower revenues and lower costs. But because the decrease in revenues is lower than the decrease in costs, the overall result is improved profitability. These results indicate that better environmental performance does not induce higher sales; companies did not take advantage of selling products with "environment friendly" brand nor were industry leaders that set standards. Higher profitability is more likely to be caused by reducing pressure from state administration and public.

It might be interesting to compare the results with conclusion of my research, as both surveys are made on the dataset of Czech companies. We can observe, whether there was any progress in reducing environmental impact after the transition is finished[2].

2.3 Financial incentive approach

Second approach investigates, which companies are likely to invest in cleaner technologies and as a consequence reduce their emissions. This approach focuses not on the impact of environmental investments on financial indicators, but it evaluates assumptions under which the investment is undertaken. Economic and financial performance of investing companies is evaluated. This analyses can reveal characteristics of typical "environmental friendly" company. In this case, there is also time lag between economic and environmental performance, but in the opposite direction. The undertaken investment reflects in environmental performance few years later, as the implementation

[1] There was actually one study focusing on Lithuania prior to this one.
[2] Unfortunatelly, comparison will not be easy, due to the fact, the I focus only on CO2 emissions as the indicator of environmental performance.

of environmental friendly measure takes some time. Contrary to previous approach, these analyses are quite rare in the literature. One of the few studies that investigate this inverse relation is "Effects of Ownership and Financial Status on Corporate Environmental performance" from Dietrich Earnhart and Lubomír Lízal. They analyzed the relation from ownership structure and financial performance to environmental performance in the Czech economy in transition.

In the first part of the research, the authors found, quite surprisingly a positive effect of state ownership on environmental performance. No other significant relation between type of ownership and company's environmental performance was found. In the second part, the authors considered the issue of causality between financial performance and emissions. As the literature indicated, that both causalities were possible, they run Granger-causality tests to find out, whether financial performance in the previous periods influence current environmental performance or vice-versa. The causality was indicated from financial performance[3] to emissions. In their models, they used both amount of pollution emitted by the firm in a given year and amount of pollution per unit of output as the response variables. As the explanatory variables, they used the size of the firm (fixed assets), level of production (revenues), profits generated in the preceding time period and year indicators (they tested panel data and as the level of pollution decreased significantly within this period it was necessary to include the variable that indicated the year). The results indicate that good financial performance leads to better future environmental performance which is in compliance with the assumptions that the company with higher profits is more likely to have disposed cash to invest into new technologies that lead to the reduction of emissions. Higher production not only increases absolute emissions, but quite unexpectedly, it also increases the relative emissions (per unit of output), so there were no economies of scale in this case. It may be caused by the higher share of firms from heavy industries in the group of big companies.

[3] The authors used profits instead of financial performance, because all investments that were undertaken in the given period between 1993 and 1998 in the Czech republic were according to authors financed from retained profits.

2.4 OECD study Environmental Policy and Corporate Behaviour

I devote one special chapter to the OECD study "Environmental Policy and Corporate Behaviour", because it provides a broad overview of relations between environmental performance of the companies and firms' exogenous characteristics. In addition, it combines both described approaches, so I decided to analyze it separately. It focuses also on the impact of implemented regulatory measures. It not only covers a large-scale overview of literature but it tests numerous hypotheses on the large data sample. The authors addressed a postal survey to approximately 4200 facilities with more than 50 employees in seven various OECD countries[4]. Dataset was representative; it covered companies of various sizes, country of origin and industrial sector.

I appreciate also the survey of researches concerning influence of firms' characteristics on their environmental performance. The results are figured in Table 1[5].

Characteristics	Hypothesised Relationship	Evidence
Firm Size	Larger -> improvement	Generally supported
Capital Vintage	Newer -> improvement	Not supported
Trade Ratio	Highly traded -> improvement	Weakly supported
Investment Source	Foreign -> improvement	Not supported
Source of Equity	Public shareholdings -> improvement	Generally supported
Capital Availability	Internal -> improvement	Generally supported
Institutional Characteristics	Private firm -> improvement	Generally supported
Proximity to Final Consumers	Closer -> improvement	Weakly supported
Diversity of Product Lines	Specialisation -> improvement	Generally supported

Table 1: Firm Characteristics and Environmental Performance – Empirical evidence, source: OECD study Environmental Policy and Corporate Behaviour

In own research, study draws these conclusions:

- Facilities that consider environmental policy being stringent tend to undertake significant investments with respect to a variety of environmental impacts.
- Choice of regulatory instruments, whether market based or performance standards has no impact on reached environmental performance. However, it differs in the way how the pollution reduction is reached. Performance standards generally induce use of end-

[4] The response rate varied between particular countries ranging from 9% to 25% with the avarage 21% which still may be considered to be a satisfactory result.
[5] Results are drawn from a large numeber of empirical studies: Levy (1995), Dasgupta et al. (2000), Lefebvre et al. (1995), Konar and Cohen (1997), Aden, Kyu-Hong and Rock (1999), Henriques and Sadorsky (1996),…

of-pipe abatement while market based changes in the production process. Flexible instruments moreover encourage investments in R&D and thus stimulate innovations. Prescriptive instruments on the other hand constrain technological choices and thus discourage from further innovations.

- Perceived policy stringency encourages changes in production process which are based rather on the production change than end-of-pipe. The study contradicts popular perception that end-of-pipe solutions are more wide-spread. The results of the survey shows, that more than 75% included companies announced that they invested predominantly in cleaner production technologies. However, there are significant differences. As a consequence of long lasting end-of-pipe promoting policy, Germany displays the lowest percentage of cleaner production among these countries. Despite prevailing advantages of cleaner technologies, government should not abandon the use of performance standards. I some cases, end-of-pipe solutions reach better environmental performance that cleaner production. E.g. additional filters of diesel cars' motors are worth mentioning.
- Environmental factors play only limited role in the overall company's financial performance. Other characteristic such as industrial sector, diversity of portfolio seem to be of greater importance. But still, other factors being equal, firm with better environmental standard has better results than their competitors.
- Perceived environmental policy stringency results in worse commercial performance. This result suggests, that company implements better environmental standard up to the level when it is advantageous for its financial performance. If the "social optimum of pollution" is lower, there is a need to implement a regulatory policy. This finding also confirms the idea that firms behave rationally. If regulation measures induce better financial results, it would be a clear sign of company's inefficient management.
- Implementation of environmental management systems (EMS) has a positive impact on environmental performance. But there are some doubts whether EMS is still an exogenous factor. EMS is often implemented as an instrument to pollution reduction. The initial decision about abatement depends on other firms' characteristics than the presence of EMS.
- Because of the positive impact of EMS, state authorities sometimes motivate companies to its introduction. They provide a conditional financial support (mainly for

SMEs[6]) or promise a reduction of inspections frequency (relevant for big companies). Although this policy is from the environmental point of view effective, there are still concerns whether decreased inspections frequency as the main incentive for EMS introduction does not yield inverse effect – deterioration of environmental performance[7].

- Study also compares the performance of various industries. The authors tested several hypothesis:
    - They divided industries between "Early Movers" and "Late Movers". In the first group industries that have been participating in voluntary environmental programs since 1980s are included and in the second group those that began to reduce pollution relatively late. Authors tested validity of "low hanging fruit" hypothesis – "Late movers" derive more economic benefits for relatively low costs of investments in cleaner technologies. However, statistical tests did not reveal any significant difference between both groups. What would be in my opinion quite interesting is to test the hypothesis of "Early Movers" for individual companies and not whole industries. The result would be influenced by two contradictory tendencies, firstly, there is no reason why "low hanging fruits" should not be present, it means those that pollute more can capture benefits stemming from pollution abatement for lower costs. On the other hand, companies may acquire considerable benefits of being the first mover. In addition to saving costs in production process which will be reached even by "Late Movers", they can acquire additional profits by attracting consumers on their environmental friendly image. Moreover, the government often sets the enforced environmental standards according to the performance of the best environmentally performing firm. Further research may be interesting to find out which effect prevails.
    - They divided industries between "Low-Growth" and "High-Growth" industries according to their average change in shipments. They tested the hypothesis of Russo and Fouts (1997) that the industry growth induces financial benefits which lead to investments in environmental improvements. There are several incentives that lead companies in fast growing sector to these investments. Firstly, in fast growing industries, there is also relatively

[6] Small and medium-size enterprises
[7] Results suggest, that the former effect of pollution reduction in relation with EMS prevails.

fast development and implementation of new technologies that are in general more environmental friendly. In addition, fast growing companies tend to accumulate big profits (in comparison with low growing) so they have higher amounts of free cash to invest. In the research the authors found out, that there was a difference between high-growth and low-growth industries, but only in some pollutants. This approach connects environmental performance first approach with the second approach economic performance first.

This survey was probably the broadest one in this field. Contrary to other researches, it covers dataset from seven countries which was not easy to achieve. Authors had to sacrifice the accuracy of the data. There is no common international scale of environmental performance. Authors of the studies focused on US companies tend to use TRI data, which is not available in other countries. Statistics issued by national ministries of environment vary and thus there is no common benchmark. Therefore, the authors asked the companies directly whether and to which extend did they had decreased pollution. We should be aware of the possible bias of exaggeration own performance but we should still take into account that it was probably the best available method how to collect such a broad data.

The data concerning financial results were collected in the same way for similar reasons. Former studies investigated mostly companies which were traded at the stock exchange, mostly those from S&P 500. There is a bias to big companies that are likely to pursue abatement activities more than the small ones, due to the scale effects. This survey on the other hand, covers wide range of companies and countries which makes its results more applicable for potential use in public policy.

Unfortunately, nor this study is perfect. It misses some benefits that contain above mentioned studies. It uses cross-sectional data and not panel data so there is no chance to observe any progress in time. It is regrettable as regards the incentive of the improvement performance which I discussed above. From the analyses we cannot distinguish whether improvement of the financial performance generates improvement of the environmental performance or vice-versa. Authors themselves point out this weak point and support further research in this field.

So far, I discussed mostly the relation between costs and improved environmental performance. In this survey, there are four ways how company can convert its improved environmental performance into better financial performance.

1) Company changes its production process; it is connected with those situations when the company originally did not use their inputs efficiently. After implementing the change in production process, company not only pollutes less waste and emissions, but it usually consumes less input for the same level of production. The main financial improvement takes place in the costs reduction.
2) Company does not change directly the production process (let us suppose that it is already efficient) but focuses on the improvements of the products' characteristics. It produces machines with lower energy (or other resource) consumption. These products save environment and due to lower operating costs, they are preferred by consumers. This is as a result reflected in higher sales and revenues.
3) Company switches to more environmental friendly production process but does not decrease its costs (we suppose that it is efficient already). In this case, company promotes this good as "environmental friendly" and consumers are willing to pay more for attached public environmental good although it does not reflect in lower costs or direct higher quality for him. Example: green energy.
4) Changes to more environmentally friendly production lead to better quality of product for customer. In this case, consumer buys not only products that harm environment less, but he/she also buys a product of higher quality. It reflects in increasing sales. Example: organic food.

	No change in product	Change in product
Costs	Through change in production process firm is able to increase efficiency of use commercial resource inputs or reduce liabilities, reducing costs and protecting public environmental goods associated with the input. (Example - reduced generation of hazardous wastes.)	Through product redesign firm is able to reduce lifetime costs by increasing efficiency in the use of a commercial input for the durable or reduced disposal costs, generating financial savings for the customer and protecting associated public environmental goods. (Example - energy-efficient condensing boiler.)
Quality	Through an environmentally beneficial change in production process the firm is able to differentiate its product even though the functional attributes of the product are identical, increasing market share and capturing rents. (Example - green energy)	Through environmentally beneficial change in production process, the firm is able to differentiate its products on basis of associated non-financial personal preferences. (Example - organic agriculture)

Table 2: Classification of Firm-Level "Wins-Wins", Source: OECD study Business and Environment: Policy Incentives and Corporate Responses

To summarize this discussion, we should distinguish between two directions of relations between economic and environmental performance. It is also possible to make a complex analysis that connects these two approaches and researches this relation in a dynamic version. As a result, we can both determine which companies are likely to invest in pollution reduction and evaluate the impact of the investment on financial performance in few years' time series.

3. Extension on CO_2 emissions

3.1 Specificity of CO_2 emissions

In the past, most papers handling with economic and environmental performance investigated mainly local pollutants like SO_2, CO, NO_X or waste. Mainly these pollutants have been regulated because their impact on the local environment is strong and thus evokes public pressure for the regulation. Efforts to decrease these emissions have been highly successful, as the abatement costs have been relatively low and factories at least in developed countries were forced to tackle these emissions.

However, in my research, I focused on CO_2 emissions data which have not been so common to analyze in the past. There were several reasons for it. Firstly, regulators and public did not pay much attention on this issue until the problems of global warming has become a broadly discussed topic. And even if it is a serious problem now, people do not see direct consequences of CO_2 emitted by local energy plant in their surrounding and thus although people are aware of consequences that global warming is likely to cause, public pressure towards companies to decrease CO_2 emissions is still relatively weak. CO_2 does not cause breath illnesses or lung cancer; it does not poison water in the neighboring stream. Moreover, skeptics still doubt about the scope of effects of global warming and alert to exaggerated panic. In addition, it has been observed, that the abatement costs of CO_2 are much higher than abatement costs of local pollutants and the reduction with today available technology is quite costly.

The OECD study Business and Environment Policy Incentives and Corporate Responses (2007) confirms these expectations. Companies were asked whether they had decreased their environmental impact. Results varied according the type of pollution. More than 50% companies experienced decrease in solid waste, followed by wastewater and air pollution with global pollutants lagging far behind (less than 20% companies mentioned reduction).

All these reasons have impeded the efforts to reduce CO_2 emissions. Due to lack of data, researches concerning CO_2 reduction were rather rare in comparison with other pollutants. The boom in this field has started as a result of discussions targeted on the European

Trading Scheme (ETS) with emissions allowances which has come into force in 2005. As so far the biggest allowances trading system ever, EU ETS has induced a broad discussion between economists.

However, despite growing interest in CO_2 emissions reduction and impact of introduction of EU ETS on it, there is still lack of literature evaluating relations between CO_2 reduction and economic performance at the firm level. Most papers are focused on the evaluation of the carbon market and allocation process, relation between companies' economic and CO_2 performance is far less discussed. As far as I know, my research belongs to the first ones done in this field and the expectations about the results were therefore very ambiguous. I stem from the above mentioned literature investigating relations between economic and environmental performance and decomposition of effects that lead to CO_2 reduction. On the basis of this knowledge, I estimate, whether the results for CO_2 will vary significantly from local pollutants or not. OECD studies suggest that contrary to local pollutants, companies' efforts to decrease global gases emissions are not so strong. I will compare how the reduction on CO_2 emissions influence financial performance of the company and thus how strong is companies' motivation to abate CO_2.

3.2 Factors influencing CO_2 reduction

As I explained earlier, companies can hardly expect that a decrease in CO_2 emissions will lead to an increase in their revenues. So the only way how they can benefit from CO_2 abatement may be a decrease in costs. In this chapter I decompose the CO_2 reduction into several effects and analyze whether some of them may result in a decrease in expenditures. I have not found any literature on the single company's decomposition, so I stem from the researches that analyze the whole economy. But as the whole economy is an aggregate of single companies, I can expect similar outcome also for single companies. I will focus on the link between emissions reduction and energy consumption, because lower energy consumption results in lower costs.

In the paper "Decomposition of industrial CO_2 emissions: The Case of European Union" authors Liaskas, Mavrotas, Mandaraka and Diakoulaki decomposed the changes of CO_2 emissions between four factors:

1. output level
2. energy intensity
3. fuel mix
4. structural change

In the empirical part, they analyzed the effects of the mentioned factors on the change of CO2 emissions in 13 EU countries in the years 1973-1993[8].

Results of the decomposition method

Country	Period	ΔCO_2 (kt)	Decomposition (%)[a]					Positive effect	Negative effect	Net effect
			Output	Energy intensity	Fuel mix	Structure	Residual			
UK	1973–1983	−72 475	18%	33%	17%	16%	−17%	83%	17%	66%
	1983–1993	−18 470	−34%	38%	9%	1%	17%	66%	34%	32%
SWE	1973–1983	−9024	−11%	43%	36%	−6%	−4%	79%	21%	58%
	1983–1993	−39	−33%	−6%	47%	−10%	4%	50%	50%	1%
POR	1973–1983	2921	−53%	17%	2%	−21%	7%	26%	74%	−48%
	1983–1993	−421	−20%	16%	18%	−25%	21%	55%	45%	11%
NET	1973–1983	−17 138	−10%	60%	8%	12%	−11%	79%	21%	59%
	1983–1993	6081	−61%	−19%	7%	5%	8%	20%	80%	−59%
ITA	1973–1983	−34 549	−19%	40%	8%	−17%	16%	64%	36%	29%
	1983–1993	−5426	−37%	30%	10%	−8%	14%	54%	46%	8%
GRE	1973–1983	1054	−37%	28%	13%	−12%	−10%	41%	59%	−17%
	1983–1993	474	3%	−60%	21%	13%	−3%	37%	63%	−25%
GER	1973–1983	−44 115	−14%	40%	16%	25%	−5%	82%	18%	64%
	1983–1993	−3558	−45%	8%	34%	12%	1%	55%	45%	9%
FRA	1973–1983	−34 532	−27%	45%	16%	11%	−1%	72%	28%	44%
	1983–1993	−10 753	−15%	23%	35%	1%	26%	85%	15%	71%
FIN	1973–1983	−5793	−31%	22%	40%	3%	−5%	65%	35%	29%
	1983–1993	147	−34%	30%	18%	0%	−17%	49%	51%	−2%
ESP	1973–1983	−3147	−37%	32%	23%	−6%	−2%	55%	45%	10%
	1983–1993	−2969	−45%	27%	19%	1%	8%	55%	45%	10%
DAN	1973–1983	−4934	−23%	48%	20%	6%	3%	77%	23%	53%
	1983–1993	−3	−8%	−28%	47%	4%	−14%	50%	50%	0%
BEL	1973–11983	−20 208	−26%	52%	13%	3%	6%	74%	26%	47%
	1983–1993	4486	−17%	−50%	−4%	14%	15%	29%	71%	−41%
AUT	1973–1983	−3604	−28%	42%	16%	−3%	11%	69%	31%	38%
	1983–1993	−655	−39%	25%	12%	−6%	18%	55%	45%	10%

[a]The sign (−) in the decomposition results indicates that the corresponding factor is opposite to the reduction of CO_2 emissions.

Table 3: Decomposition of CO2 emissions reduction in EU countries between years 1973-1993

The results demonstrate that most countries experienced a decrease in industrial CO_2 emission in especially in the first period[9]. In majority of the countries, the increase of industrial output has a negative effect on CO_2 emissions reduction, but it was outweighed by the change in the energy intensity and fuel mix. Decrease in energy intensity which was observed especially in the first period as a consequence to the increase in oil price together with change of the fuel was the most important determinant of the decrease in

[8] Because there were different results at the beginning and at the end of the period, authors divided it in two shorter periods 1973-1983 and 1983-1993.
[9] We must realize, that the study focuses just on industrial emissions. It is likely, that the emissions of the whole economy increased, especially due to the increase in trnsport and services.

emissions. Structural changes of industries were quite surprisingly less important and had both positive and negative impact on the decrease in emissions.

B.W. Ang and G. Pandiyan in their article "Decomposition of energy-induced CO_2 emissions in manufacturing" add one more factor that influences change in the CO_2 emissions – fuel CO_2 emission coefficients. However, CO_2 emission coefficients remain the same over time for the fuels like oil, natural gas and coal[10]. The article investigates factors that influenced changes of CO_2 intensity in manufacturing industry in China, Taiwan and South Korea between years 1980-1993, so the data sample is quite different from the article from Liaskas et al. The results showed major influence of energy intensity reduction, while other factors were far less significant. We should realize, that only CO_2 intensity was analyzed and not the total emissions like in the previous case. If we considered total amount of emissions, importance of change of output would be probably quite significant. Although the CO_2 intensity decreased during the period (especially at the beginning of the period and in China), total emissions grew in all three countries.

Other authors estimated the cheapest ways that would lead to CO_2 reduction in future. In OECD Working Paper Costs of Reducing CO_2 Emissions, Evidence from Six Global Models, authors Andrew Dean and Peter Hoeller gathered results from several various analyses concerning costs of CO_2 reduction. From several projections of development of CO_2 emissions in 21st century in the business-as-usual scenario they derived the tax fees that would lead to emissions abatement to a certain level. They decomposed the CO_2 reduction between the same effects like Liaskas et al.

Each model considered different value of parameters and therefore also results varied significantly. The exact tax charges are not important for goals of this thesis; I will rather focus on possibilities of the emissions reduction that the study reveals. According to the substitution elasticities, authors decomposed the reduction between following effects. They examined the most efficient (and cheapest) ways of CO_2 emissions reduction in the time horizon till the end of 2020, in the scenarios that considered 2% annual reduction in comparison with the business-as-usual scenario.

[10] The only change in CO2 emission coeficient was in the case of electricity, but here it is again the matter of the original of fuel that generates power in the power station. So the change in the CO2 coefficient is in the case of electricity determined by the fuel mix that generate electricity. It is possible to include this change in the sources of energy between the change of fuel.

The reduction could be caused mostly by decreased energy intensity, followed by the increase of the share of carbon-free fuels. Lesser contribution is caused by the change of carbon intensity in fossil fuels and the lowest reduction is generated by output decrease (which is roughly 3%). It is also worth mentioning that this annual reduction by 2% (in comparison with Business as usual) counts with CO_2 tax about 300 USD/ton. If we compare it with the current price of CO_2 allowances on the market it seems to be immense, but we should take into account that the authors included all taxes that are imposed to the consumption of all goods that contain CO_2 like gasoline tax and not only particular CO_2 tax.

The results of all studies suggest that decrease in emissions intensity is mostly linked with a decrease in energy intensity. This outcome indicates that a decrease in emissions is caused by lower energy consumption and thus leads to decrease in costs. This outcome suggests, that companies are motivated to decrease it CO_2 emissions by a decrease in energy expenses.

3.3 Summary of differences between local pollutants and CO_2

There is in fact no indication, that introduction of technologies that emit less CO_2 saves money and has therefore a positive impact on the revenues of companies. Decrease in emissions is not reflected by public and customers like in the case of local pollutants. As CO_2 emissions are not visible nor they harm the health of the population, consumers do not directly feel any improvement in the environmental performance. There is also less publicity in media, even big polluters are not exposed to massive negative campaign like big local pollutants emitters[11].

Change in the production process is neither reflected in higher quality of products, nor their lower energy consumption, so there is actually no positive impact that consumers would appreciate. On the other hand, some companies (like car producers) now tend to produce goods with lower consumption and thus lower emissions, but this is not related to

[11] However, public awarness of CO2 emissions has been growing rapidly in the last few years and I expect that in few years time horizon it may become a monitored issue.

the production process itself and companies do not experience emissions reduction in their factories.

As I mentioned above, another motivation that leads companies to invest in cleaner technologies is the goal to become the industry leader who sets the standards that the competitors must later adjust to. Until 2004, there were no kinds of standards or other regulations as far as the CO_2 is concerned. This incentive to decrease the emissions also fails. Situation has changed after the introduction of EU ETS in 2005.

The last ground, why companies should decrease the emissions is the avoidance of control inspections. Companies with good environmental record are rather less exposed to the inspections as they do not capture the attention of the regulators. This hypothesis may be relevant also for CO_2 emissions, because officer from the monitoring agencies, contrary to public, observe the amount of CO_2 that companies emit. Last but not least, company with improved CO_2 record may retrieve its bad reputation in other pollutants. It would be the case if the firm has lower marginal costs for CO_2 emissions abatement than for other pollutants. This hypothesis has also its contras, firstly, companies with very high emissions has usually quite low marginal costs of abatement (see low-hanging fruit) which are unlikely to be lower than marginal costs of CO_2 abatement that often require profound changes in the production process. In addition, we can also question the assumption, that better CO_2 performance calms the inspectors. Emissions of various gases are often controlled by entirely different institutions, so we can doubt that decrease in CO_2 emissions discourages from controls of e.g. SO_2 emissions.

When it comes to costs, the situation is different and reduction of CO_2 emissions is supposed to have positive impact on company's costs, i.e. it will result in a decrease in costs. End-of-pipe solution does not work in the case of CO_2, so there is no possibility to use this method. The only way how to achieve CO_2 abatement is the change of the production process which requires high investments which result in a decrease in energy intensity or switch to a fuel with lower carbon index. In the case of improvement of energy intensity, company can save considerable amount of money for energy and thus the costs should decrease. However, this hypothesis is questioned by the results of OECD study, according to which only 20% companies experienced reduction of GHG emissions. We can doubt why companies do not invest more into improvement of energetic

efficiency if it pays off. Possible reason may be that the initial investment to change production process is too high and companies are hesitant to undertake it. Still, if companies finally invest, I do suppose that decrease in emissions should result in a consequent reduction of costs. The expected outcome is the same as for local pollutants.

The survey of the incentives is summarized in the table provided below. There is no clear expectation of the impact of CO_2 reduction on revenues, but we can expect a later decrease in costs as a consequence of CO_2 reduction.

	Hypothesis verified for ther pollutants	Expected outcome for CO2
Revenues	Better "green" image of the company, increase in popularity between customers	CO2 has not direct consequences on the health of the people and environment in the neighborough of the company, public pressure is not so high like in the case of local pollutants, investment in cleaner technology does not significantly improve the image and does not lead to increase in sales
	Company may be a "green" leader in the industry, regulators may set standards according to its performance, others will have to adjust, comparative advatage	There are no standards so far as CO2 is concerned. Even if there were, it would be set at the EU level, Czech companies are not considered to be those one that set the standards
Costs	Change of the production process leads to more efficient use of resources less waste and thus to costs savings	CO2 emissions do not signalize inefficiency, are in no way linked with other waste generation. Investments in CO2 emissions abatement are quite costly and do not pay off.
	Decrease in the frequency of inspections, less additional costs, possibility to hide deficiencies.	There are no special inspections of CO2. Improved CO2 performance does not discourage inspectors of other pollutants because the instution that monitor other pollutants are not the same.

Table 4: Verified impact of improved environmental performance of the companies on their costs and revenues and expected outcome for CO_2 emissions

So far I discussed only environmental incentive approach. I suppose that models that stem from financial incentive approach generate the same result for CO_2 as for local pollutants. Companies with sufficient amount of money generated in the form of profits can invest it into measures that lead to reduction of energy consumption. Such investment is very desirable for companies because it can save considerable amount of money in future. On the other hand, initial investment might be quite high as well, so it remains unclear whether such investment will be profitable. However, once the investment is done, it will result in emissions reduction.

4. Impact of EU ETS

4.1 Description of the system

There is one additional aspect that may influence the relation between revenues, costs and environmental performance. In 2005 the European Union introduced Emission Trading Scheme (EU ETS) with CO_2 emissions allowances in order to decrease CO_2 emissions and to reach the target ratified in Kyoto Protocol. Because the EU member states were unsuccessful in fulfilling their obligations from Kyoto, EU decided to regulate the overall emissions.

Apart command-and-control regulation, there are two market based instruments that are supposed to lead to the emissions reduction, taxation and cap and trade system. Cap and trade system is further divided into thee versions – auctioning and grandfathering. Auctioning has some similar features with taxation, companies have to pay for allowances and the system generates revenues for government which can be used e.g. to cut of other taxes, in benchmarking the caps are derived from the emission-rate standard in certain industry. European Union, voted for grandfathering[12], which does not generate any profits for government but which is politically more feasible, companies get their caps for free according to their historical emissions. Big polluters concern about their increasing costs and therefore oppose any kind of measures that would generate additional revenues for state budget (Goulder and Parry 2008). However, not only a division of allowances is important, but the overall cap is crucial as well. Even grandfathering may harm companies significantly if the overall cap is too small (Bovenberg et al. 2003).

This system may compensate incentives to abate CO_2 emissions that are quite rare in the business-as-usual scenario in comparison with local pollutants as I described in the previous section. Each company receives a cap, i.e. certain amount of emissions that company is allowed to emit. The advantage of cap-and-trade system is its flexibility. Companies, that produces more emissions and the CO_2 abatement is more costly for them, can buy additional allowances on the market. On the hand, those companies, that can abate CO_2 emissions cheaper can sell their redundant allowances and thus get the financial

[12] However, some countries like Ireland or Denmark decided to divide small share of their caps in the auctions. The share of auctioned allowances will increase in the second phase of EU ETS and after 2013 it is expected that auctioning will prevail.

incentive for further reduction. This mechanism is efficient; the reduction takes place in the companies, where it is the cheapest. The desired level of emissions will be reached in any case; it is determined just by the overall cap that the government sets. The necessary condition is that the penalty that the regulation authority sets for exceeding the cap is sufficiently above the marginal costs of abatement.

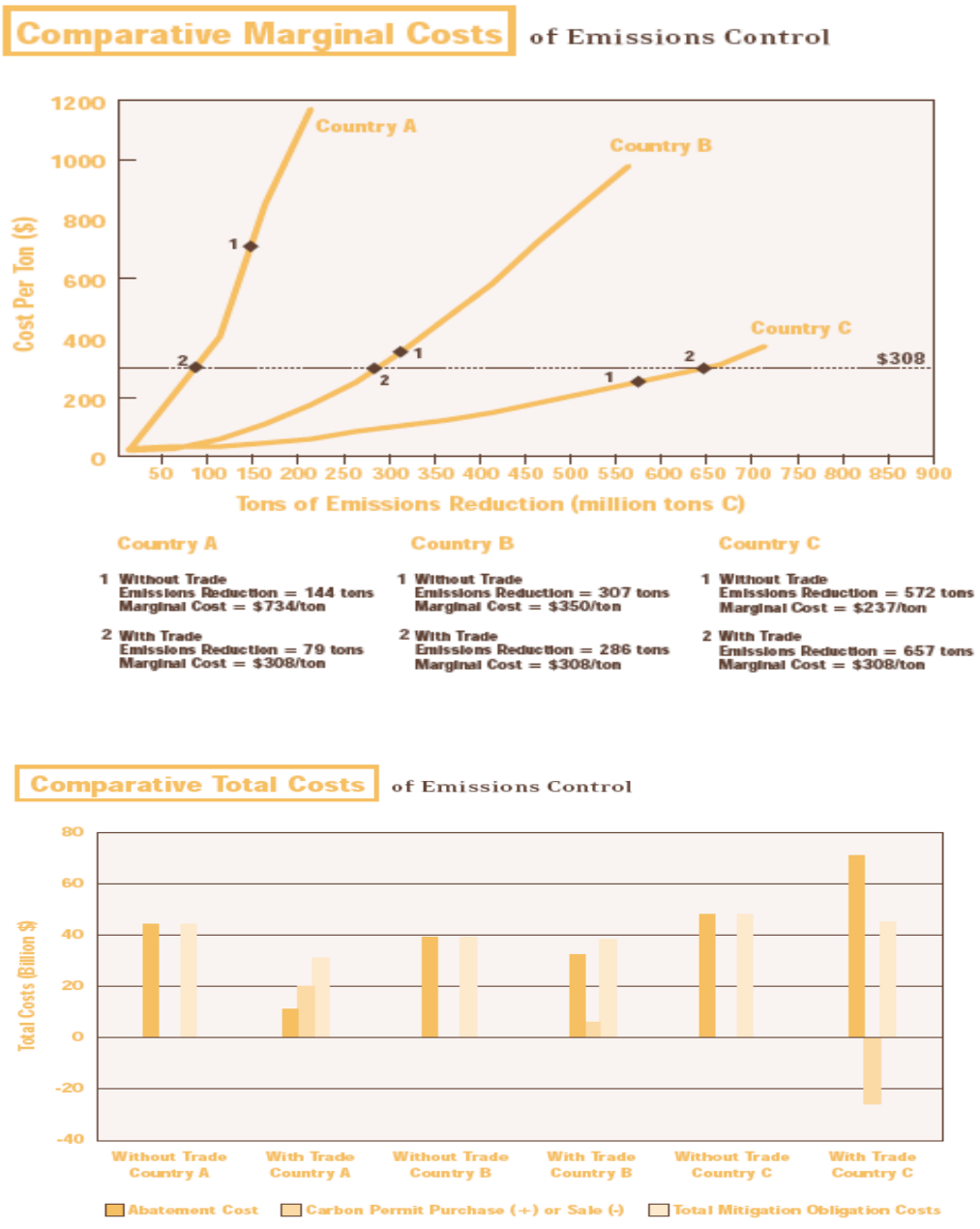


Figure 1: How does the emissions trade work? We can see that each country (or company) has different marginal costs of emissions reduction. With trade countries A and B buy the permits that country C with low marginal costs saved. As a result the same reduction is ensured with lower costs for all three countries. Source: Joe Edmonds, Michael J. Scott, Joseph M. Roop, Christopher N. MacCracken: International emissions trading and global climate change

In the ideal world, companies behave rationally and they all count whether it worth investing into abatement measures or not. They invest up to the point, where the marginal costs of the investment equal marginal benefits, i.e. the price for which they can sell the redundant emissions on the market.

4.2 Controversy of allowances allocation

However, in reality, there are several problems that undermine the advantages of cap-and-trade system. The main problem is the amount of allowances that is allocated. The government is on the one hand biased by lobbying companies that require the highest possible cap. On the other hand certain emissions reduction should be reached and therefore the caps for companies must be stricter than in the business-as-usual case. In the 1st Phase of EU ETS European Commission had to approve the overall amount of emissions for each state and it was up to the single states how they divide allowances between companies. Allowances were allocated according to the historical emissions, also benchmarking was take in consideration, but as the production patterns of single companies vary significantly there was no possibility to reach any common standard for more firms (Ellerman and Buchner, 2007). Unfortunately, data on CO_2 emissions had not been systematically measured in member countries prior the introduction of EU ETS and the amounts were used from a variety of different sources that had monitored it. Therefore, the data cannot be considered as entirely reliable and this lack of reliability could be one of the reasons of overallocation.

Sometimes the overallocation was done even intentionally. Especially Eastern European countries exaggerated their demands for allowances in order not to harm their industries. This bias was confirmed on the data from the year 2005 which show that all new member countries were in the net long position, i.e. they disposed overall abundance of allowances. Also old member states' governments worried about competitiveness of their industries and therefore their decisions about the allocation were also biased. Generally, they did not ask for more allowances than they used, but the allocation within the states was biased towards non-electricity industrial sector, which were mostly in the net long position (Kettner et al. 2006). Governments did not want to impose additional costs on

exporting industries and rather shortened the allowances for power generating companies which are not exposed to international competition. Because energy sector is quite monopolistic in member states, companies could impose the additional costs on the customers via increase in price of energy. Overall overallocation that was revealed in April 2006 resulted in a sharp decrease in the CO2 allowance price that I will further discuss in the next chapter.

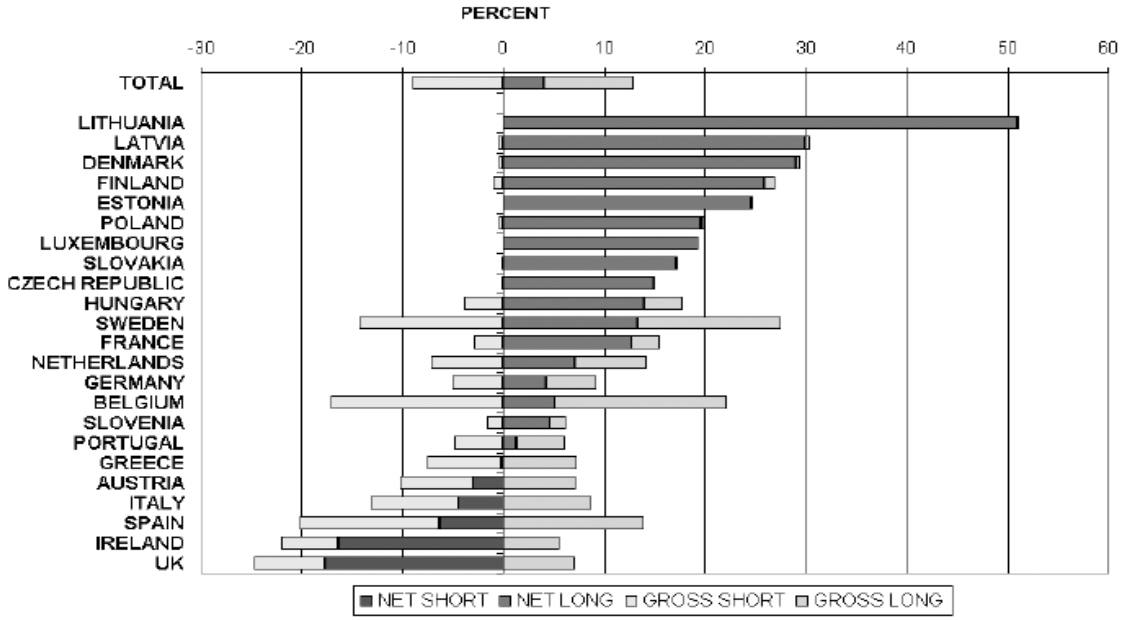


Figure 2: Short and long positions by member state in 2005.
Source: Community Independent Transaction Log (2006) and Kettner et al. (2006).

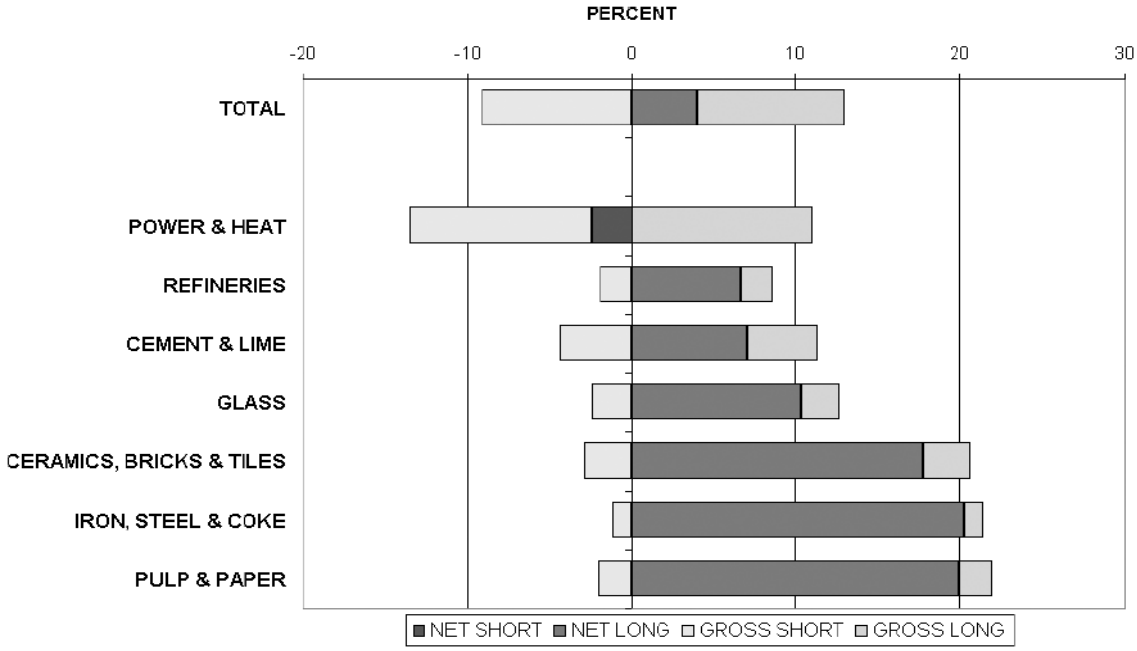


Figure 3: Short and long positions By EU-Wide sectors.
Source: Community Independent Transaction Log (2006) and Kettner et al. (2006).

4.3 Carbon market

At the beginning of the first phase of the EU ETS, until the end of April 2006 the system worked quite well, and traders with allowances generally expected that there would be a lack of allowances in the majority of member states. The price of the allowances and also the price of forwards indicated this development; they were growing and reached more than 30 EUR/ton. The bigger was then the surprise, when Walloon region of Belgium, French and Spanish governments released the first figures from the year 2005. The first two states disclosed that they had been strongly long on EUAs (i.e. they disposed the abundance of allowances, contrary to expectation) while Spain had been short, but much less then it had been expected. This development induced prompt reaction on the market. Price of the allowance fell by more than 50% to 12 EUR/ton. Following three months, the average price was around 16 EUR, but since September 2006 the price was falling, reaching only 5 EUR at the beginning of 2007. Since February, it has not exceeded 2 EUR, which was less than 10% of the maximal price reached before the collapse in April 2006.

The forward price and current price of EUA in the Phase 2 did not suffer such big volatility, it has been moving around 20 EUR/ton.

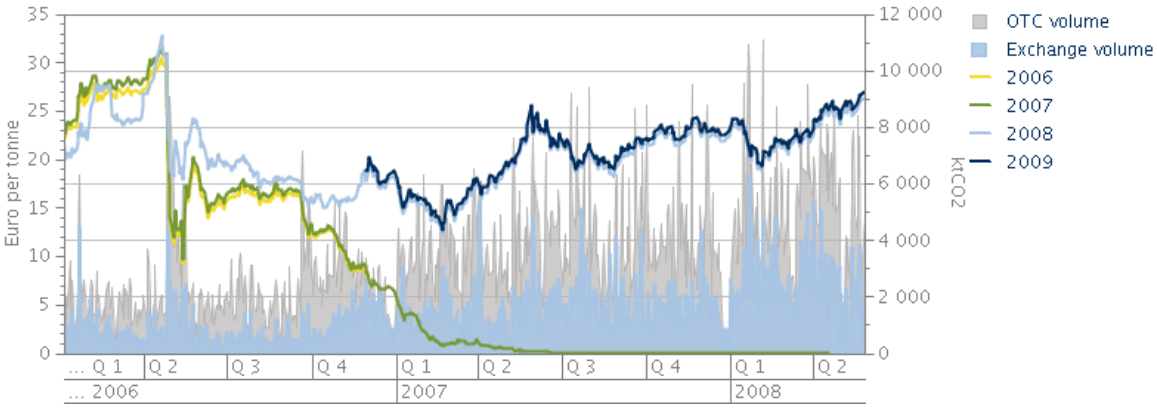


Figure 4: Prices and amounts traded at the carbon market in 2006-2008.

Source: www.pointcarbon.com

The volatility of the system had several negative impacts. Firstly, it undermined the credibility of EU ETS. It prooved, that the allocation of most member states was too generous and that the governments were captured by interests of companies that carried through their exaggerated demands for allowances. However, there remained one tricky

fact, companies supposed that the high price matched the real needs of the market, so they were not aware of overall abundance of allowances. We can just speculate whether they just underestimated the negotiating and lobbying skills of their competitors or whether they even underestimated their real needs for allowances.

The second impact of overallocation was an unfair diversification of the costs and benefits. Especially companies that invested into new technologies were harmed. When the price of CO_2 was high, they invested motivated by the prospect of significant revenues for the sell of abundant allowances at the end of the Phase 1, but the contrary was the case. As the price dropped under 1 EUR, they investment did not worth and they went through a considerable loss. On the other hand, those that did not invest at all, and behaved like in the business-as-usual scenario, spent at the beginning allowances intended for later and bought missing allowances in 2007 for a tiny price were the winners. Even more earned those companies that at the beginning expected abundance of allowances. They could at the times, when the price was high sell its allowances and buy them later on for much lower price.

If the marginal benefits of abatement remained stable, companies could better calculate whether investments into CO_2 reduction would be profitable or not. Revenues from sold redundant allowances would replace additional revenues stemming from better image in the case of local pollutant. However, this holds only in the well functional carbon market.

Situation in the first phase of EU ETS with high volatility implies high uncertainty and thus are companies rather reluctant to investments because the reward for decrease in emission in insecure.

5. Dataset

In my research I focused on Czech companies included in the 1st Phase EU ETS and analyzed the development of their emissions, financial indicators and relations between them.

5.1 Sources of data

I gathered data about CO_2 emissions of each installation from the Czech Ministry of Environment. Years 1999-2001 and 2004-2006 are covered. Unfortunately there were no reliable data in the years 2002 and 2003 and their inclusion to the dataset would distort the results. Because of the time discontinuity, I also had to exclude data from 1999-2001. Finally, I could only use data from year 2004, 2005 and 2006. However, there could also appear possible distortion because data from 2004 were collected by other methodology than verified emissions from 2005 and 2006. Data on financial performance were drawn from the Aspekt database that collects financial data and other information about Czech companies. Unfortunately, the database is not complete and due to the absence of the data on the characteristics that I required I had to exclude approximately half of all companies. Finally, 125 companies out of 261 companies included in NAP 1 (National Allocation Plan) are covered within 3 years in my dataset. However, it covers majority of big polluters, my dataset includes 48% of all companies but these companies emit 71% of total emissions[13].

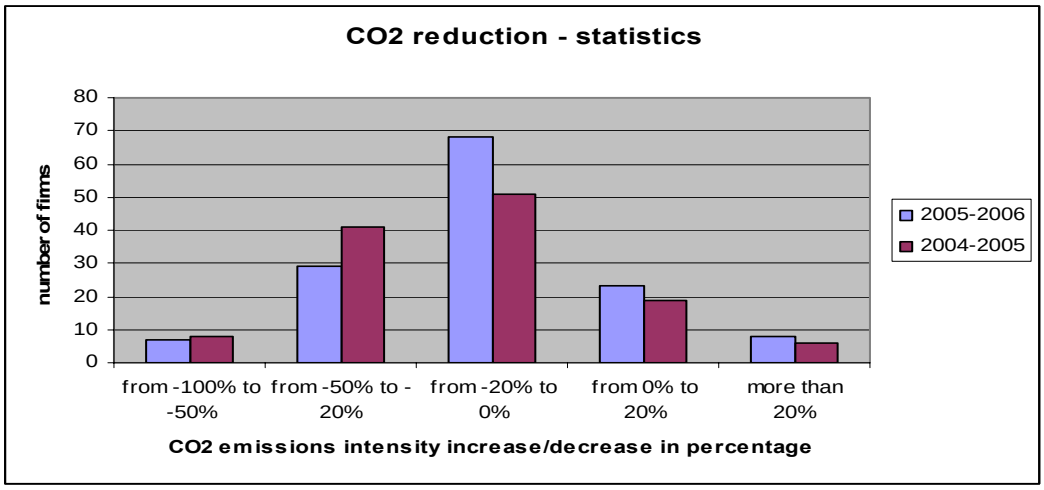
5.2 Descriptive statistics

In my analysis that I will describe in the chapter I used these 125 companies in the time horizon 3 years (2004-2006) and investigated numerous characteristics of these companies.

Firstly I focused on review of their environmental performance, I looked how the emissions intensity (emissions/revenues) changed between years 2004/2005 and

[13] In 2005 companies included in my research emitted 58,5 mil. tons of CO2 while all companies participating in NAP emitted 82,5 mil. tons.

2005/2006. Data show that majority of the companies decreased their emissions intensity, which holds for both years. Majority of the companies reduced their emission intensity by 0-20% and between 2004/2005 considerable number of companies reduced their emission intensity even more, by 20%-50%. This outcome is depicted in the graph 1 and indicates that if I talk about change of emissions intensity, it is emissions intensity reduction in 80% cases[14]. Average emissions intensity reduction was 11% between 2004 and 2005 and 12% between 2005 and 2006. However, it is necessary to point out that total emissions increased by 3% between 2005 and 2006 so the emissions reduction was not high enough to offset the economic growth.



Graph 1: Survey of change of emissions intensity

Second group of variables that describe my dataset is the kind of ownership. I divided this group between three subgroups, the first is joint stock companies, the second limited companies and the last is others[15]. We can see that most companies in my dataset were joint stock companies, followed by limited companies and only three companies called others.

[14] Because of the majority companies reducing their emissions, I afford to call this work „Impact of CO_2 emissions reduction on firms' financial performance" instead of "Impact of changes of CO_2 on firms' financial performance".
[15] State ownership or cooperatives.

dummy	observations	share in the dataset
a.s.	86	0.688
s.r.o.	36	0.288
others	3	0.024
CZ	71	0.568
foreign	54	0.432
iso	24 - 26	0.192 - 0.208

Table 5: Dummies and number of observations and their shares in the dataset

Also second category concerns ownership, but in this case we consider the residence of the majority owner. Czech owners slightly prevail over foreign. Further important dummy variable is the presence of ISO 14001, which is granted to companies with environmental management systems. The number of the companies that hold this certificate grew over time as new companies received it[16].

Companies participating in NAP1 were divided between 12 industries and so I followed this division.

sector	observations	share in the dataset
public power	34	0.272
business power	42	0.336
rafineries	1	0.008
chemicals	11	0.088
coal	1	0.008
metal and steel	5	0.040
cement	5	0.040
lime	2	0.016
glass	6	0.048
ceramics	10	0.080
paper	6	0.048
pulp	2	0.016
total	125	1.000

Table 6: Industries with number of companies in each sector and their share in the dataset.

Most companies are from public power sector or business power sector. The second one is rather specific, because it includes quite heterogeneous companies from various industries. Their only common feature is that they own only their own power or heat station. Other sectors are significantly less numerous. Oil manufacturing and coke are represented only by one company while lime and pulp by two. Only chemicals and ceramics reach numbers above 10.

[16] In 2004 24 companies hold ISO 14001, while in 2005 and 2006 26 companies.

Other variables are continuous. For the purpose of my analyses, I consider data in constant price of the year 2005. Data from 2004 and 2006 are modified by GDP deflator which in my opinion corresponds better to the nature of the data than CPI[17]. I analyzed revenues (r), profits (p) and costs (c) of the companies. Revenues and costs are highly correlated and profits are given as a difference between them. Average revenues reach 5036 bil. CZK per year while profits 530 mil. CZK per year. It indicates that an average firm is profitable. However, high values of standard deviation and the heterogeneity of included companies estimate huge differences in the data sample. Companies like ČEZ or Škoda Auto have revenues over 100 bil. CZK a year while the smallest company only 33 mil CZK a year. The same is true for profits and costs. Assets (a) is the variable which represent the size of the company. The differences are quite big again.

For the purpose of my analyses I often use not the total values but ratios. In this way I want to smooth away the size effect and rather focus on efficiency or productivity. E.g. instead of revenues I do not consider total revenues, but I use the ratio revenues/assets (ra) which indicates, how efficiently companies use their assets[18]. The variable for size is included in the model as well, it is represented by assets. It should indicate whether there are any economies of scale present in the model. I use ratios also for costs (costs/assets) (ca) and for profits. Ratio profits/assets (pa) is well known in finance as the *return on assets* ratio. In indicates the ability of the company to turn its assets into profits and is very important in company's valuation. I observe that in the case of ratios, differences between extreme values are much lower.

In the case of the indicator of environmental performance, i.e. emissions (e), I also avoid using total values. I rather consider the ratio emissions/revenues (er) which describes emissions intensity. Average emissions of the companies are 470 000 tons of CO_2 and average emissions intensity is 93 tons of CO_2/1 mil. CZK. The highest emission of ČEZ company are 35 mil. tons while the lowest only 87 tons. Huge differences are also between ratios. Big companies that own only small heat plant have much lower emissions intensity than companies that produce exclusively heat for public.

[17] Consumer price index
[18] Each industry has different level of this ratio stemming from the characteristics of the branch. More about this topic in the next chapter.

In this descriptive statistics are included also above mentioned variables in a logarithmic form. I will describe purpose of using logarithms in the next chapters.

In the second part of my model I have to exclude 35 companies that experienced a loss at least one year within the given time period. More about the reasons and consequences is in chapters 6.1.2 and 6.2.1. However, for this chapter are relevant new characteristics of the data used in this part of model. The descriptive statistics covers only companies that were profitable within all three years.

I will not too deeply describe the statistics of restricted data sample, but just refer to interesting differences in comparison with the complete dataset. First of all, profitability of companies increase, which is not surprising as we excluded companies in a loss. The results are indicated by profit margin which is almost 10%. Also average revenues, costs, assets and profits grew which means that these companies are in average also larger. From environmental point of view, companies have not only higher total emissions but also emissions intensity.

6. Model

In my models, I investigate relations between companies' economic and environmental performance. I stem from researches focused mostly on local pollutants and I test the hypothesis that hold for them. These hypotheses are discussed in previous chapters where I also derived their relevance on CO_2 data. Some of the hypothesis that holds for local pollutants should theoretically hold also for CO_2 some of them for various reasons not.

Firstly, I investigate how environmental performance influences economic performance and secondly vice-versa.

6.1 From environmental to financial performance

6.1.1 Specification of variables

In this model, I consider financial performance being determined by environmental performance of the company in the given or previous year. I test how environmental performance results in the financials already during the year, when decrease/increase in emissions took place and one year later. I observe this relation on following variables: as environmental performance I use CO_2 emissions intensity of the company, i.e. the CO_2 that company emitted in the given year divided by the total value of its product. In fact, I do not consider overall change in CO_2 emissions but rather the change in emission per unit of output. This approach reflects better environmental efforts of the companies. If only total level of emissions was considered, environmental impact of companies that grow rapidly (and thus also grow their emissions) would be overestimated.

I analyze the impact of reduction/increase in emissions intensity on most relevant aspects of financial performance of the company, i.e. its total revenues, total costs and profits. However, I also modify these data. The main reason is that I need to avoid huge differences in the data sample. There are few companies like ČEZ a.s. or Škoda Auto a.s. with extraordinary high revenues and costs, that would stand out of the data sample and bias the results of the statistics. Therefore I use ratio of revenues and costs on the total companies' assets.

There are basically two models in the direction from environmental performance to financial. The first one involves data of both variables from the same year, i.e. it investigates how the environmental performance results in financial already in the year when emissions reduction/increase took place. But the immediate impact may be diverse from the longer-term effect. Therefore, I also use a modified model where I analyze the impact of emissions reduction/increase one year after this change took place. I use lagged variable emissions/revenues.

6.1.2 Explanatory variable emissions/revenues

Revenues in the given year will probably be positively influenced by a decrease in emissions. I analyze data for 2004, 2005 and 2006. In the last two years EU ETS was running. Companies that reduced CO_2 emission could be rewarded by additional revenues from the emissions allowances that they sold on the market. Therefore, the effect of emissions/revenues ratio on revenues/assets could be negative. However, because companies received their caps not for one year but for a three years period and because they could transfer permits from one year to another, also companies that did not decrease emissions below their cap could sell the allowances and benefit from the high price on the market. They could rely on decrease in allowances price in the next period, which really happened and buy missing allowances in 2006 or 2007 for much lower price.

If the increase in revenues was a consequence of reduction in emissions and not just speculations, a negative relation between emissions and revenues would hold in both models with and without lagged variable. Investments into emissions reduction have a long term impact, new technology work not only in the year when investment was done but company benefits from it in a long term horizon. In the case of opposite sign in models with and without lagged variable, I can assert that companies just transferred allowances from one period to another and no significant investments into emissions reduction took place.

As for costs, I expect that companies with lower emissions invested into modern technologies. These investments are particularly aimed at reduction of energy consumption. Lower energy consumption leads to lower operating costs. This finding could tempt me to make a hasty conclusion that lower emissions should result in lower

costs. But as I use book costs, I am aware that also depreciation is included in the costs. And more expensive the investment is, higher its depreciation is. So big investments does not result in a lump-sum increase in costs in one year and lower costs in the following year as a common sense would suggest, but in a longer term increase in costs due to higher depreciation and in a long term decrease in operating costs. The question is which effect prevails. Revenues remaining unchanged, company is rational and calculates whether the investment pays off, i.e. whether a decrease in operating costs outweigh an increase in costs due to higher depreciation.

However, the assumption of revenues remaining unchanged is very strong and does not hold in this case. As I described above, the presence of EU ETS enables companies to sell the abundant allowances on the market and thus increase their revenues. Therefore, the decision of companies to invest into CO_2 emission reduction is determined not only by a comparison of decrease in operating costs and depreciation, but also by possible increase in revenues. It means that also investments that have higher depreciation than savings in operating costs can be profitable for the company if revenues from sold allowances are sufficiently high. Lower emissions can have both positive and negative impact on costs. As in the case of revenues, the impact should be the same for both models with and without time lag.

I will observe how decrease/increase in emissions results in profitability in last models with dependent variable profits/assets. If the carbon market worked well and companies were rational in their decision making, lower emissions should result in higher profits in both models with and without lagged variable. However, this research will be done only on limited dataset of 90 companies out of original 125. It is due to the fact that as I use logarithm of profits/assets, I can include only companies that have this ratio positive within all three years. I must be aware that the results are derived from the dataset of profitable companies only and therefore cannot be applied on all companies.

6.1.3 Other explanatory variables

So I explained the impact of emissions on three main variables of my concern. But as I believe that also other factors may have a significant influence on the revenues and costs of the companies than their CO_2 emissions, I include them in the model as well. Similarly

like emissions intensity, their effect on revenues, costs and profits should be the same in both models with and without lagged variable. First two explanatory variables concern the major owner of company; it may originate from Czech Republic or from abroad[19]. I suppose that companies with foreign owner may tend to have higher revenues/assets as the foreign investors pick out the companies that derive benefit from their assets effectively. Because I expect a positive impact on revenues/assets the same will be probably true for costs/assets as costs and revenues are highly correlated. As a residuum, Czech ownership's expected sign is negative. However, I think that nationality of the owner may be more important in the case of the inverse relation.

Another variable is the kind of ownership. I consider three kinds – joint stock companies (a.s.), limited company (s.r.o.) and other kinds of ownership (mostly cooperations)[20]. Expected outcome is not entirely clear, but it is more likely that companies that are traded on the stock exchange are more under pressure to use their assets efficiently and therefore are more likely to have higher share of both revenues/assets and costs/assets in comparison with limited companies. I expect that this will hold also for profitability. The case of other kinds of ownership is unclear, also due to very few companies included in this group.

I add other variable iso, which equals 1 for the companies that are certified by the standard ISO 14001. This certificate is granted to the companies that introduced environmental management systems and constantly effort to improve their efficiency. The effect of this characteristic will be probably much higher on the emissions than on revenues, but still, I expect that companies that introduce this system are more profitable and more efficiently use their assets, so the sign of this variable will be positive.

Another important aspect is the industry where companies operate. I divided companies into 12 branches which are mentioned in the table 7. It is evident that there are considerable differences between companies in single industries in all ratios emissions/revenues, revenues/assets and costs/assets. Some industries, e.g. companies generating power for public have much higher emissions intensity than chemicals. Differences are also present in three financial ratios, e.g. business power, which includes

[19] Czech owner is considered as a benchmark.
[20] Limited company is a benchmark.

companies from almost all industries have high share of revenues on assets, while the industries that require high level of assets like refineries or lime have this share considerably smaller. The most profitable companies are in cement and ceramics industry, while the least profitable industries are refineries and coke. In order to get a more comprehensive view on the determinants of companies' ratios revenues/assets and costs/assets it is desirable to include also variables for industries in my model[21].

		E/R		R/A		C/A		P/A	
industry	number	average	stan. Dev.	average	stan. Dev.	average	stan. Dev.	average	stan. Dev.
public power	34	304.517	742.595	0.934	0.933	0.881	0.925	0.057	0.065
business power	42	36.762	78.301	1.640	1.043	1.603	1.050	0.046	0.137
refineries	1	86.255	0.670	0.384	0.036	0.372	0.035	0.014	0.001
chemicals	11	19.580	21.794	1.214	0.338	1.158	0.349	0.063	0.078
coal	1	38.206	4.375	1.905	0.198	1.883	0.262	0.031	0.096
metal and steel	5	25.773	24.681	1.756	0.543	1.686	0.525	0.081	0.078
cement	5	218.252	114.328	0.966	0.365	0.775	0.414	0.195	0.112
lime	2	1601.519	1947.512	0.849	0.534	0.782	0.490	0.073	0.054
glass	6	35.575	15.152	1.131	0.239	1.050	0.220	0.087	0.056
ceramics	10	38.053	24.722	1.400	0.526	1.199	0.388	0.208	0.211
paper	6	32.920	23.862	1.390	0.479	1.350	0.501	0.049	0.045
pulp	2	25.149	13.923	1.051	0.081	0.940	0.061	0.117	0.039
total	125	140.019	512.645	1.302	0.881	1.235	0.881	0.074	0.123

Table 7: Statistics of the data set divided according to the industry. Please note that data are taken from the period 2004-2006 and each company is included three times. Therefore there is standard deviation not equal 0 for 1 observation.

There are two more variables that I include in the model. The first one is the level of assets, which enables me to observe the effect of economies of scale. Bigger the company is, more negative effect it has on all three ratios (I realize that assets is a denominator in this variable, so the relation is obvious). More interesting will be the effect of economies of scale on the environmental performance in the inverse relation. Last variable is the year, I included dummy variable for years 2005 and 2006[22]. I expect that as Czech economy grew fast within 2004-2006, also the output of companies included in NAP grew. I am of course aware that there is a ratio revenues/assets in model but still, I expect that the revenues grew more rapidly than assets, therefore the expected sign for both year2005 and year2006 is positive, absolute value of the coefficient for year2006 being higher. Also profitability is likely to rise in the growing economy. The expected impact of all explanatory variables on revenues, costs and profits is summarized in table 8.

[21] I used variable public power as a benchmark
[22] 2004 is a benchmark

Before I show the entire model, I need to alert that I have a logarithmic model where I measure the elasticities of variables, i.e. what impact has a change of emissions/revenues on revenues/assets. I chose this model for several reasons. Firstly, it is a dynamic version so we can observe real reactions and I could also predict an outlook in the future. Secondly, I also tried to use non-logarithm version, but the results were a big disappointment, as the R-squared were very low and also single variables were found not significant according to their t-statistics and consequently P-values.

Model 1: explanatory variable revenues/assets, dependent variable emissions/revenues without time lags[23]:

$$\ln(R/A)_t = \beta_0 + \beta_1 * \ln(E/R)_t + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

Model 2: explanatory variable costs/assets, dependent variable emissions/revenues, without time lags:

$$\ln(C/A)_t = \beta_0 + \beta_1 * \ln(E/R)_t + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

Model 3: explanatory variable profits/assets, dependent variable emissions/revenues, without time lags:

$$\ln(P/A)_t = \beta_0 + \beta_1 * \ln(E/R)_t + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

Model 4: explanatory variable revenues/assets, dependent variable emissions/revenues, with 1 year lag:

$$\ln(R/A)_t = \beta_0 + \beta_1 * \ln(E/R)_{t-1} + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

Model 5: explanatory variable costs/assets, dependent variable emissions/revenues, with 1 year lag:

[23] I did not write each single dummy variable in the model, instead of dummies for nationality of majority owner which covers Czech and foreign I use vector ***nat***, instead of kind of ownership which covers joint stock companies, limited companies and others I used vector ***own***, instead of all 12 industries I used one vector ***ind*** and instead of dummies for years I used just a vector ***year***. I followed this pattern also in all other models.

$$\ln(C/A)_t = \beta_0 + \beta_1 * \ln(E/R)_{t-1} + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

Model 6: explanatory variable profits/assets, dependent variable emissions/revenues, with 1 year lag:

$$\ln(P/A)_t = \beta_0 + \beta_1 * \ln(E/R)_{t-1} + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

explanatory variable	description	expected impact on		
		ln(R/A)	ln(C/A)	ln (P/A)
ln(E/R)	emissions/revenues	+	?	+
CZ	Czech owner	-	-	-
for	foreign owner	+	+	+
as	joint stock company	+	+	+
sro	limited company	-	-	-
other	other form of ownership	?	?	?
iso	environmental management	+	+	+
ind1	public power	-	-	-
ind2	business power	+	+	-
ind3	refineries	-	-	-
ind4	chemicals	-	-	-
ind5	coal	+	+	-
ind6	metal and steel	+	+	+
ind7	cement	-	-	+
ind8	lime	-	-	+
ind9	glass	+	+	+
ind10	ceramics	+	+	+
ind11	paper	+	+	-
ind12	pulp	-	-	+
ln(A)	total assets	-	-	-
year	year	+	+	+

Table 8: Expected impact of explanatory variables

6.2 From financial to environmental performance

6.2.1 Explanatory variable profits/assets

This model investigates the inverse relation, how financial performance influences environmental performance. I investigate the relation between profitability and emissions of the companies. Companies that generate high profits have lots of cash which they can invest and thus increase the value of their assets. Part of the investments is invested into projects that decrease consumption of energy and thus decrease emissions. It means that higher profits should theoretically lead to lower emissions.

I use operating profits because it is probably the best indicator of actual economic performance of the company which does not include any extraordinary revenues or high financial costs that are present especially by highly indebted companies[24]. As in the previous models, instead of absolute values ratios are included in the model. I use two ratios in the model. The first one is profits/assets, which is known as return on assets (ROA)[25]. It measures how the company is successful in turning its assets into profits. If I use this ratio, I smooth away potential bias to bigger companies which tend to have higher profits in absolute value. The scale effect is included in other important variable assets, which I describe later in more details. The second ratio is the same like in the previous chapter; emissions/revenues are in the model as a response variable.

I expect that companies that are profitable have increased their revenues and thus emissions and therefore should have lower emission intensity in comparison with less profitable ones. So the expected sign of profits/assets is negative.

Because of the similar reasons like in the first models, I consider logarithmic form of models again. These models provide us with information, how the ratio emission/revenues reacts on the change of ratio profits/assets in the same year considering specificity of companies in various industries and different owners. As in the models 3 and 6, I can have logarithm only for positive numbers. Therefore I have to exclude companies that have experienced a loss from the dataset. I am aware that all conclusions from the model hold only for profitable companies.

Ratio emissions/revenues is more likely to be influenced also by other variables in the regression like company's ownership, industry or environmental management system than in the case of ratios revenues/assets or costs/assets.

6.2.2 Other explanatory variables

First of all, I focus on the impact of ownership. According to the OECD study "Environmental Policy and Corporate Behaviour" foreign ownership should increase the

[24] However, the results for overall profits would be probably quite similar as both variables are highly correlated. $\rho=0,96$

[25] In the case of ROA we consider overall profits not only operating. Therefore I will not call it ROA.

probability of better environmental performance, because foreign owner tends to unify the production standards in all his plants in different countries. In such process he has to choose the country with the strictest environmental standards as a benchmark. However this impact of foreign ownership was not proved in the empirical research. In the case of the Czech Republic, the original hypothesis could hold. Environmental performance of Czech companies is still relatively poor in comparison with developed countries that most foreign owners originate from. Therefore, foreign owner could have a negative impact on the share emissions/revenues. Nevertheless, even this hypothesis does not have to hold necessarily as CO_2 emissions do not have any prescribed standards. The expected outcome for Czech ownership is intuitively residuum to foreign, e.g. positive impact on emissions/revenues.

As far as kind of ownership is concerned, I expect negative relation for joint stock companies. This outcome was confirmed in the above mentioned OECD study. Theoretically, companies whose shares are traded at the stock exchange are exposed to higher pressure of their shareholders to have "environment friendly image". However, this hypothesis may be questioned for CO_2 emissions, as the public pressure for this pollutant is not so strong. Another problem is that only minimal amount Czech joint stock companies are traded publicly traded in the stock exchange. The expected negative outcome of a joint stock company for the ratio emissions/revenues is not entirely clear.

On the other hand, certificate ISO 14001 for companies that have introduced environmental management system is very likely to have a significant influence on companies' environmental performance. Those companies that attempt to decrease their environmental impact and reduce their costs are certified by ISO 14001 and thus the holding of this certificate is a common feature of companies that reduce their emissions intensity. As in the previous model, I include dummy variables for the industries. In table 7, it is evident that companies of certain branches tend to have lower or higher emission intensity. The highest ratios emissions/revenues are typical for energy producers or industries with high energy consumption like cement[26] or public power whose main activity is power generation. On the other hand, we can observe relatively low emissions

[26] See table 7. Companies in lime industry have the highest emissions intensity, but I do not consider this number reliable due to low number of observation and high standard deviation do not consider this number reliable due to low number of observation and high standard deviation.

intensity in industries with lower energy consumption like chemicals or business power that include firms of many various branches. As far as the assets are concerned I can expect economies of scale. Bigger companies can afford investing into energy efficiency more and therefore are likely to have lower share emissions/revenues.

The sign for dummies year2005 and year2006 year is supposed to be negative, because Czech economy grew in the given period and so the denominator was rising in the time, while emissions decreased between 2004 and 2005 and increased relatively slightly between 2005 and 2006.

explanatory variable	description	expected impact on ln(E/R)
ln(P/A)	profits/assets	-
CZ	Czech owner	+
for	foreign owner	-
as	joint stock company	-
sro	limited company	+
other	other form of ownership	?
iso	environmental management	-
ind1	public power	+
ind2	business power	-
ind3	rafineries	-
ind4	chemicals	-
ind5	coal	-
ind6	metal and steel	-
ind7	cement	+
ind8	lime	+
ind9	glass	-
ind10	ceramics	-
ind11	paper	-
ind12	pulp	-
ln(A)	total assets	-
year	year	-

Table 9: Expected impact of explanatory variables on emissions/revenues

Model 7: Explanatory variable profits/assets in the given year, dependent variable emissions/revenues.

$$\ln(E/R)_t = \beta_0 + \beta_1 * \ln(P/A)_t + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t$$
$$+ \beta_5 * ind_t + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

7. Results

7.1 Methodology

Because my models include panel cross-sectional data I cannot run ordinary least squares regression. Instead, I use general least square regression[27]. First of all, I have to analyze whether I can run the random effects model. I use Breusch and Pagan Lagrange multiplier test for random effect model (See e.g. William H. Greene: Econometric Analysis, 5th edition, p. 298-299). For all my models 1-7 I reject null hypothesis of using classical regression model and choose random effects model (see results in table 10). However, it does not mean that random effects model must necessarily be the best choice.

In some cases, it is more appropriate to use fixed effects model. It is more appropriate when the random part (not expressed directly by measured variables in the model) of the model is somehow correlated with variables included in the model. Fixed effect models are less efficient but on the other hand more consistent than random effects models. There is some kind of trade-off which method is better to use. I can decide intuitively in the case that I suppose that the random part could be correlated with some variables. In my case, it could be e.g. dummies for industries which may be correlated with variables for single companies. However, as I am not sure whether it is really so, so I rather choose a more sophisticated method. It is Hausman's specification test for random effects model (see again William H. Greene: Econometric Analysis, 5. edition, pages 301-303). In the trade-off between consistency and efficiency, this estimate can help us to decide, which of these two characteristics is better to give up.

In my case, the results differed in each model. Test rejected null hypothesis in models 1, 2, 4, 5, 7 and thus suggest using fixed effect model. The result is, that R-squared decreased (but not too significantly), many variables (dummies because their values for single observations do not change during the given period) were dropped, but the consistency has improved. On the other hand, results for models 3 and 6 support random effects. The decrease in R-squared that would occur if we chose fixed effect model would be so high, that it is more convenient to have less consistent random effects model.

[27] I did all the regression in Stata software.

Before estimating the coefficients and interpreting the results, I have to check the assumptions of GLS model. Firstly, the distribution of residuals should be normal. I test the normality by Shaphiro-Wilk test. The normality of residuals was rejected in models 1, 2, 3 and 6. However, this condition is not necessary for GLS models. It means that GLS model estimate is not the best among all estimates but only the best among linear estimates which is sufficient for my purposes.

Second assumption is homoskedasticity of residuals. If it is broken, the variances of coefficients are underestimated, t-statistics overestimated and thus some variables seem to be significant although they are not. According to the results of Breusch-Pagan test, homoskedasticity is broken in models 3, 6 and 7. I need to use a remedy which migh be robust models or feasible GLS model.

Lastly, because I work with panel data, I have to check the autocorrelation of residuals. The presence of autocorrelation would have the same effect like heteroskedasticity, i.e. variables that are not significant would be marked as significant. I can test autocorrelation only in datasets that cover at least three period. Therefore I could not test autocorrelation in models 4, 5 and 6 with a lagged variable. In model 7 Wooldridge test rejects the hypothesis of no autocorrelation while in model 3 it does not. In models 1 and 2, p-values are very similar, but if I chose 5% significance level, in model 1 no autocorrelation is rejected while in model 2 it is not. I would have to choose entirely different methods for estimating the results of the regression. Because I will compare the results of these two models, models should be consistent and I should use the same method for estimating the coefficients. If I accept 1% significance level, I do not reject the null hypothesis of non-correlated residuals and for estimating coefficient in both models fixed effects model will be chosen.

The remedy for autocorrelation in model 7 is feasible generalized least squares model which treats also heteroskedasticity, so I will use it also in other models where homoskedasticity is broken (3 and 6). In specification I choose specific AR(1) coefficient for all panels and heteroskedasticity of residuals in model 7 and heteroskedasticity in models 3 and 6. For models 1, 2, 4, 5 I use fixed effects model.

summary	normality: Shaphiro-Wilk		homoskedasticity: Breusch-Pagan		autokor (AR1): Wooldridge	
model	p-value	result	p-value	result	p-value	result
1	0.000	no	0.684	OK	0.062	OK
2	0.000	no	0.239	OK	0.049	OK
3	0.001	no	0.000	no	0.095	OK
4	0.584	OK	0.637	OK	N/A	N/A
5	0.417	OK	0.298	OK	N/A	N/A
6	0.000	no	0.000	no	N/A	N/A
7	0.069	OK	0.005	no	0.000	no

Table 10: Tests for normality, homoskedasticity and autocorrelation of residuals.

Because fixed effects model drops variables that do not change over time, I use different method to estimate the impact of these variables on the response variable. I stem from the article "Handling unobserved site characteristics in random utility models of recreation demand" by Jennifer Murdock. To explain the effects of other variables, author used fitted values from the fixed effects model and run a new OLS regression where fitted values were a response variable while dummy variables that have not changed were explanatory variables. Then she could interpret the impact on original values of response variable. I use the same approach to estimate the impact of industries, ownership etc. on emissions, revenues, costs and profits.

7.2 From environmental to financial performance

7.2.1 Models without lagged variable

In the first model, where revenues/assets are dependent variable and where no lag is present, the results of fixed effects models show, that many variables were dropped.

$$\ln(R/A)_t = \beta_0 + \beta_1 * \ln(E/R)_t + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

Only variables that did change with the time period iso[28], year2005, year2006, logarithm of emission/revenues and logarithm of assets remain in the regression. P-values of iso and both years indicate that these variables are insignificant. Constant has high value of t-statistic, which may be caused by at least partial inclusion of some dropped variables in the constant part. Also logarithm of assets is significant and negative sign indicates that companies with higher values of assets have certain problems with turning them into

[28] Two companies introduced iso in 2005, therefore this dummy changed in the time series and is included in FGLS model.

revenues. But this explanation may be biased as there is once assets as a denominator in dependent variable and once as a numerator in independent variable. The most interesting variable for us is logarithm of emissions/revenues. It is significant and the sign is negative, which is consistent with my theory. Possible interpretation is that companies that decrease their emissions intensity may sell their abundant allowances on the carbon market and thus increase their revenues.

MODEL 1 ***lnra***				
variable	coef.	st. Error	t-stat.	p-value
iso	0.122	0.176	0.69	0.488
lner	-0.336	0.031	-10.70	0.000
lna	-0.334	0.044	-7.52	0.000
year2006	0.022	0.028	0.79	0.429
year2005	-0.033	0.027	-1.26	0.209
cons	3.485	0.377	9.25	0.000
as	-0.405	0.073	-5.56	0.000
oth	-0.585	0.251	-2.33	0.020
cz	0.371	0.070	5.34	0.000
iso	-0.317	0.094	-3.37	0.001
ind2	0.833	0.080	10.54	0.000
ind3	-0.760	0.348	-2.18	0.030
ind4	0.448	0.117	3.81	0.000
ind5	-0.250	0.339	-0.74	0.461
ind6	0.368	0.166	2.22	0.027
ind7	0.140	0.174	0.80	0.422
ind8	-0.618	0.251	-2.47	0.014
ind9	0.326	0.153	2.13	0.034
ind10	0.473	0.125	3.80	0.000
ind11	0.201	0.148	1.36	0.176
ind12	0.570	0.258	2.21	0.028
cons	-0.172	0.086	-1.99	0.048

Table 11: Model 1 without lags and with dependent variable revenues/assets

Source: own caluculations in Stata

The results for dummies are quite unexpected. Companies with limited liability have higher ratio revenues/assets than joint stock companies. Czech companies also use their assets more effectively than companies with foreign owner. Companies with environmental management system also turn their assets in revenues less effectively. As for industries, the outcome corresponds to our expectations. Heavy industries like public power, refineries and coke has quite lower revenues/assets ratio while business power, chemicals and paper relatively high.

The second model with costs/assets as dependent variable and without lags shows similar outcome as the first one, probably due to very high correlation between revenues and

costs. Variables that do not change within the observed period are dropped and from the remaining ones, iso and both years are insignificant.

$$\ln(C/A)_t = \beta_0 + \beta_1 * \ln(E/R)_t + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

The outcome for assets has similar explanation like in the case of revenues. Higher the value of assets is more problems have the companies with their utilization. As for costs/assets ratio, this key variable of our interest emissions/revenues is significant with a negative sign. It indicates that companies with lower emissions have higher costs. So the depreciation of investments probably overweighs decrease in operating costs.

MODEL 2 ***lnca***				
variable	coef.	st. Error	t-stat.	p-value
iso	0.179	0.182	0.98	0.327
lner	-0.330	0.032	-10.20	0.000
lna	-0.345	0.046	-7.52	0.000
year2006	0.022	0.029	0.77	0.443
year2005	-0.039	0.027	-1.42	0.155
cons	3.456	0.388	8.91	0.000
as	-0.413	0.073	-5.65	0.000
oth	-0.598	0.252	-2.38	0.018
cz	0.386	0.070	5.52	0.000
iso	-0.277	0.094	-2.94	0.003
ind2	0.815	0.079	10.27	0.000
ind3	-0.787	0.350	-2.25	0.025
ind4	0.423	0.118	3.59	0.000
ind5	-0.280	0.340	-0.82	0.411
ind6	0.345	0.167	2.07	0.039
ind7	0.149	0.174	0.86	0.392
ind8	-0.607	0.251	-2.42	0.016
ind9	0.316	0.154	2.05	0.041
ind10	0.465	0.125	3.71	0.000
ind11	0.181	0.149	1.22	0.224
ind12	0.561	0.259	2.17	0.031
cons	-0.240	0.087	-2.76	0.006

Table 12: Model 2 without lags and with dependent variable costs/assets

Source: Own calculations in Stata

Also results for dummies are very similar like in the model 1 with revenues. Companies with high ratio revenues/assets have also higher ratio costs/assets, so it indicates only that they have quicker turnover of their assets.

So far, I have analyzed the impact of emissions on both revenues and costs. But what may be even more important, is the impact on profits. With lower emissions, both revenues

and costs rise. But what does increase more - revenues or costs? The answer provides us model 3 with dependent variable profits/assets.

$$\ln(P/A)_t = \beta_0 + \beta_1 * \ln(E/R)_t + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

MODEL 3 ***lnpa***				
variable	coef.	st. Error	t-stat.	p-value
as	-0.161	0.074	-2.19	0.028
oth	0.799	0.116	6.90	0.000
cz	-0.544	0.079	-6.87	0.000
iso	0.578	0.094	6.16	0.000
ind2	0.213	0.133	1.61	0.106
ind3	-1.485	0.130	-11.38	0.000
ind4	0.418	0.114	3.66	0.000
ind6	0.428	0.178	2.40	0.016
ind7	0.505	0.109	4.62	0.000
ind8	-0.380	0.358	-1.06	0.289
ind9	0.440	0.108	4.06	0.000
ind10	1.212	0.127	9.58	0.000
ind11	0.180	0.115	1.56	0.118
ind12	0.028	0.184	0.15	0.880
lner	0.007	0.023	0.31	0.758
lna	-0.006	0.027	-0.23	0.815
year2006	-0.073	0.039	-1.89	0.058
year2005	-0.105	0.039	-2.70	0.007
cons	-2.539	0.234	-10.86	0.000

Table 13: Model 3 without lags and with dependent variable costs/assets

Source: Own calculations in Stata

In the model, many dummy variables are significant so I can interpret their sign. But variable that interests me most emissions/revenues has very high p-value and thus is insignificant. The impact of change in emissions on profits is not clear and I cannot assert whether increase in revenues or increase in costs prevails. However, it may be interesting to focus on other variables. Size of assets is also insignificant, but both years 2005 and 2006 show lower profitability than year 2004 which is rather surprising with respect to growing economy.

Joint stock companies are less profitable than limited companies which may be also quite surprising finding. But companies with Czech owner tend to be significantly less profitable than those owned by foreigners. Companies certified by iso are more profitable. It indicates that companies that introduce iso improve their financial performance. But I must be aware of possible inverse causality. Maybe companies that are already profitable can afford environmental management. As industries are concerned, ceramics and cement

are the most profitable sectors, while public power and refineries have the lowest ratio profits/assets.

7.2.2 Models with lagged variable

The fourth model includes ratio revenues/assets as a dependent variable, but this time with emissions intensity from previous year.

$$\ln(R/A)_t = \beta_0 + \beta_1 * \ln(E/R)_{t-1} + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

In this case, variable iso is excluded as well because no firm introduced it in between years 2005 and 2006. Logarithm of assets in the given year is not significant, while year2006 is significant[29]. Positive sign of year2006 indicates that companies turned their assets into revenues more efficiently in year 2006 than in 2005 which is consistent with the overall increase in productivity in Czech economy.

Ratio emissions/revenues is again significant, but now with a positive sign. It indicates that companies with lower emission have lower revenues in the following year. This outcome is opposite to the results of model 1 that show that companies with lower emissions have higher revenues in the given year. If the reduction really took place, emissions would be lower and revenues higher also in the next year. Possible explanation is that companies with lower emissions predicted collapse of carbon market in 2006 and sold more allowances than they saved in the first year when the price on the carbon market was high and in the following year no more free allowances for sale were left. Or if they still had some, the price that they got on the market was so low that it did not reflect in overall companies' revenues[30]. It is also necessary to realize, that revenues from the sale of allowances are for majority of the companies just a small fraction of their total turnover so revenues might be influenced by many other variables that are not included in the model and that are randomly correlated with emission and thus bias the results.

[29] Please remeber, that this model includes data only form two years, so year2005 is a benchmark in this case.
[30] See figure 4.

MODEL 4 ***lnra***				
variable	coef.	st. Error	t-stat.	p-value
lner	0.152	0.046	3.29	0.001
lna	0.047	0.070	0.67	0.501
year2006	0.162	0.033	4.97	0.000
cons	-0.854	0.446	-1.92	0.058
as	0.079	0.035	2.27	0.024
oth	0.125	0.102	1.22	0.223
cz	-0.046	0.034	-1.38	0.168
iso	0.048	0.043	1.11	0.269
ind2	-0.421	0.038	-11.13	0.000
ind3	0.046	0.168	0.27	0.784
ind4	-0.343	0.056	-6.08	0.000
ind5	-0.142	0.164	-0.87	0.386
ind6	-0.275	0.080	-3.45	0.001
ind7	-0.006	0.083	-0.08	0.938
ind8	0.354	0.121	2.93	0.004
ind9	-0.218	0.074	-2.95	0.003
ind10	-0.243	0.060	-4.06	0.000
ind11	-0.224	0.071	-3.13	0.002
ind12	-0.310	0.124	-2.51	0.013
cons	0.267	0.041	6.54	0.000

Table 14: Model 4 with lags and with dependent variable revenues/assets

Source: Own calculations in Stata

Quite striking is that most dummy variables have an opposite sign than in model 1. However, these results are not reliable enough due to higher p-values which turn most variables into insignificant. More rigorous econometric analysis is needed to reveal the opposite sign which might have biased also the results for emissions/revenues coefficient.

Costs/assets are the object of our interest in the model 5.

$$\ln(C/A)_t = \beta_0 + \beta_1 * \ln(E/R)_{t-1} + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t + \beta_5 * ind + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

The results are similar like in the model 4. All variables except year2006, emissions/revenues ratio, constant and assets were dropped and even the assets is insignificant. Positive sign of variable year2006 confirms the hypothesis of better utilization of company's assets.

MODEL 5 ***lnca***				
variable	coef.	st. Error	t-stat.	p-value
lner	0.178	0.046	3.9	0.000
lna	0.014	0.069	0.2	0.844
year2006	0.175	0.032	5.45	0.000
cons	-0.791	0.440	-1.8	0.075
as	0.055	0.040	1.36	0.176
oth	0.086	0.118	0.72	0.470
cz	-0.001	0.039	-0.01	0.994
iso	-0.012	0.050	-0.23	0.815
ind2	-0.499	0.044	-11.4	0.000
ind3	-0.051	0.194	-0.26	0.793
ind4	-0.444	0.065	-6.79	0.000
ind5	-0.252	0.190	-1.33	0.186
ind6	-0.361	0.092	-3.92	0.000
ind7	0.029	0.096	0.3	0.762
ind8	0.397	0.140	2.83	0.005
ind9	-0.266	0.086	-3.11	0.002
ind10	-0.284	0.069	-4.09	0.000
ind11	-0.303	0.083	-3.66	0.000
ind12	-0.352	0.143	-2.46	0.015
cons	0.247	0.047	5.21	0.000

Table 15: Model 5 with lags and with dependent variable costs/assets

Source: Own calculations in Stata

Contrary to model 2, there is a positive sign of emissions/revenues. It indicates that companies that had lower emissions have lower costs in the following year. Positive sign itself is not surprising, it simply shows that costs stemming from depreciation were lower than savings in operating costs. It would mean that in the following year after emissions reduction, the investment itself pays off, if I do not take into account revenues. But why it was not the case already in the first year? There are two explanations. Firstly, the investment in the first year was not tangible; investment was not a subject of depreciation. It could have been e.g. the costs for hiring the consultant that advice how to save more energy or switch to fuels that emit less CO_2 (e.g. biomass instead coal). Such investments do reflect only in one-shot increase in costs, but does not reflect in depreciation in other years. Therefore the costs in following years fall down. The second explanation is that the investment was a subject of depreciation but it started working and saving the costs in the next year. Therefore the reduction in operating costs was not reflected in the first year.

The outcome for other variables is again opposite in comparison with model without lagged variable. Although some variables are insignificant, there are still many significant with opposite sign. I do not have any explanation for such a difference. It may even undermine the reliability of results of the impact of emissions/revenues on revenues and

costs. If almost all variables have opposite sign in the models without any relevant explanation, is there something wrong with the coefficient of emissions/revenues? Before making final conclusions I should be aware of this defect of my results.

Model 6 shows the impact of companies' emissions in the next year profitability. I investigate how profitability of companies is influenced by their environmental performance. As I showed in the model 5, companies with lower emissions have both lower revenues and costs. The question is what will be the impact on profits.

$$\ln(E/R)_t = \beta_0 + \beta_1 * \ln(P/A)_{t-1} + \beta_2 * nat_t + \beta_3 * own_t + \beta_7 * iso_t$$
$$+ \beta_5 * ind_t + \beta_6 * \ln A_{t-1} + \beta_7 * YEAR_t + \ln \varepsilon_t$$

This time variable emissions/revenues is significant and shows that companies with lower emissions are less profitable in the next year. It contradicts economic rationality – why would they invest into emissions reduction if it does not pay-off? There might be several explanations for this outcome; one of them is that companies relied on quite stable price of allowances on the carbon market. Consequent sharp fall in the price was a disaster for companies that decided to invest significantly and experienced a drop in expected revenues. These lower revenues did not pay the investments. However, I do not exaggerate the importance of CO_2 market introduction as the incentive to abate CO_2. The first 1st Phase of EU ETS was a period of high uncertainty and volatility on the carbon market and companies were rather reluctant to profound changes and investments into CO_2 reduction as they did not know how the 2nd Phase of EU ETS will be designed. Revenues and costs stemming from CO_2 trading were just a small fraction of their overall sales. But still, decrease in profitability of companies with low emissions might have been influenced by lower price on the carbon market at the end of the period.

MODEL 6 ***lnpa***				
variable	coef.	st. Error	t-stat.	p-value
as	-0.053	0.082	-0.64	0.521
oth	0.833	0.137	6.06	0.000
cz	-0.698	0.092	-7.62	0.000
iso	0.590	0.106	5.59	0.000
ind2	0.329	0.168	1.95	0.051
ind3	-1.375	0.160	-8.59	0.000
ind4	0.467	0.150	3.12	0.002
ind6	0.747	0.156	4.78	0.000
ind7	0.373	0.125	2.99	0.003
ind8	-0.647	0.560	-1.16	0.248
ind9	0.327	0.106	3.10	0.002
ind10	1.182	0.123	9.58	0.000
ind11	1.177	0.173	1.02	0.306
ind12	0.045	0.201	0.22	0.822
lner	0.058	0.030	1.97	0.049
lna	-0.033	0.031	-1.06	0.290
year2006	0.037	0.038	0.98	0.327
cons	-2.627	0.285	-9.22	0.000

Table 16: Model 6 with lags and with dependent variable profits/assets

Source: Own calculations in Stata

As other variables are concerned, I observe a similar outcome like in model 3. So the impact of various characteristics on profitability in the following year did not change much from the impact in the given year. This finding is in contrast with outcome for revenues and costs and may indicate some problems in these models.

7.3 From financial to environmental performance

In this chapter, I analyze model that investigates impacts of profits/assets on emissions in the same year. As I described at the beginning of chapter 7, I use feasible GLS model which can be applied on heteroskedastic data and data with AR(1) process (both are present in model 7).

$$\ln(E/R)_t = \beta_0 + \beta_1 * \ln(P/A)_t + \beta_2 * nat_t + \beta_3 * own_t + \beta_4 * iso_t$$
$$+ \beta_5 * ind_t + \beta_6 * \ln A_t + \beta_7 * YEAR_t + \ln \varepsilon_t$$

Dummy variables of ownership are significant. Joint stock companies and companies with foreign owner tend to have higher emissions/revenues ratio. This outcome contradicts original hypothesis. My criticism in chapter 6.2 was correct. On the other hand, industries are significant and the signs of coefficient confirm the hypothesis derived in chapter 6.2.

Companies from public power, cement and lime tend to have higher emissions/revenues ratio while companies from business power, paper and pulp lower.

As for assets, expected economies of scale really take place, which is proved by a negative coefficient for logarithm of assets.

MODEL 7 ***lner***				
variable	coef.	st. Error	t-stat.	p-value
as	1.080	0.154	6.99	0.000
oth	1.765	0.317	5.56	0.000
cz	-0.866	0.184	-4.71	0.000
iso	0.457	0.251	1.83	0.068
ind2	-3.140	0.178	-17.60	0.000
ind3	0.614	0.477	1.29	0.198
ind4	-1.822	0.267	-6.83	0.000
ind6	-1.349	0.482	-2.80	0.005
ind7	0.004	0.334	0.01	0.990
ind8	0.611	0.475	1.28	0.199
ind9	-1.585	0.235	-6.74	0.000
ind10	-1.699	0.192	-8.83	0.000
ind11	-1.260	0.222	-5.69	0.000
ind12	-2.332	0.700	-3.33	0.001
lnpa	-0.144	0.028	-5.22	0.000
lna	-0.512	0.053	-9.64	0.000
year2006	-0.287	0.030	-9.41	0.000
year2005	-0.182	0.022	-8.25	0.000
cons	7.917	0.419	18.91	0.000

Table 17: Model 7 without lags and with dependent variable emissions/revenues

Source: Own calculations in Stata

The variable that interests me most, ratio profits/assets is significant with a negative sign. It means that more profitable company is, lower emissions intensity it has. It may confirm the original idea that profitable companies invest into emissions reduction, but we must be aware of pitfalls of causality. If the company is profitable in a given year, it has lower costs which may be a consequence of energy savings which came first. So the causality between profits and emissions remain unclear. Unfortunately, my own research is determined by limited knowledge of econometrics and it is a challenge for further research when e.g. Granger causality test or more sophisticated two stage models could be applied.

8. Conclusions

In my thesis I analyzed relations between firms' environmental and financial performance. I provided a survey of literature that concerns this topic and which is mostly focused on local pollutants and tested the hypothesis on dataset that covered CO_2 emissions of Czech companies included in the 1st Phase of European Union Emissions Trading Scheme.

I investigated the relation in both directions, how environmental performance influences financial results of the companies and how financial results affect companies' future emissions. Majority of articles supported the hypothesis that emissions reduction has a negative effect on companies' costs, because companies that reduce their waste use their resources and raw materials more effectively and thus save more money. Emissions reduction has positive impact on companies' revenues. Companies that reduced their pollution can benefit from better public image which results in increasing demand for their products. Thus according to the literature, it seems that emissions reduction decreases costs and increases revenues, so it has a positive impact on companies' profits.

The literature on the impact of financial performance on environmental performance is quite scarce. Studies confirm the hypothesis that more profitable companies can accumulate lots of cash that they are able to invest. New technologies that companies introduce are mostly more environmentally friendly and thus generating less pollution.

Because the literature is mostly focused on local pollutants, the impact of CO_2 emissions reductions that I analyzed was quite unclear. Therefore I compared the incentives and effects of local pollutants reduction and CO_2 emissions reduction and estimated whether the hypotheses for local pollutants hold also for CO_2. As costs are concerned, the impact is of CO_2 reduction on firms' costs is similar like impact of local pollutants. I investigated possible ways of CO_2 emissions reduction and found out that it is mostly a consequence of energy savings which lead to lower costs.

In the case of revenues, incentives to reduce CO_2 emissions stemming from better image are weaker. However, I took into account European Union Emissions Trading Scheme which should provide additional incentive to emissions reduction. More company reduces

its emission, more allowances it can sell on the market and more revenues it gains. So after the EU ETS introduction, revenues should also rise in consequence of CO_2 emissions reduction like in the case of local pollutants. However, as EU ETS did not work perfect in the 1st Phase and suffered from high volatility, I criticize the idea about additional incentive and assert that it may hold only in a perfect functional market.

In the empirical part of my thesis, I tested above mentioned hypotheses on the dataset of 125 companies included in the Czech National Allocation Plan of CO_2 emissions allowances.

Firstly, I investigated how firms' emissions affect revenues and costs in a given year. In all regressions I included also other explanatory variables characterizing companies like industry, ownership, environmental management system and size of their assets. I found out that more CO_2 company emitted, lower revenues and costs it has. It suggests that company that decreased emissions could earn additional revenues on the carbon market. But at the same time, company experiences an increase in costs because emissions reduction requires investments into change of the production process, mostly aimed at energy savings that are reflected on higher depreciation and thus higher costs. Investments into new technologies tend to decrease consumption of energy and thus decrease overall operating costs. But according to results of my model, the impact of higher depreciation prevails and companies with lower emissions tend to have higher costs.

The impact of emissions reduction on firms' profits remains unclear; I cannot say whether revenues or costs increase more in consequence of lower emissions.

Further on, I investigated how environmental performance results in financial performance in the following year. Surprisingly, there was an inverse impact on both revenues and costs to the previous models. This inconsistency undermines the hypothesis that companies took some long-term measures that lead to emissions reduction. Quite striking is the conclusion that companies with lower emissions in one year have lower profits in the consequent year. It indicates that the investments to CO_2 emissions reduction did not pay off. The reason for this outcome was high volatility on the market (that stemmed from overallocation) that decreased predicted revenues for sold allowances in the second half of 2006.

I also investigated the inverse relation, how profitability influences companies' emissions. I found out that more profitable companies tend to have lower emissions at the same year. However, as my knowledge of econometrics is limited, I have not revealed causality between profits and emissions that could be analyzed in further research using more advanced econometric techniques.

When interpreting the results, I am aware that tests were done only on a limited dataset, especially time series could be longer, in order to be able to distinguish between results before and after the introduction of EU ETS. It would be also appropriate to analyze the sum of emissions during the entire 1st Phase of EU ETS. This approach would eliminate potential bias of results caused by transfer of allowances between single years.

To summarize my thesis I conclude that introduction of EU ETS did not encourage significant investments into CO_2 emissions reduction. Three years time horizon was too short for calculations of profitability of the investments and uncertainty of development of carbon market after 2007 did not enable to predict potential future revenues. And if the companies really invested into CO_2 reduction, the impact on their financial performance in the following year was negative, because the price of allowances on the carbon market dropped in 2006 and they received less revenue from sold allowances than they expected.

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