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Carbon emission costs in capital budgeting

– The effect of the EU ETS on Swedish companies –

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Abstract

In this essay we studied how Swedish companies that are included in the European Union Trading Scheme (EU ETS) handle the cost of carbon emissions in their capital budgeting processes. We especially investigated whether there were any differences between the different sectors included. The results also made it possible to give an indication on the efficiency of the EU ETS.

After characterising the EU ETS in Sweden with respect to its relevance for investment decisions, an analysis model was developed. By applying the model to the results from interviews with actors from all sectors, it was concluded that the firms do treat the cost of carbon emissions in their capital budgeting. The level of sophistication differs between firms, but is generally low. The companies chosen had all among the highest emissions and the general practice in Sweden could therefore be assumed to be even lower.

Among the actors, the Mineral sector and the Energy sector were found to have the most sophisticated processes. The former most likely due to the nature of the production processes and the latter due to previous experience with similar types of derivatives.

In the evaluation of the EU ETS, indicators were found that the allocative efficiency of the system can be questioned. On the other hand, the only noticeable negative effect was a price related risk connected to the emission allowances.

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Thank you!

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1 Introduction

According to an article published in Svenska Dagbladet (Flood, 2009) some Swedish companies have made large profits on the European Union Emission Trading Scheme (EU ETS). Flood writes that the large Swedish companies that Svenska Dagbladet has investigated together earned €42.1 million in 2008 from carbon[1] emission allowance sales. SSAB, one of the companies included in this paper, made a profit from emission allowances sales of €23 million and Höganäs, also included, profit was tenfold compared to 2007.

Drax Group Limited in the United Kingdom, operator of Western Europe's largest coal-fired power plant, spent €135 million on carbon emission allowances in the first six months of 2008, up from €14 million in the same period of 2007.

Drax was given 9.5 million allowances for free in 2008, but this only covered about 60% of its estimated 15.4 million tonnes (Mt) of carbon emissions. In 2007 the plant emitted 22.2 Mt, about 44% more than its 2008 estimated emissions. This piece of news was published on Carbon Finance Online (Enviromental finance publications, 2006).

The articles show evidence of how the cost of carbon emissions can have a major effect on companies within the EU ETS.

1.1 Background

In year 1997 the United Nations Framework Convection on Climate Change (UNFCCC) adopted the Kyoto protocol (UNFCCC, 2008b). The protocol was established to handle the rising level of global warming and it has been signed by over 180 nations committed to reduce the anthropogenic[2] contribution of greenhouse gases (GHG) to the atmosphere (UNFCCC, 2008b).

1.1.1 The Kyoto protocol

In the Kyoto protocol the countries involved are divided into Annex 1 and Non-Annex 1 countries. Annex 1 countries include in principle all the industrialised nations due to their large contribution to the GHG emissions, while the Non-Annex 1 countries are all the developing countries (UNFCCC, 2008c).

The goal that has been defined in the protocol is an average reduction of GHG gases of 5.2% by 2012, below the 1990 levels of the Annex 1 countries (UNFCCC, 2008d). According to Brescia (2006), the protocol also states that climate change is a common problem and therefore it is not important where the reductions are achieved. Based on this assumption the protocol provides three different mechanisms to achieve the emission reduction: Clean Development Mechanism, Joint Implementation and Emission Trading (UNFCCC, 2008b).

[1] For brevity, the term "carbon" will be used instead of "carbon dioxide" throughout the text.

[2] Caused by human actions.

Clean Development Mechanism (CDM) allows actors operating within the Annex 1 countries to implement emission reducing projects in Non-Annex 1 countries to obtain allowances for GHG emissions at their own sites. Joint Implementation (JI) is almost the same except that the project is implemented in another Annex 1 country (Brescia, 2006). The third mechanism, Emission Trading, enables trading of GHG emission allowances in an organised financial market. This is a fast growing market and in 2007 the transactions exceeded $50 billion globally, according to Daskalakis et al. (2009, p. 1231). Daskalakis et al. further state that the largest and most developed emission trading scheme today is the EU ETS.

1.1.2 EU ETS

EU ETS is the single largest market for GHG emission allowance trading and accounted for approximately 98% of the global transactions in 2007 (Daskalakis et al., 2009, p. 1230). EU ETS was launched in 2005 and was the first company-level GHG trading system in the world (European Commission, 2008). EU ETS is a so-called Cap-and-Trade system where the cap sets the total amount of emissions during a period and the trade makes it cost effective. The allowances that are traded in EU ETS are called EU Emission Allowances (EUAs) and one EUA gives the right to emit one tonne of carbon. The involved companies can trade these allowances freely on the existing market and the price is set by supply and demand (Daskalakis et al., 2009). At the end of each year, the companies included in the EU ETS must surrender emission allowances corresponding to their actual emissions, or they will have to pay a fine which presently is €100 per tonne (Brescia, 2006).

The first period of EU ETS was between 2005 and 2007 (Phase I), which was a three-year pilot period used to implement the necessary infrastructure and to set a price on carbon emmissions (European Commission, 2008). In 2008 the second phase was initiated; the cap for this period is more stringent than Phase I and the target is set to make a substantial contribution to the goal set by the Kyoto protocol.

The countries involved in the EU ETS are the 27 members of the EU[1] together with Iceland, Liechtenstein and Norway (European Commission, 2008). According to the EU Commission, the EU ETS covered some 11,000 heavy energy-consuming sites in power and heat generation as well as manufacturing in 2008, accounting for 50% of EU's total carbon emissions.

The activities covered by the EU ETS are energy, production and processing of ferrous metals, mineral industry and other activities, mainly pulp and paper. A list over further requirements for sites to be included in the EU ETS is presented in Table 4 in Appendix A.

A third phase is planned to begin in 2013 (European Commission, 2008), but it is not yet decided how the system will change. The EU Commision has proposed a substantial revision of the EU ETS to strengthen and expand the system. The main proposals are (European Commission, 2008):

[1] Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

- Broadening of the system to include additional industries and green house gases.
- Replacing the existing national caps with a single cap for the whole system.
- Linear cap reduction of 1.74% until year 2020 and beyond. This means that the total reduction in year 2020 would be 21% below the 2005 level.[1]
- Full auctioning of allowances by 2020 instead of the current system of free allocation of most allowances.

All these proposals would mean a more stringent system affecting the companies in the EU ETS to a larger extent. Without GHG reduction measures, the companies would most likely experience increased costs as they would have to buy emission allowances.

1.2 Problem discussion

The companies that are included in the sectors presented in the previous section all have in common that they are capital intensive (Smale et al., 2006). Smale et al. (2006) claim the reason is the associated economies of scale that make the production sites large. An investment by these companies usually involves large initial costs and long economical lifetimes. As a consequence of this, the investment will substantially impact how the company will perform in the future and it is therefore crucial to make the decisions on right grounds.

In the analysis of investment decisions, capital budgeting methods are used and a number of methods have been established throughout the years. According to Sandahl and Sjögren (2003), who have studied the use of capital budgeting methods in Sweden, the most common methods are payback and NPV.

The number of input variables differs between the methods but all include the use of revenues and costs. Costs can be divided into a initial costs and production costs. Production costs such as fuel price, electricity price and the price of raw material are all volatile costs; this means that there is an uncertainty associated with the cost when making an investment decision.

In the second phase of the EU ETS the market of trading allowances has grown considerably. From January 2008 until September 2008 the turnover was 1.8 billion allowances, 28% more than the total turnover in 2007 (Swedish Energy Agency, 2008). According to the Swedish Energy Agency, 95% of the EUA derivatives were traded through forwards[2], futures[2], options[3] and the rest mostly on the spot market. As the market grows so does the number of financial products that have EUAs as the underlying derivative. More and more, companies take advantage of the possibility to trade with allowances. According to the concept of "opportunity cost", any emitter who chooses to use an allowance to cover a tonne of carbon dioxide

[1] The reduction in the period 2013-2020 is thus 14.8%.

[2] Forwards and futures are an agreement between two parties to buy or sell an asset at a specified point of time in the future.

[3] An option is an agreement between two parties that gives the buyer the right, but not the obligation, to buy or sell an asset at a specified point of time in the future.

forgoes the possibility of selling this allowance at the market price (Harrison et al., 2007, p. 5). Therefore, companies seeking to maximise profits thus always face a cost of emissions.

Opposing the view that an emission allowance is a financial derivative, Benz and Trück (2009, p. 5) argue that the cost of carbon emissions should be considered a factor of production and should therefore be introduced in the capital budgeting as an operating cost. The price of carbon emissions is described by Daskalakis et al. (2009, p. 7) as historically very volatile, thus it should be considered an uncertain cost just like fuel cost, electricity cost and cost of raw material. In contrast to the traditional production factors, the price of carbon emissions has only existed in Europe since 2005 and the market is still emerging. To explain the markets of the traditional production factors methods have been developed that today are well-recognised, but similar methods applicable to carbon emission pricing do not exist.

As previously mentioned, the cost of carbon emissions is related to an uncertainty. With this in consideration, it is reasonable to assume that certain capital budgeting methods are more suitable when considering investments that include costs of carbon emissions.

In capital budgeting uncertainty is handled by some of the used methods; NPV and IRR both include a risk factor whereas payback does not. In addition, the risk is managed in different ways.

As the market is emerging and complicated, it is reasonable to believe that only the largest actors and the ones that are considerably affected by the cost of carbon emissions will work with these issues regularly. Sandoff (2007) found that large companies have already invested in emission reduction measures to a larger extent, whereas middle-sized and small companies more often were in the process of planning such measures.

In summary, it can be stated that the cost of carbon emissions influence the investments done in the EU ETS-sectors. Emission allowances, in turn, can be regarded either as financial derivatives or as factors of production and there are arguments for both views. Due to the fact that they are not well defined, in combination with the large uncertainty in size and risk of the cost of carbon emission, it is therefore complicated to say how it should be handled when it comes to capital budgeting.

This problem discussion leads up to the formation of the following research question:

> **Research question:** *How do Swedish companies that are included in the EU ETS handle the cost of carbon emissions in their capital budgeting process?*

As mentioned earlier the EU ETS include four different sectors as defined in *Directive 2003/87/EC* (EU Commission, 2003). This division is very common in literature when different groups of companies are investigated. There are many differences between these sectors, but of special importance for this study is their markets. An example of this is the difference between the energy sector and the sector producing and processing ferrous metals. The energy sector's geographical market is the EU ETS region, which means that all the competitors are part of the EU ETS. For the companies in the sector producing and processing ferrous metals many of the competitors are located outside the EU ETS.

Based on these differences, it is reasonable to believe that the answer to the research question will differ depending on which sector that is studied. To investigate this, the following

question defines one specific area of interest for the study:

Sub-question 1: *Are there differences between the EU ETS sectors?*

A prerequisite for the EU ETS to have the desired effect of reducing carbon emissions where the cost of doing so is the lowest, is that the companies react according to economic theory. Companies shall implement emission abatement measures as long as the cost of doing so does not exceed the cost of the corresponding emission allowances. However, on the subject of capital budgeting, there is a well known theory-practice gap documented by Graham and Harvey (2001) and, for the Swedish case, by Sandahl and Sjögren (2003). With this in mind, it is of interest to investigate whether the results acquired from the answering of the two previous questions gives insight in whether the policy actions of the EU ETS are efficient.

Sub-question 2: *What can be learnt from the answer to the Research question about the efficiency of the policy actions of the EU ETS?*

1.3 Purpose

The purpose of this paper is to analyse how Swedish companies within the sectors included in the EU ETS handle the cost of carbon emissions in capital budgeting. The analysis aims both to describe the handling and to explain it. By comparing the companies' strategies to each other as well as to the theory, this paper will investigate possible differences between companies in different sectors as well as differences between theoretical models and practice. In addition to this, the results will also be used to provide an indication on the efficiency of the EU ETS.

By describing how major companies with large emissions handle the cost of carbon emissions as well as present how the literature treats the subject, we hope that this paper can bring insight into these issues for many affected actors. Smaller companies, that might not have the possibility to work actively with the questions, can hopefully get inspiration for their own operations. Larger firms can see how their peers work and the interviewed companies will get an external perspective on their treatment of the cost of carbon emissions in investment decisions.

1.4 Delimitations

The investigation will be limited to companies in Sweden as the authors are located there, thus having better access to high quality data and greater ease of rewarding contacts with companies. All the EU ETS activities are also represented in Sweden. The study is furthermore limited to the capital budgeting process and does not include the companies' strategic work regarding EU ETS.

2 Method

This section will describe the working procedure used to answer the research question and fulfil the purpose of this paper. Section 1 has presented the problem domain, carbon emission allowance trading and capital budgeting, as well as the actual problem (as proposed by Sørensen, 1994, p. 7). Starting with Section 2.1, the procedures used in pursuing the aim laid out in the purpose will be described.

Initially, the work performed will be presented in the order it was intended to be performed, thus giving a clear overview of methods applied. The first step in the investigations was literature studies which were next used for the subsequent construction of the analysis model. This, in turn, was used to structure the interviews that followed and which constituted the main method of information gathering, as well as analyse the results from these. The result from this analysis was also used to get an indication of the efficiency of the EU ETS.

The last two sections will describe the differences between the intentional and the actual work flow, and the validity and reliability of the methods and answers. The reason for presenting the differences between the intended work flow and the actual is that the former shows the motives for choices of, for example, methods and theories, while the latter gives an insight into consequences of these choices; valuable information for researchers with the intention of continuing this work.

Another purpose of explaining to the reader exactly how the work was performed is that "any of your peers should be able to reproduce what you have done and obtain the same result" (Sørensen, 1994, p. 8).

2.1 General approach

The information gathering was divided into two major parts: Establishing the necessary theoretical framework and carrying out empirical investigations in the form of interviews. The results of these are presented in Sections 3 and 4 respectively. In the subsequent analysis, Section 5, the different empirical results are compared with each other as well as with the theory.

2.1.1 Theoretical framework

As the name of the section indicates, the purpose is not only to present theory, but the aim is instead threefold. First, to elucidate characteristics of the emission trading scheme and emission allowances potentially impacting the capital budgeting process of Swedish firms. Second, to construct an analysis model, which could be used to structure the investigations, facilitating the answering to the research question as well as the sub-questions. Third, to evaluate how applicable the analysis model is for determining the efficiency of the EU ETS.

To find the characteristics of the emission trading system as well as start investigating the applicability of the analysis model for evaluating the EU ETS, the method for retrieving the theories was literature studies. We initially searched the ISI Web of Knowledge[1] with

[1] An online database that searches multiple databases, e.g. Web of Science and ISI Proceedings.

keywords related to carbon emission costs, capital budgeting, investment decisions and EU ETS efficiency. As an increasing number of relevant articles were found, we gradually progressed to investigating their references as well as later published articles having them in their reference list. In addition to articles, we also searched for books on the subject. This search was done through LIBRIS[1] and resulted in a few relevant titles. As literature studies were the foundation for the construction of the theoretical framework, these will next be described in more detail.

The work of clarifying a specific aspect of the emission trading system and emission allowances was of a descriptive character. Although not directly addressing the research question or the sub-questions, it could be used in the later analysis to help explain the actions of the companies as well a constitute a foundation for the second step. The information sought during this step was not based on analyses and opinions, making the choice of source less of an issue. However, as the area is dependent on policies subject to frequent change, a problem encountered was to find sources reliable with respect to their level of contemporaneousness. Another issue was the fact that the subject of emission allowances in Europe has been a very popular research area the last years, albeit mostly with a macroeconomic view or focusing on firm strategies. This results in a large number of publications to filter out and, at the same time, shows that our specific problem addresses a subject that might previously have been overlooked. The number of publications on our problem domain were few, and none were found that addressed exactly our research question.

Literature studies were also used for the construction of the analysis model, however only for the initial step. The major part of the work was the result of discussions amongst the authors as well as between the authors and a academic having experience from previous empirical studies in the subject. This process is described in more detail in the next section and the resulting model is presented in Section 3.2.

Also for the investigation of the possibility of using the analysis model to evaluate the efficiency of the EU ETS, literature studies were used. The purpose of this part was however to summarise earlier research on the subject. The literature studies were here complemented with an discussion comparing the stated aim of the EU ETS with the type of results obtainable from the analysis model. Based on this, the extent to which these results could be used to evaluate the EU ETS could be decided.

Given the formulation of the research question and the purpose of the literature studies the method of choice was a qualitative study as described by Esaiasson et al. (2003, pp. 233-234). Moreover, as the aim was to collocate previously presented ideas and analyses, the approach was to systematise rather than criticise them (Esaiasson et al., 2003, p. 234).

Once the aim of the literature studies had been decided upon, the next decision was whether to use predefined categories or an open approach (Esaiasson et al., 2003, p. 240). We chose the latter as it was necessary to constantly review previously found characteristics when new were found in the first phase of the literature studies. Doing this allowed us to

[1]LIBRIS is a Swedish national search service covering Swedish university and research libraries as well as about twenty public libraries.

build a comprehensive yet relevant set of characteristics. Of prime importance here was to find characteristics that were actually relevant for the question at hand and not just general descriptions of emission allowances or the trading system. The potential danger of losing focus is also what Esaiasson et al. (2003, p. 241) denotes as one of the main disadvantages with the open approach.

The next section will describe the construction of the analysis model used to structure and analyse the empirical investigations.

2.1.2 Construction of the analysis model

The search for an answer to the research question was greatly facilitated by the construction of the analysis model as it helped both the comparison of firms as well as between firms and theory. Seeking a scale by which to measure in what ways and how thorough firms treat the cost of carbon emissions in their capital budgeting processes, we initially searched the literature. Although no scales were found by which to evaluate the treatment of any specific cost in the capital budgeting process, the results of the search could be used as a foundation for further work. Especially of use were the numerous articles aiming to investigate the connection between the level of complexity of the capital budgeting process and corporate performance. These articles tend to initially construct a scale to measure the level of sophistication of the capital budgeting process; a procedure by which we were inspired in the construction of our scale. Many of our ideas are inspired by an article by Farragher et al. (2001), which in turn builds on the methods of, among other, Klammer (1973), Kim and Farragher (1982) and Pike (1984). It is, however, important to note that our scale does not measure the level of sophistication of the capital budgeting itself, just provides a measure of how advanced the treatment of the cost of carbon emissions is.

In analogy with Farragher et al. (2001), we first sought to define the variables by which to perform the evaluation. The selection of variables was made following a discussion with an academic having experience from previous empirical studies on the subject (Sandoff, 2009). The starting-points of this discussion were the variables of Farragher et al. (2001), basic capital budgeting concepts (for example discount rates and cash flows), the case specific theory presented in Section 3.1 and the experiences of the academic. The resulting eight variables are found in Section 3.2 together with motivations for our choices.

With the variables in place, the next step was to decide on a scale within each variable that measured how much a firm had adopted its capital budgeting process to treating the cost of carbon emissions. This grading was done by starting from the two extremes; the variable not being at all affected by the costs of carbon emissions and the variable being affected to a very large extent, demanding complex treatment and major efforts. We do not claim that our top category is the most advanced treatment imaginable, but only that it is a very advanced treatment, often involving scenario analyses or a real option approach. Inspiring the top category were recent publications, for example by Laurikka and Koljonen (2006). Between the two extremes, we then sought to divide the scale into clearly defined steps, where each should

represent a more advanced method of treating the costs of carbon emissions requiring more effort from the firm. The resulting analysis model is described in Section 3.2. It consists of eight variables, all having four categories of different sophistication except two, for which five categories could be defined.

With the analysis model in place, the next step was investigate how Swedish firms acted in practice.

2.1.3 Empirical work

The work covered in the previous sections resulted in a description of the environment in which the affected companies act (necessary for an accurate analysis), a partial answer to Sub-question 2 and an analysis model that facilitated the answering of both research question and sub-questions. This section describes the work to obtain the information from companies necessary to complete the answer to Sub-question 2 as well as to address Sub-question 1 and the research question itself. The search for information as well as the results are divided into three major parts. First the general impact of the EU ETS on business is investigated. The results serve as foundation for the second part where the companies are evaluated according to the analysis model. This evaluation constitutes the major part of the investigations. The last part covered how the companies believe that the EU ETS will develop in the future, information which is used to interpret and complement the results from the analysis model.

To ensure a high-quality answer to the research question, primary data had to be collected from the companies themselves. This decision also follows the recommendations from Esaiasson et al. (2003, pp. 253-254) to contact respondents[1] over informants[1] when we are interested in the respondents themselves and not their view on an external phenomena or process. Using solely literature studies might, of course, have been an option, but considering that publications on our problem were scarce and articles addressing exactly the same research question were non-existent, the results would have been insufficient. Choosing to collect data from companies raised two questions, namely what companies to study and the method for obtaining the sought information. Starting with the latter, we noted that our study, on the one hand, would benefit from the same questions being posed to all respondents. On the other hand, we also recognised the risk that the companies could potentially be treating the costs of carbon emissions very differently (or not at all). I addition to this, the information sought ranged from very large scale (if they treated the costs at all) to very detailed (for example in what particular way the intrinsic risk of emission allowances enters the discount rate). This variation required us to be able to adopt to the answers for which reason a survey with open questions[2] was chosen over a plain survey or a conversational interview[3] (Esaiasson et al., 2003, pp. 258-259). This is even more important as the literature (as previously mentioned in Section 2.1.1) on our specific area of interest is limited, making it hard to predict into improvise.

[1] Authors' translation
[2] Authors' translation of Swedish "frågeundersökning med öppna frågor" (Esaiasson et al., 2003, p. 259)
[3] Authors' translation of Swedish "samtalsintervjuundersökning" (Esaiasson et al., 2003, p. 259)

With the choice of method made, the next important decision was the choice of interviewees. This selection process is described in the next section.

2.1.4 Selection of interviewees

In order to find suitable interview objects, a search for data presenting the Swedish installations taking part in the first phase of EU ETS (2005-2007) was launched. From the Swedish Energy Agency we got a list presenting the actors together with their allocated emission allowances and actual emission quantities, and from the Swedish Environmental Protection Agency we got a list presenting which business sectors the installations were acting within. By coordinating the two lists, we could order the actors by business sectors and emission quantities. To mitigate the effects of changes in production caused by, for example, business cycles or weather[1], yearly averages for the period 2005-2007 were used.

For each business segment, the turnovers for the first phase were collected from annual reports for the ten actors with the highest emission quantities. The decision to investigate the actors with the highest emissions only was taken based on the assumption that it among these would be possible to find actors where emission costs could potentially have a large impact. Thereafter, the emission quantities were divided with the turnovers in order to get a measure of emission intensity in the business.

Within each sector, it was desirable to find three actors suitable for interviews. From the initial selection of ten actors per sector, the two actors with the highest emission quantities were selected as well as the actor with the highest emission to turnover ratio. We did, however, decide to make some adjustments to the result from these selection criteria. The company with the largest emissions in the energy sector is Lulekraft AB, but when looking closer at this company it shows that Lulekraft AB[2] is closely connected with SSAB that is one of the chosen companies in the ferrous metal sector. Because of this, we chose to neglect Lulekraft AB. Another exception in the energy sector is that we chose Swedish businesses of Vattenfall AB above E.ON Sverige Värme AB, as Vattenfall AB is the largest Swedish energy company and a major player in the European market. We believed that a personal interview with staff from Vattenfall AB could give important information that would be essential to this paper and therefore this company should be included.

Moreover, in analogy with the arguments put forward in Section 1.2 for why the four sectors should be investigated separately, we also chose to treat refineries separately from the energy sector, to which they belong. As a consequence of this, we chose one refinery in addition to the three actors already selected form the energy sector. The thirteen companies resulting from the selection procedure are presented in Table 1 below.

[1] Temperature and precipitation strongly affects the energy market.

[2] Lulekraft AB is owned jointly by SSAB (50%) and Luleå municipality (50%) and uses only industrial gas from SSAB as fuel. Lulekraft AB is not allocated any emission allowances, but SSAB transfers the allowances they are allocated for the industrial gas.

Table 1: The companies selected for interviews, their CO_2 emissions, turnover and emission intensity.

Sector	Actor	CO_2 emissions[a] [tonnes]	Turnover[a] [MSEK]	$\frac{Emissions}{Turnover}$ $\frac{[tonnes]}{[MSEK]}$
Pulp & Paper	Holmen Paper AB	173725	18023.3	10
	Södra Cell ek.för.[b]	157285	11613.9	14
	Stora Enso Skoghall AB	145487	4962.0	29
Energy	Vattenfall AB[c]	307622	44458.7	7
	AB Fortum Värme	819605	6133.1	134
	Mälarenergi AB	592706	2462.0	241
Ferrous metals	SSAB	2364708	25099.3	94
	LKAB	463118	15112.3	31
	Höganäs AB	700487	5185.0	135
Mineral	Cementa AB	2150050	1535.6	1400
	Nordkalk AB	311771	815.5	382
	SMA Mineral AB	212620	374.5	568
Refinery[d]	Preem AB	2030791	61574.3	33

[a] Yearly averages for the period 2005-2007.

[b] Ek. för. is the Swedish abbreviation for "ekonomisk förening". This is best translated "economic association" and describes the type of enterprise.

[c] Only data from the operations in Sweden is taken into consideration.

[d] Belongs to the energy sector.

To select the interviewees, we contacted the environmental manager of the respective companies by phone. We introduced our research subject and the kind of questions that we needed answered. In many of the companies this person could answer our questions and we booked a interview, in some cases we were redirected to other people within the firm. The actors included together with interviewed employees are further presented in Appendix B. The questionnaire used during interviews was designed based on the analysis model and is presented in Appendix C.

Even though the sections of Chapter 2 covered so far include some practical considerations, we acknowledged that the actual work flow might not follow the relatively straight path laid out. These considerations are covered in the next section.

2.2 Actual workflow

At the end of the working process, it could be confirmed that the work flow had indeed been more a set of nested feedback loops than plainly linear. Initially, background information was collected through various sources, mainly own experiences and literature studies. Through iterative comparisons between problem formulation and literature, in order not to overlap previously published material, a research question and two sub-questions were formulated.

Next, the literature study was performed, resulting in a theoretical framework for continued investigations as well as initial attempts to answer parts of the sub-question 2. Subquestion 2 also had a different formulation at the time. During this phase, also the analysis model was designed.

Hereafter, the empirical investigations took place. These showed some new areas of interest, and since these were not previously covered in the literature studies, we returned to complement the results of the previous phase.

Starting the analysis of the empirical findings, we realised that neither the theoretical framework nor the empirical results were complete. This was solved by complementary literature studies as well as additional, short interviews. Moreover, the first formulation of sub-question 2 was more normative. As the literature was found to be very far from practice, sub-question 2 was replaced. The new formulation did not require any additional empirical investigations, but the frame of reference had, yet again, to be complemented with literature studies.

Finally, the answers to the research question, as well as the two subquestions, could be used to formulate the conclusions, fulfilling the stipulate purpose of the study.

2.3 Validity and reliability

The validity of an investigation is a key issue or even, as Esaiasson et al. (2007, p. 63) puts it, "perhaps the most difficult and, at the same time, most important problem in the empirical social sciences". This section will present the issues of validity and reliability encountered in the investigations as well as the attempts to mitigate them.

Starting with the internal validity of the study, the first issue arose already at the onset of the investigation and concerned the translation of theoretical concepts and variables into operational indicators that could be investigated (Esaiasson et al., 2007, p. 64). Concerning the research question at hand, both the formulation "to handle something in the capital budgeting process" as well as the term "the capital budgeting process" itself needed to be operationalised. In the literature studies this was only a minor problem as most publications tended to use the same terms as found in the formulation of the problem. Still, the studies presented in literature could have operationalised incorrectly, but by taking the vast majority of information from peer reviewed journals, we believe that this risk was minimised.

For the empirical studies, on the other hand, the issue of operationalisation was considerably larger. To mitigate the problem to as large extent as possible, we formulated the analysis model (see Sections 2.1.2 and 3.2) to be as concrete as possible. The questions for the interviews were then formulated with the analysis model in mind, and we also kept it at hand

during the interviews, to help formulate follow up questions. It could furthermore be argued that already the concretisation of the theoretical variables gave rise to errors. Although there might be some truth to this argument, we believe that the result of the concretisation clarifies our view on the theoretical concepts as these are not unambiguously defined and, especially, what aspects of them that are interesting in our case.

There is another aspect of operationalisation that is highly relevant for our study. Esaiasson et al. (2007, p. 65) points to the fact that the problem of validity increases with the distance between theoretical concept and operational variable. In our area of study, emission allowances and capital budgeting, we could expect to meet firm representatives with different backgrounds, most probably engineering of finance. This meant that our questions during the interviews had to be formulated with this in mind. When we met representatives responsible for emission allowances with a background as economists, the issue of operationalisation was smaller than when the representative had an engineering background. Although this problem could not be solved completely, it was once again mitigated by having a concrete analysis model.

To achieve what Esaiasson et al. (2007, p. 64-66) call a high "validity of concepts"[1], the study must not only have correct operationalisations, but systematic errors must also be absent. In the literature studies, a potential risk of causing systematic errors arises when we have found an interesting article and examine its references as well the publications referencing to it. This may result in us investigating only one "path" in literature. However, as we searched very large search engines with several keywords combined with the fact that all three authors conducted relatively independent searches, we believe us to have mitigated the risk significantly. In the empirical work, a risk similar to that in the literature studies arose, partly because of the choice to use a survey with open answers (see Section 2.1.3). As we did not follow a rigid questionnaire, there was a risk that we paid to much attention to certain interesting aspects of the subject, missing other completely. Our approach to mitigate this problem, which has also been described in Section 2.1.2, was to have the analysis model at hand during the interviews complemented with notes in the interview guide describing when the different parts of the analysis model should be covered. Next, we turned from validity of concepts to the important aspect of reliability, the absence of unsystematic errors (see for example Esaiasson et al. (2007, p. 70)).

According to Esaiasson et al. (2007), the sources of unsystematic errors are random errors and careless mistakes when collecting, processing and presenting data. Regarding the literature studies, the problem of reliability is generally very small. We had access to all texts for a longer period of time, making the risk of careless mistakes small, although not non-existent. During the interviews, however, the risk of making the aforementioned errors were considerably larger and we took several measures to reduce the probability of them occurring. To begin with, the ambition, although not always successful, was that all authors should be present and taking notes at all interviews. Next, the interviews were recorded and the recordings were used during the analysis of the material.

[1] Authors' translation

Finding no further major issues with the validity of concepts or the reliability we next address the external validity of the study. According to Esaiasson et al. (2007, p. 64), this term describes the possibility to extend the conclusions of the study to a larger population or another context.

We believe the external validity of the literature studies to be relatively high. This, we argue, is due to the fact that many sources were theoretical in nature, thus being possible to apply to other situations as well. Many were relatively specific in subject, which limits the external validity.

The question of how applicable the empirical results are to other populations is a very important issue for the investigation, although impossible to answer with certainty. Remembering the criteria for the selection of firms to interview from Section 2.1.4, it can be seen that they should result in the firms with among the largest possibilities or incentives to treat the costs of carbon emissions, and treat them thoroughly. This means that the results should not be assumed to be valid for all Swedish firms. Similarly, only Swedish firms have been interviewed and the results should therefore not be extended to other countries. Still, it is not unlikely that comparable firms in countries with a corporate climate similar to Sweden act in a similar way.

These comments on the validity and reliability of the study concludes the description of the methodology and the next section will describe the construction of the frame of reference.

3 Frame of reference and literature study

This section is divided into three main parts. The first, Section 3.1, describes the characteristics of an emission trading scheme, focusing on the EU ETS and the aspects relevant for investment decisions. The second, Section 3.2 presents the analysis model used to evaluate to what extent emission allowances are taken into consideration in the capital budgeting process. The third, Section 3.3, describes to what degree the analysis model can be used to evaluate the efficiency of the EU ETS.

3.1 Emission allowances

A company owning sites included in the EU ETS system must first secure emission permits for the sites in question (EU Commission, 2003, p. 33). In addition to this, the operator must also have emission allowances equal to or exceeding the actual carbon emissions in order to actually run the site, or they will be forced to compensate for the deficit at possibly substantial costs (Pauksztat and Kruska, 2006, p. 153-154). Emission permits and emission allowances are both new factors that have to be taken into consideration. However, to acquire an emission permit, a company must only submit information on the site in question and how they plan to monitor the emissions (Fichtner, 2006, p. 106). This means that the need for emission allowances is the critical factor. There are three types of emission allowances that are possible to trade within the EU ETS: European Union Allowances (EUAs), Emission Reduction Units (ERUs) and Certified Emission Reductions (CERs), each providing the holder the right to emit one tonne of carbon. The latter two, CERs and ERUs, are a part of the Kyoto protocol and are awarded for investments in CDM and JI respectively. This section will first describe general characteristics of an emission allowance relevant for its treatment in connection with investment decisions. Next the development at current design of the EUA market is presented before the section is concluded with theoretical concepts found to be important for this paper.

3.1.1 General characteristics of emission allowances

As argued in Section 1.2, emission allowances introduce a different type of cost in investment decisions. Due to this, it is of interest to characterise them more carefully in order to be able to treat them correctly. Not least the choice of pricing model is strongly dependent on the classification of the derivative or asset to be priced (Benz and Trück, 2006, p. 33).

Considering the fact that an emission allowance shares features with financial derivatives, it could seem reasonable to treat it as one (Benz and Trück, 2006, p. 32). However, both the derivative and, above all, the underlying asset have characteristics that differ from standard financial options preventing the emission allowance from being treated as such.

Starting with the underlying asset, it is best described as the lack or absence of emitted carbon (Benz and Trück, 2006, p. 32). A consequence of this is that carbon emission allowances can be either an asset or a liability, depending on whether the actual emissions exceed or fall below the current possession of allowances (Benz and Trück, 2009, p. 5). Moreover, one of the most prominent differences between emission allowances and shares is the pricing mechanism.

While the value of shares is based on expectations on future profit, an emission allowance is priced based solely on supply and demand (Benz and Trück, 2009, p. 5). This is due to the fact that there are a finite number of emission allowances issued each year and an important result hereof is that enterprises actually have the possibility to influence the availability and, thus, the price (Benz and Trück, 2006, p. 32). Shares, on the other hand, can be issued by companies at any time.

Another important characteristic, emphasised by Benz and Trück (2006, p. 33), is the limited duration of validity as nothing has yet been decided for Phase III, 2013-2020. Because of this, no futures can be traded today that extend farther than 2012. This is of course problematic for the affected companies, and frameworks for pricing and hedging are presently being developed by, for example, Daskalakis et al. (2009).

A more appropriate view on emission allowances, argued for by, among other, Fichtner (2006, pp. 106-107), is to categorise them as factors of production. In addition to the arguments presented above, another strong indication that should not be treated as financial derivatives is that they are consumed when the corresponding amount of CO_2 is emitted (Benz and Trück, 2006; Fichtner, 2006). As factors of production, they can be classified as homogeneous and easy to transfer (no need for transport nor storage), making it possible to vary the firm's stock of allowances with short notice (Fichtner, 2006, p. 106). Being received from outside the firm categorises them as primary input factors and as they can be used for the production of different goods, they are also termed flexible (Fichtner, 2006, p. 107).

There is empirical evidence supporting the theoretical arguments for not treating emission allowances as financial derivatives. Sandoff (2007, p. 83) found that the interest for the emission allowance market among the Swedish actors was very limited. Only 40% of the Swedish actors had an explicit trading strategy with respect to emission allowances and in most cases this meant matching the supply of emission allowances to the projected emissions or trading only at the end of the year.

As argued above, the emission allowances are best regarded as factors of production, not financial instruments. An appropriate estimate of emission allowance prices, and therefore firm costs, should therefore be based on factor pricing models.

3.1.2 Historical EUA market

The operational trade of EUAs began in 2003 and the period until the official start in 2005 was mainly used to set up the infrastructure (Benz and Trück, 2009). Benz and Trück (2009) explain that the trade volume during this period was quite low and that prices were forward prices on a not yet traded underlying asset.

In 2005 the first period of the EU ETS began and 6.3 billion allowances were issued in the whole scheme to the existing installations for the period 2005-2007 (PointCarbon, 2006). During the first year, energy markets and the weather were established as price determinants (Benz and Trück, 2009, p. 8), and the development of these set the price level higher than expected. In 2006 it became clear that the market participants had been granted around 10% more allowances than needed and the price crashed 60% within one week (Benz and Trück,

2009, p. 8).

For Phase I of the EU ETS, Swedish companies emitted on average 2.9 million tonnes less than allocated (Swedish Environmental Protection Agency, 2008). Explanations for this, according to the Swedish Environmental Protection Agency (EPA) (2008), were a transition to biofuels and energy efficiency actions. The EPA also partially attribute the low emissions to the EU ETS. This conclusion is supported by the findings of McKinsey & Company (2006), who (after an interview study) claim that half of the interviewed European companies are of the opinion that the EU ETS has a strong or medium impact on decisions to develop innovative technology.

The year 2008 started the second period of the EU ETS, for which the total volume of emission allowances issued was set to 6.5% below the 2005 level (European Commission, 2008). This period was also the first period of the Kyoto Protocol, under which the EU-15 countries[1] are committed to reducing their collective GHG emissions by 8% below levels in chosen base year, usually 1990 UNFCCC (2008a). The other twelve states[2] in the EU have individual targets under the Kyoto Protocol. Due to the collective goal set for the EU-15, Sweden has been allowed to increase the carbon emissions by 4%, but has chosen a more stringent target. The goal for Sweden for the period 2008-2012, set by the Swedish government, is a 4% carbon emission reduction (Sandoff, 2007).

3.1.3 The current Swedish system

In Sweden the EPA is responsible for the implementation of the EU ETS. The total allocation of allowances for Phase II was 22.5 million tonnes whereof 2.62 million were dedicated to new sites, the New Entrance quota (Berggren, 2009). In this phase the existing electricity and district heating sites are not allocated any allowances (though new sites could apply), which is unique for the Swedish system. According to EPA, Sweden has not applied any kind of auctioning during the first two periods of EU ETS; all allowances have been allocated for free. A list of reported emissions and allocations is presented in Table 2 below. The Swedish National Allocation Plan includes about 750 sites divided into the four sectors described in Section 1.1.2. During the second phase, the use of carbon offsets, such as CERs and ERUs, is limited to 10% of the total amount of allocated allowances. The Swedish EPA decides how many carbon offsets that each company is allowed to surrender each year (Berggren, 2009).

[1]The EU-15 countries are Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

[2]Bulgaria, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia

Table 2: (adapted from Berggren (2009)) Average reported emissions and allocated emission allowances per sector for Phase I as well as 2008.

Sector	Average emissions 2005-2007 [tonnes]	Average allocation 2005-2007	Emissions 2008 [tonnes]	Allocations 2008
Energy	4799655	5364204	5160972	2260758
Ferrous metals	6818482	7690716	7194109	8317352
Pulp & Paper	1842605	2655404	1434172	2289738
Minerals	3271069	3527096	3289797	3677447
Refinery	2710005	3024274	2018116	3186180
Total	19441817	22359673	20097121	20832475

3.1.4 Allocation methods

A factor that is widely discussed when it comes to the estimated future price of the EUA is the allocation method used. The fundamentals and complexities of different allocation methods are presented and discussed in a report published by the International Emission Trading Association (IETA)(Harrison et al., 2007). Common to Cap-and-Trade systems, regardless of allocation method is that it leads to an increased marginal cost. This is due to the fact that the emission allowances can be sold, thus giving rise to an opportunity cost if they are used (Harrison et al., 2007, p. 15).

Grandfathering

During the two first periods of the EU ETS the allowances have been allocated to the companies freely by the method grandfathering[1]. This method give each participating site an allocation based upon historical emissions.

At the start of the EU ETS grandfathering was a logical allocation methodology as it offered simplicity and an easy transition with fewer objections into the EU ETS (IETA, 2006). Governments also felt that grandfathering was more objective, at least in the initial stages.

An obvious problem connected to Grandfathering, according to IETA, is that sites with high levels of historic emission receive correspondingly high allocations although the cap will be lower than the emissions in prior years.

In the first two periods of the EU ETS it has been acknowledged that the electricity companies can pass through the opportunity costs of allowances to the electricity consumers, and thus the higher the permit price and the higher the proportion of allowances allocated for free, the higher the profit (Hepburn et al., 2006). This profit is clearly a drawback of grandfathering.

[1]The EU ETS allows governments to auction up to 10% of the allowances issued in Phase II.

Benchmarking

Instead of basing the allocation of emission allowances on historical performance, this can be done with benchmarking, which means a comparison of the performance of companies with more or less similar activities (Groenenberg and Blok, 2002, p. 107). Groenenberg and Blok (2002) describe the result of a benchmarking procedure as a ranking of the companies according to their performance. From a benchmarking procedure a number of key variables can be derived, e.g. the average performance of all companies, the average performance of the best 10%, or the best plant performance.

The advantages with a benchmark-based allocation method are that it does not require participants to pay for emission allowances beforehand, as in an auctioning system, and it does not reward inefficient industries, as in a grandfathering system (Groenenberg and Blok, 2002, p. 108). The drawbacks are that benchmark efficiencies need to be constructed, benchmark-based allocation is more data-intensive than grandfathering, and it does not provide an incentive to reduce emissions by limiting production.

Auctioning

The European Directive on the EU ETS allows governments to auction up to 10% of the allowances issued in Phase II, a number which is proposed to increase during Phase III (Hepburn et al., 2006). Auctioning is generally the allocation method supported by economists.

Hawksworth and Swinney (2009) summarise the desirable properties with auctioning: First, it sends out a price signal for allowances, which promotes price transparency. Second, revenue is raised for the policy maker in the form of scarcity rent that can be used to cut distortionary taxation or to fund research and development into green technology. Finally, auctioning reduces distortions within an ETS as it allows new entrants to be treated the same way as incumbents, i.e. all participants must buy their allocation of allowances.

One argument against auctioning is that it would simply add costs that would be passed through to consumers (Hepburn et al., 2006). However, as seen in the EU ETS this can happen with grandfathering as well. Because of this, Hepburn et al. (2006) claim that auctioning will have little impact on product price when the competition is within EU ETS.

3.1.5 Carbon leakage

When climate change mitigation policies introduce a cost for some but not others within the same sector, competition among companies is distorted. The introduction of domestic or regional emission trading schemes that cap GHG emissions for sectors whose products compete internationally (e.g. the EU ETS) is an example of this (Reinaud, 2008).

Reinaud (2008) defines carbon leakage as the ratio of emissions increase from a specific sector outside the country (as a result of a policy affecting that sector in the country) to the emission reductions in the sector (again, as a result of the environmental policy).

Reinaud (2008) further claims that to date, the EU ETS does not reveal any leakage for the sectors concerned. Analyses of steel, cement, aluminium and refinery sectors show no significant changes in trade flows and production patterns during Phase I. Reinaud attributes

this mainly to the free allocation of allowances, sometimes in generous quantities, and to the still functioning long-term electricity contracts, which softened the blow of rising electricity prices.

It has been found (see for example Barker et al. (2007)) that carbon leakage from the implementation of the EU ETS is unlikely to be substantial because transport costs, local market conditions, product variety and incomplete information all tend to favour local production.

3.1.6 Clean Development Mechanism and Joint Implementation

A company can earn emission allowances in the country of operation by engaging in projects resulting in the actual reduction of GHG emission in other countries. Projects that are undertaken in developed countries (non-Annex 1) are called Clean Development Mechanism (CDM) and projects in other Annex 1 countries are called Joint Implementation (JI) (PointCarbon, 2006). The emission allowances earned from CDM projects are called Certified Emission Reduction Units (CERs), and those from JI projects are called Emission Reduction Units (ERUs).

However, Oleschak and Springer (2007) argue that most existing studies ignore the risks associated with investments in climate change mitigation and emission trading. The majority of the projects (the CDM projects) are undertaken in developed countries where regulatory uncertainty as well as economic and political instability often are present.

Taking investment risks into account reduces the likely benefits and scope of the flexible mechanisms considerably. Furthermore, Chadwick (2006, p. 256) argues that CDM projects are associated with high transaction costs due to passage through "vigilant approval, monitoring and evaluation procedures". Those transaction costs are unrelated to the physical process of eliminating GHGs, and if the transaction costs are extensive they could undermine the success of the CDM.

PointCarbon (2006) argues that CDM is expected to be the project mechanism of choice among the EU ETS actors, also in the future. The association further claims that developing countries are taking their participation in the market seriously, and are years ahead of large JI sellers when it comes to project approval frameworks. In addition, according to PointCarbon (2006) it seems clear that CDM will survive even without a successor agreement to the Kyoto Protocol.

CER-EUA arbitrage

Arbitrage is a mechanism under free trade that means that prices of two similar commodities tend to converge to parity. The mechanism is widely used in foreign trade where it describes simultaneous purchase and sale of securities or foreign exchange in different markets in order to profit from price discrepancies (Merriam-Webster's Online Dictionary, 2009).

According to the Linking Directive[1], individual EU ETS installations can purchase CERs and ERUs and trade them for EUAs at a conversion rate of one-to-one (Jepma, 2007). Ac-

[1]The Linking Directive allows operators to use a certain amount of Kyoto certificates from flexible mechanism projects in order to cover their emissions.

cording to Jepma (2007), the assumption that the credits are comparable involves a dilemma. Since any credit is fully determined by the terms and conditions of its underlying system, and these systems differ between the credits, they are not comparable.

Examining the price trends of EUAs and CERs during the first period there seems to be a structurally different price trend between them. There is a lack of price parity between the credits and Jepma (2007) presents a couple of explanations for this: First, credit markets still lack transparency, only a part of the allowances are traded on the transparent carbon exchange market. Second, the rationality assumption is not valid; arbitrage assumes rational traders who take full advantage of given price differentials in the market.

3.1.7 Post 2012

In a recent market survey, 50% of the participants argued that EU ETS plays a key role in long term decisions (McKinsey & Company, 2006). Furthermore, the approached companies, industry associations and governments all ranked emission targets and allocation rules among the most important topics regarding EU ETS, which both relate to long-term uncertainty. Another outcome of the survey was that a vast majority wanted trading periods of at least ten years, which could limit the uncertainty surrounding investment decisions. This view is confirmed by Hoffmann (2007) in his case study of investment decisions in the German electricity market.

The first topic mentioned in the survey was the emission targets. As described in Section 1.1.2, there is only a proposal of how the cap will change in the years ahead, which includes a 1.74% cap reduction every year between 2012 and 2020. This is the overall cap for the entire EU, but (as noted in Section 3.1.2) the national cap can differ from these targets. Sweden, for example, has set a target 8% lower than required by the EU.

Another concern found in the survey is the allocation methods: grandfathering, benchmarking and auctioning. The pros and cons of these were described in Section 3.1.4.

A third problem was that the trading periods were seen as too short. In Section 3.1.2 the first two periods are described. The first phase was three years and the second will last for five years. The third period is planned to last eight years until the end of 2020. There is no additional phase planed after the third.

There exist no derivatives today extending beyond 2012 at the emission allowance trading markets (Daskalakis et al., 2009), and if banking were not to be allowed over the phase change, the emission allowance price is expected to drop drastically when the end of the present phase emerges. As a consequence, investments made before the phase change exhibit long-term uncertainty and it is favourable to depreciate the investments before the end of the present phase.

3.2 Analysis model

As previously mentioned in Section 2.1.2, this section will describe the result of the construction of the analysis model, which was used to determine how sophisticated the firms' treatment of the cost of carbon emissions in their capital budgeting processes were. It is once

again noted that we consider only the level of adoption, not the level of sophistication of the capital budgeting process itself. As emission permits have been concluded to be almost irrelevant (see Section 3.1.1), the model focuses on the impact of emission allowances on the firms' capital budgeting processes[1].

The initial step in the construction of the model was, as previously described, to define the variables to be evaluated. Leaving out most strategical considerations, in accordance with Section 1.4, we chose to start the evaluation of the capital budgeting process at the point where the firm had chosen to make an investment, but had yet to decide between several options. Seeking the impact of the EU ETS on the firm's choice, the first variable is termed *investment motives* and evaluates the firm's motives for making an investment where their emission allowances are affected. The higher the firm rank the reduction of costs for emission allowances among the purposes for undertaking the investment, the more impact we consider emission allowances to have on the capital budgeting process.

Although the NPV rule maximises the value of the firm (Berk and DeMarzo, 2007, p. 150), firms do use several different methods for the evaluation of projects, either alone or in different combinations (see for example Sandahl and Sjögren (2003) or Graham and Harvey (2001)). Besides changing what methods are used, it is also possible to change the criteria to be met for each method (for example how long payback time to use). Just the fact that the choice of method is central in the capital budgeting process is reason enough for investigating it. In addition to this, we have previously argued that although emission allowances are best seen as factors of production (see Section 3.1.1), it can seem reasonable to treat them as financial options at first glance. This, in combination with the many sources of risk and the fact that emission allowances are expected to increase in importance when the emissions cap is reduced, motivates the choice of *decision criteria* as the next variable to evaluate.

Emission allowances bring increased risk and uncertainty to the investment decision through the uncertain future of the EU ETS (Section 3.1.7), the high volatility (Section 1.2) and the potentially substantial penalty for failing to submit enough emission allowances (Section 3.1.1). To be able to make fully informed investment decisions, the companies may have to adjust their organisations to understand the new risks and uncertainties. Since human resources often is one of the firm's most valuable assets, a change in organisation to focus more on these issues is a strong indication on the firm treating them seriously. We chose to evaluate this possible, organisational adaption for the purpose of treating emission allowances in the variable *organisation*.

Cornerstones of the capital budgeting process are the prediction and the treatment of a project's future cash flows. This is a good incentive for evaluating how firms treat the possible cash flows arising from emission allowances, and we therefore termed our next variable *cash flows*. As discussed in Section 3.1.4 the majority of the emission allowances are presently allocated according to the grandfathering principle, resulting in emission allowances being a opportunity cost. These should, however, according to basic economic theory (see for example (Berk and DeMarzo, 2007, p. 182)), be included in the capital budgeting as well. In addition

[1]This includes effects of acquisition, possession and disposal of emission allowances.

to this, the political uncertainty about the system, described in among other Section 3.1.7, might result in the emission allowances being allocated through auctions (see Section 3.1.4), turning the opportunity costs to actual costs.

Together with allocation method and allocated quantities, the cash flow from emission allowances is determined by the future price. The prediction of this is, however, connected to many difficulties including unknown future methods of allocation and the high price volatility. In fact, as previously described in Section 3.1.7 there does not even exist a futures' market after 2012. The importance of the price, together with the large uncertainty, makes it an interesting variable and our next variable was therefore chosen to be the *price*. Here we evaluated how sophisticated methods the firms used for determining the future price.

The next variable, *discount rate*, was motivated by the often mentioned risk connected to the emission allowances. As Berk and DeMarzo (2007, Ch. 12) describe, in order to fund a risky project, investors will demand a risk premium, increasing the cost of capital. Following this, the discount rate should be adjusted accordingly.

Another variable we chose to investigate separately is the *time horizon* of investments. We evaluated if, and to what extent, companies chose to compensate for the uncertain future of emission allowances (see for example Section 3.1.7) by adjusting the time horizon.

The purpose of the last variable, *risk analysis*, was to see if the involvement of emission allowances in projects lead firms to utilise a more thorough evaluation of their capital budgeting results. The high price volatility, for example, could motivate a risk analysis to investigate the effect of a drastically changed price of emission allowances. Risk analyses are cumbersome and, in addition, require the appropriate competences. Only the most important variables are included in risk analyses. Different from the previous categories, risk analysis is additive, i.e. each category include the methods from the previous as well as one additional method.

Within each variable, it was our intention to define the same number of categories of differing sophistication for the sake of comparability. This was successful in all but two variables. For each variable, we started by defining a most and a lest sophisticated category. We do not claim the highest category to be the most extreme alternative possible, but it should represent a very thorough, yet reasonable, method. Next, starting from the least refined category, we constructed a ladder of procedures leading up to the top category. The steps were chosen as to be clearly separated and defined by significant changes in variables central in capital budgeting. In the process, it was found that a separation of each variable into four categories was suitable for most variables. The only exceptions to this were the investment motives and the cash flow, for which five levels were defined.

Based on the argumentation above, an analysis model has been compiled and is presented in Table 3 below. The specific criteria in the categories of each variable are based on the principles presented in the previous paragraph.

Table 3: The analysis model used to evaluate the sophistication of the treatment of the cost of carbon emissions in the capital budgeting.

	Variables			
Category	Investment motives	Decision criteria	Organisation	Cash flow
Category 0	There is no connection between investment motives and emission allowances.	The decision criteria are not changed when projets involve emission allowances.	No adaptions of the organisation have been made to handle emission allowances.	The cost of emission allowances is not included in the capital budgeting methods.
Category 1	A less important investment motive is to limit the cost of emission allowances.	Decision criteria are occasionally changed when projects involve emission allowances.	A single employee has emission allowances as one of several areas of responsibility.	The cost of emission allowances is included as part of the initial cost.
Category 2	One of the main investment motives is to limit the cost of emission allowances.	Changes in decision criteria are encouraged when projects involve emission allowances.	Several employees have emission allowances as one of several areas of responsibility.	The cost of emission allowances is distributed over the periods.
Category 3	The main investment motive is to limit the cost of emission allowances.	Decision criteria are changed in accordance to explicit guidelines when projects involve emission allowances.	A single/several employee(s) has/ have emission allowances as the sole area of responsibility.	The cost of emission allowances is discounted independently and varies between phases.
Category 4	The sole investment motive is to limit the cost of emission allowances.			The option of selling the emission allowances in contrast to using them is evaluated on regular basis.

Table 3 (continued)

	Variables (ctd.)			
Category	Price	Discount rate	Time horizon	Risk analysis
Category 0	The company has no notion of the price of emission allowances.	The discount rate is not changed for projects involving emission allowances.	Emission allowances are not taken into consideration when setting the time horizon for the investments.	Emission allowances are not included in any risk analysis.
Category 1	A fixed price of emission allowances based on a common idea is used.	The change in discount rate is standardized for projects involving emission allowances.	A standardized change in time horizon is applied for projects involving emission allowances.	Emission allowances are included in a sensitivity analysis.
Category 2	The price of emission allowances is projected to change over time, however no quantitative analysis is made.	The change in discount rate is based on historical data.	The change in time horizon is based on historical data as well as expected future developments.	In addition to Category 1, emission allowances are included in a scenario analysis.
Category 3	A forecast of the price of emission allowances is made based on a quantitative analysis of underlying data	The change in discount rate is based on historical data as well as expected future developments.	Decision criteria are changed in accordance to explicit guidelines when projects involve emission allowances.	In addition to Category 2, emission allowances are included in a real option analysis.

With the analysis model defined, the next section will investigate to what degree the results from an investigation with the analysis model can be used to determine the efficiency of the EU ETS.

3.3 EU ETS efficiency

In Directive 2003/87/EC, the purpose of the EU ETS is formulated as "to promote reductions of greenhouse gas emissions in a cost-effective and economically efficient manner" (EU Commission, 2003, p. 34). For the purpose of determining whether the analysis model presented in Section 3.2 above is suitable for evaluating the efficiency of the policy actions implemented under the EU ETS, this section is divided in two parts. First, previous research on the subject is presented. Second, the appropriateness of each variable in the analysis model with respect to the evaluation of the efficiency of the EU ETS is discussed. The first part will be an implicit foundation for the second as well as explicitly used in the subsequent analysis.

3.3.1 Previous research

This section summarises previous research on the efficiency of the policy actions of the EU ETS. Focus will be on the studies investigating the impact on investment decisions.

Hoffmann (2007, pp. 465-466) reviewed this research and chose to divide it into four general groups. He did, however, stress that much research did not measure the actual effects of the EU ETS, but instead the expected effects. This could be explained by the fact that the system was still so new at the time, and not many effects could yet be seen.

The first group was empirically oriented and investigated the *attitude of companies* towards the EU ETS in the early stages of the system (Hoffmann, 2007). It was found that the companies that were to be included in the system in general had a low level involvement (Brewer, 2005). Furthermore, the large uncertainty about the future system design resulted in information gathering being the main activity of the firms. In Sweden, firms were found to have a positive attitude to emission trading systems in general (Paulsson and von Malmborg, 2004). They had, however, not engaged actively in emission trading due to the political uncertainty. On a world-wide basis, Pinkse (2007) found no difference in attitude towards emission trading systems between firms in the EU ETS area, and firms outside. The interpretation was that the emission trading system itself was not a more effective incentive than the general climate and environment debate in society.

The second group of research concerned the *performance of the EU ETS* in achieving its previously mentioned aim (Hoffmann, 2007). It consists of theoretical studies and simulations on what the expected effects of different system design will be on an aggregate level. It is mainly concerned with different allocation methods (see for example Vesterdal and Svendsen (2004)).

The third group is also theoretically focused and studies the *effect of emission trading on operating and investment options*. Different from the previous group it takes on the firm perspective. The studies elucidate the effects of different emission allowance prices on business or, like Laurikka and Koljonen (2006) discuss, an investment decision from a real option view. Common for these are that they often use relatively complicated methods, like real options (Laurikka and Koljonen, 2006) or long equations for long-term and short-term production factors (Letmathe and Wagner, 2006).

The fourth and last group studies what Hoffmann (2007) calls the *second aim of the EU*

ETS, i.e. innovation incentives. This group includes reviews of the effects of other emission trading systems (Gagelmann and Frondel, 2005) and evaluations of the EU ETS from a technological innovation incentive perspective (Schleich and Betz, 2005). The findings of the latter was that the EU ETS constituted a moderate incentive for low-carbon emission focused innovation.

3.3.2 Analysis model evaluation

The following section will discuss whether, and how well, the eight variables of the analysis model can evaluate the effectiveness of the EU ETS in their respective areas.

It is first remembered that the primary objective of the EU ETS is cost effective reduction of greenhouse gas emission and the secondary objective is to be an incentive for the innovation of emission reducing technology. Both the reduction of emissions and invention of technology are external variables that cannot be said to explicitly describe the work of companies, only the result. There is however a strong correlation between the both, which means that the variables of the analysis model (originally designed to measure an internal process) to some extent can be used to evaluate the efficiency of the EU ETS. The applicability of the variables is discussed below, each starting with a summarising grade.

Investment motives
Very good – The intention of the system is that the introduced cost of carbon emissions should constitute an incentive to invest in options low in carbon emission.

Decision criteria
Average – Although affecting the decision criteria can indeed change the choice of investment, possibly towards lower carbon emitting options, this is not certain.

Organisation
Low – How a company changes its internal structure to handle the new costs of emission does not directly correspond to the selection of low-emission investment options.

Cash flow
Very Low – The treatment of the cash flows arising from carbon emissions is a purely internal choice of method and does not correlate to any of the aims of the EU ETS.

Price
Reversed – A very thorough treatment of the prediction of the future price of emission allowances indicates a large inherent uncertainty in the system, which opposes the idea behind the EU ETS. However, it could also be argued that the system must have a high enough emission allowance price to discourage from carbon emissions in favour for abatements. Still, we do claim that the analysis model focuses on measures taken to reduce uncertainty rather than to cope with a high price. Thus, the categorisation of the variable *price* as Reversed still holds.

Discount rate
Reversed – If the companies feel forced to quantitatively evaluate the risk in the EU ETS, this means that the risk in the system is large, as this requires quite some effort. A large risk in the system is not in line with the aims of the EU ETS as firms then avoid, rather engage in the system.

Time horizon
Reversed – If the firms adjust their time horizons for projects, this is either a result of the uncertainty in the EU ETS as a whole or of specific events, most probably the phase changes. This is an undesirable effect.

Risk analysis
Reversed – A thorough and sophisticated risk analysis is caused by large intrinsic risks or uncertainties. Neither are wanted results of the EU ETS.

It should be added that also a variable which scale is reversed, i.e. negatively correlated to the goals of the EU ETS, can be useful. It shall merely be interpreted correctly. Moreover, it could be argued that the EU ETS could achieve its goal by introducing extensive uncertainty. This could be an incentive for the companies to invest in projects that would exclude them from the system. This would mean that they would take a known, but perhaps high, cost instead of an unknown.

3.4 Key findings

In addition to the analysis model, the most important features of the theoretical framework are presented below.

- *Emission allowances* The operator must have emission allowances (EUAs) equal to or exceeding the actual carbon emissions in order to be allowed to run a site. The emission allowances are best regarded as factors of production, not financial instruments.
- *EUA market* The year 2008 started the second phase of the EU ETS and the first period of the Kyoto protocol. This period ends in 2012. In Sweden all allowances are allocated for free during this phase, except for existing electricity and district heating sites that are not allocated any allowances.
- *Allocation methods* The vast majority of emission allowances are presently allocated through Grandfathering, but for the future system also Benchmarking or Auctioning are possible candidates.
- *Carbon leakage* The introduction of a climate policy such as the EU ETS may lead to the distortion of competition between companies in the system and companies outside.

- *Clean Development Mechanism and Joint Implementation* Two flexible mechanisms where a company can earn emission allowances in the country of operation by engaging in projects resulting in the actual reduction of GHG emission in other countries. The emission allowances earned from CDM projects are called Certified Emission Reduction Units (CERs), and those from JI projects are called Emission Reduction Units (ERUs).

- *CER-EUA arbitrage* According to the linking directive, individual EU ETS installations can purchase CERs and ERUs and trade them for EUAs at a conversion rate of one-to-one. During the second phase, this conversion is limited to 10% of the total amount of allocated allowances. As the EUAs and CERs/ERUs have different prices, there is an arbitrage opportunity.

- *Post 2012* There are concerns about cap, allocation methods and the lack or absence of defined market after 2020.

- *EU ETS efficiency* The eight variables in the analysis model can be used (to different degrees) for the evaluation of the efficiency of the EU ETS.

4 Empirical findings

This section presents the empirical findings on what impact the EU ETS has on the concerned companies' capital budgeting. The impact on the capital budgeting is the main focus of this paper, but as the purpose also is to understand and describe the impact, is it important to understand the background. The term background refers to what changes that have been made in the included sectors and in the business as such. In Section 3.1.7 the uncertain future of the EU ETS is described; this uncertainty affect capital budgeting today and it must therefore also be studied.

In general, all subsections presented here will start with a short recapitulation of the applicable theory, followed by a short summary of the empirical results.

The empirical findings start with introducing the *impact on business*, which describes how the businesses and the sectors have been affected by, and have adapted to, the EU ETS. These results provide the background to understanding the results that follow. Next, the key findings are presented in *impact on capital budgeting*, which is divided into the eight different sections of the analysis model. The next section, *concerns about the future*, describes how the companies believe and hope the EU ETS will develop. Finally the empirical findings are concluded in a summary.

4.1 Impact on business

EU ETS and emission allowances constitute new variables, heavy in risk and uncertainty, that have to be taken into consideration in investment decisions. The industrial sectors face different risk depending on their businesses. To handle the new variables the organisation must adapt, which can be done either to a small extent, through e.g. service training, or to a large extent, through major restructuring of the organisation. Another adaption concerns the adjustment of allowances that each site possesses. Regarding this adaption, it have been studied how the companies trade allowances.

The empirical findings can be divided into three variables. On the subject of the impact of the EU ETS on the business of the firms, the following order was established, ranging from almost insignificant to major: Refinery, Pulp & Paper, Ferrous metals and Mineral. For the Energy sector, the impact was varying from positive to somewhat negative. Concerning the trade of allowances, all companies make a clear distinction between using allowances to cover for emissions and use them for speculation. Only four of the interviewed companies stated that they speculate, and then only with a portfolio intended for trading. Furthermore, although all firms engaged in a passive search for information on the EU ETS, only some actively sought out politicians at national or EU level for the acquisition of information and lobbying.

Perceived impact of the EU ETS differs between sectors
The level of impact on the business as claimed by interviewed companies, varied greatly with the sectors.

The representatives for the Pulp & Paper sector claimed that the EU ETS did not impact their businesses to any larger extent. Södra ek.för. planned to eliminate their use of fossil fuels and thus be excluded from the EU ETS altogether (Andersson, 2009a). Holmen AB agreed that neither for them can the major costs be found in emission allowances (Jernhall, 2009); especially in comparison to the electricity certificates[1]. Holmen AB did however point out that the indirect effect of emission allowances is significant. It is manifested through, among other, sharply increased electricity prices. Stora Enso AB agreed with Holmen AB on the comparison between emission allowances and electricity certificates (Olsson, 2009). They furthermore stated that they have had no project where emission allowances had been the main focus.

The companies in the Mineral sector claimed themselves to be very much affected by the EU ETS. The business idea of both Nordkalk AB and SMA Mineral AB is to calcine limestone to lime; a carbon emission intensive process. The emission of carbon is a result both from burning fossil fuels in the furnaces and as a side product when the limestone turns to lime (Lundström, 2009). Combined with the fact that the end product, lime, is relatively inexpensive, the cost of carbon emissions equal a full 50-60% of the value added (Öhman, 2009). Cementa AB explained that they are a part of the multinational company HeidelbergCement, and if auctioning is introduced as the main method of allocation, HeidelbergCement will choose to invest in production facilities outside of the EU ETS (Lyberg, 2009).

The Ferrous metals sector seem slightly more worried than the Pulp & Paper sector. LKAB explained that they historically have been allocated too few emission allowances and had been necessitated to buy (Nordström, 2009). Their total yearly cost for emission allowances is 140 MSEK. Höganäs AB stated that the cost of emission allowances is presently not the key factor in investment decisions, but that this can change in the future (Pettersson, 2009). They further stated that the indirect effect, through the electricity price, is much more important.

The Energy sector emphasised different effects of the EU ETS. Vattenfall AB said that the energy market is extremely exposed to the EU ETS, but pointed out that the electricity price rose about $0.15 SEK/kWh$ with the introduction of the scheme (Andersson, 2009b). AB Fortum Värme, on the other hand, said that for them the electricity price was far more important than emission allowances (Åsman, 2009). Although these did result in higher costs, other fees, such as carbon tax for electricity and district heating, had been lowered giving a reduced net effect.

The third interviewed company in the Energy sector, Mälarenergi AB, stressed the importance of emission allowances (Nehrman, 2009). As an example they pointed out that the allowances constituted 20% of the fuel costs, which in turn are the largest costs in the operations. A result of this is that the emission allowances are taken into consideration in the planning of the investments and affect the decisions made. Due to investments presently being made, they expect to reduce the need for emission allowances by 2013.

[1]Electricity certificates are termed Renewable Energy Certificates (REC) and are earned by electricity producers using renewable energy sources. The energy consumers (excluding the electricity intensive industry) are obliged to buy RECs, a trade which is made through the companies distributing electricity. These buy the certificates and add the cost to the price of the delivered electricity.

In the last sector, the Refinery, Preem AB explained that for them, the emission allowances for the period 2005-2012 were not a major concern (Brinck, 2009). They had been allocated more than they had the need for and had thus faced no costs for emission allowances. Pending the outcome on regulations for the third trading period, 2013-2020, this situation might change and Preem feared a case where full auctioning would put Preem's refineries in a very tough competitive situation.

No speculation with allocated allowances
Regardless of method of allocation, no evidence can be found that the companies consider the opportunity of selling their emission allowances in the day-to-day production planning. All companies interviewed make a clear difference between the allowances used to cover the emissions and those used for trading. The emissions that are allocated to each site are used to cover the demand and only if there is a surplus will they sell allowances. None of the companies want to speculate with the allocated allowances.

In most companies the finance department buy and sell allowances based on the demand of each production site. As mentioned in Section 4.1, the companies in the Mineral sector are greatly exposed to the cost of carbon emissions; an example of this is that the buy/sell strategies of Nordkalk AB and SMA Mineral AB are discussed by the executive board.

Four of the companies have a trading floor to trade energy products; three of them are in the energy sector. The companies that trade energy products also speculate in allowances. AB Fortum Värme describe that it then is logical to trade with emission allowances because there is already an organisation for trading energy products (Åsman, 2009).

Whether or not the companies have had the need to buy or sell allowances differs. There is no pattern more than that the companies in the electricity and district heating sector[1] are not allocated any allowances and are required to buy all allowances.

Information on the EU ETS is acquired through active or passive contacts with authorities
Common to all companies interviewed were that they used what we chose to call a *passive approach*. This means that they acquired the sought information through websites[2], through mailings with updates on legislation or through EU directives. Likewise, going through the respective trade organisations, the most advanced method mentioned by Höganäs AB (Pettersson, 2009), is also considered passive. Some companies stated that they were frequently in contact with Swedish authorities, which we chose to call a *semi-active approach* as it requires a higher level of commitment. This was the highest activity level utilised by SSAB (Kärsrud, 2009) and Södra Cell ek.för. (Andersson, 2009a).

To qualify for the *active approach*, the companies had either to explicitly state that they had employees visiting either Brussels or the Parliament of Sweden or that they were a present or former consultive body. This was said to be an opportunity to get the latest information as well as do lobbying work or, in the case of the consultive body, actively shape the rule

[1] Electricity and district heating are a part of the Energy sector.

[2] For example from those administrated by the European Commission, the Swedish Environmental Protection Agency and the Swedish Energy Agency.

set. Qualifying for this category were the two largest companies in the Mineral sector, LKAB (Nordström, 2009), Preem AB (Brinck, 2009) and Stora Enso AB (Olsson, 2009). In the case of the Mineral company Cementa AB, they stated that HeidelbergCement, of which they are a part, were a consultive body in some countries (Lyberg, 2009). Also worth noting is that no specific information on this matter was received from some of the firms, among them Vattenfall AB, and their approach is therefore not categorised.

4.2 Impact on capital budgeting

This section presents the results related to the analysis model. The section is divided into the eight different areas of the model.

4.2.1 Investment motives

There are two main types of investments when categorised according to the importance of emission rights as motive for the investment: an investment with the sole purpose of decreasing emissions (a green investment) and an investment with other main purposes in addition to affecting the amount of emitted carbon. In the latter type of investment, the cost of emission allowances has different focus and thereby affects the capital budgeting methods to a different extent.

The general opinion in the sectors Pulp & Paper, Ferrous metals and Refinery was that reducing the need for emission allowances were not the main motive for investments. It did, however, contribute to the profitability of the projects. For the Minerals sector, emission allowances can be an important motive for investments. An example was a cost reduction project, where emission allowances stood for 20% of the savings. The energy sector is divided, and examples were given where emission allowances affect either investments or the choice of fuel mix.

In the Pulp & Paper sector, the cost of emission allowances is not a main investment motive
Starting with Pulp & Paper, Södra Cell ek. för. explained that they have had the goal to reduce the usage of oil with 5 per cent per annum already since 2000; several years before the introduction of the EU ETS (Andersson, 2009a). This goal is thus not motivated by emission allowances, but by the oil price. Holmen AB stated that the cost of oil and, above all, electricity is much higher than that of emission allowances (Jernhall, 2009). They further described a project where they changed the fuel from oil to pitch oil[1] (Jernhall, 2009). This project was not motivated with the resulting lower need for emission allowances, but it was essential for the profitability. Without the possibility to reduce the cost of carbon emissions, the project would not have been executed. Stora Enso Skoghall AB were on the same page as the two other firms. They claimed that they had no projects where the reduction of the cost of carbon emissions through emission allowances were they main driver (Olsson, 2009). There were, however, projects, where this effect was a welcome side effect.

[1] Pitch oil can be extracted from liquid rosin, which is a byproduct from some of Holmen AB's processes.

In the Ferrous metals sector, energy prices are more important than emission allowances
The general opinion in the Ferrous metals sector was that the cost of emission allowances was not a main driver for investments. SSAB does, however, describe that for all investment that include coal or coke, the emission allowances are taken into consideration (Kärsrud, 2009). Höganäs AB stressed that it is the total price of energy including the emission allowances, not the price of the emission allowances themselves, that is the motive behind many projects (Pettersson, 2009). They added, though, that there are certain types of facilities that cannot be built in Sweden as the cost of emission allowances would make them too expensive.

In the Refinery sector, emission allowances are only a small part of the costs
Preem AB explained that they make several energy reduction projects and that emission allowances are taken up as a possible cost reduction here (Brinck, 2009). They do, however, only represent a minor part. Preem AB further described a project where the EU ETS could have been a major issue. In 2006, they made an investment that increased their annual carbon emissions at the site from 1.1 million tonnes to 1.7 million tonnes. As the total efficiency was increased, they were however allocated emission allowances from the New Entrance quota.

In the Mineral sector, emission allowances can be a major motive for investment
Due to the large carbon emissions inherent to the production of cement and lime, emission allowances can be a major cost for the companies. Cementa AB has recently mostly done cost-effectiveness work and they explained that emission allowances can represent about 20% of the total cost reductions (Lyberg, 2009). Nordkalk AB describes a project where they built a new lime furnace in Norway and expected free allocation of emission allowances (Lundström, 2009). When this at first was not approved, it seemed as if the furnace would have negative profitability. After an appeal to the EU, the site was however allocated emission allowances as of January 2009.

In the Energy sector, opinions on the effects of emission allowances differ
Vattenfall AB stated that emission allowances provide strong incentives for investments (Andersson, 2009b). Emission allowance costs enter all investments, either directly or indirectly through the electricity price. The largest impact for Vattenfall AB can be found for coal fired power plants in Central Europe (Andersson, 2009b). If an old plant is replaced with a new, the yearly emissions can be reduced by 8 million tonnes. Emission allowance costs have also helped motivate a change from coal to biofuels in a plant in Denmark. Concerning investments, Mälarnergi AB has invested in increased biofuel capacity as a result of the high, and uncertain, costs of emission allowances (Nehrman, 2009). They are also planning an investment in a flexible fuel facility, which will lead to a reduced demand for emission allowances by 2013. The investment is motivated by the large political uncertainty in the EU ETS as well as the possibility to use different fuels (Nehrman, 2009). The last company in the Energy sector, AB Fortum Värme, stated that emission allowances had not directly affected any investment decisions so far, although the indirect effect through the electricity price was mentioned (Åsman, 2009). Emission allowances had also affected the profitability

of the business. In addition to this, they have also impacted the product mix, as the coal fired facilities would have been utilised to a larger extent if it were not for the cost of emission allowances.

4.2.2 Decision criteria

A first step in making an investment calculation is to decide what system boundaries that should be used; what capital budgeting decision criteria should be used and what should be the result of a successful project. It is of interest to investigate if the cost of emission allowances and the EU ETS have changed the used decision criteria and if so, in what way and to what extent.

A number of the interviewees claimed that they expected the amount of emission allowances to be lowered in the future and thus taking this into consideration when evaluating their potential projects. In addition, a common thought in the Energy sector was that it will become more expensive to emit greenhouse gases. Another matter that affected the decision criteria was strategic issues that to some extent limited the requirement of maximum profitability.

Expected future system stringency
Nordkalk AB claimed that the cost of emission allowances was among the decision criteria due to a believed future limitation in allowance allocation (Lundström, 2009). Furthermore, Vattenfall AB stated that they expected a future auctioning scenario, which affects the capital budgeting processing (Andersson, 2009b). Mälarenergi AB and AB Fortum Värme expected the price of emission allowances to be higher in the future (Nehrman, 2009; Åsman, 2009).

Strategic issues limiting profitability requirements
SSAB and Preem AB said that strategic aspects are affecting the profitability requirements (Kärsrud, 2009; Brinck, 2009). AB Fortum Värme mentioned strategic issues such as environmental impact and energy consumption (Åsman, 2009).

4.2.3 Organisation

If the cost of carbon emissions has an impact on investment decisions it is also reasonable to believe that the organisation has made some adaptions to handle this new area. Through examining how much human capital that is allocated to the carbon emission issues, this organisational change can be described.

A general result was that the companies had personnel at the sites who reported the demand and usage of emission allowances to either one individual or a group.

Emission allowances are not a full-time job
Of the interviewed companies, non had an employee whose sole responsibility was the handling of emission allowances. Closest to this was LKAB, where the interviewee was responsible for carbon questions, although these did not constitute a full 100% of his responsibilities (Nord-

ström, 2009). Also other energy related questions belonged to his responsibilities. In addition to their carbon emissions responsible employee, LKAB also had a group for carbon coordination where the employee met others with different competences, for example finance, procurement and external environment monitoring, to discuss carbon questions. This group differed LKAB from the other firms in the Ferrous metals sector, which only had one employee coordinating the carbon emissions.

In all companies there were personnel at the respective sites with emission permits who answered for calculating the emissions as well as the projected need for emission allowances. In Preem AB, the interviewee alone were responsible for all steps in the handling of the carbon emission allowances (Brinck, 2009).

For the other companies, there were differences in the coordination of the information from the sites. In the Mineral sector, the Pulp & Paper sector and the Energy sector, the results differed between having a single individual and a group responsible for the coordination.

An organisational change that all companies have had to make was to introduce a system for reporting the carbon emissions. LKAB did however state that they started reporting their carbon emissions already in the 1990ies (Nordström, 2009).

Another general remark, applicable to all companies, was that the actual buying and selling of emission allowances was never the responsibility of the same individual, or group of individuals, that were the persons in charge of carbon emission abatement.

4.2.4 Cash flow

The cost of emission allowances could result in different types of cash flow in relation to the used capital budgeting method. It is of interest to study the level of sophistication regarding such potential cash flows; differing resource allocations in determining the cash flows and how they are varying over time.

Common to include emission allowance costs in other costs
AB Fortum Värme and Nordkalk AB are managing the emission costs as a supplement charge on the fuel costs (Åsman, 2009; Lundström, 2009). Moreover, Holmen Paper AB claimed that the cost of emission allowances is considered as a regular operating cost (Jernhall, 2009) and Cementa AB stated that the cost of emission allowances is considered as a variable cost (Lyberg, 2009). Vattenfall AB stated that the cost of emission allowances is included in the electricity price (Andersson, 2009b).

4.2.5 Price

As mentioned earlier the cost of emission allowances is an opportunity cost based on the possibility to sell the emission allowances.

Fixed or variable price of allowances
The companies can be divided into two groups, those that use a fixed price based on a common idea and the ones that use a forecast where the price is projected to change over time.

The majority of the companies use a fixed price, including all the companies in the Mineral sector. All the companies in the Energy sector use a forecast. Vattenfall AB explain that for them, the analysis department produces forecasts from information provided by trading floor (Andersson, 2009b). For the estimated fixed price, a range between €20-40 is used, mostly based on information from EU websites.

Among the interviewed companies only one explicitly remarked that they have not taken advantage of the CER-EUA arbitrage.

4.2.6 Discount rate

As discussed in Section 1.2 the cost of carbon emissions implies an additional risk in the capital budgeting processes; historically the price has had high volatility that together with the uncertainties connected to phase changes are the two largest factors.

In summary, none of the interviewed actors takes the EU ETS into consideration when they decide discount rate(s). Furthermore, actors seem to use one specific discount rates within the corporation, in other words not connected to the actual project. There were no major differences between the four sectors.

Corporation specific discount rates are very common
All of the interviewed actors used a corporation specific discount rate. However, Vattenfall AB stated that exceptions to this could be made, although on very rare occasions (Andersson, 2009b). Moreover, a few of the actors highlighted that there existed different discount rates for different business areas and business regions. For example, Holmen Paper AB is using different rates within their business areas Holmen Skog and Holmen Energi (Jernhall, 2009) and Stora Enso Skoghall AB is using different rates e.g. within their business regions Sweden and China (Olsson, 2009). However, those factors are not directly connected to emission allowances but brought up due to potential interest among the readers.

The discount rate is not affected by the cost of emission allowances
In general, the interviewed actors do not take the EU ETS and the cost of emission allowances into consideration when deciding their discount rate(s). AB Fortum Värme and LKAB claimed that emission allowances had affected the electricity price, which in turn gave a certain effect on the general risk level of the business. This affects the cost of capital and thus also possibly the discount rate.

4.2.7 Time horizon

Due to the earlier discussed uncertainties connected to phase changes, investment time horizons are highly interesting. Actors affected by the EU ETS may consider the effect of emission allowances differently when setting the time horizons for the investments.

Differing time horizons between actors
Time horizons are very dependent on the amount of capital invested in a project and their

lengths are thereby connected to different sectors due to project characteristics; Ferrous metals and Energy were the only sectors in which time horizons exceed a time span of ten years. Stora Enso Skoghall AB and Cementa AB stated that corporate strategies could extend the time horizons, however, no patterns regarding this issue could be found between the sectors.

Phase changes seem to have low impact on time horizons
The phase changes do not seem to affect the time horizons to any substantial extent. Some of the actors, Stora Enso Skoghall AB among others, claimed that their time horizons seldom range more than two to three years. However, the short horizons were an effect of the low access to capital and not due to phase changes (Olsson, 2009).

4.2.8 Risk analysis

When identifying and assessing factors suitable for risk analysis, the EU ETS and the cost of emission allowances could be of interest. However, a risk analysis could be performed with different complexity in accordance to the relevance of the involved factors.

During the interviews it was found out that the distribution between actors including emission allowances in their risk analysis and actors doing the opposite was fairly even. In the Mineral sector, all the three interviewed actors included the cost of emission allowances. In addition, one of the Mineral actors performed scenario analysis in which possible changes in the EU ETS was included. Furthermore, several of the interviewees claimed that the electricity price was affecting capital budgeting to a much larger extent, thus becoming a more important factor.

There were identifiable differences between sectors
The outcome of the performed interviews showed that none of the actors in the Pulp & Paper sector included emission allowances or effects of changes in the EU ETS in their risk analysis. In contrast, all studied actors in the mineral sector at least performed sensitivity analyses including the cost of emission allowances. Furthermore, SMA Mineral AB took it to the next level and made complementing assessments through scenario analysis (Öhman, 2009). The representative of Nordkalk AB stated that production of lime is highly influenced of the price of emission allowances due to the low price of lime in comparison to the cost of carbon emissions, and thus making the profit very sensitive to changes in the price of carbon emission allowances (Lundström, 2009).

In the energy sector one of the interviewed actors explicitly stated that they include the cost of emission allowances in their sensitivity analyses. Mälarenergi AB varied the cost of carbon emissions by a 40% increase and decrease, and in addition performed scenario analyses in which potential outcomes clearly were written down in text together with their economic consequences. In the Ferrous sector only SSAB claimed to include cost of carbon emissions.

Energy cost was of higher relevance
A recurring thought among the interviewed actors was that fluctuations in the energy costs

had higher relevance than the cost of emission allowances. However, due to the contribution of carbon emissions in the energy cost those actors could implicitly be considered to include the cost of carbon emissions in their risk analyses. It was hard to recognise any clear sector patterns regarding those thoughts.

4.3 Concerns about the future

As discussed in Section 3.1.7, there exists only a proposal of how the EU ETS will develop in the future. Further into the future, especially end of Phase III, the uncertainty becomes even larger. The included companies are affected by this long-term uncertainty and they were asked to state their opinion about it.

The conclusion is that most companies express no concerns regarding the future; the companies believe that they know their position in the next phase. Among the companies four different groups can be distinguished: The Energy companies believe that they will not be allocated any allowances for free, six companies claim to be in the carbon leakage group and will be allocated allowances for free also in the future, one company tries to be excluded because of low emissions and three companies believe that they will be included without exceptions.

More stringent cap in the future
It is a common thought among the companies that there will be a more stringent cap in the future; this is especially noted among the Energy companies. Both AB Fortum Värme and Mälarenergi AB point out that they are not allocated any allowances in the second phase. Vattenfall goes one step further and states that they are in favour of auctioning of allowances. Also Södra ek.för mention that they believe in auctioning, this because grandfathering have lead to misallocation e.g. pulp sites in Germany that have been allocated ten times more than needed. Södra ek.för. expects not to be included in the next phase due to low emissions.

Important to avoid carbon leakage
The six companies that stated that they strive to be included in the carbon leakage group are the companies in the Ferrous metals sector, Preem AB, Cementa AB and SMA Mineral AB. The argument for inclusion is that they are subject to competition from outside the EU ETS. LKAB explains that they meet the basic criteria for the carbon leakage group but the question is what kind of allocation method that will be implemented (Nordström, 2009). SMA Mineral AB makes the same observation and claims that benchmarking must be based on fuel mix (Öhman, 2009). On the subject of allocation methods, Höganäs AB stated that full auctioning would give rise to additional costs for several of their major products and probably force them to move some of the production outside the EU ETS (Pettersson, 2009). Also Cementa AB stated that they are strongly against auctioning. Benchmarking is explicitly proposed by three of the companies in the carbon leakage group.

4.4 Key findings

The key findings that will be used in the analysis model are summarised.

- *Investment motives* In the sectors Pulp & Paper, Ferrous metals and Refinery, reducing the need for emission allowances were not the main motive for investments whereas for the Minerals sector, it can be an important motive for investments.

- *Decision criteria* Several interviewees claimed that they consider the declining amount of allocated emission allowances when evaluating their potential projects. Another aspect that affected the decision criteria was strategic issues that to some extent limited the requirement of maximum profitability.

- *Organisation* All companies had personnel at the sites who reported the demand and usage of emission allowances to either one individual or a group. Of the interviewed companies, none had an employee whose sole responsibility was the handling of emission allowances.

- *Cash flow* Carbon emission costs are normally included aggregated with other production costs.

- *Price* The companies can be divided into two groups, those that use a fixed price based on a common idea and the ones that use a forecast where the price is projected to change over time. The majority of the companies use a fixed price, including all the companies in the Mineral sector. All the companies in the Energy sector use a forecast.

- *Discount rate* Non of the interviewed actors do take EU ETS into consideration when they decide discount rates.

- *Time horizon* EU ETS and the phase changes seem to have low impact on time horizons.

- *Risk analysis* All companies in the Mineral sector and one company in the Ferrous sector included the cost of emission allowances in their sensitivity analysis. In addition, one of the mineral actors performed a scenario analysis in which possible changes in EU ETS was included. Mälarenergi AB also performed scenario analyses including the cost of carbon emissions.

5 Analysis

In this section, the empirical results will be compared as well as discussed in relation to the theoretical framework. The structure will initially be the same as the for the empirical findings, starting with the impact on business followed by impact on capital budgeting and finally concerns about the future. Thereafter, the two sub-questions will be addressed. The analysis of the impact on the capital budgeting evaluates the companies according to the analysis model (Table 3 in Section 3.2).

Impact on business
Similar to a previously performed study showing that 50% of the firms said that the EU ETS played a key role in long term decisions, the impact on business, as perceived by the firms themselves, was found to differ much between the sectors. From almost insignificant to very large perceived impact, four of the sectors can be ordered as: Refinery, Pulp & Paper, Ferrous metals and Mineral. For the Energy sector, the results differed from positive to negative perceived impact. The four factors that can explain the differences between the first sectors are allocation (method for and amount of), energy dependance of the production process (mainly fossil fuels, but also electricity), other carbon sources in production process and value of end product.

Regarding allocation methods, the three different kinds are presented in Section 3.1.4: grandfathering, benchmarking and auctioning. The allocation methods were all discussed by the companies. Benchmarking was explicitly preferred by three of the companies in the carbon leakage group. The strongest argument in favour for the method was that it does not reward inefficient industries, which is also mentioned in Section 3.1.4. All the Electricity and district heating companies believed in a more stringent system in the future and Vattenfall AB explicitly stated that they favoured auctioning. This is not surprising since, as also mentioned in Section 3.1.4, the cost has been passed down to the customer.

For the Energy sector, the varied results could be explained by the diversity of the investigated companies. They are differently impacted by, for example, the increased power price and the absence of allocated emission allowances to Electricity and district heating companies.

As mentioned in Section 3.1.4, the cost of emission allowances is an opportunity cost as the companies always have the possibility to sell the allowances at the market price. According to this assumption the cost should be included not only in an investment analysis but also in production planning. No evidence of this was found in any of the companies. If active trading with emission allowances was indeed performed, as theory bids, this was exclusively done with allowances not projected to be needed for the future production. The motives for the decision not to trade actively to avoid the opportunity cost were not explicitly sought in this investigation. However, based on the answers to other questions, we propose that a combination of the following arguments is used to justify the standpoint of ignoring or neglecting the opportunity cost.

- The *risk and uncertainty* connected to the EU ETS are perceived as too high. The companies do not feel they have enough insight into the trading scheme to justify the risks

connected to trade using emission allowances they need for production. The volatility of the price is high and the penalties for being short on allowances at the end of the year are steep.

- The cost of emission allowances are today an *opportunity cost*, and the loss of a possible income is seen as less important than being subject to actual, but perhaps lower, costs.
- Trading emission allowances is not part of the *core business* of the company. The pay-off from focusing resources elsewhere should therefore be larger and the company does not have the competence needed for profitable trading.
- The *lost income is too small* compared to other cash flows from the operations. It is not the best use of company resources.

The arguments above are clearly of different importance to different firms. The last point, for example, might be valid for a company in the Refinery industry, while it is definitely invalid in the Minerals sector.

In most companies, it was the finance department that was responsible for the buying and selling of allowances based on demand forecasts from the sites. For two of the companies in the Minerals sector, the buy/sell strategies were discussed by the executive board. This may be a result of the companies being the most exposed to the costs of emissions (both actual and perceived, see Table 1 and Section 4.1) or that they are smaller firms. Probably a combination of both. Of all companies, only four speculated in emission allowances, of which three were in the Energy sector. This is explained with the fact that they already had trading floors, and one additional derivative could be implemented with relative ease.

Due to the uncertain future design of the EU ETS resulting from the large political uncertainty discussed in Section 3.1.7, the companies had to keep updated. Classifying the approaches on the area of information gathering as passive, semi-active or active, it might have been expected that the companies with a high emission ratio or large resources would fall into the last category. No pattern could, however, be discerned other than the fact that several firms from different industries relied on their respective trade organisation to be well up on the subject. The trade organisations were also the main method by which the companies tried to reduce the political uncertainty through lobbying.

Impact on capital budgeting

The companies in the study have been evaluated according to the analysis model. The result, which is presented in Appendix D, is analysed and discussed below.

For the first variable of the analysis model, the cost of carbon emissions as a motive for investments, the following division could be made: Claiming costs of emissions not to be the major motive, but contributing to profitability were the firms in the Pulp & Paper sector, the Ferrous metals sector and the Refinery sector. These three sectors are also those with the lowest emission intensity. Claiming the costs to sometimes be an important motive was the Minerals sector, while the Energy sector was once again divided. Although somewhat coarse, the division bears resemblance to the perceived impact. Standing out from the others

is the Mineral sector, which may not be surprising as the cost of emission allowances can equal 50-60% of the value added when producing lime. This is also reflected in the high emission intensity of the sector. The political uncertainty, frequently discussed previously in this report, also provides motives for investments. A company in the Energy sector partly motivated the investment in a flexi-fuel plant with the fact that they could use fuels not needed to be covered with emission allowances, thus avoiding the political uncertainty of the EU ETS. This recommendation is also given in the previously discussed study by Laurikka and Koljonen (2006), based on the results of a simulation of different kinds of investments within an emissions trading scheme. It is one of the purposes with the EU ETS that it should provide strong incentives for investing in low carbon emission technology, however, such an effect was not seen.

Connected to the motives for making investments are the decision criteria used to evaluate them; resulting demand for emission allowances might be added to the list of variables to evaluate. It was found that most companies had not adapted their decision criteria at all to the cost of carbon emissions, rendering low scores in the analysis model. Among the firms, it was only one that explicitly stated that the cost of emission allowances was among the decision criteria. In accordance with what could be assumed, the firm stated that the costs were included due to the believed future limitation of allowance allocation. Another approach, put forward by two firms, was that the subject of emission allowances could be seen as strategic and therefore potentially lower profitability requirements. A motive for this standpoint was the uncertain future of the system. An explanation for the lack of flexibility regarding the decision criteria could be that we found no evidence that the companies changed their criteria as a response to any factors. Flexibility and risk management is instead included in other ways.

Contrary to the decision criteria, the firms had been forced to adapt their organisations to the EU ETS. Common to all was that a system for reporting the carbon emissions had been introduced and all but one had several employees for which emission allowances were one of several areas of responsibility. In spite of the impact that emission allowances have had on the business of some firms, none had employees working 100% with carbon emission issues. Even though most companies had several employees working with emission allowances, their tasks were mainly collection of data and preparation of reports. We found no evidence of analytical or strategic work. We find this somewhat surprising as the value of the emission allowances, at least for some companies, can be substantial. An example is SSAB which has carbon emissions exceeding two million tonnes per year (see Table 1), corresponding to a value of roughly €40 million.

The only results found concerning the treatment of the cash flows arising from the costs of carbon emissions in capital budgeting showed firms distributing the costs over periods. That the costs are included as well as distributed over time shows that they are treated in the theoretically correct way as opportunity costs and factors of production (see Section 3.1.1). Although the procedures are fairly sophisticated, the costs could be treated more thoroughly. This could be done by discounting the costs independently, as the unique characteristics of the cash flow, e.g. phase changes, differs from the main project.

To accurately predict the cash flow arising from emission allowances, the company must,

in addition to future allocation, estimate the future price. The firms could here be divided into two groups using the analysis model; those that use a fixed price (€20-40) based on a common idea and the ones that used a forecast where the price was projected to change over time. The majority of the firms belonged to the first group, including all from the Mineral sector. It is somewhat surprising to find all the Mineral firms in the fixed price group as they are the most strongly affected by the cost. Also worth noting is the huge spread in assumed future price, a full 100%. We believe a reason that some companies use €20 is that this price was used in some early reports from the European Union. Although the higher prices may be the result of an estimated high future volatility, we think it is more likely that the price include a subjective risk premium. No one wants to be responsible for grossly underestimating the future costs of a project. Another reason could be that a higher price can be used to make green investments more profitable.

It is somewhat surprising that not all firms use a forecast instead of a fixed price as for example using the price of the futures is not labour intensive. In the Energy sector, though, all companies used a forecast, which is the theoretically correct approach. This is probably due to the fact that they already have organisations for and experience from handling the trading of energy products, and it would be relatively easy to add one commodity to the list.

The discount rate should, from a theoretical point of view, contain a risk premium accurately reflecting the risk in the project for which it is used. The historically high volatility of the price of emission allowances and the political uncertainty inherent to the EU ETS provides incentives for increasing the risk premium for projects involving emission allowances. Evidence of this was, however, absent. This is explained by the fact that most firms used the same rate for all projects or, in the best case, within each business unit. The uncertainties in the EU ETS does however constitute a part of the general corporate environment and may therefore affect the discount rate slightly. Two firms explicitly mentioned the indirect effect of emission allowances on the energy price, and due to the importance of this variable the emission allowances can indirectly be said to enter the discount rate.

The EU ETS contains certain dates more important than others, above all the ends of the second and third phases. Based on this, it could be expected that the companies in the system adjusted the time horizons in their capital budgeting processes to avoid planning projects over phase changes. Considering first the normal time horizons, only the capital intensive Ferrous metals and the Energy sectors used horizons extending beyond 10 years into Phase III. Some actors did not even have projects extending over the first phase change. Although the opinion that strategical considerations could affect the time horizon of a project was encountered, no evidence was found that any company had adjusted a time horizon to avoid the uncertainty connected to the EU ETS. We propose that the indifference to the first phase change (2012-2013) is a result of the fact that in practice, almost no uncertainties about the design of the future system remain. Furthermore, the next phase change (2020-2021) is not within the time horizon of most companies. For those who have projects extending this far in time, we believe that they assume the possible costs to be small enough not to make a major difference when discounted to present time.

Another way of coping with risk is to do a risk analysis of the results of the capital bud-

geting process. This can be done using more or less advanced methods. Regarding whether or not the cost of emission allowances was a variable in risk analysis and, if so, in what kind of process, there were some differences to be found between the sectors. In the Pulp & Paper sector, the cost was not included in any risk analyses. In the Mineral sector, all three companies included the cost in a sensitivity analysis and one company also in a scenario analysis. Concerning the Energy sector, two actors included the cost in a sensitivity analysis, of which one also did a scenario analysis. The results found are not surprising as there is a correlation between the level of sophistication of the treatment of emission allowances in risk analyses and the emission intensity of the firm. The Pulp & Paper sector has the lowest emission intensity and does not include the emission allowances in the risk analyses. The Mineral sector was the most thorough and also has the highest emission intensity. The Energy sector has a relatively thorough treatment of the emission allowances, which probably can be explained with the fact that the cost of carbon emissions is an actual cost for these actors, not an opportunity cost. Another possible explanation is their previous experience from similar derivatives and well developed infrastructure. A common opinion was that the cost of energy was a more important variable, but also the indirect effect of emission allowance price on energy price was mentioned. If the energy price is then included in a risk analysis, emission allowance price might be argued to be implicitly included as well.

Concerns about the future

The uncertainty of the EU ETS has already been mentioned on several occasions. Judging from the results, the general conception seems to be that this risk is best avoided by being exempted from the system. Of the 13 interviewed actors, 6 strived for being included in the carbon leakage group or were already qualified. These were the three actors from Ferrous metals, the one from Refinery and two from Minerals. It was expected to find all three Mineral companies in this group since they have the highest emission intensity, but only two explicitly stated so. This could probably be explained with the fact that the transaction costs are high in comparison to the product price, which also Barker et al. (2007) discuss. The sector with the second highest emission intensity is the Energy sector, but they are not affected by carbon leakage because they have no competition from outside the EU ETS. Ferrous metals, on the other hand, is a sector which is subject to worldwide competition as the transaction costs are low in comparison to product price.

The 6 companies that explicitly stated that they strive to be included in the carbon leakage group represent 30% of the total emissions of the Swedish part of the EU ETS. We believe that this is a remarkably large number and think it is improbable that this large share of the emissions could be exempted from the system.

The general idea about the future was that the caps would be lower, which is correct as well as clearly stated in the description of the EU ETS. The kind of allocation method the companies hope for differs a lot depending on business situation. One electricity producer is strongly in favour of auctioning as this will raise the price of emission allowances, and thus electricity, the most. The same opinion is expressed by a company from Pulp & Paper, which argued that grandfathering had led to many overallocations for other actors. They have also

previously expressed that they strive for becoming fossil fuel free, and would in that case not be included in the EU ETS. This helps explain their enthusiasm for the system as it would induce costs for competitors. Finally, one company from the Mineral sector that knows that they will be included in the system dreads auctioning as allocation method. They claim that this method would "kill" their whole business idea.

Auctioning has previously been stated (see Section 3.1.4) to be the method favoured by economists as it maximises the welfare. This is, however, not the reason why some of the companies favour auctioning, but they believe it to give them a competitive advantage.

Sub-question 1 - Are there differences between the EU ETS sectors?
This question is formulated with respect to the research question and thus seeks possible differences in how companies in different sectors handle the cost of carbon emissions in their capital budgeting process. The patterns that could be found are presented below.

Differences between the EU ETS sectors were found in three of the eight variables in the analysis model.

Concerning the role of emission allowances as motive for investments, it was relatively small for Pulp & Paper, Ferrous metals and Refinery, whereas it was large for the Mineral sector. The Energy sector was diverse. Regarding how the price of emission allowances was set, all firms in the Energy sector used a forecast while the firms in the Mineral sector used a fixed price. Concerning the explicit inclusion of emission allowances in risk analyses, the most prominent result was that the Mineral sector was the most thorough. For the remaining five variables, there were no discernable differences between the sectors.

In addition to the results from the analysis model, the following differences between the sectors were found.

For the perceived impact on business, the sectors could be ordered from low to high as: Refinery, Pulp & Paper, Ferrous metals and Minerals. The Energy sector was diverse. On the issue of how emission allowances were handled, only four companies, whereof three were in the Energy sector, were engaged in speculations.

Summing up, the Mineral sector was the most affected by the EU ETS. The effect on their capital budgeting process was, above all, that the risk analysis included the cost of carbon emission. Also the Energy sector seems to be much affected, especially when it comes to the price of emission allowances. However, this is most likely explained by the fact that they already have an infrastructure capable of analysing also emission allowances.

Sub-question 2 - What can be learnt from the answer to the Research question about the efficiency of the policy actions of the EU ETS?
In general, most companies were awarded low scores on most variables, which has different interpretations regarding the efficiency of the EU ETS depending on the variable. Some variables are also better described as measuring the absence of unwanted effects of the EU ETS rather than directly measuring the fulfilment of the aim[1].

[1]It is, for example, not a goal of the EU ETS to introduce additional risk and uncertainty in the business of the affected firms.

The result of evaluating the efficiency of the EU ETS using the variables of the presented analysis model is that the allocative efficiency of the EU ETS can be questioned, but possible adverse effects are quite small. The analysis model did not investigate whether the right actions, from a cost perspective, were taken within the companies. The low level of trading combined with the differences in abatement costs that is presumed to exist, at lest between sectors, does however indicate that abatement measures are not always made in the most cost efficient companies.

Considering each variable of the analysis model and starting with the effect on the investment motives, it was overall quite small. As investment motives were a very good measurement of the efficiency of the EU ETS, the interpretation is that the system has not achieved the desired effects on this area. For the decision criteria, graded a reasonably good measurement, it was often not possible to evaluate the companies. When possible, the scoring was generally quite low. The relevance of the variable combined with the scoring give the conclusion that the aims have implemented to a small extent when it comes to affecting the decision criteria. Turning next to the organisation, effects here were not seen as a good measurement of the efficiency of the EU ETS. In spite of having higher scores than the decision criteria variable, the organisational effects does not show signs of the EU ETS having been successfully implemented. The last of the variables actually providing a measurement of the efficiency of the EU ETS (as compared to the lack of adverse effects) is cash flows. These were graded a very poor measurement and their low score does not reveal much information regarding whether the goals of the system have been successfully enforced or not.

The remaining variables (price, discount rate, time horizon and risk analysis) all provide a measurement of the absence or presence of adverse effects of the EU ETS. Two of them, discount rate and time horizon, scored a zero, meaning that the system has not introduced any uncertainties of such magnitude that the two variables have to be considered. The same interpretation can be made for the variable risk analysis, scoring very low, albeit not zero. Of more concern is the last variable, price. A non-negligible effect of the EU ETS was found on the firm treatment of the price of emission allowances. This indicates the existence of a price related risk that is an unwanted effect of the EU ETS, not in line with the aims of the system.

6 Discussion

This section will address the implications of the delimitations and the choice of research method. Both of which can give rise to questions about the external validity of the results.

In spite of the fact that the EU ETS affects several countries, the first delimitation was to consider only companies in Sweden. A result of this is that it is not possible to directly apply the results to all firms included in the EU ETS. Different countries have different corporate environments for the firms to act within and in addition to this, the corporate culture often differs. Both these factors limits the applicability of the results outside Sweden. A fact that increases the external validity of the results is that several of the studied companies are represented in additional countries within the EU ETS, and can thus be assumed to act in a similar way there.

The next important delimitation is the choice to consider only the treatment of the costs of carbon emissions in the capital budgeting process. The first issue here is the definition of the capital budgeting process. Other authors may not agree with our choice of starting point and end point, but the concept is not clearly defined. Instead, we strived for being transparent in our argumentation displaying the logic behind our choice to help readers interpret the results. In addition, the choice of focusing on the capital budgeting process makes this study a better complement to literature, as many previous studies have had a more strategic standpoint. In fact, the results of this study cannot be extrapolated to be said to explain how firms as a whole treat costs of carbon emission. We do, however, believe that as capital budgeting is central among the activities of the firm, the results can give a good indication of the effect on the whole firms. Some more general questions about the effects of the EU ETS were also included in the study. Another aspect of this limitation is that only internal effects have been investigated. No results on possible changes in market balance or similar are therefore presented.

In addition to the delimitations, also the choice of method has had an effect on the external validity of the study and the quality of the results. The first important choice is which firms to interview. The complexity of the subject necessitated the use of personal interviews, which in turn limited the number of companies that could be approached. The choice of the actors thought to have the most advanced treatment of the costs of carbon emissions did, of course, make it hard to say something about Swedish firms in general. Considering the generally quite simple methods it is highly probable that the bulk of firms included in the EU ETS have a very low level of adaption of the capital budgeting process.

The next major issue concerns the choice of employee within each firm to interview. Although attempts were made to find the most suitable individual before the initial contact with the firm, this was not always possible due to the unofficial nature of the information needed. On some occasions, the first contact referred us to someone else. Regardless of with whom the interview was made, it is still the fact that the area of interest is interdisciplinary. As not all interviews were complemented with a second round of questions to another employee in the same company, this problem was probably one of the main causes of why not all actors could be evaluated in all variables of the analysis model. An approach that could have

mitigated this problem would have been to send out a questionnaire prior to the interviews, asking the employee to answer this first, and we could then have had the answers as basis for discussion. A downside with that approach is that it requires somewhat more work from the interviewees and could therefore have a negative impact on the answering frequency.

The last issue to be addressed in this section is the construction of the analysis model. Although the model is based on basic capital budgeting variables and constructed partially with the help of an experienced researcher, it remains a fact that large parts are our own construction. As the reason for constructing our own model was that none appropriate was found in the literature, it follows that all aspects do not have direct support in presently published theory. We are aware of this issue and do not claim that our model is the only conceivable for the investigation of our area of interest. Our standpoint is that the model is constructed and applied to the best of our ability, but we have focused on transparency in the construction and application of the model. This allows the readers to make a judgement of their own regarding the validity of the model and the possibility to extrapolate the results.

7 Conclusions

The part of the purpose of this study that has guided the investigations was:

> The purpose of this paper is to analyse how Swedish companies within the sectors included in the EU ETS handle the cost of carbon emissions in capital budgeting. The analysis aims both to describe the handling and to explain it. By comparing the companies' strategies to each other as well as to the theory, this paper will investigate possible differences between companies in different sectors as well as differences between theoretical models and practice. In addition to this, the results will also be used to provide an indication on the efficiency of the EU ETS.

In order to understand and correctly explain the results from the study of the firms, it is necessary to understand the preconditions for running a business included in the EU ETS. The emissions trading system has introduced a new cost; a cost which is best categorised as a production factor. With the emission allowance allocation method currently used in Sweden, grandfathering, the allowances are allocated for free, which results in the creation of an opportunity cost. The exception to this is the producers of electricity and district heating, who must buy their entire supply of allowances. In addition to the cost, which affects different sectors to a varying extent, the system also introduces a major political uncertainty about the future. Of special importance is the transition between the different phases of the system, at which the system design can change drastically. The dates of interest are the transition from 2012 to 2013 (Phase II to Phase III) and 2020 to 2021 (end of Phase III). The rules for Phase III are however relatively well defined by now.

The main result of the study was that all investigated companies did include the cost of carbon emissions in their capital budgeting, regardless of sector. The level of sophistication of the treatment was generally low according to our analysis model and varied a lot between the individual firms.

An evaluation of the treatment of the cost of carbon emissions in the capital budgeting process revealed differences between the sectors included in the EU ETS. Altogether, the Mineral sector and the Energy sector were found to have the most sophisticated processes. For the Mineral sector, this is explained by the fact that the carbon emission intensity of the business is very high, and they also showed the highest level of perceived impact. In the case of the Energy sector, the main explanations of the result are that they are large firms with resources and that they have an already existing organisation for treating similar derivatives (for example electricity certificates).

The efficiency of the EU ETS was evaluated by comparing the results from the analysis performed using our analysis model, with the goals of the EU ETS. The conclusion was that the allocative efficiency of the EU ETS can be questioned. However, no evidence of most of the expected negative effects were found. The exception was an indication that the emission allowances of the EU ETS came with a price related risk.

To summarise this study, and provide an answer to the research question, it can first be said that Swedish firms that are included in the EU ETS do treat the cost of carbon emissions

in their capital budgeting process, regardless of sector. The level of sophistication does differ between firms, but is generally low. Considering the fact that the actors most likely to have an advanced process were studied, the general level of sophistication in Sweden is most probably very low.

7.1 Suggestions for further research

The first obvious suggestion for further research is to expand the study beyond the delimitation used for this study. Such expansion could consist of approaching companies in the whole of the EU ETS to get an understanding of the general effect of the system on the capital budgeting processes. It would then also be possible to investigate whether there are any differences between countries and regions in addition to sectors.

Another possible expansion is a result of the fact that the theoretical recommendations we found for handling the cost of carbon emissions offer strategies on other areas than capital budgeting. Follow-up studies could investigate corporate strategies or look at how the market positions have shifted after the introduction of the EU ETS.

In addition to expanding the study, the results can also be motives for further investigations. One of the most interesting results is that the level of adaption among the firms most likely to adapt was very low. As this indicates that the general level in all Swedish firms in the EU ETS is even lower, a future study could send questionnaires to all firms to get an general view of the situation in Sweden. This is interesting not only from a corporate perspective, but also from the perspective of the design of the EU ETS. Does it actually function as intended?

Next, another interesting finding was that out of 13 contacted corporations, 6 strived to be included in the carbon leakage group. As these firms represent 30% of the total carbon emissions in Sweden, this points to a possible flaw in the system. The first aspect that would be interesting to investigate would therefore be the regulations surrounding the carbon leakage criteria. Why do so many firms hope to be included? Is it at all possible to introduce this kind of system when it is not worldwide? The second aspect would be to take a closer look at the work from the companies' side towards being included in the carbon leakage group. What are their strategies? How and where do they lobby for their standpoints?

The last suggestion for further research is to repeat exactly the same study in a few years time. The EU ETS is fairly new, and many firms might not have had the time to fully adapt their capital budgeting. In addition to this, there is an interesting date coming up with the shift from Phase II to Phase III in 2012/2013; how do firms work just before and just after this? Another motive for repeating the study is that the cap on carbon emissions is decreasing by the year, a fact that would make the companies more inclined to treat the cost of carbon emissions more thoroughly. Perhaps the average firm level in the analysis model will increase?

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A Activities included in the EU ETS

Table 4: (Adapted from Pauksztat and Kruska (2006, p. 153)) Sectors covered by the EU ETS as declared by the EU Commission (2003).

Activities
Energy activities
Combustion installations with a rated thermal input exceeding 20 MW (except hazardous or municipal waste installations)
Mineral oil refineries
Coke ovens
Production and processing of ferrous metals
Metal ore (including sulphide ore) roasting or sintering installations
Installations for the production of pig iron or steel (primary or secondary fusion) including continuous casting, with a capacity exceeding 2.5 tonnes per hour
Mineral industry
Installations for the production of cement clinker in rotary kilns with a production capacity exceeding 500 tonnes per day or lime in rotary kilns with a production capacity exceeding 50 tonnes per day or in other furnaces with a production capacity exceeding 50 tonnes per day
Installations for the manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day
Installations for the manufacture of ceramic products by firing, in particular roofing tiles, bricks, refractory bricks, tiles, stoneware or porcelain, with a production capacity exceeding 75 tonnes per day, and/or with a kiln capacity exceeding 4 m^3 and with a setting density per kiln exceeding 300 kg/m^3
Other activities
Including industrial plants for the production of
pulp from timber or other fibrous materials
paper and board with a production capacity exceeding 20 tonnes per day

B Interviewed Actors

Below is a list presenting the employees that were interviewed as well as the business of their respective firms.

Anders Jernhall, Group Controller and head of the Control function, Group Finance, Holmen Paper AB. For Holmen Paper AB we interviewed Anders Jernhall who is responsible for financial evaluations of investments. Holmen Paper AB is a daughter company to Holmen AB and is manufacturing and selling printing paper. The market of Holmen AB is mainly located within Europe.

Albin Andersson, Energy Coordinator, Södra Cell ek.för. For Södra Cell ek.för. we interviewed Albin Andersson who is responsible for energy strategies, monitoring of political decisions and lobbying within the economic asociation. Södra Cell ek.för. produces pulp, wood products and bio fuel. The market of Södra Cell ek.for. spreads worldwide.

Peter Olsson, Manager Strategy and Investment, Stora Enso Skoghall AB. For Stora Enso Skoghall AB we interviewed Peter Olsson who is responsible for strategic planning within the corporation involving emission allowances. Stora Enso Skoghall AB is a daughter company to Stora Enso AB and is producing paper, packaging and wood products. The market of Stora Enso AB spreads worldwide.

Nils Andersson, Senior Advisor, Group Function Communication, Vattenfall AB. For Vattenfall AB we interviewed Nils Andersson who is working with strategic consulting and political influence for the corporation. Vattenfall AB produces electricity and district heating. The market of Vattenfall AB is mainly northern Europe.

Ove Åsman, Analyst, Investments and Analyses, AB Fortum Värme. For AB Fortum Värme we interviewed Ove Åsman who is analyst at the Department of Investment and Analysis. AB Fortum Värme produces electricity and district heating. The market of AB Fortum Värme is Sweden.

Catrin Nehrman, Business Controller, Business area Heat, Mälarenergi AB. For Mälarenergi AB we interviewed Catrin Nehrman who is involved in investments and production planning. Mälarenergi AB produces electricity and district heating. The market of Mälarenergi AB is Sweden.

Kim Kärsrud, Director of Environmental Affairs, SSAB. For SSAB we interviewed Kim Kärsrud who is responsible for carbon emissions within the corporation and political influence. SSAB produces steel products. The market of SSAB spreads worldwide.

Kenneth Nordström, Carbon Dioxide Responsible, External Environment Department, LKAB. For LKAB we interviewed Kenneth Nordström who is corporate responsible for carbon emissions. LKAB produces iron ore products. The market of LKAB spreads worldwide.

Magnus Pettersson, Energy coordinator, Höganäs AB. For Höganäs AB we interviewed Magnus Pettersson who is energy coordinator at the company and also working with lobbying. Höganäs AB produces metal powder products. The market of Höganäs AB spreads worldwide.

Anders Lyberg, Technical Director, Cementa AB. For Cementa AB we interviewed Anders Lyberg who is responsible for carbon emissions within the corporation and lobbying. Cementa AB is a daughter company of HeidelbergCement and is producing cement products. The market of HeidelbergCement spreads worldwide.

Fredrik Lundström, Quality and Environmental System Manager, Nordkalk AB. For Nordkalk AB we interviewed Fredrik Lundström who except for trading is responsible for everything connected to emission allowances within the corporation. Nordkalk AB produces lime products. The market of Nordkalk AB is mainly Europe.

Magnus Öman, Production Director, SMA Mineral AB. For SMA Mineral AB we interviewed Magnus Öman who is carbon coordinator in the company involving lobbying, prognoses and follow-ups. SMA Mineral AB produces lime products. The market of SMA Mineral AB is mainly Europe.

Leif Brinck, Senior Manager Business Control, Preem AB. For Preem AB we interviewed Leif Brinck who is responsible for carbon emissions within the corporation and company representative towards authorities. Preem AB produces petroleum products. The market of Preem AB is located mainly in northern Europe.

C Interview guide

The interview guide used during the interviews is presented below. For each area of interest, the questions are complemented with a short description of the variable.

C.1 Introduktionsfrågor

Denna del består av ett antal generella frågor för att få en uppfattning om företagets situation gällande EU ETS. Analysområden som behandlar organisation.

- Er titel och beskriv era ansvarsområden
- Generellt, hur hanterar Ni utsläppsrätter inom organisationen?
- Inom organisationen, har Ni specifika anställda som arbetar med frågor gällande utsläppsrätter?
  * Om svar ja: Vilka och hur mycket resurser används i termer av antal anställda och tid?
- Anser Ni att företaget har goda kunskaper om EU ETS?
  * Hur har företaget inhämtat denna kunskap?
  * Om svar nej: Har Ni några planer på att anskaffa kunskaper inom snar framtid?
- Har företaget gjort några anpassningar till EU ETS?
  * Om svar ja: Ge gärna exempel

C.2 Investeringskalkyler

Denna del består av frågor gällande företagets investeringskalkyler och hur de inkluderar utsläppsrätter i dessa. Analysområden som behandlas är investment motives, decision criteria, cash flow, price, time horizon.

- Beskriv ett eller flera projekt som påverkade Er utsläppsmängd, utfört efter 2005. Inkluderade ni utsläppsrätter i dessa investeringskalkyler?

Om ja:

- Vad hade projekten för kalkylhorisonter? Påverkades dessa av att utsläppsrätter var inkluderade?
- När Ni utvärderade lönsamheten för detta/dessa projekt, vilka kalkylmodeller använde Ni? På vilket sätt inkluderade Ni utsläppsrätter?
- Hur påverkade de kalkylen?
- Har ni andra krav jämfört med investeringar som inte påverkar utsläppsrätterna?
- Hur uppfattade Ni kostnaderna för utsläppsrätterna i förhållande till storleken på investeringen?

Om nej:

- Vad ligger till grund för det beslutet?

- Ses utsläppsrätter istället som ett tak för produktionen?

I båda fall:

- Tas det hänsyn till utsläppsrätter på något annat sätt i planeringen av en investering?

C.3 Kalkylräntor

Denna del består av frågor kring risk och specifikt påverkan på företagets kalkylränta. Analysområden som behandlas är discount rate och risk analysis.

- I de tidigare diskuterade projekten, hur hanterade Ni risken förknippad med utsläppsrätter?

- Vad använde ni för riskanalyser som inkluderar utsläppsrätter?

- Använder Ni Er av en diskonteringsränta?

Om ja:

- Har denna justerats som en följd av EU ETS? Och i så fall hur?

- Har faserna i EU ETS påverkat valet av diskonteringsränta?

C.4 Framtidsplanering

Denna del behandlar frågor kring den osäkra framtiden förknippad med EU ETS.

- Behandlar organisationen osäkerheten gällande nästa period (2013 och framåt)?

- Hur görs projektioner för hur många utsläppsrätter företaget kommer att tilldelas i framtiden?

- Om ni har projekt som sträcker sig över 2012, vilka antaganden har Ni gjort angående hur systemet kommer att utformas inför nästa fas?

C.5 Handel med utsläppsrätter

Denna del består av frågor kring hur företaget förhåller sig till handel med utsläppsrätter.

- Hur förhåller Ni er till handel med utsläppsrätter?

  * Har Ni övervägt att sälja utsläppsrätter under året innan Ni säkert vetat vad Er utsläppsmängd skulle landa på?
  * Har Ni sålt utsläppsrätter under pågående fas?

  * Har Ni köpt utsläppsrätter under pågående fas?
  * Har Ni köpt utsläppsrätter under pågående fas med syfte att senare sälja vidare dessa?

- Är möjligheten till handel inkluderad i kalkyleringen för en investering? Med andra ord, anses utsläppsrätterna förknippade med en viss investering vara tillgångar som kan generera inkomster?

- Vid planering av ett projekt, utvärderas olika strategier gällande utsläppsrätter och produktion i relation till priset på utsläppsrätter och värdet på producerade enheter?

D Result of analysis model evaluation

On the next page the results from the evaluations of the individual companies according to the analysis model from Section 3.2 are presented.

Table 5: The result of the valuation of the studied companies according to the analysis model.

	Evaluation variables[a]							
Sector and actor	Investment motives[b]	Decision criteria	Organisation	Cash flow[b]	Price	Discount rate	Time horizon	Risk analysis
Pulp & Paper								
Holmen Paper AB	1	-	2	2	1	0	0	-
Södra Cell ek.för.	0	-	2	-	1	-	0	-
Stora Enso Skoghall AB	1	-	2	2	2	0	0	0
Average[c]	0.50	-	2.00	1.50	1.33	0	0	-
Energy								
Vattenfall AB	2	1	2	2	3	-	0	-
AB Fortum Värme	0	1	2	2	3	0	0	0
Mälarenergi AB	2	2	2	-	2	0	0	2
Average	1.00	1.33	2.00	1.50	2.67	0.00	0.00	1.00
Ferrous metals								
SSAB	2	1	2	-	3	-	0	1
LKAB	-	-	2	-	1	0	0	-
Höganäs AB	1	-	2	-	2	0	0	0
Average[c]	1.13	-	2.00	-	2.00	0.00	0.00	0.50
Mineral								
Cementa AB	2	-	2	2	1	0	0	1
Nordkalk AB	2	1	2	2	1	0	0	1
SMA Mineral AB	-	-	2	-	1	0	0	2
Average[c]	1.50	-	2.00	1.50	1.00	0.00	0.00	1.33
Refinery								
Preem AB	1	1	1	-	1	0	0	-
Average[c]	0.75	1.00	1.00	-	1.00	0.00	0.00	-

[a]For cells containing a '-' we were unable to evaluate the company according to the variable in question.

[b]The values in this variable have been scaled to correspond to the same Category 0-3 used for the other variables.

[c]For sector averages to have been calculated, no more than one value was allowed to be missing