Stockholm School of Economics
Department of Economics
Master's Thesis

Transaction Costs for Swedish Actors Participating in the European Emission Trading Scheme

Abstract

On January the 1st 2005 the European Union Emission Trading Scheme (ETS) took effect. The idea of the scheme is to minimize the marginal control cost for carbon dioxide emission reduction through trade with transferable permits. As a member of the European Union, Sweden is subject to the rules and regulations of the ETS. **In this thesis, we empirically investigate what the ETS has implied for Swedish actors during January – December 2005. Of special interest are the transaction costs of ETS, which we investigate and estimate.**

We find that the ETS seems to be rather cost effective in terms of transaction costs considering that the market is still immature. We also find actors allocated few permits in the scheme appear to be inactive in trade. One plausible explanation is that the transaction costs for these actors are much higher relative to the other actors. Opting out this group from the scheme would not have a great influence on the total level of emission in Sweden, nor on the total size of the transaction costs. One alternative way of minimizing the ETS transaction costs would be to use auctioning as an allocation method for the transferable permits.

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List of Abbreviations and Acronyms

• Actor	Firm or public actor participating in ETS
• Annex I countries	Developed countries that have signed the Kyoto Protocol
• Asymmetric information	One part (the actor) is better informed than the other party (the regulatory body)
• CDM	Clean Development Mechanism
• Efficient allocation of emission	The cost minimizing allocation of emission between different actors in ETS
• Emission charge	A carbon dioxide tax that is paid as a fixed fraction per unit of emission
• Efficient level of emission	The chosen level of emission i.e. socio-economic development path
• ETS /the Scheme	The EU Emission Trading Scheme
• Externality	An externality occurs when someone who is external to the market transaction is affected directly by it but not compensated.
• Group 1	Actors allocated 1-1,000 permits
• Group 2	Actors allocated 1,001-20,000 permits
• Group 3	Actors allocated 20,001-100,000 permits
• Group 4	Actors allocated more than 100,001 permits
• JI	Joint Implementation
• NAP	National Allocation Plan
• Marginal control cost	The cost of controlling one more unit of emission
• Marginal damage cost	The damage that one more unit of emission causes
• MC	Marginal Cost
• Permits/transferable permits	Transferable permits, property right traded in ETS, 1 ton of carbon dioxide is equal to one permit
• Transaction costs	Costs for participating in ETS, e.g. administration, verification, trade costs, know-how etc.

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1. Introduction

Over the past 15 years the warming effects on the climate due to the Greenhouse gases has gained increased attention. According to the UN IPCC fossil fuels are the leading cause of this effect. A trade off between rapid economic growth and future environmental concerns has been spawned by modern societies' dependency on fossil fuels. On January the 1st 2005 the European Union Emission Trading Scheme (ETS) took effect. The ETS, is the largest effort in the world to reduce climate change. ETS includes all firms and public actors (here after referred to as 'actors') with production units that are energy intensive[1]. These actors are now expected to pay for their emissions of the greenhouse gas carbon dioxide.

The principal idea of transferable permits schemes was presented by Crocker (1966) and Dales (1968) in the 1960's. In the scheme a transferable permit is set to equal a specific amount of emission. The marginal control cost for the emission reduction is equalized among all actors through trade with the transferable permits. In this way the total control cost can be minimized. As reduction of carbon dioxide may be costly also in terms of the GDP development, a critical factor for the ETS is that the scheme is as cost effective as possible and that it gives the incentives to the development of new technology that efficiently controls carbon dioxide emission (Pew Center on Global Climates Change). If trade activity with the transferable permits is low, this may in turn hinder that the cost of reducing emission of carbon dioxide is minimized.

As a member of the European Union, Sweden is subject to the rules and regulations of the ETS.[2] In this thesis we focus on the initial year of ETS, January – December 2005. **We empirically look at the activity of permit trade among the Swedish actors and which trading strategies that the actors have used. Of special interest are the transaction costs of ETS, which we investigate and estimate. We also look at if the ETS market is perceived as efficient and if it has influenced the investment rate in new technology. The result is evaluated with respect to the cost effectiveness of the ETS for the Swedish society.** We base our thesis on the assumption that transaction costs, which may

[1] Including installed combustion installations with a rated thermal input exceeding 20MW.
[2] In section 2 and 4 general information about ETS, its implementation in Sweden, regulatory requirements and environmental issues found at www.utslappshandel.se have been used, if no other source is referred to. This website is constantly updated with the latest information regarding issues related to the ETS and the Greenhouse effect. The Swedish authorities, Naturvårdsverket and Energimyndigheten administer website.

arise when trading with transferable permits, can prevent actors to participate actively in trade.

In order to empirically investigate these issues, we performed a survey among all Swedish actors in ETS. The actors were divided into four groups depending on the amount of permits that they had been allocated for 2005. We will not discuss the importance of which sector the actor belongs to, nor consider actors outside of Sweden. The rational behind these choices is that such a study would be beyond the scope of this thesis. To date there is, to our knowledge, no study empirically investigating the relation of ETS transaction costs and trade patterns with respect to Swedish actors. Therefore, the contribution of the thesis is to fill this gap in empirical research on the ETS. In the following we will briefly present some of the previous research, which is related to the topic of this thesis.

Schleisch and Betsz (2004), discuss how a transferable permit scheme influences different actors. They claim that small and medium sized companies are especially vulnerable to transaction costs as the transaction costs are not proportional to companies' sizes.

In a European Commission survey reviewing of ETS it is found that about half of the EU actors add the value of carbon dioxide on their product prices and 70 percent of the actors will do so in the future. In addition, half of the actors state that ETS is a key issue for long-term strategy decision making for the actor. Finally, approximately half of the respondents state that ETS influences the development of new technologies (Review Emission Trading Highlights, 2005).

The direct cost of implementing the ETS in Sweden has been estimated and presented in SOU 2004:62. During 2003-2004 the cost was estimated to SEK 23-28 million. These costs were mostly public expenses related to the preparation of trade in the ETS. The costs for public maintenance of the ETS during 2005 were estimated to be approximately SEK 12-13 million. In SOU 2005:10, it is proposed the actual production rather the installed production capacity that should decide whether the actor should participate in ETS.

Energimyndigheten[3] has performed a similar study to this thesis but with respect to transaction costs in the system for green electricity certificates. It revealed that the administration associated with the scheme was the largest cost. It was also affirmed that the efficiency on the market for electricity certificates was rather low during the first year (Delrapport 1 2004: Transaktionskostnaderna i elcertifikatsystemet).

In a report published in 2006 NUTEK estimates the cost associated with ETS. The costs that are estimated are the ones that are directly associated with the regulatory demands of ETS (see appendix G). This narrow definition of costs for ETS does for example not include new administrative systems that an actor invests in. The cost associated with ETS for Swedish actors were, according to this definition, estimated to approximately SEK 13.5 million during 2005.

The outline of this thesis is the following. In ***section 2***, a background of the issue and challenge that the Greenhouse effect implies is presented. The section aims to clarify why it is urgent to implement policies, which reduce Greenhouse gas emissions, and to explain the interconnection between the Greenhouse effect and economic development. In ***section 3***, we outline the central economic theories of externalities and how negative effects from externalities can be handled through an emission trading scheme. Finally, the nature of transaction costs and how they may influence actor strategies in the presence of transaction costs are explained. We will later use these widely accepted theories for the analysis of our empirical investigation. The implementation of the Kyoto Protocol and ETS within the EU in general and more specifically within Sweden, is presented in ***section 4***. This section aims to show how the theories of transferable permit trade has been implanted in reality and how the ETS is designed on an EU and a member state level. In ***section 5*** the data set, which was obtained by a survey among the Swedish actors that participates in the ETS, is described as well as the method for how the analysis is to be conducted. The results of the survey are presented and analyzed in ***section 6.*** The trade activity, trade strategies, size and nature of transaction costs, investments in technology and market efficiency are all evaluated in order to be able to evaluate the total transaction cost for the Swedish society. Finally, in s***ection 7***, we discuss the empirical findings and in ***section 8***, we draw our final conclusions.

[3] Energimyndigheten is the Swedish Energy Agency

2. The Greenhouse Effect and its Threats

Climate change is a complicated issue and involves a variety of interacting problems. In order to understand the rationale for climate change policies, it is essential to grasp the underlying forces at work. We will therefore outline the major factors involved in climate change and how they interact.

When fossil fuels are combusted they create greenhouse gases. Greenhouse gases, which spread into the atmosphere, are a necessity for life on Earth. They absorb long-wavelength radiation from Earth's surface and atmosphere, trapping heat that would otherwise radiate into space (Tietenberg 1996). Without them the temperature on Earth would be about 35 degrees Celsius colder. However, in too large amounts, they capture too much heat, which generates the warming effect of the atmosphere that we refer to as the Greenhouse effect.

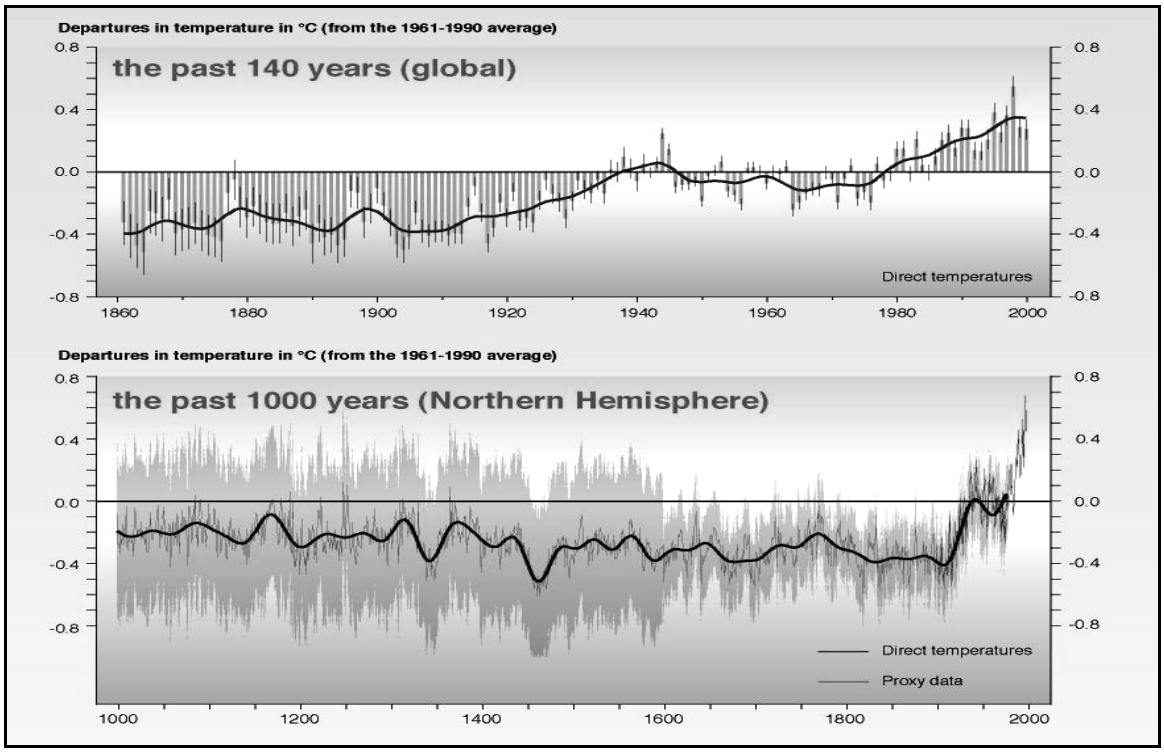


Figure 1. Global Temperature Change Source: IPCC Graphics

The most severe greenhouse gas is carbon dioxide[4]. This severity is due to the fact that carbon dioxide is almost not destroyable. Once it is in the atmosphere it remains for up to 200 years. Since pre-industrial times, the increased use of fossil fuels has lead to a 30 percent increase of carbon dioxide in the atmosphere. Due to this increase, the global

[4] Carbon dioxide: CO_2

surface temperature on Earth has increased as indicated in *figure 1*, on average with 0.6 ± 0.2 degrees Celsius during the 2000th century (UN IPCC 2001).

The current emission of Greenhouse gases is estimated to lead to a global warming of approximately six degrees before 2100. These temperature changes may sound moderate, but can have significant implications for the climate through, for instance, current and future increases in extreme weather conditions such as storms, draughts and flooding.

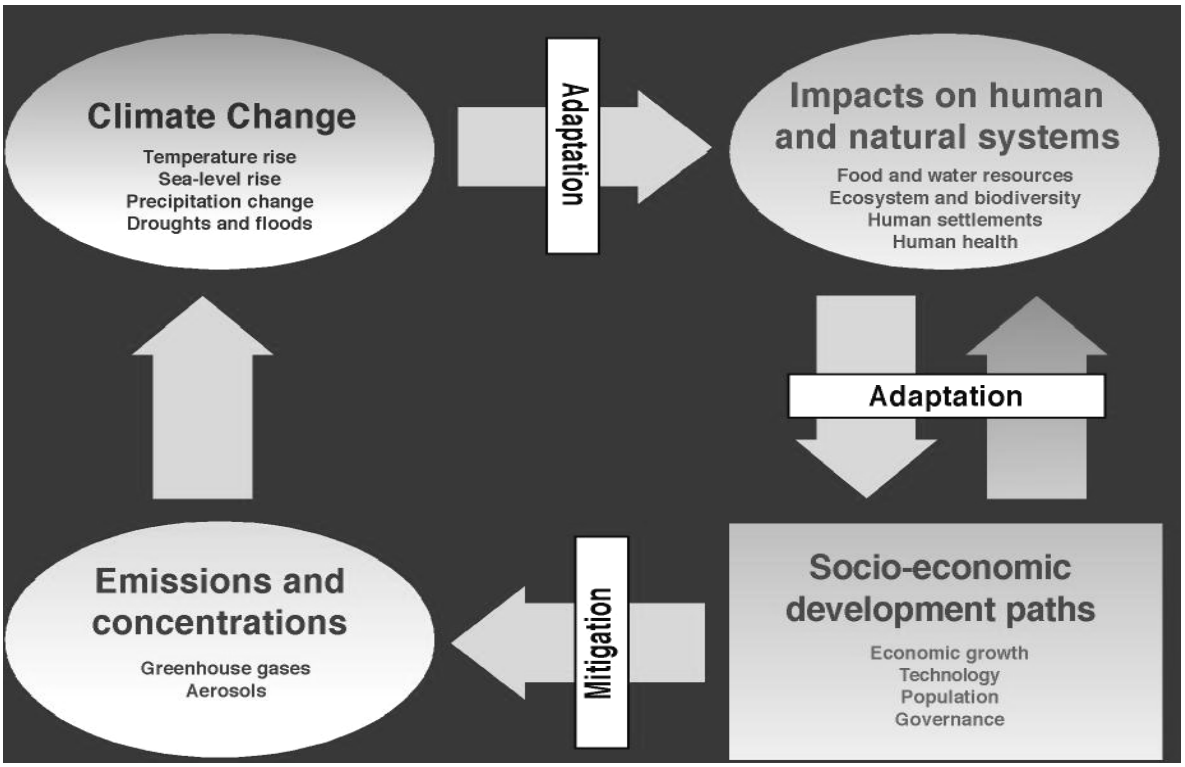


Figure 2. Climate Change – An Integrated Framework Source: IPCC Graphics

As seen in *figure 2*, climate change has implications on the basic resources needed for human life, such as food and water supply. When the basic conditions for the production of these resources change, human life must adapt accordingly. In turn, the available socio-economic development paths are influenced. The socio-economic development path chosen is the core of global warming. It is a trade off between society's economic wealth in the short-run and the reduction of the Greenhouse effect's negative influence on future generations.

Currently, the world's developed countries are jointly responsible for roughly two thirds of carbon dioxide emissions. For example, In Africa between 1999-2000 average per capita

emissions were 1 ton. In the United States, emissions during the same period were almost 22 ton per capita.

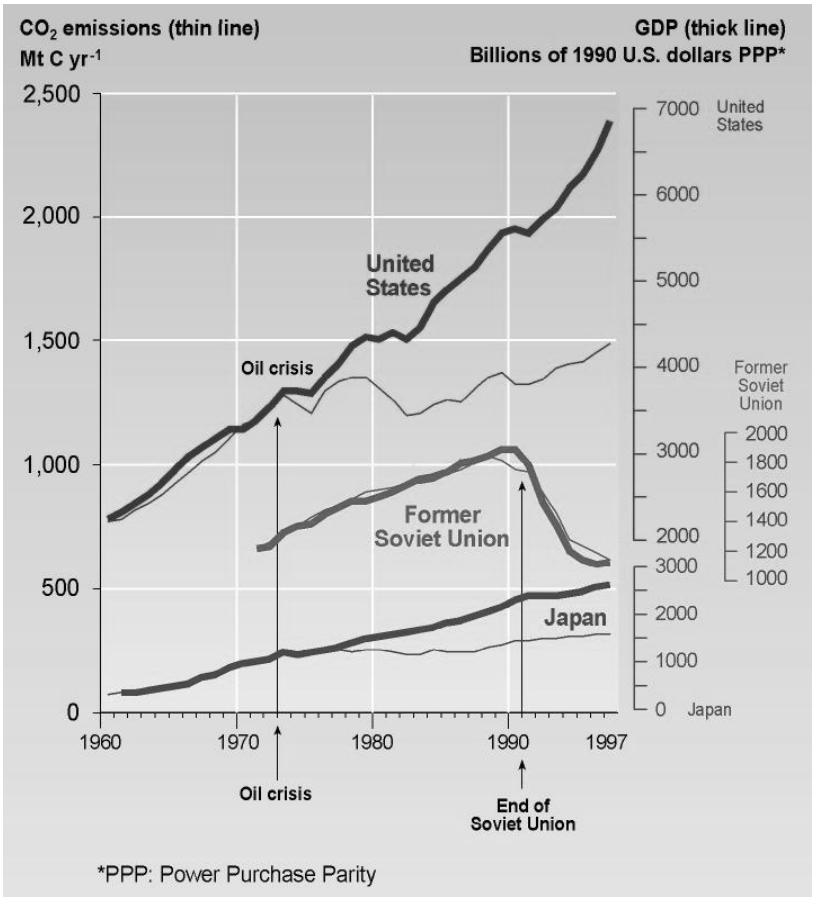


Figure 3. GDP Development and Carbon Dioxide Emission
Source: IPCC Graphics

How GDP growth is related to the use of fossil fuels and carbon dioxide is depicted in *figure 3*. There is a clear correlation between carbon dioxide emissions and the level of industrialization and GDP development. Other factors that are determinants of the socio-economic path and of specific importance for the level of emission are population growth, governance and improved technology (Schmalensee 1993).

3. Economic Theory of Transferable Permits and Transaction Costs

In the following section the economic literature relevant for the purpose of this thesis is presented, drawing on basic theory on market externalities, pollution control and transaction costs. Using this theoretical background, we intend to build a framework, which can be used for evaluating the results from our empirical study.

3.1. Why Markets Fail: Externalities and Pollution Control

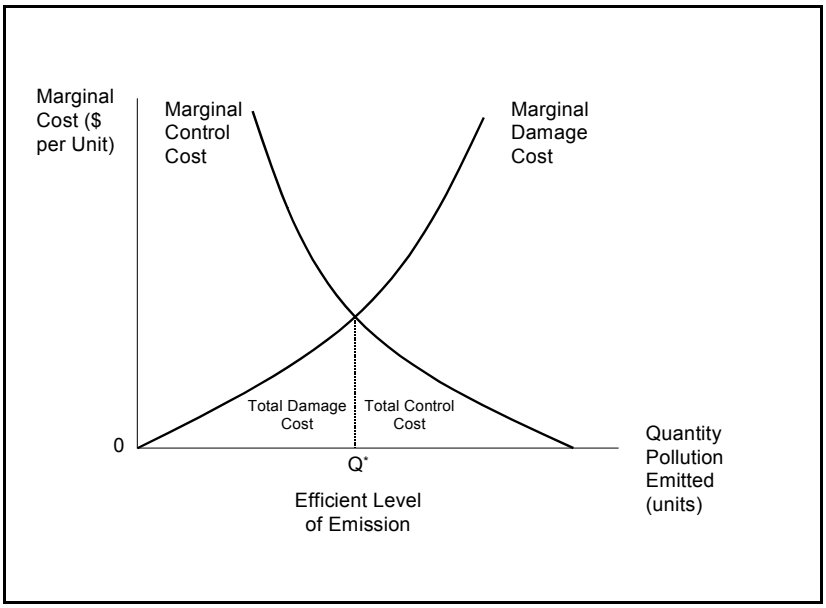
The following section is based on Tietenberg (1996). The fact that the atmosphere is a so called public good, makes reduction of the Greenhouse Effect by individual actors unattainable. As with all public goods, there is an incentive to "overuse" the good.

> …The damage caused by greenhouse pollutants is an externality both in space and time. Emitters impose costs not only on resident of other countries, but on subsequent generations as well (Tietenberg p.393, 1996).

The damage caused by carbon dioxide is an externality whereas the cost to control carbon dioxide is borne by the emitting actors. Thus, the actors overexploit the atmosphere and the cost for the damage is borne by society. A regulatory body setting a policy to control emissions of carbon dioxide can solve this problem. A policy can be found by defining the efficient level and the cost-effective allocation of carbon dioxide. The efficient level of emissions is the total amount of carbon dioxide that can be released into the atmosphere, minimizing negative impact on the environment, while still maintaining an efficient amount of aggregate output produced by the actors. The efficient level of emissions is equivalent to choosing the socio-economic development path described in section 2. In the analysis of the efficient level of emissions there are two marginally increasing costs involved:

- The marginal control cost to control emissions and;
- The marginal damage cost caused by the emission of carbon dioxide.

Although both of these costs are marginally increasing, they are mirroring pictures in *graph 1*. The logic behind this is that the marginal control cost increases the less amount of carbon dioxide emitted, while the marginal damage cost increases the higher amount emitted. The efficient level of emission of carbon dioxide, Q*, is where the two cost curves intersect in *graph 1*. To be precise, this point is where the total control cost equals the total marginal damage cost.

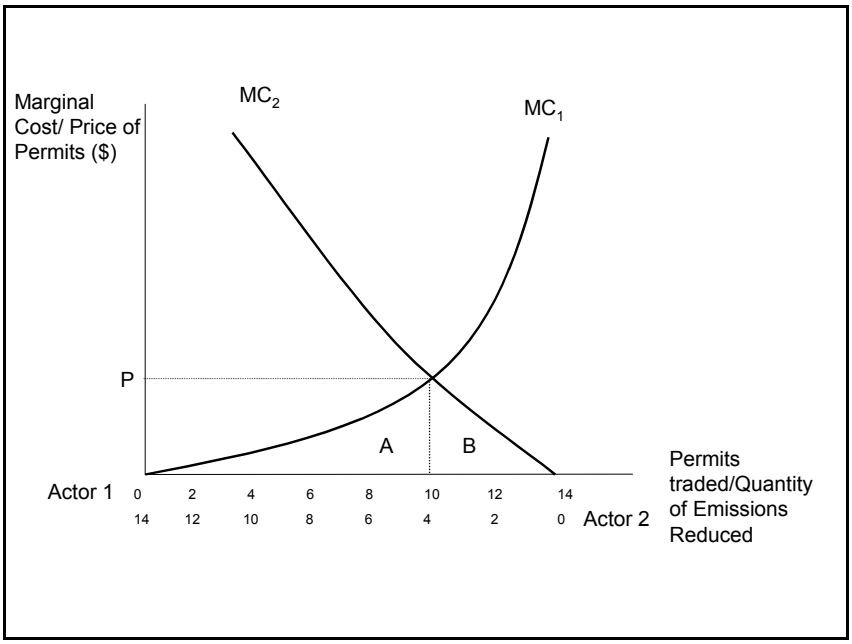


Graph 1. Efficient Level of Emission of Carbon Dioxide

As can be seen in the *graph 1*, the optimal level of carbon dioxide differs from zero, which can be explained by two main reasons. First, the environment has, some absorptive capacity of emissions. Second, because moving to a greater degree of control, which in *graph 1* would be to the left of Q*, would imply that the total control cost would exceed the total damage cost caused by carbon dioxide.

In addition, the regulatory body must find the cost-effective allocation of the control cost among actors that emit carbon dioxide as it also aims to set a policy where the control cost is minimized. This is facilitated by the fact that carbon dioxide dilutes evenly in the atmosphere, regardless of the geographic location of the emitting actor. Thus, the regulatory body only needs to control the total amount of carbon dioxide in the atmosphere. We illustrate how the cost-effective allocation can be found by an example with two actors. Actor 1 and actor 2, emit 28 units of carbon dioxide together. However, the regulatory body has set a policy so that only 14 units can be emitted in total.

In *graph 2* marginal control cost for actor 1, $MC_{1,}$ is measured from the left hand side on the axis while marginal control cost for actor 2, $MC_{2,}$ is measured from the right hand side on the axis. Regardless of which point is chosen on the marginal cost curves in *graph 2,* a reduction of 14 units in total can be achieved, but with different levels of burden sharing, and different costs for the actors.



Graph 2. Cost-Effective Allocation Between Two Actors

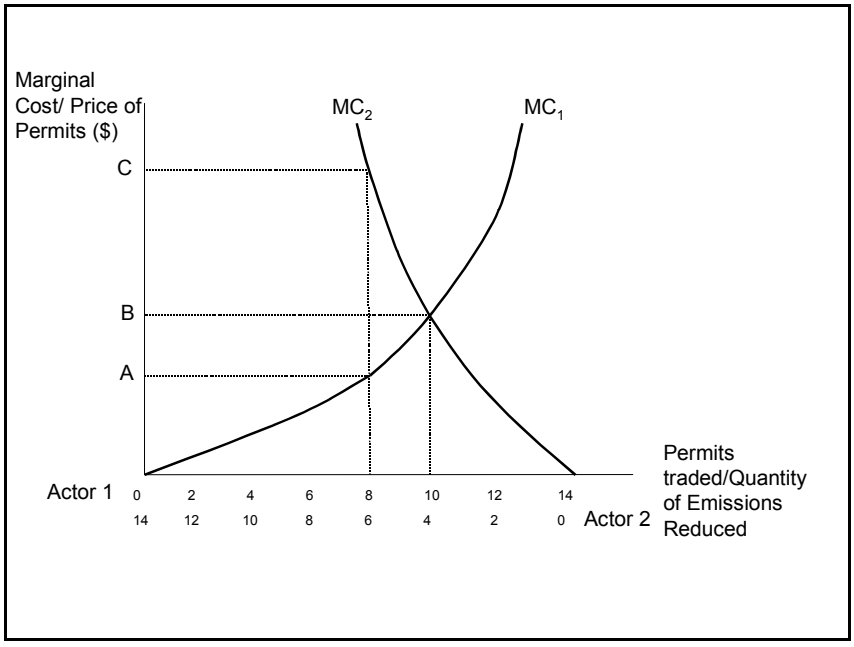
Although the actors have different marginal control costs, an allocation where control costs for the both actors are minimized can be found, i.e. where the two marginal control cost curves intersect. The analysis results in that…

> …the cost of achieving a given reduction in emissions will be minimized if and only if the marginal costs of control are equalized for all emitters (Tietenberg, p.334 1996).

3.2. Implementing Cost-Effective Policies, Transferable Permits

Although straightforward in theory, it is not possible for the regulatory body to establish the exact marginal control costs for the two actors. This is due to the asymmetric information between the regulatory body and the actors. Fortunately, there are strategies to find a policy where the regulatory body can minimize cost without having information about the actors' control costs, namely by emission charge and transferable permits.

The regulatory body can levy an emission charge, in general a tax, on each unit of carbon dioxide. An emission charge reduces carbon dioxide in the atmosphere and also gives an incentive to invest in new technology that efficiently reduces carbon dioxide emissions. However, a great drawback is that it is difficult for the regulatory body to implement an appropriate total target level of emissions. The appropriate target level of emissions can be found by a "trial-and-error-process" implying a continuous adjustment of the size of the emission charge. There is a way for the regulatory body to both set a targeted level of total reduction and find a cost effective allocation of emission among actors without going through the "trial and error" process. With a transferable permit scheme, the regulatory body sets a target level of reduction of carbon dioxide and issues a specific number of permits, which yields the desired target. Each permit explicitly defines the amount of carbon dioxide, which the owner, i.e. the actor, is allowed to emit. With a transferable permit scheme in *graph 3*, actor 1 will, for instance, be given 6 permits by the regulatory body. Still, Actor 1 emits 14 units of carbon dioxide, which means that it has to reduce its emissions by 8 units. Actor 2, which also emits 14 units, is given the rest of the permits[5].



Graph 3. The Transferable Permit Scheme

Actor 2's marginal control cost, MC_2, in *graph 3*, is substantially higher than actor 1's marginal control cost, MC_1. Actor 2 can reduce its emissions of carbon dioxide in-house through different methods. Normally, the reduction of carbon dioxide emissions is achieved

[5] The regulator allows a total of transferable permits of 14, which gives 14-6=8 permits left for actor 2.

through the adoption of improved technologies, or by switching to another type of fuel. An alternate method to reduce carbon dioxide emissions is by reducing its production. However, if it turns out to be a marginally less expensive way to reduce the emissions by buying transferable permits, the two actors have an incentive to trade with the permits until their marginal control costs equalize. Trade results in a cost-effective allocation where actor 1 owns only 4 permits, whereas actor 2, with a higher marginal control cost for reducing the emissions, owns 10 transferable permits. Equilibrium price B is the market price, which yields the cost-effective allocation. So, the regulatory body has achieved the reduction of carbon dioxide without initial knowledge about the actors' precise marginal control cost.

3.3. Ways of Distributing the Transferable Permits

The regulatory body can chose to either freely distribute or auction the transferable permits to the actors. Free distribution means giving permits to all actors based on past events, such as historic emission. This method is called grandfathering. Else, the permits can be allocated for free through a target rate, in proportion to their market share or production on a rolling basis. The main advantage of free distribution is that it compensates the actors for their sunk costs in fossil fuel intensive investments. However, there is a drawback to the free distribution method. Compensation for the sunk costs yields a transfer of wealth from society since society has to pay the bulk of costs for internalizing the carbon dioxide. When an auction is used to distribute the permits, the full cost of carbon dioxide is born by the actor. The regulatory body can, through revenue recycling, use the revenues from the auction, for example by creating projects aimed at reducing carbon dioxide or cutting existing distorting carbon dioxide (Goulder et al, 1997).

3.4. Transaction Costs

In this section we refer to Stavins (1995), if no other reference is stated. Economic analyses of trade with transferable permits, such as those described in section 3.1. and 3.2., often assumes perfect markets. In reality, this is not always the case. The regulatory body must also consider factors that depart from a perfect market when setting a policy. Market imperfections possibly affecting the transferable permit as a cost-effective policy are:

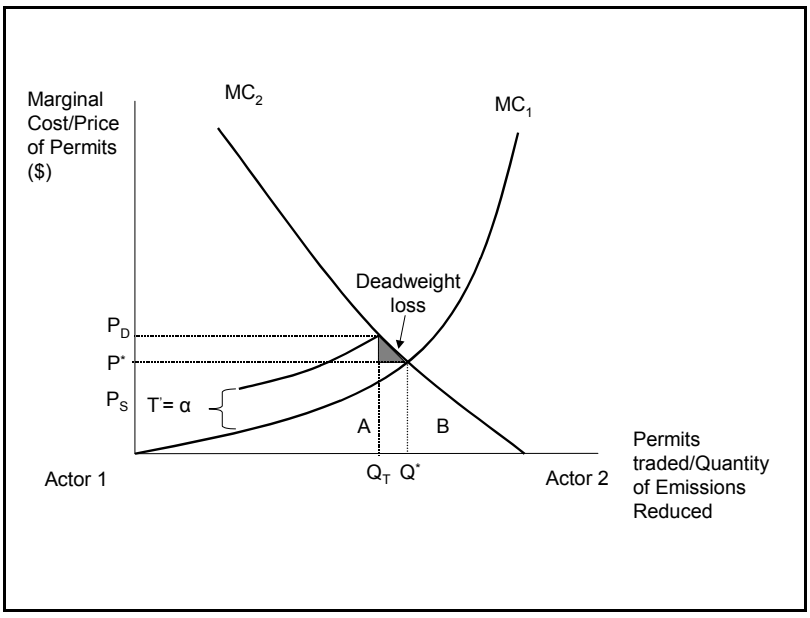
- Concentration of permits to certain actors on the market giving them market power,
- Non-profit maximizing behaviour in order to get a higher number of transferable permits allocated,
- The pre-existing regulatory environment, for example carbon dioxide tax,
- Transaction costs.

As stated in our introduction, this thesis focuses on the prevalence of transaction costs on the transferable permit market. In general, when there is a transfer of property rights, transaction costs arise. So is also the case with trade with transferable permits. Thus, the transaction costs must be taken into consideration in the analysis of the efficient level and cost-effective allocation of carbon dioxide previously described. There are three general types of transaction costs that can arise in a market for transferable permits, namely:

1) *Search and information*. Searching of potential trading partners is costly for the actor. Market information is normally underprovided although all actors participating in the trade are in need of it. External parties, such as brokers or consultants, sometimes provide information at extra cost.
2) *Bargaining and decision*. The size and nature of the actors gives different room for bargaining in the trade with permits and decision making. Aiming to benefit from emissions trading and the development of coordinated trading and emission control costs strategies, actors need to project emissions and make decisions considering possible reduction measures (Schleisch and Betsz 2004).
3) *Monitoring and enforcement*. The enforcement costs for a transferable permit scheme is generally borne by the regulatory body and not by the actor on the market. Monitoring, on the other hand, is a cost borne by the actors. For example, the actors face cost for application procedures for allocation of the transferable permits, service charges for the accounts in the electronic registers, costs for monitoring, verifying and reporting carbon dioxide emissions to the regulatory body (Schleisch and Betsz 2004).

The prevalence of transaction costs has several effects on the transferable permit market. They affect the input of resources since it takes time and administration to handle the transaction costs and they increase the difference of the price between the buying and selling permits. The increase in price difference between the seller and buyer gives room for brokers, which decrease some of the trade costs while also at the same time

internalizing some of the transaction costs. *Graph 4* depicts the effects of transaction costs on permit trade. Since actor 1 has a lower marginal control cost, actor 1 should be willing to sell permits to actor 2, who has a higher marginal cost of control to a price of P_S. However, the marginal transaction cost, T, in this case assumed to be constant (α), adds to actor 1's control costs and gives a new, higher total control cost. This results in the market price, P_D. The seller will hence demand a higher price of the permits in order to sell and the buyer will find it cost-effective to make reductions to a higher cost in house. These in house reductions can be made through improvement of technology, change of fuel etc. Thus, transaction cost decreases the volume of trade.



Graph 4. The Transferable Permit System with Constant Transaction Costs

Hence, the cost effective allocation equilibrium, Q^*, where marginal costs are equated among all actors, is not achieved in the presence of transaction costs. The new equilibrium when Q* moves to Q_T creates a deadweight loss.

So, rather than merely minimizing control costs, as described in *graph 3*, the regulatory body should minimize the sum of control cost plus transaction costs in order to create an efficient market. Stavins claims that the allocation of the transferable permits influences the cost of the scheme, and argues that in the presence of transaction costs, auctioning transferable permits may yield the lowest cost.

3.5. Actor Strategies in the Presence of Transaction Costs

Unless otherwise stated, this section will be based on the findings of Williamson (1975, 1981). When making a strategic business decision, on whether to produce in-house or to buy products on the market, actors must take three factors into account:

- The degree of uncertainty/complexity of the transaction.
- The transaction frequency, i.e. how often the transactions occur.
- The transaction specific costs, i.e. specific costs related to a particular investment, for instance finding suitable trading parties and holding negotiations.

This theoretical reasoning can be applied to a transferable permit scheme as well. Actors participating in trade with transferable permits use different trading strategies to minimize their transaction costs and to achieve efficiency. As transactions involve many complex aspects, uncertainty is always present to some degree. Hence, actors only need to take the other two factors into consideration when choosing a trading strategy.

	Transaction Specific Costs	
Transaction Frequency	**Low**	**High**
High	Bilateral Trading	Internal Trading
Low	Market Exchange Trading	Trading through a Broker

Table 1. Trading Strategies to Manage Transaction Costs Source: Von Malmborg

Whenever transaction frequency and the transaction specific cost are small, the actor may choose the market exchange to trade with the transferable permits. However, when the frequency is high the actors are inclined to choose bilateral agreements. Transactions with a single trading partner repeatedly decrease negotiation costs as well as the total cost of the contract. This reduces the transaction cost and uncertainty for the trading actor. Hierarchical solutions, such as internal trading, become attractive when the frequency of transaction is high as well as the transaction specific cost is high. It reduces some of the uncertainty around the transaction as well as negotiation costs. The fourth strategy used, when transaction costs are high, but frequency is low, is to use a broker for trading with the transferable permits.

Noll (1982) evaluates the efficiency of a scheme with transferable permits trading and states that efficiency can be achieved if there are competitive prices and low transaction costs on the market. Noll points out that a "thin market", i.e. when there are only few participants on the market, normally brings about high transaction costs as well as noisy price signals, which makes it more difficult to achieve efficient markets. If one assumes that few participants means low frequency of transactions on the market, this would imply that a frequent use of brokers, as can be seen in *table* 1, would be a signal of an inefficient market. Stavins claims that that internal trading in preference to external trading is a sign of high transaction costs, which is in line with Williamson, i.e. high transaction specific costs leads to an internal trading strategy. However, as mentioned earlier, Williamson distinguishes the frequency of transactions, and claims that internal trading should occur when transaction frequency is high.

4. Regulations and Schemes: What's in Use?

4.1. The United Nation Framework Convention and the Kyoto Protocol

Since the 1990's the issue of climate change has climbed world leaders' agendas. The first major step taken towards a global plan for action was the 1992 years Earth Summit on environment and development in Rio de Janeiro. About 150 countries signed the United Nation Framework Convention on Climate Change. The aim of the Convention on Climate Change is to stabilize the level of greenhouse gases in the atmosphere, to a level, that will neutralize dangerous human interference on the climate. (Miljömålen 2005). The 1997 Kyoto Protocol is an amendment to the Convention. It is an important start in achieving the objectives stated in the Convention, since it establishes legally binding quantitative goals for emission reduction. The aim of the Kyoto Protocol is to decrease the amount of global greenhouse gases in the atmosphere with a minimum of five percent, calculated from the 1990's year's level of emission, during the period 2008-2012 (Kyoto Protocol). This Protocol statement, of a total level of emission reduction, is in line with what we refer to in the theoretical part as the efficient level of emission.

The Kyoto Protocol incorporates three flexible mechanisms to allow for cost efficient reduction. These three mechanisms seek to achieve a cost effective allocation between

countries by giving incentives to reduce emissions of carbon dioxide where the marginal control cost is the lowest.

- **Joint Implementation (JI) and Clean Development Mechanism, (CDM)**

The first and second mechanisms make it possible for developed countries (Annex I countries), to carry through carbon dioxide reduction projects in other countries that have ratified the Kyoto Protocol (JI) or in non ratifying countries (CDM). The projects are carried through in host countries that have a lower marginal control cost, and count for the investor as emission reductions within its home country.

- **Trade with Transferable Permits**

The third type of flexible mechanism allows for the actors to trade with their individual emission reduction commitments through a transferable permit system.

Countries that have ratified the protocol are committed not to emit more than their quoted levels. By the end of 2005, the so called Annex I countries, shall have made demonstrable progress in achieving their commitments under the Kyoto Protocol (Kyoto Protocol, art.3).

4.2. Implementation of the Kyoto Protocol in the EU

According to the Kyoto Protocol, during the period from 2008-2012, the EU is committed to reducing its level of emissions by 8 percent in comparison to its emissions 1990. In order to achieve this efficient level of emission, the EU Emission Trading Scheme (ETS) was implemented on the 1st January 2005. Although it is only EU-15 that is committed to the 8 percent target of reduction, all 25 EU member states are included in ETS. Between the EU countries there is a burden sharing agreement implying that some countries have to reduce their emissions while others may increase their levels of emissions (Appendix A). Each country in turn makes a National Allocation Plan (NAP) of how it will allocate its EU quota among actors within the country, which for each trade period, must be submitted to, and assessed by the Commission. An important aspect of ETS is that it allows actors to use credits from JI and CDM projects. (EU Commission-EU action against climate change)

Since the reduction of carbon dioxide is costly for the actors and thereby may impede GDP growth the EU Commission identified a target control cost for the EU reductions. A cost effective measure was defined as one yielding a control cost of less than EURO 20 per ton carbon dioxide (European Climate Change Programme Report 2001, Executive Summary). ETS is estimated to cost EURO 2.9-3.7 billion per year. This is less than 0.1 percent of EU's GDP. Other policies, yielding the same target reduction level of carbon dioxide,

would according to estimates have cost up to EURO 6.8 billion per year. (EU Commission, EU action against climate change).

4.3. The EU Emission Trading Scheme

The ETS is divided into several trading periods as shown in *figure 4*. The first trading period 2005-2007, is only a testing period. The second period will run, from 2008 to 2012, and a third period will most likely start in 2013 ("Post Kyoto", 2004).

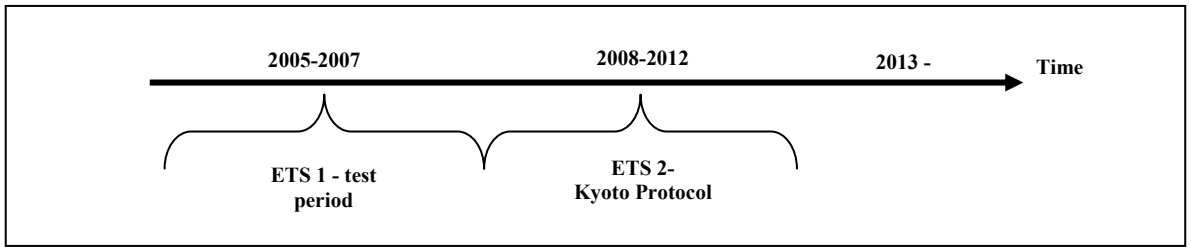


Figure 4. Time Frame of the Different Trading Periods for the ETS

Transferable permits are only valid within the trading period in which they have been issued. The permits can however be banked between the years within the same period. Each transferable permit represents one ton of carbon dioxide and can be traded among actors and countries, hence making the cost effective allocation of emission reduction possible. The total number of production units incorporated in the scheme is 11,500, accounting for approximately 46 percent of EU's total carbon dioxide emissions EU in 2010. All actors in the ETS have initially been, grandfathered, i.e. allocated permits for free. During the first trade period, five percent of the permits may be auctioned if the member state would wish to. During the second period, ten percent may be auctioned.

4.4. The Market of Transferable Permits

The price of the transferable permits is set on the European market. (European Climate Exchange 2004). There are no EU directives regulating who can trade, or how emission trades should be organized. A firm, public actor, individual or organization willing to engage in trade has a multitude of options. Trade deals can be done bilaterally, with the help of a broker, a bank or through other established trading organs such as exchanges. Trades that result in an exchange of ownership between actors must be registered in accounts in an electronic registry system. Each member state must establish their national own electronic register. Collectively, all member states registers constitute a common European hub (EU Commission, Questions and Answers). During the first six months of

ETS there were transactions of more than 90 million transferable permits. Of these 90 million permits, 65.6 million were brokered, 10.2 million were traded on exchanges, and an estimated amount of 15 million was traded bilaterally. The traded volume during this period was estimated to have an equivalent financial value of EURO 1.37 billion (EU Commission-EU action against climate change).

4.5. Implementation of the Kyoto Protocol in Sweden

As a member of EU-15, Sweden ratified the Kyoto Protocol in 2002. In comparison to many other EU countries, Sweden has a relatively low level of carbon dioxide emission (Appendix B). According to the Kyoto Protocol Sweden could increase its emission with four percent. However, the Swedish government has decided that average greenhouse gas emissions during the period from 2008 until 2012 shall be at least four percent lower. This represents 96 percent of the 1990-year's level of emissions (for comparison with other EU member states see appendix A). This goal must be achieved without any deduction for the Kyoto mechanisms JI or CDM[6] (Miljömålen 2005). Implementation of the transferable permit system in Sweden is estimated to save one to three billion SEK in contrast to other alternative policies for reducing carbon dioxide (SOU 2003:60). The total quota for Swedish emissions is 22.4 million ton carbon dioxide per year. In addition, there are 2.19 million tonnes reserved for new entrants to the market during 2005-2007.

4.6. European Trading Scheme in Sweden

Several governmental institutions are involved in the regulation and implementation of the Swedish transferable permit system. The institutional frames for ETS are outlined in the EU Emission Trading Directive, 2003/87/EG but the Swedish scheme is also regulated in the Lag om handel med utsläppsrätter, SFS 2004:1199, from December 2004. Each Swedish authority and their individual responsibilities are outlined in *figure 5*. Naturvårdsverket decides about the regulatory framework for the allocation of the transferable permits and makes the final decision about allocation to each actor. In addition Naturvårdsverket has the responsibility of supervising the system. The actors must report their yearly emissions of carbon dioxide to Naturvårdsverket and make sure that they have an equivalent number of permits to cover their emission. For 2006, the permits will be allocated to the actors before

[6] Carbon sinks, i.e. for example large forest resources that absorb carbon dioxide, do not count either for Swedish actors, which may be the case for other countries.

the actors have to send in their usage reports for 2005, which makes borrowing permits to 2005 from 2006 possible. Before the emission reports are sent to Naturvårdsverket, an independent accredited emission controller must authorize the report. Naturvårdsverket has the right to implement the penalty fee of EURO 40 per ton of carbon dioxide and to publish the names of actors that have released more carbon dioxide than they have permits for.

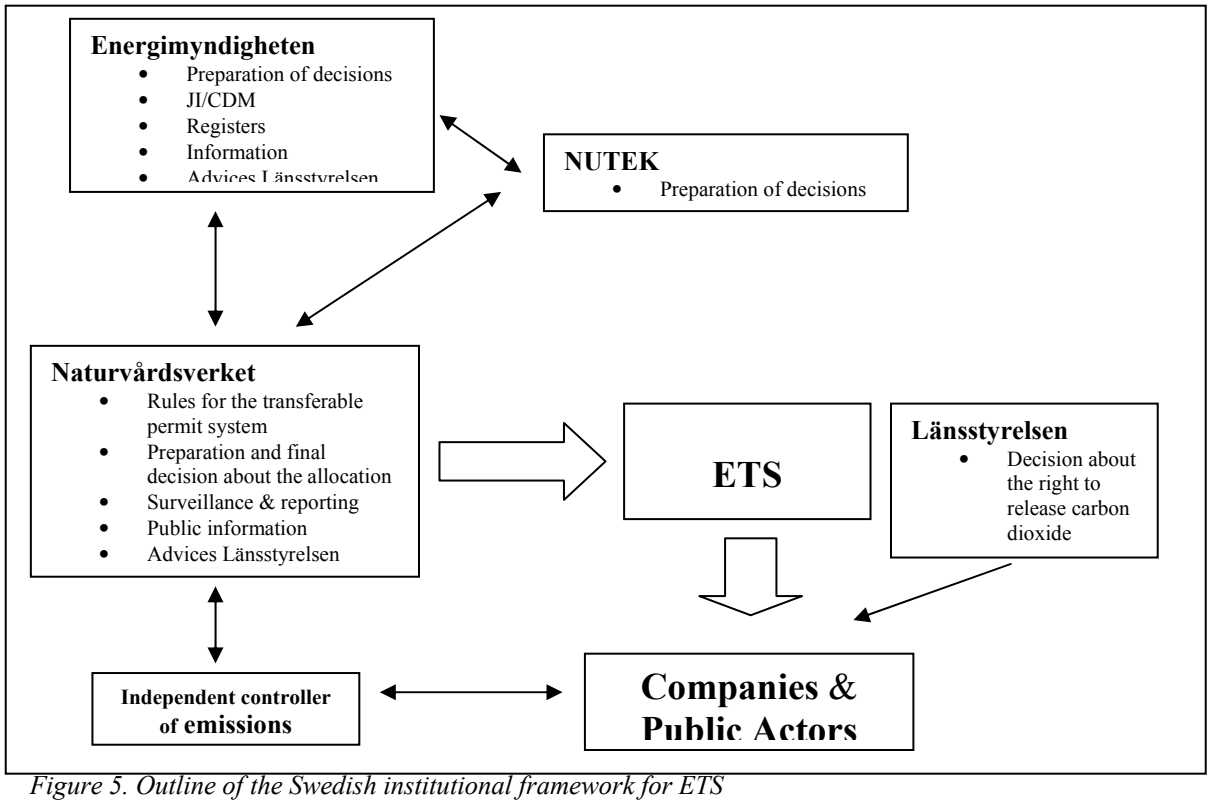


Figure 5. Outline of the Swedish institutional framework for ETS

Energimyndigheten is responsible for making the practicalities in the trading system work. Technically, the transferable permits are allocated through an electronic data register called Svenskt utsläppsrättssystem[7] (SUS). All transactions of transferable permits must be registered in SUS. This register makes information about the transfers of permits between different account holders, and a declaration of total carbon dioxide emissions and the number of permits that have been used public. SUS is not a market place for permits; it only keeps track of the movements of the permits.

4.7. Actors on the Swedish Market

In Sweden there is a total of approximately 715 units representing about 30 percent of the national carbon dioxide emissions, which are included in ETS. Of these 715 units,

[7] Svenskt utsläppsrättssystem is the Swedish Transferable Permit System

approximately 540 units emit less than 10,000 ton and roughly a 100 units release less than 100 tons carbon dioxide per year (von Malmborg). Counting the 715 units in number of companies, the amount is smaller due to that many of the included companies run several units.

The number of permits allocated to each sector in Sweden is found in Appendix F. The Swedish authorities have in accordance with the EU Trade Directive chosen to use grandfathering as the allocation method of the transferable permits. Actors are thus given a certain number of transferable permits for free. The number of permits allocated depends on how much carbon dioxide the actor released during the period 1998-2001. For actors that were taken into use after 2001, allocation is based on later years. The Swedish government considers the energy sector to be the sector that can reduce carbon dioxide at the lowest cost. Moreover, this sector only has European competition whereas the industry sectors face international competition. Therefore, the energy sector has been allocated transferable permits equivalent to only about 80 percent of their needs for the period 2005-2007, while the industrial sector has received 100 percent of their historic emission (Promemoria 2004-04-22). The allocation formula used in Sweden is found in Appendix E.

5. Data and Method of Collection

As there was no public transaction cost data and data of trade activity for Swedish actors participating in ETS, we obtained data by a survey (Appendix C) that was conducted in December 2005 among all Swedish actors that have been allocated transferable permits for the trading period 2005-2007. The survey was only sent to the Swedish actors, and thus, does not cover all participants in the ETS. The reason limiting the survey to Swedish actors is, as previously mentioned, that it is beyond our scope to investigate all European actors.

The aim of the survey was to investigate the Swedish actors' trade in ETS. This included such factors as, incentives to trade, how actors trade with their transferable permits, eventual transaction cost size and type of costs, investment rate in new technology, and how the actors perceive the efficiency of the ETS market. All questions aimed to examine the permit trading period of January-December 2005. The survey consisted of 21 questions. The majority of the questions were in a yes and no format in order to reduce the scope of

misunderstanding and to reduce the complexity of our analysis. General problems arising in the data set are missing values and or misunderstandings of the questions. A survey of this form is based on the actors' self-assessment. This self-assessment of course gives rooms for the exaggeration of costs and rough estimates since the actors sometimes did not know the exact costs themselves. However, we considered a survey of this kind to be the most accessible way to reach a large number of actors. The total number of surveys sent and respondent frequency are outlined in *table 2*. The total population of actors was 208, and the respondent rate of 120 gives that we cover 57.7 percent of this population with our survey. Of the 120 respondents, 46 percent belong to the energy production sector and 54 belong to energy intensive industry.

Population Data	**Number**		**%**
Population of production units	715		100
Population of actors i.e. surveys sent	208		100
Total number of respondents	120		57.7
Respondents per Sector	**Number**		**%**
Respondents energy producing sector	55		45.8
Respondents energy intensive industry	65		54.2
Respondents per Group	**Number of surveys sent**	**Number Respondents**	**%**
Group 1: 1-1,000 permits	29	18	62.1
Group 2: 1,001-20,000 permits	99	54	54.5
Group 3: 20,001-100,000 permits	45	30	66.7
Group 4: more than 100,001 permits	32	18	56.3

Table 2. Descriptive Data of the Survey

Not every actor responded to all of the questions. Therefore, we will in the tables present the number of responses to each question as "number of cases" or as "(5/13)", which means that there was 5 yes out of 13 responses on the question. In cases where we found that there were obvious misunderstandings of the question, the observation was replaced by a missing value. Question 14, asked respondents to state the type of costs that they included in their estimate of total transaction costs. This was an open answer type of question, and therefore we had to normalize the answers into different categories. In addition, in Question 21, the respondents were asked to scale their answer between 1 and 5.[8] As background and

[8] We here assume a contingent scale

complement to this survey we have performed interviews with, NUTEK[9], Naturvårdsverket[10], and Fortum Värme.

The list of 715 production units that have been allocated transferable permits is public knowledge and can be found on Naturvårdsverket's Internet site[11]. Energimyndigheten[12] publishes updated contact information to actors who are actively participating in the trade. This information was used as far as possible. When this information was unavailable, actor information was searched on company websites on the Internet. In the sample there were three actors that we were unable to contact due to missing contact information. Due to the fact that an actor may have several units, we reworked the list so that a survey was sent to each actor and not to each production unit. Using Naturvårdsverket's list of allocated transferable permits per unit, we manually sorted out which units belong to a single actor. This gave us a total of 208 actors on the Swedish market. We acknowledge that some individually trading units may have mistakenly been merged into one actor. In some cases several actors belonged to one company group, and it turned out that the transferable permits in general were handled at a group level. In these cases, only one survey was sent to the group. The bulk of surveys were sent by e-mail, except three surveys, which were sent by mail. If the actor did not respond to the survey, we e-mailed them, up to three times per actor. Realizing that telephoning was an effective way of making the respondents answer the survey, we called every third actor on our list that had not responded after three emails. The results of the survey are discussed and presented anonymously in section 5. A summary of all results ordered by question in the survey is to be found in Appendix D.

The actors have been subdivided into four groups depending on the number of transferable permits that they have been allocated. The respondent rate is fairly even between these groups, as can be seen in *table 2*, ranging from 55 to 67 percent. The rational to divide the sample into a total of four groups was that the value of allocated transferable permits in Group 1 is low, while the value of transferable permits for Group 4 is very high. The reason for dividing Groups 3 and 4 into two groups is that Group 3 consists mainly of publicly

[9] NUTEK is the Swedish Agency for Industry and Business Development
[10] Naturvårdsverket is the Swedish Environmental Protection Agency
[11] www.naturvardsverket.se
[12] www.utslappshandel.se, *"Rapporter ur SUS"*.

owned district heating firms without specific trading know-how, while Group 4 consists of larger actors that often have own in-house trading desks (von Malmborg). In addition, it turned out that there was a difference in the size of the actors regarding number of employees. The spread between different staff sizes for each of the four groups is outlined in *table 3*.

Number of Employees	Less than 100	100-500	More than 500
Group 1	11	2	5
Group 2	30	19	5
Group 3	7	16	7
Group 4	0	5	13

Table 3. Question 10: "Size of Staff"

In Group 1 and 2, most of the actors have less than 100 employees whereas Group 3's respondents mostly have 100-500 employees. Group 4, was not only the group that had been allocated the largest amount of transferable permits, but also contained actors with the largest number of employees.

6. Results

In this section we present the results from of our survey. First of all, we look into whether or not actors on the Swedish actors are pleased with the number of allocated transferable permits they received. This gives us an indication if the actors have an incentive to trade. Secondly, we focus on trade activity, such as, if the actors trade or not, and if there are significant differences in trade between groups. Thirdly, we look at the strategies of trade among the actors, and if these strategies indicate a prevalence of transaction costs on the ETS market. This is followed by section 6.4., in which we investigate the occurrence of transaction costs on the market, and if so, the size and nature of these transaction costs. In section 6.5., we explore how the respondents in our sample perceive the ETS market with respect to efficiency, transparency, and risk. Thereafter, we look into if the actors have made any technological changes in 2005, or whether they intend to do so during 2006. Finally, based on our results, we calculate the transaction costs of the ETS for the Swedish society and comment what these may imply for the cost effectiveness of ETS.

6.1. Swedish Actors' Trade Activity in ETS

The first step in our analysis is to determine the motivation to trade within our sample. As outlined in theory, the differences in marginal control costs are the underlying factor that

should drive trade. However, due asymmetric information the marginal control cost for each actor indeterminable. A factor that we could measure in our survey and which, also may give some incentive to trade, is if the actors consider the number of permits they have been allocated as a fair amount considering their historic and present activity and emission levels. All groups are pleased with their allocated permits in general (Appendix D). Group 1 seems to be the most satisfied group with 70.6 percent of the respondents stating that they consider the number of permits they have been allocated as fair. In contrast, Group 2 (52.8percent), Group 3 (63.3 percent) and Group 4 (58.8 percent) are less satisfied with their allocation of permits. These results would suggest that Group 1 has the smallest incentive for trading. In Group 4 there are many large energy producers who are less satisfied with their allocation of transferable permits. One actor that responded to the survey and was not satisfied with their allocation stated that…

> …Sweden has been treated unfairly in comparison to other countries and for example, firms in the Energy sector have only been allocated 80 percent of their historic values. Firms, which earlier been good at changing to renewable fuels have been punished by the allocation criteria that have been used…

The Swedish government has set more ambitious levels of reduction for Swedish actors than other EU members. As mentioned earlier, Swedish actors are required to reduce levels to 96 percent of 1990 years emission levels instead of the Kyoto requirement of + 4 percent. This gives us reason to believe that Swedish actors in the ETS should have an incentive to trade. Swedish actors have already adapted to specific Swedish carbon dioxide taxes and green certificate policies aiming at reducing carbon dioxide emissions. Therefore, Swedish actors have already made technological investments to reduce their emission. This means that adding additional more advanced control measures in Sweden should yield a high marginal control cost in comparison to many other EU member countries. Other member countries that have done less historically should be able to control their level of emissions by implementing existing modern technique at a lower cost. According to theory this implies that Sweden should be a net buyer of transferable permits.

36 actors stated that they had sold permits while 18 had bought permits (Appendix D). As 47 actors have stated that they had been active traders this means that 7 actors in the sample had both sold and bought permits during 2005. This is in contradiction to the above statement that Swedish actors should bet net buyers. This could imply that the actors who have traded are the ones that could make quick profits by selling their transferable permits at the unexpectedly high prices during 2005.

6.2. Difference in Trade among the Groups

According to Noll, the number of actors on the market influences the transaction costs. In our sample we found that out of 117 respondents, only 47 (40.2 percent), had been active in trade during 2005. From *table 4* it appears as if Groups 1 and 2 have been less active in the trading of permits than Groups 3 and 4.

	Total Trade for the Group
Group 1	5.6 % (1/18)
Group 2	30.8 % (16/52)
Group 3	58.6% (17/29)
Group 4	72.2 % (13/18)
Total	**40.2 % (47/117)**

Table 4. Question 3:"Has the actor traded with transferable permits during 2005?"

Since trade activity in the different groups is something we want to investigate further, we state several hypotheses to compare the four groups with one and other. The null hypothesis, $H_{0,}$ states that Group1 is as active in trade in ETS as the other three groups.

$H_{0:}$ Group 1 = Group 2, Group 3 and Group 4

$H_{1:}$ Group 1 ≠ Group 2, Group 3 and Group 4

The alternative hypothesis, $H_{1,}$ suggests that Group 1's trade activity is different from the other groups. The same kind of hypothesis is stated for the groups:

$H_{2:}$ Group 2 = Group 1, Group 3 and Group 4

$H_{3:}$ Group 2 ≠ Group 1, Group 3 and Group 4

$H4_{:}$ Group 3 = Group 1, Group 2 and Group 4

$H5_{:}$ Group 3 ≠ Group 1, Group 2 and Group 4

$H_{6:}$ Group 4 = Group 1, Group 2 and Group 3

$H_{7:}$ Group 4 ≠ Group 1, Group 2 and Group 3

We use the following general formula for testing if all groups in our sample are active in trade. Group A-D denotes one of the four groups each time the formula is used to test one of the hypotheses.

$$Y_{Trade} = \beta_A + \beta_B X_{GroupB} + \beta_C X_{GroupC} + \beta_D X_{GroupD}$$

$$P_{Trade} = E(Y = 1 \left| Group_{A,B,C,D} \right.) = \frac{1}{1 + e^{-Y_{Trade}}}$$

As the dependent variable, trade (Y_{Trade}) is a binary variable, i.e. the actor either trades (1) or not (0); we cannot use a normal linear regression. Instead we used a binary logistic regression, a probability model, and our objective was to find the probability of trade (P_{Trade}), given different groups (A-D) and significant differences between the groups. We ran the test four times to test our hypotheses using SPSS. Each time when testing one of the above stated hypothesizes the group that we focus on is used as "the base constant", or constant (β_A). This reveals if any or several groups (β_B, β_c or β_D) differ significantly from this constant (Gujarati 2003). The results of the regression are presented in *table 5*.

(H_0 vs. H_1) Group 1 constant	**B**	**Standard Error**	**P-value**	**Predicted Probability**
Group 1 (constant)	- 2.833	1.029	0.006	0.056
Group 2	2.022	1.072	0.054	0.308
Group 3	3.182	1.096	0.004	0.586
Group 4	3.789	1.156	0.001	0.722
(H_2 vs. H_3) Group 2 constant				
Group 2 (constant)	-0.811	0.300	0.007	0.308
Group 1	-2.022	1.072	0.059	0.056
Group 3	1.159	0.482	0.016	0.586
Group 4	1.766	0.606	0.004	0.722
(H_4 vs. H_5) Group 3 constant				
Group 3 (constant)	0.348	0.377	0.356	0.586
Group 1	-3.182	1.096	0.004	0.056
Group 2	-1.159	0.482	0.016	0.308
Group 4	0.607	0.647	0.348	0.722
(H_6 vs. H_7) Group 4 constant				
Group 4 (constant)	0.956	0.526	0.069	0.722
Group 1	-3.789	1.156	0.001	0.056
Group 2	-1.766	0.606	0.004	0.308
Group 3	-0.607	0.647	0.348	0.586

Table 5. Regression: Trade as the dependent variable, Group 1, 2, 3 and 4 as independent variables

We see that H_1 and H_2 can be confirmed on a 10 percent significance level. The result from SPSS merits some more analysis. The binary logistic regression also shows that Groups 1

and 2, the groups that have been allocated fewer transferable permits, differs significantly from Groups 3 and 4 at a five percent level. Hence, we can see that Groups 1 and 2 do not participate as actively in trade as the other Groups 3 and 4. At a ten percent level of significance there is a difference between Groups1 and 2, and we can thus expect Groups 2 to be rather active in relation to Group 1. By looking at the predicted probabilities we can see that Group 1, which has been allocated least transferable permits, participates in the trade with only 5.6 percent probability, while there is a 30.8 percent chance that Group 2 participates in trade. The probability of trade for Group 4 is 72.2 percent where as it is 58.6 for Group 3.

6.3. The Actors Trading Strategies

According to Williamson's theories on transaction costs, as described in section 3.5., actors trading strategies will depend on the transaction frequency and the amount of transaction specific costs. In the survey, actors that had been active traders were asked to state how they had conducted their trade. In *table 6* it appears as if the most common trade strategies in the sample were bilateral trade and trading with the help of a broker. As described in the theory, bilateral trading occurs when there is a high frequency of transactions and low degree of transaction specific costs. Trading through a broker occurs when there are a low number of transactions but high specific transaction costs.

Trade Strategy	Number of Transactions
Market Exchange Solution	16
Bilateral Trading	24
Internal Trading	15
Trading with a Broker	23

Table 6. Question 6, 7, 8 and 9: "Has the actor conducted: Bilateral trade? Exchange? Broker? Internally?"

A high rate of broker use in our sample could imply that the market is inefficient. This finding is also in line with the EU commission's estimate that using a broker was the most common form of permit trade in EU during the first six months of ETS.

6.4. Transaction Costs

We have now established that there are differences in trade activity (section 6.3.) among the different groups in our sample. We have also seen in the last section that there are

indications of high transaction costs on the ETS market. As this indicates a prevalence of transaction costs, we will in the present section investigate differences in the size of the transaction costs between the four different groups. The actors were asked in the survey to estimate their total transaction costs for ETS and the transaction costs as a percentage of turnover for January-December 2005. Sometimes an actor only responded to one of the two questions, either in terms of absolute costs or in percent of turnover. This is the reason to why, for example, the minimum transaction cost in Group 1 is 0 percent of turnover but SEK 15, 000 in absolute value. The cost in "SEK" and "% of turnover" should therefore be considered as two separate estimates. The average transaction cost of all respondents in the sample was found to be SEK 655,981 (*table 7)*.

Transaction Cost Group 1	**Number of Cases**	**Mean**	**Standard Error**	**Median**	**Max**	**Min**
In SEK	9	79,444	40,961	100,000	150,000	15,000
% of turnover	5	0,3210	0.4600	0,0050	1,0000	0,0000
Transaction Cost Group 2						
In SEK	37	378,176	1,630,102	87,500	10,000,000	0
% of turnover	27	0,1339	0.2920	0,0500	1,5000	0,0002
Transaction Cost Group 3						
In SEK	24	353,542	898,426	137,500	4,500,000	10,000
% of turnover	24	0,1410	0.2865	0,0220	1,0000	0,0000
Transaction Cost Group 4						
In SEK	9	3,181,111[13]	8,336,994	450,000	25,400,000	80,000
% of turnover	7	0,0341	0.0739	0,0030	0,2000	0,0000
Transaction Cost All groups						
In SEK	79	655,981	3,071,188	100,000	25,400,000	0
% of turnover	63	0,1404	0.2903	0,0240	1,5000	0,0000

Table 7. Question 13: "How large are the total estimated transaction cost for 2005 ?"

The standard deviation for the whole sample is large SEK 3,071,188. It turned out that there are two outliers in the sample of Question 13. When we did a sensitivity analysis and excluded those outliers (respondents that had a transaction cost of more than 2 standard deviations from the mean) the mean transaction cost decreased to SEK 213,279. The logic behind excluding these two observations is that in the sample some actors had incorrectly included the value of their allocated permits in the estimate of their transaction costs.

[13] Group 4 has two outliers of SEK 10,000,000 and SEK 25,400,000.

Excluding the observations can be considered data-mining, but since the rest of the sample had a quite even distribution of transaction costs at a much lower level than these two outliers, we want to present this mean as an additional result. As mentioned in section 4, the total quota for Sweden is 22.4 million tons of carbon dioxide per year, i.e. the Swedish actors have been allocated 22.4 million transferable permits. The total transaction costs of the actors in the sample is SEK 136,444,048[14], which results in an average transaction cost of approximately SEK 6.1[15] per permit in Sweden. However, excluding the outliers we received a transaction cost of SEK 2.0[16] per permit.

Trying to compare the mean of the size of the transaction costs divided by the turnover for the actor yields no specifically interesting information, except that Group 1 has a higher percentage than the other groups. So, overall, the transaction cost appears to be rather low, but when looking closer at Group 1, which has been allocated least permits, another result appears. One can assume that an actor in Group 1, on average, has been allocated 500.5 ((1+1,000)/2) transferable permits. The mean transaction cost for trading on the market for an actor on Group 1 is SEK 79,444, which results in that the transaction cost per permit turns out to be SEK 158.7[17]. With the same reasoning, Group 2 has a transaction cost of SEK 36.0[18], Group 3 has a transaction cost of SEK 5.9[19] and Group 4 has a transaction cost of SEK 1.5[20]. The transaction cost per permit for Groups 1 and 2, deviate more from the Swedish average transaction cost per permit than do the other two groups

In addition, the actors were asked to list, in descending order of size, what different types of costs and expenses that constituted their estimate of the transaction cost. The outcome is presented in *table 8*:

[14] Total transaction cost for the sample: 655, 981(average transaction cost/actor) * 208 (Swedish population of actors) = 136,444,048
[15] Transaction cost per permit: 136,444,048(total transaction costs/22,400,000(total number of permits Sweden) = 6.1
[16] Transaction cost per permit without outliers: 44,362,032(total transaction costs without outliers)/22,400,000(total number of permits Sweden) = 2.0
[17] Group 1, transaction cost per allocated permit: 79,444/(1+1,000)/2)=158.7
[18] Group 2, transaction cost per allocated permit: 378,176/(20,000+1,001)/2)=36.0
[19] Group 3,transaction cost per allocated permit: 353,542/((100,000+20,001)/2)=5.9
[20] Group 4, transaction cost per allocated permit: 3,181,111/((4028907+100,001)/2) = 1.5 The upper limit of Group 4 is the number of transferable permits that the actor, which has been allocated the highest number of transferable permits, has received.

Costs	Number of Cases	1st Cost	2nd Cost	3rd Cost
Group 1	10	Administration	Consulting	Verification
Group 2	40	Administration	Consulting	Verification
Group 3	24	Administration	Verification	Consulting
Group 4	13	Administration	Verification	Technology

Table 8. Question 14: "Specify the cost included in question 13 in descending order"

All groups ranked administration as their largest cost associated with the ETS. Administration is for example, work internally and time for administrating the permits and requirements from the different authorities outlined in section 4.5. (see also Appendix G). Verification is generally keeping track of the actor's amount of emission and verification of this level by an independent controller. Consultants are hired for different reasons, but can generally be assumed to deliver know-how of how ETS works and how to handle it strategically and practically. Technology means new administrative data systems and monitoring equipment for carbon dioxide to handle ETS. Other costs that were mentioned less frequently than the ones in the table above were, education, traveling, obtaining information and lobbying towards the authorities. The respondents were also asked to answer specifically if they had hired a consultant to handle ETS issues. The result (Appendix D) was that Groups 1 and 2 were most inclined to hire consultants, which further strengthens the results in *table 8*. When asked whether the respondents had made any changes in staff during 2005, the result was quite similar between the different groups. Since the actors in Group 4 have a greater number of employees (see *table 3*) in general, one can presume that these actors should have more resources to make changes in their staff than the other groups. We assume that Group 4 did not increase their staff size due to the fact that these actors already possess in-house knowledge on how to handle the system. This was also confirmed by the interviews made with Fortum Värme, Naturvårdsverket and NUTEK, all stating that before the start of ETS, most large actors already had competent internal trading functions in-house.

6.5. Market Efficiency

Finally, the respondents were asked how efficient they believed the market for transferable permits to be on a scale of 1 to 5, where 1 is very poor and 5 is very good. The mean turned

out to be 2.7 (see *figure 6*), which indicates that the respondents, on average, consider the market to be quite inefficient.

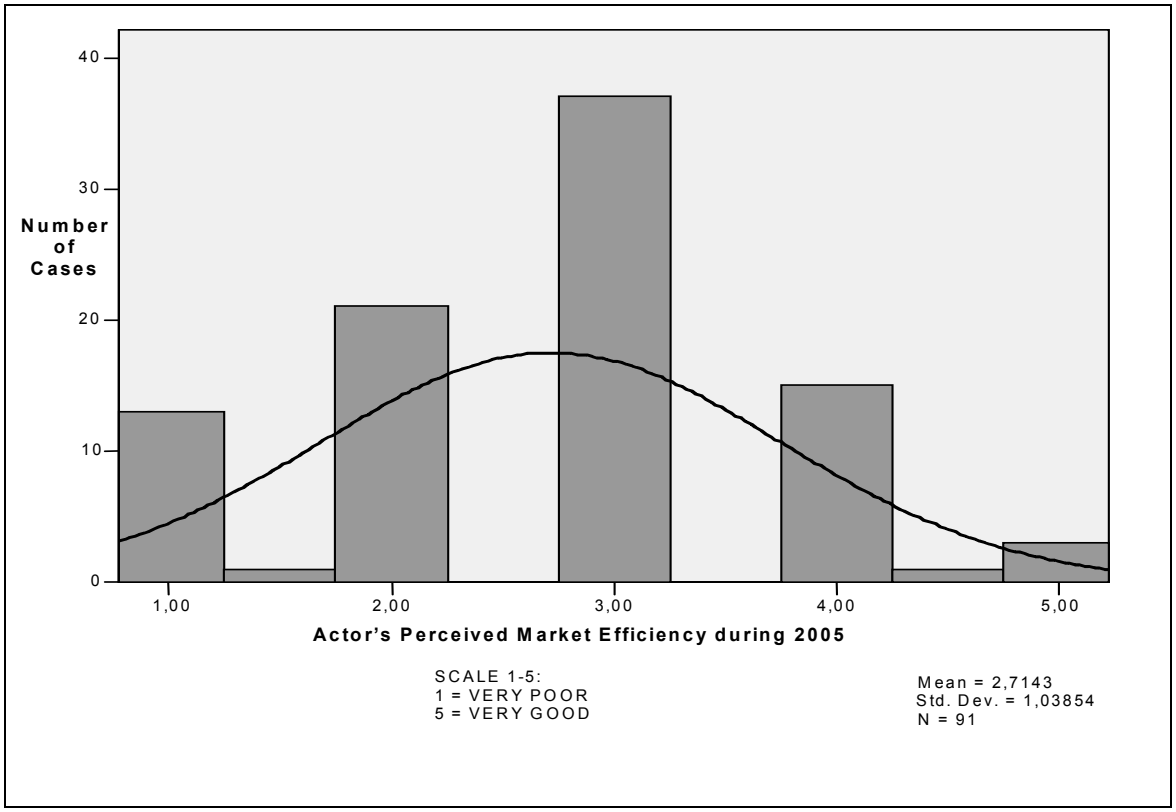


Figure 6. Question 21: "Does the actor perceive the market for transferable permits as efficient ?"

This is in line with the evaluation study of transaction costs of electricity certificates, which stated that there was a rather low perceived efficiency during the initial period. A low rating might not necessarily be due to a poor market design, but to the ETS market being immature. Immature markets often suffer from not stabilized structures and teething troubles. In addition, the respondents were asked to state if they believed the market to be transparent and whether they considered it to be risky to act on the market.

Transparency	Number of Cases	Yes (%)	Risk	Number of Cases	Yes (%)
Group 1	4/12	33.3	Group 1	2/12	20.0
Group 2	14/38	36.8	Group 2	15/43	34.9
Group 3	14/24	58.3	Group 3	8/23	34.8
Group 4	9/15	60.0	Group 4	3/16	18.8

Table 9. Question 19 and 20: "Does the actor consider the pricing mechanisms on the ETS market to Be transparent?" "Does the actor consider it to be risky to trade on the market for transferable permits?"

In *table* 9 it can be seen that actors in Groups 3 and 4, perceive the market to be more transparent than actors in Groups 1 and 2. This can be seen in the light of our earlier results

from section 6.2. i.e. that Groups 3 and 4 are more active traders. Trade activity can probably increase the actor's ability to obtain information. As already described, large actors in ETS often already have in-house trading desks, which should facilitate access to market information. The results show that actors in general do not consider it to be risky to trade in the ETS.

6.6. Technological Change

As explained in section 3, actors can either purchase transferable permits on the market, or reduce their amount of emission in-house. This in-house reduction may be accomplished by investment in new technology. This choice depends on which alternative that yields the lowest cost. Since the trading rate of 40.2 percent is rather low, it would be expected that the actors have invested in new technology. However, as can be seen in *table 10,* investments during 2005 were rather low. The planned investment rate for 2006 for all groups is also expected to be low except for Group 4. The investment rate in our sample is low considering that the European Commission found that approximately 50 percent of the actors claim that ETS influences the development of new technology. The most reasonable explanation for these rates is that technological progress takes time and one year is too short to see any large changes.

Type of Action	Group 1 (%)	Group 2 (%)	Group 3 (%)	Group 4 (%)
Investments 2005	12.5 (2/16)	13.2 (7/53)	6.7 (2/30)	22.2 (4/18)
Investments 2006	18.8 (3/16)	28.8 (15/52)	23.3 (7/30)	44.4 (8/18)
Change of fuel 2005	11.8 (2/17)	21.2 (11/52)	17.2 (5/29)	35.3 (6/17)

Table10. Question 10: "Has ETS resulted in that the actor has made new technological investments to reduce emission of carbon dioxide?", Question 17: "Will new technological investments to reduce carbon dioxide be done during 2006?". Question 18: Has ETS lead to that the actor changed to a fuel that emits less carbon dioxide during 2005?"

The actors have also changed their use of fuel to some extent. This may further explain the low level of investment in new technology. Again, Group 4 is the most active group in fuel changing.

6.7. Total Transaction Cost for the Swedish Society

As outlined in *table 13,* the mean transaction cost for the 79 (out of 120) actors who responded to question 13, was SEK 655,981 per actor. The total number of actors in our

population was 208, which gives a total transaction cost for of SEK 136,444,048[21] if using the mean transaction cost as an estimate for all 208 actors participating in the ETS. Of the respondents to Question 13, there are two observations that are outliers. In the sensitivity analysis, section 6.4., the mean transaction cost decreased to SEK 213,279. The total transaction cost calculated on this mean yields a total of SEK 44,362,032[22]. This sum can be interpreted as an estimate of total transaction costs for the Swedish actors in ETS. These costs can, according to theory in section 3.5., be considered as deadweight loss. However, one should also bear in mind that some of these costs are a necessity for the implementation, maintenance and enforcement of ETS. As mentioned in the introduction it is estimated in SOU 2004:62 that the public maintenance cost of the ETS is SEK 12-13 million per year. As explained in section 3.5., these costs are also transaction costs, but are borne by the regulatory body. An estimate of the total transaction costs for Sweden to participate in the ETS is SEK 148,944,048[23] or, based on the total transaction cost from the sensitivity analysis, SEK 56,862,032[24].

The Swedish actors have been allocated a total number of 22.4 million transferable permits (see section 4.5.), which gives the transferable permits a total value of SEK 5,329,960,000[25]. Thus, the total transaction costs represent 2.8[26] percent (1.1[27] percent with the results from the sensitivity analysis) of the total value of the allocated permits in Sweden. This number seems rather low, but one should not forget that far from all transferable permits are on the market. In our survey, only 40.2 percent of respondents claimed that they had traded on the market (section 6.1.), and 59.8 percent still have their transferable permits as an asset. Thus, the transaction cost per permit traded is presumably higher.

[21] 208(number of permits)*655,981(average transaction cost/actor) = 136,444,048
[22] 208(number of permits)*213,279(average transaction cost without outliers/actor) = 44,362,032
[23] Transaction costs for Sweden: 136,444,048(total transaction cost for the actors) + 12,500,000(public transaction cost) = 148,944,048
[24] Transaction costs for Sweden without outliers: 44,362,032(total transaction cost for the actors without outliers) + 12,500,000(public transaction cost) = 56,862,032
[25]Total value of Swedish permits: 22,400,000(total permits in Sweden)*9.15(SEK/EURO)*26.0(price of transferable permits) = 5,329,960,000. http://www.forex.se and http://www.nordpool.no (January 28, 2006)
[26]Transaction cost for Sweden in relation to total value of permits: (transaction costs for Sweden) 148,944,048/5,329,960,000(value of Swedish permits) = 0.0279
[27]Transaction cost for Sweden in relation to total value of permits: 56,862,032(total transaction costs for Sweden without outliers)/5,329,960,000(value of Swedish permits) = 0.0108

In section 6.4., it was estimated that the transaction cost per permit was, on average, SEK 158.9 for Group 1. This represents 68 percent of the value of a transferable permit[28]. Thus, it is rather costly for Group 1 to trade with their transferable permits, and as can be seen in *table 5,* only 5.6 percent of the Group 1 respondents in our sample stated that they have participated in trade. If actors in Group 1 were to be excluded from participating in the ETS, the Swedish society would save SEK 2,303,876[29] in transaction costs, plus possible additional costs savings from reducing a fraction of the yearly SEK 12-13 millions in public maintenance.

7. Discussion of Results

In this thesis we specifically investigated and estimated the transaction costs facing Swedish actors during the initial year (2005) of ETS and the activity of trade among the Swedish actors. This is important to look at since the cost effectiveness of ETS is based on the fact that all participants should be active in trade. The thesis's basic assumption was that transaction costs might prevent Swedish actors from actively participating in trade with transferable permits. In our sample only 40.2 percent stated that they had actively participated in trade during 2005. Based on our assumption, we had reason to investigate further whether the actors' trade was impeded due to the prevalence of transaction costs. We also examined if the number of allocated permits, which in turn turned out to be related to the actor's size, was of importance for the trade activity.

We divided our sample into four different groups depending on the number of transferable permits the actor had been allocated. This division shows the differences between the actors both in terms of their size and in terms of the value the permits represent to them. Group 1 was the smallest in terms of staff size, Group 4 the largest. Furthering our investigation by looking at differences between these four groups in terms of trade activity, we found that there were indeed differences. We showed that Group 1 and Group 2, i.e. the groups with the fewest allocated permits, trading activity differed significantly from Group 3 and 4's at a five percent level. Thus, Groups 1 and 2 do not participate as actively in trade as the other

[28] Percent value of transferable permits: 158/(9.15(SEK/EURO*26 Price permit) = 0.679
[29] Total transaction costs for Group1: 79,444 (estimated transaction cost Group1)*29(number of actors Group1) = 2,303,876

two groups. At a ten percent level of significance, there is also a difference between Group 1 and 2, and Group 2 was found to be rather active in relation to Group 1. By looking at the predicted probabilities we saw that the probability of trade ranges from a 5.6 percent probability for Group 1 up to 72.2 percent for Group 4. Based on these sample results there appears to be difference in trade activity depending on the amount of permits an actor had been allocated.

The trade strategy chosen by actors gives an indication to whether or not there are transaction costs on the market, and also to some extent, the size of these transaction costs. In our sample we found that the most common trading strategy was either to trade with the help of a broker, or through bilateral trading. This implies that transaction costs are either high (broker) or low (bilateral), depending on how active the actor is in trade. According to Noll, a market with few participants and high transaction costs yields an inefficient market. The actors in our sample rated the efficiency of the market to be 2.7 on a scale of 1 to 5. This rather modest result does not necessarily have to be due to a poor design of market, but can also be explained by the fact that the market is still quite immature after being in place only for one year.

An important idea behind a transferable permit scheme is that actors should have an incentive to change fuel or invest in new technology, if it in the long run yields a lower cost than buying transferable permits. In our sample, the investment rate for 2005 was rather low. Group 4 was most inclined to invest during 2005, with an investment rate of 22.2 percent. The investment rate for 2006 is a bit higher for all groups. ETS seems to affect the actors' decisions to either change to a carbon dioxide friendly fuel or invest in technology which is a desired outcome.

In our sample we found that the mean transaction cost for a Swedish actor was SEK 655,981. With exclusion of two outliers in sensitivity analysis the result was SEK 213,279. All transaction costs are not borne by the actors, some of the costs are due to public maintenance of the ETS. Public maintenance has been estimated to SEK 12-13 million. Summarizing actors' and public transaction costs yields a total transaction cost for the Swedish society of SEK 148,944,048, and SEK 56,862,032 when excluding the outliers.

The results were rather moderate when looking at the transaction costs in comparison to the total value of all allocated transferable permits. However, one should bear in mind that the transaction cost per transferable permit that has actually been traded, is probably higher as only 40.2 percent of the respondents stated that they had participated in trade. When we analyzed the transaction cost in comparison to the value per allocated permit in each group an interesting result revealed. In Group 1, which has been allocated fewest permits and which is also the smallest group in terms of staff, only 5.6 percent stated that they had participated in trade. For this group the transaction cost represented 68 percent of the value of a transferable permit. There is reason to believe that the transaction cost for this group impedes their incentive to trade. This is in line with the findings made by Schleisch and Betsz (2004) that small and medium sized actors are more vulnerable to transaction costs as it is not proportional to their company sizes.

It is not implausible that we biased actors in our sample. For example the respondents in our sample could be especially dissatisfied with ETS. This type of actors may have been more inclined to answer the survey. We also saw in our sensitivity analysis that the two outliers had a great influence on our results, which was the reason to why an additional result without these outliers was presented. Nevertheless, we considered the rate of respondents 57.7 percent, and spread of the respondents among both groups and sectors to be large enough to consider these results as good indicators of the relative sizes of transaction costs and the trade activity. Our sample should also give an indication of what these factors may imply for the cost effectiveness of ETS. However, the results may be affected by the fact that the ETS only has been in use for one year. The market can, as mentioned earlier, still be considered as immature. It is likely that the transaction costs will decrease over time since some of the costs are derives from the actors cost of setting up internal systems for handling the ETS. Finally, the spot-priced used for the calculation affects the results.

8. Conclusion

As the Greenhouse effect is threatening to the environment, there is clear need to implement policies to reduce its harmful effects. When the regulatory body sets a target level of emissions it ensures that a good socio-economic development path is chosen. It is an imperative to use a cost effective policy, since these types of policies may otherwise impede the economic development. The policy makers should aim to minimize both the control cost and the transaction cost in order to minimize the total cost of the scheme so that the scheme becomes as effective as possible. Furthermore, the regulatory body should consider how ETS affects different actors.

ETS seems to be rather cost effective in terms of transaction costs bearing in mind that the market is still to be considered as immature. ETS gives rise to a total transaction cost for Sweden of SEK 148,944,048. There is trade and technical development, but not in all groups that we investigated. The group that have been allocated few transferable permits appear to be inactive in trade as well as in in-house actions. Additionally, the transaction costs for this group are much higher compared to the other groups. Opting out of this group (Group 1) from the scheme would not have a great influence on the total level of emission in Sweden, nor on the total size of the transaction costs, as it would only save approximately SEK 2,303,876. On the other hand, it would most probably simplify life and growth for these small actors.

Another option for improvement of ETS and the transaction costs is related to its design. From Teitenberg we learned that the cost of achieving a given reduction in emissions is minimized if the marginal control costs are equalized for all emitters, which is what active trade of transferable permits among all actors lead to. However, low levels of trade activity due to transaction costs may according to Stavins have an effect on the cost effectiveness of transferable permits. He claims that auctioning is the best design in presence of transaction costs. Today 100 percent of transferable permits are allocated to the actors for free. If instead using the possibility to auction part (according to EU rules, either 5 or 10 percent is allowed to auction) of these permits as an allocation method, the transaction costs would not impede trade to the same extent. With auctioning there is no risk that actors are sitting on permits that they do not need because of transaction costs, as these costs makes it

unprofitable to sell the permits. The ETS is estimated to save SEK 3 billion per year in Sweden in comparison to other policies such as emission charges. Reducing transaction costs further would certainly give an even greater cost-effectiveness to ETS.

In future research it would be interesting to study how the ETS transaction costs develop over time and also if there are differences in transaction costs on a country and industry basis.

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Interviews

- Stockholm 30th November 2005: Fredrik Von Malmborg, responsible for ETA and allocation of transferable permits at Naturvårdsverket.
- Stockholm 24th November 2005: Gunnar Käck (expert on ETS and energy policy) and Erik Dotzauer (responsible for handling ETS at Fortum Värme)
- Stockholm 17th of January 2006: Lena Asplund, Project Manager NUTEK
- Stockholm 11-12 October 2005: Attendence and material from Euroforum ibc: ”Utsläppshandel-från strategi till affär”

Appendix A: EU Member States' Burden Sharing

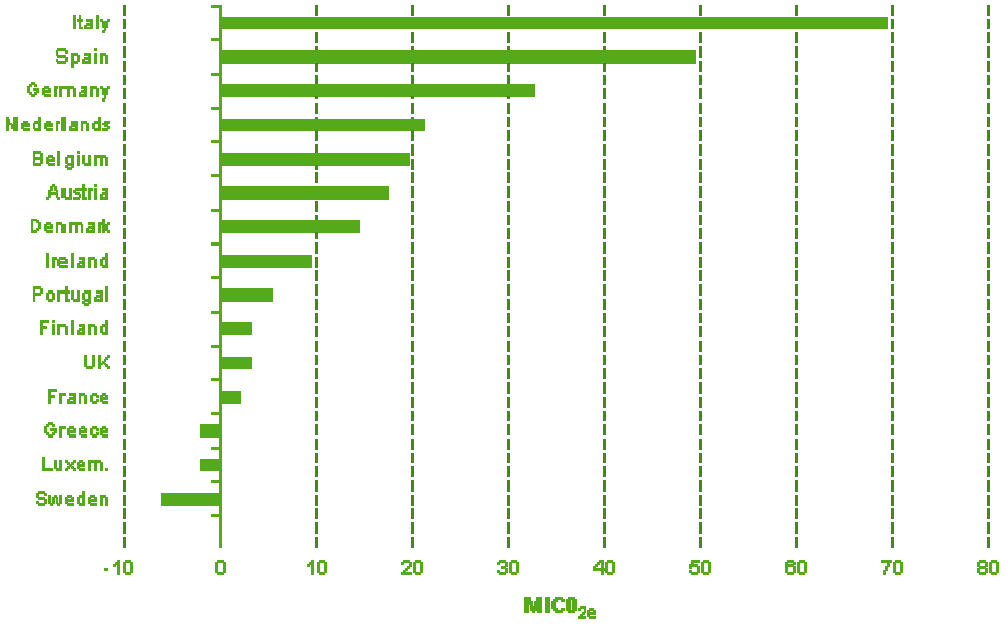
The table outlines the burden sharing between EU Member countries for the trading period 2005-2007. The Kyoto Protocol agreement to reduce the emission with eight percent within the EU is shared by EU-15. The ten member countries that became members on the first of May 2004 have individual targets under the Kyoto Protocol. Malta and Cyprus have no commitments under the Kyoto Protocol but still participate in ETS. (EU Commission, EU action against climate change)

EU Member State	Share in EU permits %	Kyoto Target %
Belgium	2.9	-7.5*
Czech Republic	4.4	-8
Denmark	1.5	-21*
Germany	22.8	-21*
Estonia	0.9	-8
Greece	3.4	+25*
Spain	8.0	+15*
France	7.1	0*
Ireland	1.0	+13*
Italy	10.6	-6.5*
Cyprus	0.3	
Latvia	0.2	-8
Lithuania	0.6	-8
Luxemburg	0.2	-28*
Hungary	1.4	-6
Malta	0.1	
Netherlands	4.3	-6*
Austria	1.5	-23*
Poland	10.9	-6
Portugal	1.7	+27*
Slovenia	0.4	-8
Slovakia	1.4	-8
Finland	2.1	0*
Sweden	1.1	+4*
United Kingdom	11.2	-12.5*
Total	**100**	

The main reason to that some member countries can increase their emission a level is to allow for economic growth. The figures do not take into account so called 'opt ins' 'opt outs', i.e. the possibility for some EU member states to opt out an actor that has done equivalent efforts to ETS to reduce CO2 emissions. One example of equivalent effort would be an actor that has participated in a preceding emissions trading scheme such as the UK-ETS. Such opt-outs cannot apply to entire sectors, just individual installations, and only apply for the first phase of the EU-ETS (2005-2007). Similarly, countries can use "opt-ins" of additional sectors and sources into the EU-ETS (Pewcenter on Global Climate Change, 2005).

Appendix B: Distance to EU Targets 2001

Distance to the EU reduction targets for member countries in 2001. Note Sweden's position in the diagram.



Source: European Climate Exchange (www.europeanclimateexchange.com)

Appendix C: Survey

(For the questions in English, please see Appendix D)

Enkät: Utsläppshandel i Sverige

Enkäten består av 21 frågor där majoriteten är i ja och nej form. Samtliga svarande kommer att behandlas anonymt.

Svar önskas så snart som möjligt, eller innan den 16 december. Vänligen ange Ert svar enligt anvisningarna vid varje fråga. Resultatet sparas på hårddisken och bifogas sedan i mail till 20385@student.hhs.se. Alternativt kan enkäten skrivas ut, ifyllas och returneras till Maria Ingelson, Kommendörsgatan 6, 114 48 Stockholm.

A. Allokering av utsläppsrätter

svarsalternativ

		1-1 000 st.	1 001-20 000 st.	20 001 - 100 000 st.	100 001 st. - eller fler
1.	Hur stor tilldelning av utsläppsrätter för koldioxid har företaget tilldelats för 2005? *(ange svaret till höger med X under det alternativ som passar bäst)*				
		ja	nej	kommentar	
2.	Anser Ni att Ert företag tilldelats rätt mängd utsläppsrätter i förhållande till företagets utsläpp? *(ange svaret till höger med X under det alternativ som passar bäst)*				

B. Handel med utsläppsrätter

svarsalternativ

		ja	nej	kommentar
3.	Har företaget handlat med utsläppsrätterna någon gång under 2005? **Om nej, fortsätt direkt till fråga 10.** *(ange svaret till höger med X under det alternativ som passar bäst)*			
		ja	nej	kommentar
4.	Har företaget sålt utsläppsrätter? *(ange svaret till höger med X under det alternativ som passar bäst)*			
		ja	nej	kommentar
5.	Har företaget köpt utsläppsrätter? *(ange svaret till höger med X under det alternativ som passar bäst)*			
		ja	nej	kommentar
6.	Har handeln med utsläppsrätterna skett bilateralt? *(ange svaret till höger med X under det alternativ som passar bäst)*			
		ja	nej	kommentar
7.	Har handeln med utsläppsrätterna skett på börsen? *(ange svaret till höger med X under det alternativ som passar bäst)*			
		ja	nej	kommentar
8.	Har handeln med utsläppsrätterna skett med hjälp av en extern mäklare? *(ange svaret till höger med X under det alternativ som passar bäst)*			

		ja	nej	kommentar
9.	Har handeln med utsläppsrätterna skett internt, mellan olika enheter på företaget? *(ange svaret till höger med X under det alternativ som passar bäst)*			

C. Kostnader för systemet med utsläppsrätter — **svarsalternativ**

		< 100	101-500	501 >
10.	Hur många anställda har företaget? *(ange svaret till höger med X under det alternativ som passar bäst)*			

		ja	nej	kommentar
11.	Har företaget förändrat sin personalstyrka i antal eller kunskapsmässigt för att hantera systemet med utsläpprätterna? *(ange svaret till höger med X under det alternativ som passar bäst)*			
12.	Har företaget anlitat konsulter för att hantera systemet med utsläpprätterna? *(ange svaret till höger med X under det alternativ som passar bäst)*			

C. Kostnader för systemet med utsläppsrätter — **svarsalternativ**

		Summa i kronor	% av omsättningen	kommentar
13.	Hur stor ***uppskattas*** den **totala** kostnaden för systemet med utsläppshandeln vara för perioden januari-december 2005 för företaget? T.ex. i from av extra konsultarvode, utbildning, administrativa kostnader etc. *(ange svaret till höger i kronor och i procent av beräknad omsättning för 2005)*			

C. Kostnader för systemet med utsläppsrätter

svarsalternativ

		Kostnadsslag
14.	Ange, **i minskande storleksordning**, de kostnadsposter som är en del av den totala kostnaden för systemet för utsläppsrätter under januari-december 2005. Observera att antalet kostnader kan vara färre än 10. (A*nge kostnaderna i minskande **storleksordning,** där 1 är den största.)*	1. 2. 3. 4. 5. 6. 7. 8. 9. 10.

		ja	nej	kommentar
15.	**Om företaget har handlat med sina utsläppsrätter under 2005, fortsätt direkt till fråga 16.** Är anledningen till att företaget inte handlat med sina utsläppsrätter att det är skulle innebära för stor kostnadsökning? *(ange svaret till höger med X under det alternativ som passar bäst)*			

D. Nyinvesteringar i teknik

svarsalternativ

		ja	nej	kommentar
16.	Har systemet med utsläppshandeln inneburit att företaget har gjort tekniska nyinvesteringar för att minska koldioxid utsläppen? *(ange svaret till höger med X under det alternativ som passar bäst)*			

		ja	nej	kommentar
17.	Kommer tekniska nyinvesteringar för att minska koldioxidutsläppen att göras under 2006? *(ange svaret till höger med X under det alternativ som passar bäst)*			

18.	Har systemet med utsläppshandeln inneburit att företaget har bytt de bränsleslag som används i produktionen? *(ange svaret till höger med X under det alternativ som passar bäst)*	

E. Effektivitet på utsläppsrättsmarknaden

		svarsalternativ					
		ja				nej	kommentar
19.	Upplever företaget att prissättningen på marknaden är transparant? *(ange svaret till höger med X under det alternativ som passar bäst)*						
		ja				nej	kommentar
20.	Upplever företaget att det är riskfyllt att handla på marknaden för utsläppsrätter? *(ange svaret till höger med X under det alternativ som passar bäst)*						
		1	2	3	4	5	kommentar
21.	Upplever företaget att marknaden för utsläppsrätter generellt är effektiv? *(ange svaret till höger med X med skal 1-5, där 1 betyder mycket dålig och 5 mycket bra)*						

Appendix D: Results from Survey

Calculations: How the percentages have been calculated is indicated in the parenthesis in the tables.

A. Allocation of transferable permits:

1. How many transferable permits have the respondent been allocated for 2005?

	Group 1 (1-1,000)	Group 2 (1,001 – 20,000)	Group 3 (20,001 – 100,000)	Group 4 (More than 100,001)
Number of Responses	18	54	30	18

2. Is the actor satisfied with the amount of transferable permits that it has been allocated?

Fairness	Total Percentage	Percentage within the Industry Sector	Percentage within the Energy Sector
Group 1	70.6 % (12/17)	50.0 % (3/6)	81.8 % (9/11)
Group 2	52.8 % (28/53)	60.0 % (15/25)	46.4 % (13/28)
Group 3	63.3 % (19/30)	76.2 % (16/21)	33.3 % (3/9)
Group 4	58.8 % (10/17)	90.0 % (9/10)	14.3 % (1/7))

B. Trade with Transferable Permits:

3. Have the actor traded with the transferable permits during 2005?

	Total Trade for the Group	Industry/Total Trade	Energy/Total Trade	Number of Cases in the Industry sector	Number of Cases in the Energy sector
Group 1	5.6% (1/18)	0.0% (1/1)	100% (1/1)	0.0% (0/0)	100.0% (1/1)
Group 2	30.8% (16/52)	25.0% (4/16)	75% (12/16)	16.0% (4/25)	44.4% (12/27)
Group 3	56.8% (17/29)	70.6% (12/17)	29.4% (5/17)	60.0% (12/20)	55.6% (5/9)
Group 4	72.2% (13/18)	61.5% (8/13)	38.5% (5/13)	72.7% (8/11)	71.4% (5/7)
Total	**40.2% (47/117)**				

4. Has the actor sold transferable permits? 5: Has the actor bought transferable permits?

Number of Respondents that have:	Group 1	Group 2	Group 3	Group 4
Sold Permits	1	9	15	11
Bought Permits	1	7	5	5

6. Has the actor conducted trade through bilateral trading?

7. Has the actor traded through an exchange? 8. Have the actor traded with the help of a broker?

9. Has the actor traded internally?

Transaction Strategy	Number of Transactions
Market Exchange Solution	16
Bilateral Trading	24
Internal Trading	15
Trading with a Broker	23

C. Costs for the System of Transferable Permits:

10. How many employees does the actor have?

Size of staff Industry	Less than 100	100-500	More than 500	Size of staff Energy	Less than 100	100-500	More than 500
Group 1	28.6 % (2/7)	28.6 % (2/7)	42.9 % (3/7)	Group 1	81.8 % (9/11)	0.0 % (0/11)	18.2 % (2/11)
Group 2	26.9 % (7/26)	57.7 % (15/26)	15.4 % (4/26)	Group 2	82.1 % (23/28)	14.3 % (4/28)	3.6 % (1/28)
Group 3	14.3 % (3/21)	52.4 % (11/21)	33.3 % (7/21)	Group 3	44.4 % (4/9)	55.6 % (5/9)	0.0 % (0/9)
Group 4	0.0 % (0/11)	9.1 % (1/11)	90.9 % (10/11)	Group 4	0.0 % (0/7)	57.1 % (4/7)	42.9 % (3/7)

11. Has the actor changed its staff, either in number or through knowledge, as a result of ETS?

Change in Staff	Group 1	Group 2	Group 3	Group 4
	16.7% (3/18)	14.8%(8/54)	20.0%(6/30)	22.2%(4/18)

12. Has the actor hired consultants in order to handle the ETS?

Consultants	Group 1	Group 2	Group 3	Group 4
	50.0% (9/18)	44.4% (24/54)	23.3% (7/30)	33.3% (6/18)

14. How large are the actors' total costs for ETS during 2005?

Transaction Cost	Number of Cases	Mean	Standard Deviation	Median	Maximum	Minimum
Total in SEK	9	79,444	40,961	100,000	150,000	15,000
% of turnover	5	0,3210	0.4600	0,0050	1,0000	0,0000

Group 1

Transaction Cost	Number of Cases	Mean	Standard Deviation	Median	Maximum	Minimum
Total in SEK	37	378,176	1,630,102	87,500	10,000,000	0
% of turnover	27	0,1339	0.2920	0,0500	1,5000	0,0002

Group 2

Transaction Cost	Number of Cases	Mean	Standard Deviation	Median	Maximum	Minimum
Total in SEK	24	353,542	898,426	137,500	4,500,000	10,000
% of turnover	24	0,1410	0.2865	0,0220	1,0000	0,0000

Group 3

Transaction Cost	Number of Cases	Mean	Standard Deviation	Median	Maximum	Minimum
Total in SEK	9	3,181,111	8,336,994	450,000	25,400,000	80,000
% of turnover	7	0,0341	0.0739	0,0030	0,2000	0,0000

Group 4

Transaction Cost	Number of Cases	Mean	Standard Deviation	Median	Maximum	Minimum
Total in SEK	79	655,981	3,071,188	100,000	25,400,000	0,0000
% of turnover	63	0,1404	0.2903	0,0240	1,5000	0,0000

Total

14. Specify the costs for ETS during January-December 2005 in a descending order.

Cost	Number of cases	1st Cost	2nd Cost	3rd Cost
Group 1	10	Administration	Consulting	Verification
Group 2	40	Administration	Consulting	Verification
Group 3	24	Administration	Verification	Consulting
Group 4	13	Administration	Verification	Technology

15. Is the reason why the actor has not participated in ETS that it would induce too large costs?

	Group 1	Group 2	Group 3	Group 4
Not participated	6.7% (1/15)	11.5% (3/26)	23.1% (3/13)	0% (0/5)

D. Investments in new technology:

16. Has ETS resulted in that the actor has made new technological investments to reduce emission of carbon dioxide?

	Group 1	Group 2	Group 3	Group 4
Investments 2005	12.5 % (2/16)	13.2 % (7/53)	6.7 % (2/30)	22.2 % (4/18)

17. Will new technological investments to reduce carbon dioxide be done during 2006?

	Group 1	Group 2	Group 3	Group 4
Investments 2006	18.8 % (3/16)	28.8 % (15/52)	23.3 % (7/30)	44.4 % (8/18)

18. Has ETS lead to that the actor has changed to a fuel that emits less carbon dioxide?

	Group 1	Group 2	Group 3	Group 4
Fuel	11.8 % (2/17)	21.2 % (11/52)	17.2 % (5/29)	35.3% (6/17)

E. Efficiency on the Market for Transferable Permits:

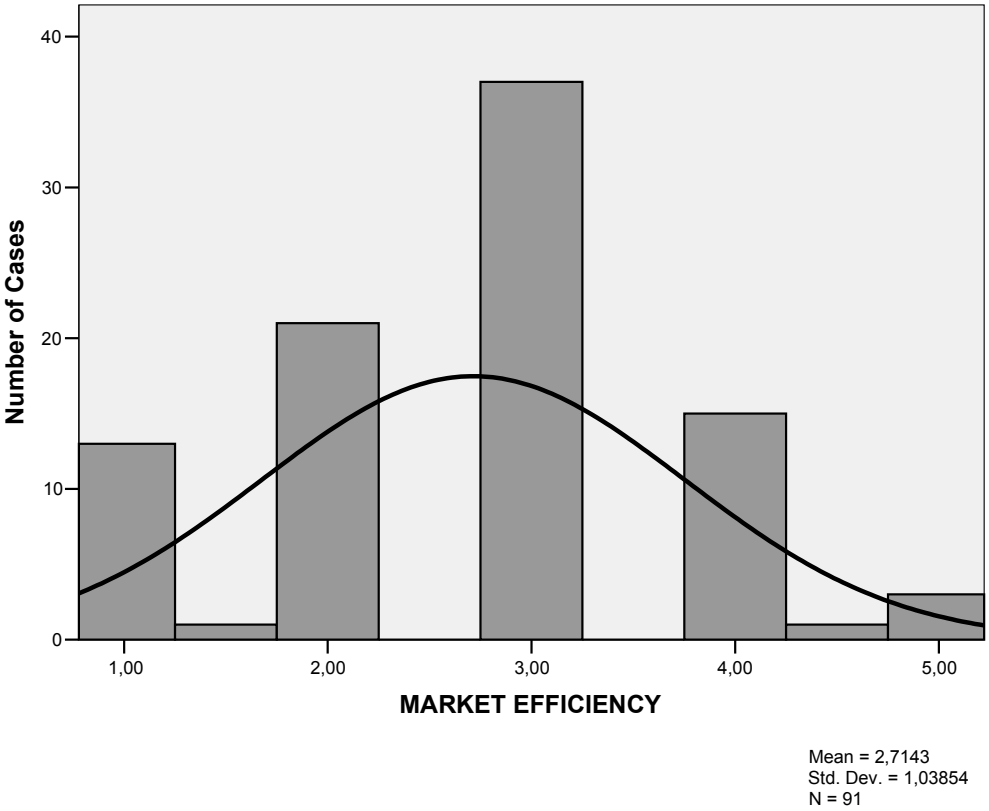
19. Does the actor consider the pricing mechanisms on the market as transparent?

Transparency	Yes (%)
Group 1	33.3 (4/12)
Group 2	36.8 (14/38)
Group 3	58.3 (14/24)
Group 4	60.0 (9/15)

20. Does the actor consider it to be risky to trade on the market for transferable permits?

Risk	Yes (%)
Group 1	20.0 (2/10)
Group 2	34.9 (15/43)
Group 3	34.8 (8/23)
Group 4	18.8 (3/16)

21. Does the actor, in general, believe the market to efficient?



Appendix E: Swedish Allocation Formula

$$Allocation = k(Emission_{rawmaterial+fuel}^{A\,var\,age(1998-2001)} \times K_{Exceptional}) + Emission_{rawmaterial}^{prediction(2005-2007)}$$

k	k = 0.8 for burning units within the energy sector, i.e. units that produce electricity or heat. k =1 for other units.
$Emission_{rawmaterial+fuel}^{A\,var\,age(1998-2001)}$	The average of the actor's historical emissions from raw materials and fuels.
$K_{Exceptional}$	A correction factor larger than 1 if there were exceptional factors influencing the actor's level of emission during the historical period 1998-2001. Factors that counts are production stops or other severe, production reducing incidents. The incident must account for at least ten percent of the yearly level of emission of carbon dioxide.
$Emission_{rawmaterial}^{prediction(2005-2007)}$	An additional supply of transferable permits, based on a prediction of carbon dioxide related to the actor's use of raw material.

Source: Promemoria, 2004-04-22

For new entrants there are special rules regulating the allocation procedure. If the unit was started during the period 2002-2004, the allocation of permits is based on a target rate (energy sector) or the best available technology for carbon dioxide reduction (industry).

Appendix F: Allocation per Sector in Sweden

Sector	Units	2005 (Permits/year)	2006 (Permits/year)	2007 Permits/year)
Energy	615	5076400	5215651	5482280
-Electricity & district heating	513	366645	3791186	4046782
Municipality	1	333	333	333
-Chemistry and pharmaceutical industry	17	600210	609075	607289
-Food and beverage	15	328684	331037	337008
-Metal industry	3	72021	72021	72021
-Mineral industry	2	2446	2446	2446
-Pulp and paper	7	245068	245747	246162
-Textile industry	25	24523	24523	24523
-Hospital	2	16287	16287	16287
-Wood industry	16	29575	29809	32773
-Manufacturing/engineering industry	14	90608	93187	94656
Refineries	5	3024274		3024274
Iron ore	3	438780	3024274	472664
Iron and Steel industry	15	7239755	438780	7241748
Mineral industry	20	3517012	3527667	3536600
-Cement industry	3	2198501	2198501	2198501
-Glass industry	4	260741	264283	266082
-Lime industry	8	994883	1002006	1009130
-Chemical industry	5	62887	62887	62887
Pulp and Paper	58	2594737	239879	2775572

Source: Naturvårdsverket www.utsläppshandel.se

Appendix G: Administrative Law Requirements related to Trade with Transferable Permits in Sweden

NUTEK has investigated the administrative burdens caused by environmental regulation. Hence, one specific part of transaction costs. The administrative burdens can be divided into to main groups, (A) the demand of a certain action in relation to what the environmental law requirements and (B) the requirement to inform the authorities that the specific action demanded has been performed.

Administrative Requirement	Type	Type of Law
1. Yearly delivery of an equivalent amount of transferable permits to the amount of carbon dioxide released during the previous trade period.	A	EG Directive-with national adaptations
2. Providing documents to the authorities to facilitate the supervision of emission	A	Swedish national demand
3. Notification of qualified representatives for ETS trade within the firm	B	Swedish national demand
4. Delivery of transferable permits	B	EG Directive-with national adaptations
5. Notification of production unit changes influencing the emission of carbon dioxide	B	EG Directive-with national adaptations
6. Request of user information	B	Swedish national demand
7. Documentation of changes in surveillance of carbon dioxide emission	A	
8. Application: personal transaction account	B	EG Directive-with national adaptations
9. Application: actor transaction account	B	EG Directive-with national adaptations
10. Notification of change of production units influencing the emission of carbon dioxide	A	
11. Notification of representatives	A	
12. Verification	A	
13. Documentation of changes in surveillance levels	A	
14. Application: actor transaction account	A	EG Directive-with national adaptations
15. Application of change in ownership	B	EG Directive-with national adaptations
16. Notification of change of surveillance method	A	
17. Application: personal transaction account	A	EG Directive-with national adaptations
18. Application: registration of changed ownership of transferable permits.	A	EG Directive-with national adaptations
19. Notification of changes in the surveillance method	B	
20. Application: user information	A	Swedish national demand

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