

Yu, Haisan

Working Paper

The EU ETS and firm profits: An ex-post analysis for Swedish energy firms

Working Paper, No. 2011:2

Provided in Cooperation with:

Department of Economics, Uppsala University

Suggested Citation: Yu, Haisan (2011) : The EU ETS and firm profits: An ex-post analysis for Swedish energy firms, Working Paper, No. 2011:2, Uppsala University, Department of Economics, Uppsala, <https://nbn-resolving.de/urn:nbn:se:uu:diva-144938>

This Version is available at:

<https://hdl.handle.net/10419/82608>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



UPPSALA
UNIVERSITET

Working Paper 2011:2
Department of Economics

The EU ETS and Firm Profits: An Ex-post Analysis for Swedish Energy Firms

Haisan Yu

Department of Economics
Uppsala University
P.O. Box 513
SE-751 20 Uppsala
Sweden
Fax: +46 18 471 14 78

Working paper 2011:2
February 2011
ISSN 1653-6975

THE EU ETS AND FIRM PROFITS: AN EX-POST ANALYSIS FOR SWEDISH ENERGY FIRMS

HAI SAN YU

Papers in the Working Paper Series are published on internet in PDF formats.
Download from <http://www.nek.uu.se> or from S-WoPEC <http://swopec.hhs.se/uunewp/>

The EU ETS and Firm Profits: An Ex-post Analysis for Swedish Energy Firms¹

Haishan Yu²

November 19, 2010

Abstract

In January, 2005, the EU launched the first international emissions trading system (EU ETS), aimed at reducing carbon emissions in a cost-effective way by means of a market-based instrument. In this paper, we use the treatment/control, before/after design of the natural experiment approach to investigate the treatment effect of the EU ETS on the profitability of a sample of Swedish energy firms in 2005 and 2006. We also investigate whether under-cap and over-cap firms respond differently to the EU ETS. The estimation results in general suggest no significant impact in 2005 and a negative significant impact in 2006. The sub-sample analysis suggests that profitability of under-cap and over-cap firms were affected differently by the EU ETS in 2005, but not in 2006.

JEL codes: D22, Q50, Q58

Key words: EU ETS, difference-in-differences, fixed effect.

¹This paper started when I studied at Örebro University and Dalarna University College, where I received valuable guidance from Niklas Rudholm. I would also like to thank Lars Hultkrantz, Daniela Andrén, Jesper Stage, Chuan-Zhong Li, Jie Li, Anders Lunander and seminar participants in the Business School at Örebro University. Much of this work was conducted while receiving the financial support from Vattenfall Sweden. This support is gratefully acknowledged. All remaining errors are mine.

² Department of Economics, Uppsala University, Box 513, SE-751 20, Uppsala, Sweden. Haishan.Yu@nek.uu.se

1. Introduction

In January, 2005, the European Union launched the first international emissions trading system, the EU ETS, intended to act as a driving force to promote business interest in reducing CO₂ emissions. The EU ETS is seen as an important tool in enabling the EU to fulfill its commitment in the Kyoto Protocol of reducing greenhouse gas emissions. At present, the system covers CO₂ emissions from a limited number of industrial sectors, primarily the energy sector and some other energy-intensive industries. The regulated units are installations carrying out prescribed activities,³—e.g., combustion of fuels, production of steel, and production of pulp—above certain capacity thresholds. The energy sector is involved as the primary trading sector in the sense that the combustion process of producing electricity causes high CO₂ emissions. It has been debated whether the EU ETS will place a premium on electricity prices and decrease the competitiveness of other energy intensive sectors, particularly those that are confronted with serious international competition. It is widely accepted that firms within the energy sector could make windfall profits with the design of the EU ETS in its first phase, 2005-2007, by benefiting from the premium on electricity price and a free allocation of allowances (Sijm et al., 2006). In this paper, we focus on a sample of Swedish energy firms associated with electricity production and district heating and investigate whether the profitability of these firms are affected by the EU ETS.

Previous quantitative studies of the EU ETS have mainly used simulation models to carry out analyses at the national or industry level. Oberndorfer et al. (2006) summarize various simulation models focusing on competitiveness and employment in relation to the EU ETS and conclude that the impact of the EU ETS on competitiveness is modest. In a related study, Brännlund and Lundgren (2007) use Swedish firm-level data on outputs and inputs between 1991 and 2001 to estimate a factor demand model, and then simulate different policy scenarios. Their simulation results indicate that the effects of the EU ETS on the Swedish primary industry will depend on the level of the current carbon tax, the price of the permits, and the future price of electricity. Empirical studies of the EU ETS are relatively few and center on the dynamics of carbon prices (Fell, 2008; Widerberg and Wråke, 2009). Econometric studies of the EU ETS at the firm level are rather scant due to a lack of data. One exception is Anger and Oberndorfer (2008), who study the impact of the relative allocation of allowances on competitiveness and employment in a sample of German firms in 2005. Their

³“Installation” here means a stationary technical unit, e.g., machines or equipment, by which one or more activities listed in Annex I of the EU ETS Directive is carried out. The activities listed in Annex I include energy activities and the production and processing of ferrous metals, mineral industries, and pulp and paper industries (Directive 2003/87/EC).

results provide evidence that the actual allocation within the EU ETS framework in the first phase did not have a significant impact on revenues and employment. Our paper, too, contributes to filling the vacuum of the small number of firm-level empirical studies on the EU ETS, by using a different econometric model on Swedish firm level data.

The focus of the paper is on energy firms, applying difference-in-differences to investigate the treatment effect of the EU ETS on profitability. The treatment group was comprised of the firms that own the regulated installations and are associated with electricity production and district heating under the Swedish Standard Industrial Classification 2002 (SNI2002). The control group was restricted to firms with the same industrial classification, so that they would consist of firms with similar industrial characteristics. The installations covered by the EU ETS in the energy sector in Sweden are mostly combustion units, with a capacity above the EU ETS threshold. It should be noted that the firms in the control group either own combustion installations with a lower capacity than the prescribed threshold or do not own combustion installations at all. As such, both treatment and control groups are to some extent involved in electricity production, making it difficult to identify the effects of the EU ETS caused by changes in the electricity price. The purpose of the study is thus to shed light on how the introduction of the EU ETS would affect firm profitability, caused by the trade of allowances and necessary technology improvement in the context. The firms in treatment are also divided into two groups according to the relative allocation of allowances. The idea is that, as a consequence of the trade of allowances, under-cap firms⁴ can gain from selling surplus of allowances, while over-cap firms⁵ suffer from buying additional allowances (or investing in abatement technology) to cover their excess emissions. The estimation results, in general, suggest no significant impact of the introduction of the EU ETS on profitability of Swedish energy firms in 2005 and a negative significant impact in 2006. The sub-sample analysis indicates that under-cap and over-cap firms respond differently to the EU ETS in 2005, however, no such evidence is uncovered in 2006.

The rest of the paper is organized as follows: Section 2 introduces a general institutional background to both the EU ETS and Swedish climate policy. Section 3 presents the theoretical reasoning, data, econometric model, and estimation results. A concluding summary is given in Section 4.

⁴“Under-cap firms” refers to firms that have verified lower emissions than the freely allocated allowances. Over-cap firms are defined as the opposite.

⁵See footnote 2.

2. Institutional Background

2.1. The general background of the EU ETS

Ever since the 1980s, climate change has emerged as one of the most urgent environmental issues. In 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted as the basis for a global response to climate change.⁶ This was complemented in 1997 by the Kyoto Protocol, in which the EU as a whole made the commitment to reduce its greenhouse gas (GHG) emissions by 8 percent during the period 2008-2012, based on the level in 1990. In 1998, the EU reached the so-called EU Burden-Sharing Agreement to differentiate this target among its member states. Since then, emissions trading has been brought forward in the interest of promoting the Burden-Sharing Agreement. Based on Directive 2003/87/EC, the EU ETS was officially put into practice in 2005, and it now plays a central role in the EU's commitment in the Kyoto Protocol. The Directive stipulates three phases in the EU ETS, namely, phase 1: 2005-2007, Learning by Doing period; phase 2: 2008-2012, Kyoto Protocol Period; and phase 3: Post 2012 period. During the first phase, there were some 11,500 installations from carbon-intensive sectors and about 46 percent of Europe's CO₂ emissions were covered by the EU ETS.⁷

The EU ETS sets the initial emissions caps and then issues a certain amount of emission allowances (EUAs) based on certain criteria. EUAs are then allowed to be traded freely within the EU and even worldwide. Different marginal abatement costs across individual firms generate the incentives for trade, and a carbon market is then created to enable firms to find the lowest cost of abatement. Generally speaking, cost-minimizing firms with higher marginal abatement costs than the price of allowances would like to buy allowances instead of reducing output or investing in abatement. Oppositely, cost-minimizing firms with lower marginal abatement cost would like to invest in abatement to save allowances for selling. Meanwhile, the initial allocation of allowances has a remarkable influence on the incentives for trade. According to the guideline of the EU ETS, a portion of the allowances were initially allocated for free. Particularly, more than 95% of allowances were grandfathered during the first phase of the EU ETS. A main objective of the free allocation was to ensure that the introduction of the EU ETS did not reduce the profitability of the eligible companies (Sijm et al., 2006). Also, within the EU ETS, the member states have considerable freedom to lay out the national

⁶ See: http://unfccc.int/files/press/backgrounders/application/pdf/unfccc_and_kyoto_protocol.pdf

⁷ In the first and second phases, the EU ETS only covers carbon dioxide instead of all greenhouse gas controlled by the Kyoto Protocol.

allocation plan (NAP)⁸ which ex-ante decides how many allowances to allocate in total for a trading period and how many to distribute to each installation. Basically, the amount allocated to each installation is determined on the basis of either historical or projected emissions of the installation. Once the NAP is decided, it cannot be changed within each phase. Moreover, banking and borrowing of allowances were not allowed from phase 1 to phase 2, but are generally allowed from phase 2 to phase 3.

In the months after the EU ETS was first launched, the price of allowances rose from € 10/tCO₂ to a peak price of almost €30/tCO₂ in the middle of 2005. Later, when the verified emissions data were released in the spring of 2006, the price fell sharply (Figure 1).

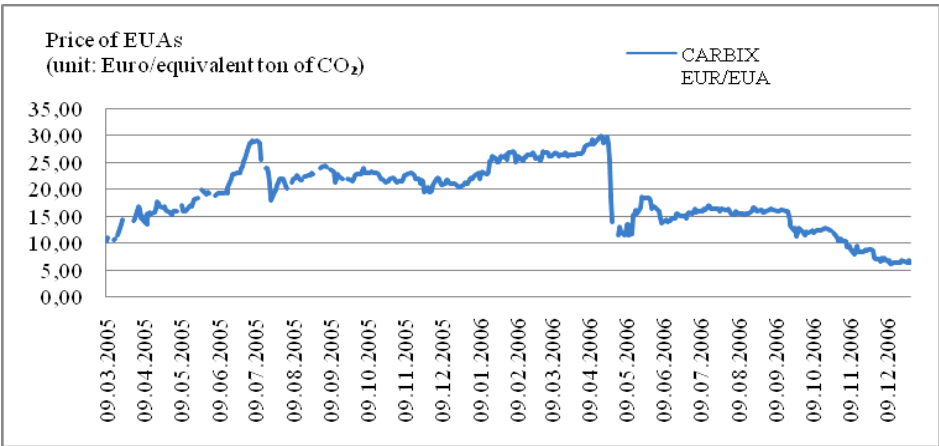


Figure 1. Intra-day auction prices of EUA (Source from: European Energy Exchange)

2.2. The EU ETS in Sweden

Since the oil crisis of the early 1970s, Sweden has gone through a structural change in regard to its energy supply. The biggest change has been the decrease in oil from 77% of the total energy supply in 1970 to 33% in 1997, which was made possible mainly due to the development of hydro power and the nuclear program (Ellerman et al., 2008). An observation has been that emissions of carbon dioxide in the Swedish energy sector have declined by approximately 40% between 1970 and 1998, after which the government put more effort into environmental regulation to try to achieve an environmentally friendly economy. Sweden is now sometimes referred to as one of the countries that have shown that it is possible to break the link between economic growth and greenhouse gas emissions.⁹

⁸ For the decentralized structure of the EU ETS and its implications for economic efficiency, see Kruger et al., 2007.
⁹ Over the last nine years, Swedish emissions have on average been 4.9 percent below 1990 levels, while the GDP over the same period has grown by around 3 percent per year. For more information, refer to the web page of the Swedish Energy

The current Swedish environmental policy is based on 16 environmental quality objectives (EQOs), of which the first is to reduce climate impact.¹⁰ The Swedish climate strategy consists of targets, instruments, regular follow-up and periodical assessment of the development towards established targets. The instruments used for achieving the climate strategies have been gradually developed since the late of 1980's and now contain carbon dioxide taxes, energy taxes, the EU ETS, the Electricity Certificate System, long term/voluntary agreements, and subsidies.¹¹ An energy tax was introduced in Sweden in the 1950s and has been an important source of public revenue (Johansson, 2006). The carbon dioxide tax joined the policy system as a supplement of the energy tax in 1991. It has been increased several times and is now relatively high compared to other countries. In order to support the expansion of electricity production and effectively control emissions, a market-based instrument, electricity certificate system (ECS), was introduced in the energy sector in 2003 and is planned to be in effect until 2030.¹²

Sweden joined the EU ETS when it was officially launched in 2005. The installations regulated in Sweden are primarily combustion units carrying out activities connected to electricity production and district heating. The introduction of the EU ETS has so far led to some changes in other climate related instruments in Sweden as well. For instance, the sectors covered by the EU ETS pay a reduced CO₂ tax. Additionally, some restrictions on CO₂ emissions and quantity of fossil fuel used subject to the Environmental Code¹³ have been removed for plants covered by the EU ETS (Econ, 2006). Nevertheless, the EU ETS is a relatively new instrument in Sweden. Table A1 in the appendix shows the quantified effects of different policy instruments used in Sweden to control of CO₂ emissions.

3. Empirical Analysis

3.1. A theoretical background

The advantage of emissions trading is that it creates certainty with regard to the

Agency. However, there has been criticism of how these emissions have been measured. UN statistics, for instance, show on the contrary that Sweden has increased its GHG by 12.7% since 1990, including emissions from deforestation.

¹⁰ For more information about the EQOs, see: <http://www.miljomal.se/Environmental-Objectives-Portal/>

¹¹ For an overview on the Swedish climate policy, see the Swedish Energy Agency et al. (2007) and Ministry of Sustainable Development Sweden (2005).

¹² During the four years after implementation, around 400 new installations have been built with expected production of renewable electricity of around 2.1 TWh per year. For an overview of the electricity certificate system, see Swedish Energy Agency (2007)

¹³ Environmental Code is the basic environmental regulation in Sweden which entered into force on 1st January, 1999 by amalgamating 15 previous environmental acts.

environmental outcome (cap), while minimizing the overall compliance cost through the market mechanism (cost-effectiveness). In this study, we use firm profitability as the outcome variable of interest, and investigate the impact of the EU ETS on a sample of Swedish energy firms. The EU ETS may affect both variable and fixed costs of firms (Smale et al., 2006). Under the regulation, CO₂ emissions become a factor of production that has to be paid in the same way as labor and raw materials. In regard to the carbon price, the introduction of the EU ETS could also affect investment decisions of firms. Oberndorfer and Rennings (2007) elaborate on how three short-term factors, i.e., energy intensity, the opportunity to abate carbon emissions, and the ability to pass through the cost of CO₂ emissions, determine the impact of the EU ETS on firm competitiveness. In this paper, we also consider that the trade of allowances causes a cash flow to firms and influences profits directly. The factors contributing to the impact of the EU ETS on firm profits are summarized in Figure 2, which is based on Figure 1 in Oberndorfer and Rennings (2007).

Next, we elaborate on how the EU ETS might affect profits of energy firms in the Swedish context according to Figure 2.

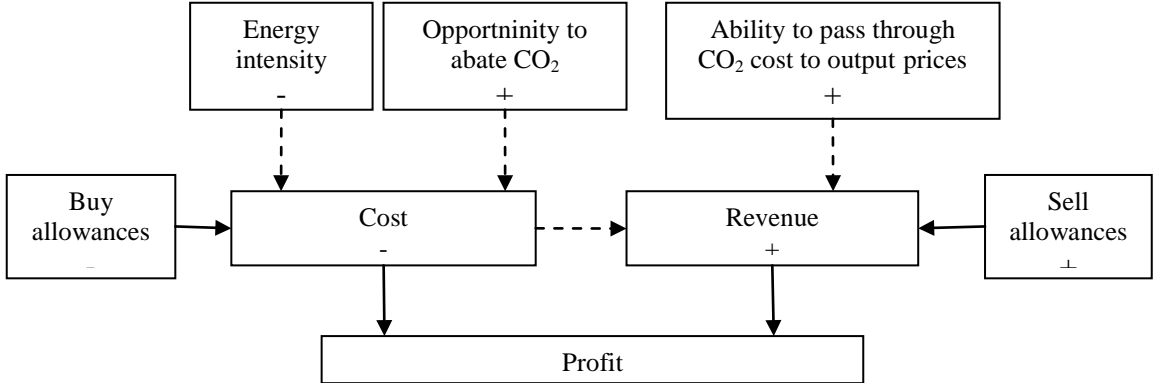


Figure 2. The short-term factors contributing to the impact of the EU ETS on firm profits

First, the more energy intensive (measured as energy used per unit of production) a firm is, the higher the costs induced by the EU ETS. This is because energy intensive firms in general generate high CO₂ emissions. However, in our sample of Swedish energy firms, nuclear power and hydroelectricity dominate power generation. These two sources together contribute to 91% and 90% of total electricity production in 2005 and 2006, respectively. Also, even though wind power makes up only 1% of the total power production, it has grown rapidly in

recent years, from a generated 203 GWh in 1997 to 1,432 GWh in 2007.¹⁴ Thus, in this setting, the electricity produced from combustion process creating CO₂ emissions may only make up a small portion of total production in our sample of firms. This indicates that the regulated Swedish energy firms are not exposed to high cost pressure under the EU ETS.

Second, it has been claimed that the energy sector had more low-cost emission abatement opportunities than other sectors in Sweden (Widerberg and Wråke, 2009). Such low-cost abatement opportunities could come from the ability to switch fuels and the potential to improve energy efficiency, which are in line with ongoing instruments such as the Electricity Certificate System (ECS) and the national climate and energy target by 2020.¹⁵ The potential for low-cost emission abatement could help the regulated Swedish energy firms to some extent to circumvent the costs induced by the EU ETS. In such a situation, the EU ETS may stimulate the firms to exploit their opportunities of abatement and encourage the innovations of improving production efficiency.

Third, it is widely accepted that the CO₂ price can be passed through to the electricity price (Sijm et al., 2006; Chen et al., 2008; Fell, 2008; Norden, 2008). In a competitive market, electricity companies bid their production costs into the market. Tarjanne and Kivistö (2008) show that, even without emissions trading, the production cost of gas and coal electricity is the highest among other generation sources. Therefore, in most power systems coal is the marginal generation source to determine the spot price of electricity. With emissions trading, the cost of CO₂ is factored into coal-fired thermal power plants. In addition to the low price elasticity of demand for electricity, the cost of CO₂ can feed through into the electricity price in a market where the coal-fired thermal power plant is on the “margin”. Although nuclear power and hydropower dominate in Sweden, the marginal generation is still relatively carbon intensive due to the electricity generated from coal. Particularly, the Swedish electricity market is integrated with other Nordic countries of which Denmark still has coal as a major source of power generation. Fell (2008) uses a co-integrated vector autoregressive model to conduct an impulse analysis of electricity prices in the Nordic market and the CO₂ price induced by the EU ETS, and reports that the cost of CO₂ is almost entirely passed through. In view of the fact that the electricity price integrated with the CO₂ price applies to all electricity in the market regardless of the sources of generation, the Swedish energy firms, including those that are not subject to the EU ETS, will benefit from the premium in electricity price,

¹⁴Total power production in 1997 and 2007 are 145,221 GWh and 144,708 GWh respectively.

¹⁵The Swedish climate and energy targets by 2020 are (i) a 40% reduction in GHG with 1990 as the reference; (ii) at least 50% renewable energy; (iii) 20% more efficient energy use; and (iv) at least 10% renewable energy in transports. For more details, see Ministry of the Environment et al., 2009.

especially those with a high proportion of nuclear, hydroelectric, and wind power.

Furthermore, we turn to the allocation of allowances. In Sweden, freely allocated allowances to energy installations in the first period of 2005-2007 constituted 80% of their average emissions during the period of 1998-2001, and most of these installations were subject to the activity of combustion. Even so, the energy sector in Sweden as a whole had a surplus of allowances during the years of our study: 262,000 tons in 2005 and 208,000 tons in 2006. One reasonable explanation for this surplus is that energy firms in Sweden have been improving their energy efficiency and switching to renewable sources of fuel. The surplus of allowances indicates that energy firms in Sweden, on average, could enjoy the benefits of selling off some of the free allocation of allowances.

Another interesting point is to distinguish the impacts of the EU ETS on under-cap and over-cap firms. These two types of firms might have similar features as in the same industry and regulated by the EU ETS, but they differ with respect to the consequences of the trade of allowances. Over-cap firms will have to buy additional allowances. On the contrary, under-cap firms can increase their profits by selling the surplus of allowances. In the empirical part of this paper, we divide the firms in treatment into two sub-samples, under-cap firms and over-cap firms, according to their relative allocation of allowances. This is done following Anger and Oberndorfer (2008), who developed an allocation factor calculated as the quotient of allocated allowances divided by verified emissions. It follows that the regulated firms with an allocation factor less than one are those with over-cap emissions.

3.2. Data

In this study, we use data on allocated allowances and verified emissions at the installation level, as well as economic data at the firm level. The data processing mainly follows Anger and Oberndorfer (2008).

The installation level emissions data published by the Swedish Energy Agency contain the annual amount of allocated allowances and verified emissions for each installation covered by the EU ETS. To be consistent with available economic data, we aggregated the installation level emissions data to the firm level. This left us a group of 216 firms¹⁶ that own the regulated installations. These firms were sorted into six sectors based on their two digital SNI2002 code¹⁷ (Table 1). On this basis, the treatment group in the study was comprised of firms within the sectors of electricity production, electricity distribution, and steam and hot

¹⁶Eleven (11) firms were excluded from the analysis due to missing economic data.

¹⁷SNI2002 is the Swedish standard industrial classification 2002 accurate to five digits.

water supply, amounting to a total of 104 firms. The reasons for this selection are: (i) The vertical integration of the electricity market makes it hard to exactly separate electricity generation from distribution across firms based on the SNI2002 codes. Some firms assigned to electricity distribution (SNI 40131) may be involved with electricity generation as well. (ii) According to Statistics Sweden, steam and hot water supply (SNI 40300) mainly covers the manufacture and distribution of steam and hot water from combined heat and power plants (CHP), which makes it hard to separate pure electricity generation within this subclass. Thus, the identification of the treatment group is not perfect, but it helps us study the question of how the EU ETS affects firm profitability within the electricity and district heating sectors. In addition, the sample of firms in the treatment group was also divided into two sub-samples according to the allocation factor calculated as the ratio of allocated allowances divided by verified emissions. In the sample, under-cap and over-cap firms, respectively, amounted to 64 and 39 in 2005 and 61 and 42 in 2006.¹⁸ About 11 firms that were under-cap in 2005 became over-cap in 2006, and about 8 firms changed in the opposite way.

The economic data used in the study were supplied by Statistics Sweden. It is a panel data set for all Swedish firms from the year 1985 to 2006, providing basic accounting variables. In this study, we used data from 2004 to 2006 to exploit the before/after structure of our research design. As for the treatment/control structure, we firstly construct the control group by using all other energy firms with the same five digit SNI2002 codes as the treatment group, i.e., SNI 40110, 40131, and 40300. This amounted to 865 firms. It should be noted that installations covered by the EU ETS in the energy sector are mainly combustion units with an installed capacity exceeding 20 MW or connected to district heating networks with a total capacity exceeding 20 MW. Hence, firms in the comparison group either do not own combustion installations or own combustion installations with a capacity of less than 20 MW. The descriptive statistics for the main variables in the study are presented in Table 2a to 2c for the respective groups, treatment, and control. It is worth noting that based on descriptive statistics firms in the EU ETS are on average larger than firms in the control group. Also, the firms within a group are quite different in size. In the empirical part, we have thus also tried a propensity score matching method attempting to find a control group similar to the treatment group with respect to firm size. The choice of comparison group and the studied years will be discussed in detail below.

¹⁸There was one firm in 2005 and one in 2006 that lacked emissions data and could not be sorted as either an over-cap or under-cap firm.

Table 1. Sector Distribution of all regulated firms

Sector	Frequency	Percent
SEC1 Manufacture of pulp, paper and paper product (21)*	38	17.59
SEC2 Manufacture of chemicals and chemical products(24)	10	4.63
SEC3 Manufacture of other non-metallic products(26)	13	6.02
SEC4 Manufacture of basic metals(27)	11	5.09
SEC5 Electricity, gas and hot water supply(40)	111	51.39
Production of electricity (40110)	17	
Distribution of electricity (40131)	18	
Trade of electricity (40132)	6	
Distribution and trade of gaseous fuels through mains (40220)	1	
Steam and hot water supply (40300)	69	
SEC6 Others(13,14,15,20,23,25,29,31,34,35,45,51,70,90,93)	33	15.28
Total	216	100

*The numbers in the parenthesis are the corresponding two digital Swedish standard industrial code 2002, which are used to classify the sectors in the data.

Table 2a. Summary of treatment group as a whole and control group

Variable	Year	Control group			Treatment group as a whole		
		Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Net profit (Unit: thousand SEK)	2004	789	22 799.34	300 204.30	103	125 516.30	889 659.40
	2005	865	29 077.15	327 809.40	104	129 775.30	600 305.00
	2006	865	18 620.34	426 975.10	104	179 550.60	1 382 461.00
Turnover (Unit: thousand SEK)	2004	789	73 484.45	457 047.00	103	643 036.40	2 674 295.00
	2005	865	76 365.81	497 442.10	104	679 419.10	2 753 180.00
	2006	865	80 904.19	514 814.30	104	771 524.30	3 345 275.00

Table 2b. Summary of sub treatment groups (2005)

Variable	Year	Over-cap firms in 2005			Under-cap firms in 2005		
		Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Net profit (Unit: thousand SEK)	2004	38	51 296.79	187 045.70	64	171 476.80	1 120 365.00
	2005	39	60 024.62	268 670.50	64	174 225.80	735 095.40
	2006	39	56 025.82	246 797.20	64	257 564.50	1 752 656.00
Turnover (Unit: thousand SEK)	2004	38	442 956.90	1 095 522.00	64	771 545.00	3 290 482.00
	2005	39	456 078.70	1 101 672.00	64	825 796.00	3 406 042.00
	2006	39	488 784.60	1 127 056.00	64	955 531.80	4 175 786.00

Table 2c. Summary of sub treatment groups (2006)

Variable	Year	Over-cap firms in 2006			Under-cap firms in 2006		
		Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Net profit (Unit: thousand SEK)	2004	42	50 019.26	179 330.80	60	179 973.40	1 157 050.00
	2005	42	154 480.70 (1)	659 514.90	61	114 486.50	566 177.70
	2006	42	54 723.67	239 141.80	61	268 001.00	1 795 150.00
Turnover (Unit: thousand SEK)	2004	42	553 641.40	1 233 921.00	60	714 246.20	3 360 174.00
	2005	42	561 112.10	1 236 162.00	61	770 169.50	3 456 097.00
	2006	42	601 572.30	1 275 711.00	61	899 609.30	4 249 048.00

(1) This large number comes from one firm that was under-cap in 2005 but over-cap in 2006 and had dramatic changes in profits in the studied years.

3.3. The econometric model

On the ground that available data are in a longitudinal format, we take the EU ETS as a natural experiment and apply difference-in-differences to investigate the treatment effect on the treated. We make use of dummy variables to distinguish firms according to the before/after, treatment/control structure of the natural experiment. Assume that we are in a two-period context that straddles the policy change: the first period ($t = 1$) refers to the pre-EU ETS year and the second period ($t = 2$) refers to the EU ETS year. Let d_{2t} denote a dummy variable for the second (post-policy change) time period, i.e., $d_{2t} = 1$ if $t = 2$ and 0 otherwise. To distinguish the firms in the treatment group from those in the control, we introduce a binary policy indicator ETS_{it} , which is unity if firm i owns regulated installations in period t . It then follows that ETS_{it} is 0 for all the firms in the pre-EU ETS year. Before introducing the model, it is worth noting that the firms in the treatment and control groups are widely different in size as indicated above, which makes first-hand comparison of profits inappropriate. To address this problem, we divide the net profits by turnover in the same year to obtain a ratio,¹⁹ which helps with the validity of comparison and mitigates the potential problem of heteroskedasticity in relation to firm size. We start with the simplest form²⁰

$$\frac{\pi_{i,t}}{TO_{i,t}} = \alpha + \beta_0 d_{2t} + \beta_1 ETS_{it} + a_i + u_{it}, \quad t = 1; 2$$

in which we write out the error term into two parts, with a_i as the unobserved time invariant component or equivalently representing heterogeneity of firms and u_{it} as the idiosyncratic component, while $\pi_{i,t}$ and $TO_{i,t}$ represent the individual profits and turnover in period t , respectively. The strategy here is to difference out the unobserved fixed effect with respect to the two time period, which gives

$$\frac{\pi_{i,t=2}}{TO_{i,t=2}} - \frac{\pi_{i,t=1}}{TO_{i,t=1}} = \beta_0 + \beta_1 (ETS_{i,t=2} - ETS_{i,t=1}) + (u_{i,t=2} - u_{i,t=1})$$

$$\text{Or} \quad \Delta \tilde{\pi}_i \equiv \frac{\pi_{i,t=2}}{TO_{i,t=2}} - \frac{\pi_{i,t=1}}{TO_{i,t=1}} = \beta_0 + \beta_1 ETS_i + \Delta u_i \quad (1)$$

¹⁹The ratio is roughly called the profit margin in financial analysis.

²⁰The model is consistent with the equation (13.26) in Wooldridge (2003). Some other models put α and a_i together as a single term to indicate the fixed effect. Here, we kept them separate to address the fact that a_i is the unobserved error term.

where $ETS_i = 1$ represents the firms in treatment. By assuming that the mean of Δu_i is zero and the variance of Δu_i is constant in (1), we can then estimate the β_1 in a standard OLS framework and obtain an unbiased estimator simply as

$$\hat{\beta}_1 = \overline{\Delta \tilde{\pi}_{treat}} - \overline{\Delta \tilde{\pi}_{control}}$$

which is also called the difference-in-differences estimator (Wooldridge, 2003).

In the study, we are interested in the questions that whether the EU ETS has impact on the profitability of energy firms and whether under-cap firms respond to the EU ETS differently in comparison with over-cap firms. The first question can be investigated by testing $\beta_1 = 0$ vs $\beta_1 \neq 0$ in equation (1). As for the second question, we introduce dummy variables for the two types of firms and estimate the following equation:

$$\Delta \tilde{\pi}_i = \gamma_0 + \gamma_1 \text{undercap}_i + \gamma_2 \text{overcap}_i + \Delta u_i \quad (2)$$

where undercap_i takes the value 1 for under-cap firms in the studied EU ETS year and 0 for other firms (including over-cap firms and non-EU ETS firms), the overcap_i is defined in the same manner. What we are interested is then to test $\gamma_1 = \gamma_2$ vs $\gamma_1 \neq \gamma_2$.

Meyer (1995) stated clearly in his seminal paper of natural experiments that one of the main threats to the validity of inference from the difference-in-differences research design is that changes besides the treatment are not likely to always influence all groups in the same way. For instance, the fuel prices would have greater influence on the more energy intensive firms; weather conditions such as precipitation would influence energy supply firms much more than the steel makers. By this token, the research design of the difference-in-differences is most plausible when the control group is very similar to the treatment. As such, we take all other firms with the same industrial classification as the treatment group to construct the control group since they share the common industrial characteristics. However, in comparison with other energy firms under the same industrial classification, we are not able to sort out the impact of the EU ETS from the premium in electricity prices. This is because both the treatment and control groups benefit from the increased electricity price if the passing-through of CO₂ price occurs. Hence, the coefficient related to the introduction of the EU ETS in the model only contains the impact from the trade of allowances and technology improvement.

Also, as is well known, the validity of the difference-in-differences estimator is based on the assumption that the trends of the outcome variable in the studied period would be the same in both treatment and control groups in the absence of the treatment. There are some differences in the raw trends in net profits in the treatment and control groups in the years

before the introduction of the EU ETS. However, it should be noted that the energy sector in Sweden has gone through big changes since 1996, for instance the deregulation in 1996, the market integration occurring in the Nord Pool market during 1996 and 2002, and the Electricity Certificate System launched in 2003. These changes make it difficult to sort out if differences in trends between the treatment and control groups before 2004 are due to the structural changes of the market, or if there are differences in the underlying trends related to firm profits. As such, we take the year 2004 as the pre-EU ETS year in this study, assuming the common trend assumption to be fulfilled for the studied period.

3.4. The empirical results

The estimation results are presented in Tables 3a and Table 3b below. The reported standard errors are White's standard errors, corrected for heteroskedasticity of unknown form (Wooldridge, 2002). The results show that, taking the treatment group as a whole, no significant treatment effect is present in 2005, while a negative effect is revealed at the 5% significance level in 2006. Regarding the sub-sample analyses, the p-values for the hypothesis test $\gamma_1 = \gamma_2$ vs $\gamma_1 \neq \gamma_2$ are 0.0491 and 0.2417 for 2005 and 2006, respectively.²¹ That is, the EU ETS affected under-cap and over-cap firms differently in 2005, but not in 2006.

As stated in the theory section, the treatment effect is mainly from the impact of the trade of allowances and technology improvement. From Figure 1 above, we see that the price of allowance in 2005 was initially around € 10/tCO₂ but rose to a highest level close to € 30/tCO₂ in July and thereafter fluctuated around €22/tCO₂ for the remainder of the time. In 2006, the price initially went up, but when the first data on verified emissions were released in the spring of 2006, it fell sharply since the data showed that most of the countries exhibited a "long" position. Since then, the price has decreased dramatically, almost touching €5/tCO₂ toward the end of 2006. This indicates that the impact from buying and selling allowances was much stronger in 2005 than it was in 2006. With respect to technology improvement, the most direct way to abatement is to invest in machinery. As shown in Table 4, the investment

²¹The test was done in Stata by the Wald test on the basis of the variance-covariance matrix of estimates. Although the estimates and standard errors are similar for γ_1 and γ_2 , the covariance between them prompts us to reject the null hypothesis that $\gamma_1 = \gamma_2$ in 2005. As the descriptive statistics show that firms affected by the EU ETS are on average much larger than firms in the control group, the results could be affected by selection bias. As such, a propensity score matching method, using the number of employees, profits after financial items and turnover as the independent variables in the first step probit estimation has also been used when selecting firms belonging to the control group. However, since all qualitative results from the estimations using all firms in the control group are similar with the ones using the control group restricted by the propensity score method, the more general results including all firms in the control group are the ones presented in this paper.

Table 3a. Estimates on the policy indicator (ETS)

Variable	2005			2006		
	Estimate	Std.	t	Estimate	Std.	t
ETS	1.763	1.4906	1.18	-1.147	0.5192	-2.21
Contant	-1.731	1.4904	-1.16	1.129	0.5189	2.18
Obs.	798			797		
R-squared	0.0003			0.0009		

Table 3b. Estimates for the separate analysis

Variable	2005			2006		
	Estimate	Std.	t	Estimate	Std.	t
Undercap	1.791	1.4918	1.20	-1.132	0.5196	-2.18
Overcap	1.716	1.4915	1.15	-1.170	0.5200	-2.25
Contant	-1.731	1.4914	-1.16	1.129	0.5193	2.17
Obs.	797			796		
R-squared	0.0003			0.0009		

Table 4. Summary of gross investment in machinery

Variable	Year	Control group			Treatment group as a whole		
		Obs	Mean	Std. Dev.	Obs	Mean	Std. Dev.
Gross invest. In machinery (Unit: thousand SEK)	2004	789	9 307.44	66 667.87	103	81 290.43	199 882.70
	2005	865	11 009.36	88 303.71	104	100 397.20	266 516.40
	2006	865	15 916.57	132 611.60	104	164 146.70	678 498.10
Growth rate ⁽¹⁾ of gross invest. In machinery	2004	339	0.15	1.67	100	0.15	1.37
	2005	349	0.12	1.73	99	0.11	1.32
	2006	392	-0.01	1.77	98	0.38	0.98

⁽¹⁾The growth rate is calculated as the log difference of gross investment in machinery. There are a few firms in the control group, with an investment in machinery equal to 0, that were excluded when calculating the growth rate by the log difference.

in machinery on average grew at a higher rate in 2006 in the treatment group than in the control group. The variable of investment in machinery in our dataset is too general to determine how much is related to the EU ETS, but it does give us a rough idea that investment in abatement and energy efficiency were occurring. However, it is worth noting that we studied the first two years of implementation, which might be too short a period to show the causal effect of the EU ETS on investment in abatement. Still, taking it for granted that the investment is occurring, a possible explanation for our findings of the insignificant impact in 2005, and the negative significant impact in 2006, is that the benefits of the free allocation under the relatively high price of allowances in 2005 were cancelled out by the induced investment costs. However, the low price of allowances in 2006 reduced the benefits from free allocation, and this made it difficult to cover the induced investment costs. The estimate in 2006, -1.147, suggests a strong negative impact of the EU ETS on firm profitability. This may be the result of the combined effect of the decreased price of allowances and potentially

more investments in abatement in 2006. The explanation for the result that under-cap and over-cap firms were affected differently in 2005 but not in 2006 could be that the price of allowances was relatively high in 2005, imposing a strong impact from the trade of allowances on profits. As we also see when the price went down in 2006, no statistically significant effects were found any more. The slightly higher estimate for the under-cap firms in 2005 supports our idea that under-cap firms could gain from selling their surplus of allowances, while over-cap firms suffer from having to buy additional allowances. However, the difference between the two types of firms is small, which is to be expected since the trade of allowances is not the main activity in energy firms generating profits.

4. Conclusion

In this paper, we use a sample of Swedish energy firms to conduct an empirical analysis of the impact of the EU ETS on the profitability of firms. The research design in the study makes it difficult to investigate the impact from changes in the electricity price in relation to the EU ETS. The purpose is rather to shed light on the effect of the EU ETS on firm profitability due to the trade of allowances and technology improvement. A difference-in-differences strategy is applied on an unobserved fixed effect two-period panel data model to investigate the treatment effect. To our knowledge, this paper is the first of its kind in the quantitative studies of the EU ETS.

The estimation results do not show any significant impact of the EU ETS on firm profitability in 2005, but suggest a negative significant impact in 2006. The results can, perhaps, be interpreted by following changes in the price of allowances and potential investments in abatement. The price of allowances was relatively high in 2005, but quite low in 2006. From Table 4, we also see an increase in investment in machinery during these years, which may be related to the introduction of the EU ETS. It could be that the free allocation and relatively high price of allowances in 2005 cancel out the induced investment costs occurring in firms, resulting in an insignificant impact of the EU ETS. However, when the price of allowances went down in 2006, the benefits from the free allocation were reduced, and the empirical analysis shows a negative impact of the EU ETS on firm profitability. Also, the sub-sample analysis shows that the EU ETS had a different impact on under-cap and over-cap firms in 2005, but not in 2006. A possible explanation for this is that the relative high price of allowances in 2005 had a strong impact on firms from buying and selling the allowances, and the low price in 2006 weakened the impact of trading allowances.

Analogous to Anger and Oberndorfer (2008), a point related to the methodology needs to be emphasized here. It is by all means very early to conduct an ex-post analysis for the EU ETS. To date, the firm-level economic data available to us is only up to 2006. For a long-term policy, an ex-post analysis of the early years can bring forward appealing insights, but the robustness of the estimated reform effects could be questioned. In this way, the main purpose of the study was to set up a model as a basis for future study. Furthermore, the analysis can be applied to other measurements of interest as well. The reason for choosing profitability is that profits should respond quickly to the reform. Other measurements, such as investment, may respond with a time lag, but could also be the focus of future studies.

References

- Anger, N. and Oberndorfer U. (2008). "Firm performance and employment in the EU emissions trading scheme: An empirical assessment for Germany," *Energy Policy* 36(1): 12-22.
- Brännlund, R. and T. Lundgren (2007). "Swedish industry and Kyoto—an Assessment of the Effects of the European CO₂ Emission Trading System," *Energy Policy* 35(9): 4769-4762.
- Chen, Y., Sijm, J., Hobbs, B., and Lis, W. (2008). "Implication of CO₂ Emission Trading for Short-run Electricity Market Outcomes in Northwest Europe," *Journal of Regulatory Economics* 34: 251-281
- Ellerman, A. D., Buchner, B. K., and Carraro, C. (2008). *Allocation in the European Emissions Trading Scheme: Rights, Rents and Fairness*. Cambridge University Press.
- Fell, G. H. (2008). "EU-ETS and Nordic Electricity: A CVAR Approach (August 15, 2008)," RFF Discussion Paper No. 08-31.
- Econ (2006). "The Use of Emissions Trading in Relation to other Means of Reducing Emissions--A Nordic Study."
- Johansson, B. (2006). "Climate Policy Instruments and Industry—Effects and Potential Responses in the Swedish Context," *Energy Policy* 34(15): 2344-2360.
- Kruger, A. J., Oates W. E., and Pizer A. W. (2007). "Decentralization in the EU Emissions Trading Scheme and Lessons for Global Policy," *Review of Environmental Economics and Policy* 1: 112-135.
- Meyer, B. D. (1995). "Natural and Quasi- Experiments in Economics," *Journal of Business*

- and Economic Statistics 13: 151-162.
- Ministry of Sustainable Development Sweden (2005). "The Swedish Report on Demonstrable Progress under Kyoto Protocol."
- Norden (2008). Relationship Between CO₂, Fuel, and Electricity Prices and the Effect on GHG Emissions in Nordic Countries. TemaNord 2008:528
- Oberndorfer, U. and K. Rennings (2006). "The Impacts of the European Union Emissions Trading Scheme on Competitiveness in Europe," ZEW–Centre for European Economic Research Discussion Paper No. 06-051.
- Oberndorfer, U. and K. Rennings (2007). "Cost and Competitiveness Effect of the European Union Emissions Trading Scheme," European Environment 17: 1-17.
- Sijm, J., Neuhoff, K., and Chen, Y. (2006). "CO₂ Cost Pass-through and Windfall Profits in the Power Sector," Climate Policy 6: 49-72.
- Smale, R., Hartley, M., Hepburn, C., Ward, J. and Grubb, M. (2006). "The Impact of CO₂ Emissions Trading on Firm Profits and Market Prices," Climate Policy 6: 29-46.
- Swedish Environmental Protection Agency (2006). "Results of the EU ETS Reporting in Sweden 2006."
- Swedish Energy Agency and Swedish Environmental Protection Agency (2007). "The Development of the Swedish Climate Strategy."
- Swedish Energy Agency (2007). "The Electricity Certificate System, 2007."
- Tarjanne, R., and Kivistö, A. (2008). "Comparison of Electricity Generation Costs," Research Report, Lappeenranta University of Technology.
- Widerberg, A. and Wråke M. (2009). "The Impact of the EU Emissions Trading System on CO₂ Intensity in Electricity Generation," Working papers in economics at the School of Business, Economics and Law, University of Gothenburg (No. 361).
- Wooldridge, J. M. (2002). Econometric Analysis of Cross Section and Panel Data, MIT Press (Cambridge, MA).
- Wooldridge, J. M. (2003). Introductory Econometrics: A Modern Approach, 2nd ed. Thomson South-Western.

Appendix

Table A1. Policy instruments for Swedish climate strategy with quantified effects (Ministry of Sustainable Development, Sweden, 2005)

Instrument/Sector	Main greenhouse gas concerned	Calculated effect in million tonnes CO ₂ per year(2010)	Status
Cross-sectional instruments			
Local Investment Programme, LIP	All	Up to 1.5 Mtonnes	Under completion
Climate Investment Programme, KlimP	All	Up to 0.5 Mtonnes	Ongoing (2003-)
Energy excluding transport			
Energy tax	CO ₂	10	Ongoing (1957-)
Carbon dioxide tax			Ongoing (1991-)
European Union Emission Trading Scheme (EU ETS)			Ongoing (2005-)
The electricity certificate system			Ongoing (2003-)
Industrial processes incl. emissions of F-gases			
Application of the environmental code	PFC	0.2	Ongoing (1999-)
Future F-gas ordinance and directive on mobile AC systems	Mainly HFC	0.15	Under planning
Transport sector			
Energy and carbon dioxide taxes	CO ₂	1.6-3.4	Ongoing
Change in taxation of company cars	CO ₂	0.2	Ongoing (1997-)
Tax reduction for transport biofuels	CO ₂	0.4	Ongoing (2004-)
Instruments for introduction of green cars	CO ₂	0.2	Ongoing
Waste Sector			
Regulations on municipal planning, producers responsibility, landfill tax, ban on depositing unsorted combustible and organic waste	Methane	1.4	Ongoing

WORKING PAPERS*

Editor: Nils Gottfries

- 2010:1 Jonathan Gemus, College Achievement and Earnings. 43 pp.
- 2010:2 Susanne Ek and Bertil Holmlund, Family Job Search, Wage Bargaining, and Optimal Unemployment Insurance. 30 pp.
- 2010:3 Sören Blomquist and Laurent Simula, Marginal Deadweight Loss when the Income Tax is Nonlinear. 21 pp.
- 2010:4 Niklas Bengtsson, The marginal propensity to earn, consume and save out of unearned income in South Africa. 34 pp.
- 2010:5 Marcus Eliason and Henry Ohlsson, Timing of death and the repeal of the Swedish inheritance tax. 29 pp.
- 2010:6 Teodora Borota, Innovation and Imitation in a Model of North-South Trade. 44 pp.
- 2010:7 Cristiana Benedetti Fasil and Teodora Borota, World Trade Patterns and Prices: The Role of Productivity and Quality Heterogeneity. 24 pp.
- 2010:8 Johanna Rickne, Gender, Wages and Social Security in China's Industrial Sector. 48 pp.
- 2010:9 Ulrika Vikman, Does Providing Childcare to Unemployed Affect Unemployment Duration? 43 pp.
- 2010:10 Sara Pinoli, Rational Expectations and the Puzzling No-Effect of the Minimum Wage. 56 pp.
- 2010:11 Anna Persson and Ulrika Vikman, Dynamic effects of mandatory activation of welfare participants. 37 pp.
- 2010:12 Per Engström, Bling Bling Taxation and the Fiscal Virtues of Hip Hop. 12 pp.
- 2010:13 Niclas Berggren and Mikael Elinder, Is tolerance good or bad for growth? 34 pp.
- 2010:14 Magnus Gustavsson and Pär Österholm, Labor-Force Participation Rates and the Informational Value of Unemployment Rates: Evidence from Disaggregated US Data. 10 pp.
- 2010:15 Chuan-Zhong Li and Karl-Gustaf Löfgren, Dynamic cost-benefit analysis of large projects: The role of capital cost. 8 pp.

* A list of papers in this series from earlier years will be sent on request by the department.

- 2010:16 Karl-Göran Mäler and Chuan-Zhong Li, Measuring sustainability under regime shift uncertainty: A resilience pricing approach. 20 pp.
- 2010:17 Pia Fromlet, Rational Expectations And Inflation Targeting - An Analysis For Ten Countries. 38 pp.
- 2010:18 Adrian Adermon and Che-Yuan Liang, Piracy, Music, and Movies: A Natural Experiment. 23 pp.
- 2010:19 Miiia Bask and Mikael Bask, Inequality Generating Processes and Measurement of the Matthew Effect. 23 pp.
- 2010:20 Jonathan Gemus, The Distributional Effects of Direct College Costs. 34 pp.
- 2010:21 Magnus Gustavsson and Pär Österholm, Does the Labor-Income Process Contain a Unit Root? Evidence from Individual-Specific Time Series. 26 pp.
- 2010:22 Ranjula Bali Swain and Adel Varghese, Being Patient with Microfinance: The Impact of Training on Indian Self Help Groups. 32 pp.
- 2010:23 Ranjula Bali Swain and Maria Floro, Reducing Vulnerability through Microfinance: Evidence from Indian Self Help Group Program. 32 pp.
- 2010:24 Ranjula Bali Swain and Adel Varghese, Microfinance 'Plus': The Impact of Business Training on Indian Self Help Groups. 9 pp.
- 2010:25 Mikael Bask and Anna Widerberg, Measuring the Stability of a Dynamic System: The Case of the Stock Market Turmoil 2007-2008. 20 pp.
- 2010:26 Stefan Eriksson and Jonas Lagerström, The Determinants and Consequences of Unemployed Workers' Wage Demands. 30 pp.
- 2010:27 Olof Åslund, Per-Anders Edin, Peter Fredriksson and Hans Grönqvist, Peers, neighborhoods and immigrant student achievement - evidence from a placement policy. 42 pp.
- 2011:1 Matz Dahlberg, Karin Edmark and Heléne Lundqvist, Ethnic Diversity and Preferences for Redistribution. 43 pp.
- 2011:2 Haishan Yu, The EU ETS and Firm Profits: An Ex-post Analysis for Swedish Energy Firms. 19 pp.