GOING GREEN, INVESTING FOR LONG TERM PROFITABILITY IN RENEWABLE ENERGIES IN THE FACE OF A CAP-AND-TRADE SYSTEM: A CASE STUDY OF SWEDISH ENERGY PRODUCING FIRMS

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Abstract

In response to national commitments to lower carbon emissions and to government-mandated firm-specific emissions reduction targets using an emission cap-and-trade system, affected firms are subjected to an added marginal cost related to carbon emissions. Assuming that affected firms are profit seeking, they must alter their business strategies and investment plans to accommodate this new cost. To examine how businesses change strategies in the face of a new marginal cost, I look at the choices made by Swedish electricity-producing firms in the face of the European Union's Emissions Trading Scheme. Through regressions of each firm's profit, I discover that the investing in renewable energies will be the most profitable strategy in the long run.

KEYWORDS: (Business Strategy, Marginal Cost, Emission Reductions)

ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED UNAUTHORIZED AID ON THIS THESIS

Signature

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Introduction

The global scientific community has come to a consensus that worldwide carbon emissions are creating climate change and have become a risk to the future sustainability of our world. Although there are multiple sources for carbon emissions, scientists conclude that certain business activities emit a large and increasing amount of carbon into the atmosphere.

Governments have responded to the threat of climate change by imposing limits on carbon emissions, and enacting policies to effect a reduction in carbon emissions. The largest global response to climate change to date is the Kyoto Protocol treaty. Under the Kyoto Protocol, developed nations have committed to emissions reduction targets and enacted policies to reduce carbon emissions. One such response is the European Union's Exchange Traded System (EU ETS), a carbon emissions cap and trade system that covers all member states of the European Union.

In this paper, I examine the effectiveness of the EU ETS in affecting a shift in business activity away from more carbon emitting practices and toward lower carbon emitting business practices by analyzing investments in a single key business sector in one country covered by the EU ETS. I hope to prove that the EU ETS effectively promotes a shift in business practices in the power production industry in Sweden, thereby helping Sweden meet its national goal of lowering carbon emissions according to its commitment under the Kyoto Protocol treaty.

Literature Review

In 1992, at the United National Conference on Environment and Development, over 170 countries agreed to work together "to stabilize greenhouse gas concentrations in the atmosphere at a level that will prevent dangerous human interference with the climate system." establishing a widespread commitment to capping and reducing carbon emissions worldwide (UNFCCC 2015).

In 1997, the majority of the world's countries agreed to the Kyoto Protocol, a treaty setting out binding emissions reduction commitments in developed countries. Those countries could reduce their emissions domestically or through international market mechanisms (UNFCCC 2015). The Kyoto Protocol includes a provision for emissions trading. The largest operating emissions trading scheme in the world is the European Union Emissions Trading Scheme (EU ETS), started in 2005.

The single largest source of carbon emissions worldwide is energy supply: the burning of coal, natural gas, and oil for electricity and heat. For this reason, and because of the relative ease of monitoring power plant output, reduction of emissions from power generation is one of the first targets for efforts to reduce global carbon emissions (UNFCCC 2015).

Since the adoption of the Kyoto Protocol, multiple studies have been done on the economic effects of a carbon emissions cap, specifically the effects on investment in renewable energy, energy prices, and the effects of an emissions cap on energy producers and energy producers' economics. In this paper, I investigate how added costs due to a carbon cap-and-trade system affect energy production firms' investment in renewable energies.

Why Cap and Trade Systems?

The question that must first be answered is why have governments chosen to regulate and promote emissions reductions using a cap-and-trade system instead of through other tools such as a carbon tax or a command and control scheme? According to Environmental Defense Fund, by attaching private profits to emission reductions, cap-and-trade systems engage private actors to be the drivers of the process: “Cap-and-trade programs harness process and organizational innovations in industry for environmental purposes, driving private profit motives to deliver public benefits” (Environmental Defense Fund 2012, p.10). Lawrence Goulder offers another explanation that political realities have made cap and trade the obvious first step for governments:

> Cap and trade has been an easier political sell than a pollution tax, partly because cap and trade is less costly to the covered firms than a pollution tax would be.[10] It is also partly because the public, often averse to any new tax, has tended to view a cap-and-trade program as something very different from a tax measure.
>
> [10] This statement assumes that the pollution tax policy does not include inframarginal exemptions. Such exemptions would function much like free allowances under a cap-and-trade system, lowering the costs to the covered firms (Goulder 2013, p.99).

Experience has shown that emissions reductions have not been an easy political sell. Developed country signatories to the Kyoto Protocol have experienced great domestic pressure not to commit to emissions reductions schedules that would hinder their economies, and many have lowered domestic mandated emissions cuts in response to political pressure. However, inherent economic advantages to firms of a cap-and-trade system, with flexibility allowing firms to reduce their emissions profile in the most cost effective manner, continues to present an appealing option for quickly reducing worldwide carbon emissions.

Carbon Cap Effects on Electricity Prices

The effects of a cap on carbon emissions have been a widely discussed since the Kyoto Protocol. A cap on carbon emissions can be seen as both an opportunity cost and a competitive advantage. The added opportunity cost of a price on carbon emissions forces firms to compensate, usually by increasing their prices. “The carbon trading system directly affects the operating price of the marginal cost plant, which will have the greatest impact on the price of electricity” (Environmental Defense Fund 2012, p.21). There have been many studies examining the role of marginal costs in electricity price dynamics. According to Kirat & Ahamada 2009:

> The price of electricity is determined by the cost of fossil fuels, the impact of environmental policies, and climatic factors such as temperature and rainfall. Economic theory suggests that the carbon price is a marginal cost and that the opportunity cost of the carbon permit equals its market price. As such, the carbon price should be reflected in the price of electricity (p. 995).

One well-documented way firms compensate for this additional cost is by passing it directly along to their customers. In a 2007 article on carbon allowances and electricity price interaction, Julia Reinaud explains that firms, wishing to maximize their profits, will pass on this new cost to the customers through increased MWh prices (Reinaud 2007, p.22).

According to microeconomic theory, electricity is an inelastic product and an increase in the price of electricity will only slightly decrease demand. Therefore, continued high demand for electricity combined with addition costs related to carbon emissions will create pressure to shift production away from carbon intensive electricity production methods and towards the less carbon intensive production of renewable energy technologies.

Many developed country energy agencies, including the European Union's, are promoting increased investment in renewable energy sources in part to address the long term cost outlook of electricity production. However, as Reinaud articulates, energy production is highly capital-intensive and changing the mix of domestic energy production is expensive and can be complicated**.**

Carbon Cost's Effect on Investment & Profit

Adding a marginal cost to carbon emissions puts added importance on the makeup of the fuel sources for electricity production. When carbon emissions come with a price, electricity producers must include carbon emissions in their cost calculations, and should find less carbon intensive production methods to be more attractive for future investment. If national and international governments remain committed to reducing worldwide carbon emissions and recognize the inelastic nature of demand for electricity, the logical outcome of a cap-and-trade system is to promote a shift to cleaner energy production systems:

> The main objective of the EU ETS is to encourage the industry's biggest emitters to reduce their carbon emissions and invest in clean technologies. Achieving this objective relies on a real carbon price signal inducing electricity producers to make long-run choices to produce electricity with fewer emissions (Kirat, Ahamada 2009, p.995).

With a large investment needed in order to create new plants, companies must weigh any investment with other uncertain factors. Reinaud elaborates on the important factors companies must consider when investing in new plants in her discussion of new self-generating plants built by larger electricity users:

> When deciding to build a self-generation plant, therefore, analysis should be made on the immediate- but also the future environment. Several elements need to be taken into account, including (Kara, 2006):
>
> - Electricity price development. When building a power plant for self-generation purposes, as mentioned above, the cost of the self-generated electricity is compared to market prices. If prices are above for a certain period, then it is rational to invest. Estimates for prices beyond forward price indications are needed.
>
> - Political steering. Political risks include, for example, the creation of economic or environmental constraints that may change the profitability of self-generation investments.
>
> - Price development of fuels and emission allowances. Natural, prices developments of the power plant's feed costs are of critical importance in the outcome of the investment's profitability.
>
> - Electricity consumption estimates may also be an important factor, but this mostly depends on whether the industrial facility has additional available capacity and sells the later to the market (Reinaud 2007, p.35).

As investing in renewable energies is encouraged in the EU ETS, understanding the economics of energy firms is important to determine how to promote investing in renewable energies. As Chesney et al. 2000 puts it; the irreversible nature of investing in projects must also be taken into account.

> If the investment project is irreversible, then the investment decision will be taken with more caution, that is, could be delayed. On the contrary, a possible ability to switch or to abandon the project once started, will have an impact on the timing of the decision, that is, will generate more incentives to invest sooner (p.94).

Electricity-producing firms weigh the opportunity cost of investing in new technology and plant versus shorter-term profit maximization. Investment in a new plant will not provide returns to the firm until much later on. In order for firms to invest in renewable energies, they must be sure that the payoff in the future is greater than the opportunity cost of not investing.

To promote investment in renewable energies, a cap-and-trade system must be structured so potential long-term profit potential favors investment in renewable energy technologies. One way which cap-and-trade systems promote investment is by changing the cost dynamics of the different energy sources. “The cost of electricity production differs according to the primary energy source used, and therefore so does profitability…In the electricity-generation sector, this supply function reflects changes in the merit order curve between the primary energies” (Kirat, Ahamada 2009, 996). As previously noted, the most direct impact of a cap on carbon emissions is to add a marginal cost to electricity production. However, the marginal cost does not affect all fuel sources evenly because different fuel sources have different emissions profiles. By increasing the cost of using carbon-heavy fuel sources by capping emissions, the marginal cost of carbon intensive fuel sources goes up relative to more efficient fuel sources, and the marginal cost changes the merit order of fuel sources. This change makes clear the benefit of investing more in renewable energies for the future.

Not only is it important to examine the make up of fuel sources and their emissions, but other factors that influence the fuel sources must also be taken into account. In this paper, my primary case study is Sweden. The majority of electricity produced in Sweden is though hydropower. Although hydropower is quite dependable as a fuel source, electricity supplied from hydropower is still dependent on rainfall. Rainfall determines the water levels of the water sources used to produce hydropower. If the water sources are reduced to a point where Sweden’s hydropower plants cannot produce at their potential output levels, demand for replacement electricity will rise. The demand for electricity that would normally be satisfied by the supply from hydropower will now have to come from other sources. The demand for replacement electricity is usually filled by higher carbon content fuel sources such as natural gas or petroleum because electricity production in these types of plants is fastest to ramp up.

A cap and trade system is designed to allow cost factors to drive overall emissions reductions. In addition to the marginal cost of producing electricity with different emissions profiles, there is another variable in a cap and trade system – the cost of carbon credits.

The Allocation of Carbon Credits

A cap-and-trade system is only effective so long as the credits hold their value. "The extent to which emissions trading programs result in cost savings crucially depends on the design of the system" (Ehrhart, Hoppe Schleich, Seifert 2006, p.32). This means that the EU ETS must have a system that will have market forces drive the credit price.

The biggest influence on the price of the credits will be the supply of credits. Many articles show the effects of over-allocation and under-allocation of credits and how the price reacts. Microeconomic theory argues that, if the supply is not at equilibrium, the price will be affected and affect the total demand for credit prices. If the amount of credits is too much, the price of credits will be low, resulting in a low added marginal cost. This will not incentive firms to invest in renewable energy source, but with too few credits circulating, firms will either not be able to produce enough electricity.

When examining the EU ETS, we must look at outcomes and expected outcomes for each established phase. The EU ETS was designed with 3 distinct phases to maximize its effectiveness. In the first phase, Phase I, started in 2005 and ended in 2007, was designed as a learning period, and through the course of Phase I the ETS tended to overallocate credits to firms, sending the price for credits plummeting down. The ETS gathered data on emissions from firms during Phase I to better project future emissions and refine future allocations to reach the desired emission reduction goals. "In addition to reducing emissions, the pilot phase successfully met its key carbon-trading infrastructure goals: to establish a price for carbon, begin trading in emissions allowances across the EU, and create the institutions necessary for monitoring, reporting, and verifying emissions" (Environmental Defense Fund 2007, p.7). By using the first phase of the ETS to establish a price mechanic, carbon credits will pose a real marginal cost.

The conclusions I have drawn from my literature review are that:

- Government regulations designed to reduce carbon emissions will continue for the foreseeable future,
- Political and free market principles have led to the adoption of carbon cap and trade mechanisms as the most cost effective means to encourage carbon emission reductions,
- A carbon cap and trade system will cause firms to pass along additional carbon-related costs to customers,
- The additional cost of carbon is expected to shift investment economics of different fuel sources, in favor of less carbon-intensive fuels, and
- Carbon credit allocation could affect short-term costs of carbon emissions, but long-term, should be used to pressure investment in less carbon-intensive fuels.

Theory

The majority of energy production firms in developed countries, whether state-owned or otherwise, operate as profit-making enterprises. Therefore, energy producers facing an emissions cap must take the added marginal cost of carbon emissions into account when investing to maintain future profitability. There are multiple ways to invest for lower carbon emissions, including decreasing electricity generation, lobbying for more favorable legislation, purchasing extra credits while maintaining existing production levels, switching fuel sources, and investing in renewable energy. Although some of the options could increase or maintain profitability of firms in the short term, results will be inconsistent, unreliable, or even contractually impossible. The most reliable option for maintaining profitability given a new added marginal cost on carbon emissions is to invest in lower carbon emitting renewable energy resources.

To investigate this theory, I will examine how four Swedish energy producers have reacted to emissions reductions called for in the Kyoto Protocol and to Sweden's participation in the European Union's Emissions Trading Scheme (EU ETS).

Did Swedish energy firms choose to decrease overall output? No, probably because of investment and cash flow planning cycles are long in electricity production, and because of the contractual nature of their existing power purchase agreements (PPAs)– PPAs require a power producer to provide a certain amount of energy at an agreed upon price for the life of the agreement.

Did Swedish firms opt to lobby for higher emissions targets? If they did, they were not successful. Sweden participates in the EU ETS cap and trade system, operating since 2007. The largest carbon emission cap and trade system in the world, the EU ETS targets electricity producers both because electricity production is the largest overall source of carbon emissions in Europe and because emissions from energy producers "can be measured, reported, and verified with a high level of accuracy" (European Commission 2013, p. 3).

The Swedish electricity market is not only influenced to reduce emission by European Union commitments, but also from domestic Swedish policies. In 2003, Sweden implemented the electricity certificate system, the ECS. According to Yu 2013;

> The aim of the ECS is to bring a greater proportion of electricity production from renewable sources into the country's energy system, increasing the production of electricity from renewable sources and from peat by 25 TWh by 2020 relative to production in 2002 (p. 63).

In order to achieve this goal, the ECS gives a green certificate for each MWh of renewable energy produced and requires all firms, with the exception of the manufacturing industry, to meet a quota of certificates. This legislation not only pressures electricity producers directly to invest in renewable energy sources, but since consumers must also meet a quota of green certificates, electricity producers are further pressured by consumers to invest more in renewable energy. Lobbying for higher emissions targets either did not happen or has not been an effective response to new carbon costs in Sweden.

At least one large Swedish firm has purchased credits to meet its mandated cap on emissions. According to Financial Times:

> The biggest single buyer of credits in Europe last year was Vattenfall, the Swedish energy group... according to figures compiled by Sandbag, an environmental campaigning group that specializes in carbon trading. Vattenfall used UN credits to cover about 7.4 per cent of its emissions (Harvey 2010).

The two remaining options for adapting to the added cost of a carbon cap are fuel switching and investment in renewable sources. Each of these is applicable to Swedish energy producers.

Switching fuel sources is an option for Swedish energy producers, depending on the existing production technology. Most electricity in Sweden is generated from hydro and nuclear are not eligible for fuel switching. According to Swedenergy 2013, "In 2012, electricity production was composed of 48% hydro-power, 38% nuclear power and 4% wind power. The remaining 10% was combustion-based production, mainly from CHP plants and industry" (p. 42). Hydro, nuclear, and wind power facilities cannot switch fuel sources. Fuel switching is primarily used to convert coal use to natural gas in and existing plant or to switch biofuel sources. The larger Swedish electricity producers have investments in coal plants in other countries in Europe where fuel switching is an option to reduce carbon emissions. However, the cost of coal has dropped in Europe as the U.S. has shifted towards more natural gas in the past few years, exporting more coal to Europe pushing coal prices in Europe down.

For the purpose of this paper, I will focus on examining investment in renewable energy because Swedish public policy leans heavily towards pro-environment policies and I believe that Sweden's electricity producers will chose to invest in renewable energy as their primary means of adapting to the additional cost of a cap on emissions under the EU ETS.

It must be noted that an electricity producers' ability to invest in renewable energy sources is affected by their internal capital flows and access to capital, and by their existing production commitments. Large investments in utilities, including renewable energy projects, must be timed appropriately and take time to implement.

My examination of the experience of Swedish energy producers' investments under the EU ETS will be restricted to 4 firms in the time from 2004 to 2013. I will review investments by two large firms selling power to the grid: Vattenfall and Fortum, a medium-sized city-owned energy firm, Goteborg Energi, and Holmen Energi, a smaller energy firm subsidiary of a large wood product conglomerate self-generating power for its own use. I believe my examination of their investments and results will show that investment in renewable energy sources is the most profitable means for absorbing the additional cost of carbon emissions under a cap and trade system.

Methods

To analyze the impact of a carbon emissions cap-and-trade system on investments in renewable energy, I will analyze the evidence of investments and financial results of energy producing firms subject to the EU ETS. When examining the results of different firms, I will take into account their differing business fundamentals while focusing on the bottom line results of investments. As the intent of the EU ETS is to reduce carbon emissions primarily by promoting increased investment in renewable energies, I expect that an examination focusing on investment in renewable energy and resulting profits will determine if the EU ETS goal is economically viable.

In order to analyze the effects of the EU ETS, I need to determine the variables that impact an energy producing firm's profit.

The data set analyzed in this study is financial data gathered from the yearly financial statements of the four firms producing electricity in Sweden. I chose these four firms to represent a cross section of Swedish energy firm decision-making. Two of the firms are the largest energy producers in Sweden, accounting for approximately 65% of energy production in the country, and two of the firms are smaller energy producers.

One of the biggest issues that I faced in examining the financial statements is that, among the four firms, there is no standardized financial reporting format for investments in renewable energy sources. Because of this, the data did not always match up perfectly, and must be interpreted in a qualitative manner. This does add a human-error element to the data, but is necessary to fully analyze the results of these four firms. Not only do their financial statements report information differently, but the firms also do not all report the same information.

To find as much information as possible on the four energy-producing firms in Sweden, I used the Hoover's online database. I gathered data from available financial statements starting from 2005, the first year of the EU ETS through 2013, the most recent year available.

The important financial variables of the four firms include investments, operating profits, the make-up of electricity produced, fuel prices, the price of electricity in the Nord Pool, and the EU ETS' CO_2 credit prices. I will analyze the effects of these variables on operating profits. By analyzing only firms that operate within Sweden, I minimize the impact of other potential variables that would affect profits such as national taxes on electricity and fuel sources.

The available pool of firms to examine with comparable data only included 7 firms operating in Sweden producing energy from 2005 to 2013. I was unable to find any firms with comparable data available that start operations in Sweden after 2005.
I chose to analyze 4 different firms in the end because the similarities and differences among them should reveal different insights about investment in Sweden under the EU ETS.
Below is a chart showing the four Swedish energy producing firms I will examine: Vattenfall, Fortum, Goreborg Energi, and Holmen Energi AB

Figure 1 List of Swedish Electricity Firms Examined in Regressions

Firm	Key Characteristics
Vattenfall	• Large, state-owned company • Many power plants around EU, largest producer in Sweden • 50% fossil fuel, 25% nuclear, 22% hydropower
Fortum	• Large, publicly-traded Finland-based company • Operations in many EU countries • Diverse fuel sources
Goteborg Energi	• Small to medium sized company, state-owned • Operations only in Sweden • Primarily fossil fuels with some wind power and hydropower
Holmen Energi AB	• Wood products company, publicly traded • Energy investments for own use • Primarily hydropower and wind power with fossil fuel back ups

Using these 4 different firms, I will account for results for firms with different fundamentals.

In my regressions, I will examine multiple independent variables in terms of one dependent variable: operating profit.

Figure 2 List of Independent Varialbes Effect a Firm's Profitability

Independent Variable	Description	Why Include This Variable?
Net Electricity Sales	The annual electricity sales (in TWh) of the firm	Sales generate the revenue stream of a firms so total sales affect a firm's total profit
Investments	The amount the firm allocates to the creation of new plants and better technology	Investing in new technologies will cost a firm in the current state but should alter the makeup of fuel sources used in the future.
Electricity Produced by Hydropower	The percentage of electricity that is produced using hydropower (TWh)	Investigating the percentage of electricity from hydropower and how it affects a firm's profit could allow us to determine how using hydropower affects a firm's ongoing profit.
Electricity Produced by Fossil Fuels	The percentage of electricity that is produced using fossil fuels (TWh)	Investigating the percentage of electricity produced by fossil fuels and how it affects a firm's profit could allow us to determine how using fossil fuels affects a firm's profit.
Electricity Produced by Wind Power	The percentage of electricity that is produced using wind power (TWh)	Investigating the percentage of electricity produced by wind power and how it affects a firm's profit could allow us to determine how using wind power affects a firm's profit
Electricity Produced by Nuclear Power	The percentage of electricity that is produced using nuclear power (TWh)	Investigating the percentage of electricity made by nuclear power and how it affects a firms profit could allow us to determine how using nuclear power affects a firm's profit
Spot Price of Electricity in Nord Pool	The average price of electricity sold in the Nord Pool	The market price of electricity sold will affect profits and possibly market demand, so examining how price fluctuations affect sales is of interest.

Spot Price of Coal in EU	The average price of coal sold to firms in Sweden and rest of EU	The price of coal effects is the marginal cost of one of the fossil fuels used in the creation of electricity. The cost of coal will directly influence the demand for fossil fuels.
Spot Price of Oil in EU	The average price of oil sold to firm in Sweden and rest of EU	The price of oil is the marginal cost of one of the fossil fuels used in the creation of electricity. The cost of oil influences the demand for fossil fuels.
Spot Price of Natural Gas in EU	The average price of natural gas sold to firms in Sweden and rest of EU	The price of natural gas is the marginal cost of one of the fossil fuels used in the creation of electricity. The cost of natural gas influences the demand for fossil fuels
EU ETS CO_2 Price	The average price of credits sold in the EU ETS	This represents the new marginal cost coming from the cap-and-trade system. With the fluctuation of the new marginal cost, the cost of carbon-emitting fossil fuels will fluctuate as well.

Although there are a lot of variables to account for, each is an important contributing factor in energy producer profits. The different independent variables will allow me to investigate how investment in renewable energies affects a firm's profitability, the dependent variable shown below.

Figure 3 List of Dependent Variables Representing a Firm's Profit

Dependent Variable	Description	Why Include This Variable
Operating Profit	An electricity-producing firm's profit coming from electricity sales	Examining how this is affected by the independent variables will allow me to analyze the independent variables and their impacts on a firm's profitability

The firm's operating profit will allow me to put a numeric value on the firm's profitability and help to recognize shifts that are significant. By looking at the operating profit in terms of the independent variables, we can analyze how the changes in a firm's profit are altered and determined.

Results

After running regressions using available data on each firm's operating profit, taking into account overall investment, mix of production technology, the firm's identity, and marginal costs of the fuel sources, I arrived at the following regression.

Figure 4 Regression of operating profit in terms of net sales, investments, mix of production technology, firm's identity, and marginal costs of fuels

Source	SS	df	MS
Model	1160487.21	14	82891.9437
Residual	25972.5659	3	8657.52196
Total	1186459.78	17	69791.7516

Number of obs =	18
F(14, 3) =	9.57
Prob > F =	0.0439
R-squared =	0.9781
Adj R-squared =	0.8760
Root MSE =	93.046

operatingprofit	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
netsales	-.0500065	.0334889	-1.49	0.232	-.1565832	.0565701
investments	-.059423	.1060014	-0.56	0.614	-.3967668	.2779209
co2etseuaeurtonneco2	309.1999	283.4731	1.09	0.355	-592.9379	1211.338
spotpriceforpowerinnordpoolpower	-4.37068	6.194779	-0.71	0.531	-24.08523	15.34387
coalicerotterdamusdtonne	-59.07026	57.039	-1.04	0.377	-240.5938	122.4533
oilbrentcrudeusdbbl	66.81892	63.45726	1.05	0.370	-135.1304	268.7682
PercenHydro	-12247.81	10426.16	-1.17	0.325	-45428.51	20932.9
PercenNuclear	-14179.28	11874.26	-1.19	0.318	-51968.47	23609.91
PercenFossil	-12864.82	10717.52	-1.20	0.316	-46972.74	21243.1
PercenWind	-8345.792	11153.2	-0.75	0.509	-43840.24	27148.66
PercenBiomass	26128.14	23002.43	1.14	0.339	-47075.84	99332.13
fortum	-209.5708	156.7997	-1.34	0.274	-708.5774	289.4358
vattenfall	0	(omitted)				
holmenenergiab	-444.9115	527.4916	-0.84	0.461	-2123.625	1233.802
goteborgenergi	-1229.886	1077.485	-1.14	0.337	-4658.926	2199.154
_cons	9825.083	8887.496	1.11	0.350	-18458.9	38109.06

With all the different variables affecting operating profit, the regression model does seem to show that none of the variables have a genuine effect on the operating profits of electricity producing firms. This is not a good sign. In order to better assess the true effects of the variables on a firm's operating profit, I examined the variables in terms of the natural log of the profit. This allows me to better examine the effects of operating profit in percentages.

I then examined how the make-up of fuel sources by itself affects profits to determine if using renewable energy sources inherently decreases profits. Without fee based carbon offset credits, can renewable energy sources be as profitable as fossil fuel based energy sources? And which energy sources are the most profitable?

The regression examining fuel source profitability is shown here:

Figure 5 Regression of operating profit in terms of fuel sources

Source	SS	df	MS
Model	39.384827	4	9.84620674
Residual	4.26058624	9	.473398471
Total	43.6454132	13	3.35733948

Number of obs =	14
F(4, 9) =	20.80
Prob > F =	0.0001
R-squared =	0.9024
Adj R-squared =	0.8590
Root MSE =	.68804

logprofit	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
PercenHydro	-68.43381	33.73754	-2.03	0.073	-144.7534	7.885806
PercenNuclear	-75.94817	34.05984	-2.23	0.053	-152.9969	1.100546
PercenFossil	-68.97264	33.75441	-2.04	0.071	-145.3304	7.385151
PercenWind	-68.79784	33.83898	-2.03	0.073	-145.3469	7.751249
_cons	74.98506	33.75308	2.22	0.053	-1.369704	151.3398

When examining the results from this regression, it does seem that the make up of fuel sources for energy production has an effect on the operating profit of firms. However, it does not seem that the make-up of fuel sources has the effect that I expected. Despite my thinking that using hydropower and other renewable sources in lieu of more carbon heavy sources would improve the profit of firms, it seems that it does not. In fact, it seems that no matter what fuel source is used, the effect on profit is negative or barely positive. In terms of profit, the use of any fuel source would adversely affect operating profit, as the use of any fuel source does represent a cost to the firm. But, with all sources decreasing profits as seen in the regression, I should take these results with a grain of salt. Based on the regression, it does seem that hydropower, wind power, and fossil fuels have the very similar effects on profit. Given the large installed hydro capacity in Sweden, a comparative profitability of hydro and fossil fuels is not a big surprise. What is interesting is that wind power has almost the same profit effect as hydro and fossil fuels.

With two more emission-friendly fuel sources having the same effect on profit as the more carbon-intense fossil fuel sources, rising prices of carbon credits over time will make investing in the more carbon-friendly fuel sources the logical plan to maintain profit levels. With the prospect of increased prices for future carbon credits, the marginal cost of the most carbon intensive fuel source, fossil fuels, will increase. This will, over time, mean fossil fuel use will have an increasingly negative effect on energy firm profits. The specter of increasing fossil fuel costs forces energy producers to plan to shift towards lower carbon production methods.

After examining the effect of the make-up of fuel source on historic operating profits, I can now re-examine investments and their effect on profit.

Figure 6 Regression of operating profit in terms of net sales, investments, and marginal costs of fuel sources

Source	SS	df	MS
Model	21.536301	6	3.5893835
Residual	3.70932458	1	3.70932458
Total	25.2456256	7	3.60651794

Number of obs =	8
F(6, 1) =	0.97
Prob > F =	0.6514
R-squared =	0.8531
Adj R-squared =	-0.0285
Root MSE =	1.926

logprofit	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
netsales	.0031108	.0014325	2.17	0.275	-.0150907	.0213123
investments	-.001479	.0037041	-0.40	0.758	-.0485443	.0455862
co2etseuaeurtonneco2	-2.989613	5.509481	-0.54	0.683	-72.99421	67.01499
spotpriceforpowerinnordpoolpower	-.1319845	.1598626	-0.83	0.561	-2.163231	1.899262
coalicerotterdamusdtonne	.6111026	1.154483	0.53	0.690	-14.05799	15.2802
oilbrentcrudeusdbbl	-.7455667	1.267832	-0.59	0.662	-16.8549	15.36377
_cons	37.4864	70.38119	0.53	0.688	-856.7914	931.7642

We can see that investments don't seem to have a current effect on the operating profit. Although this might seem discouraging to the theory that investing in renewable energies is the most profitable strategy for firms in the face of a cap-and-trade system, but this is only in consideration of present circumstances. In order to determine if past investments affect the present day profit levels, I will have to take the lagged investments against operating profits. To determine whether or not lagged investments affect profits, I generated 3 new variables in Stata, PastinVest, PastinVest2year, and Investmentmature, which correspond to investments made in the past 3 years.

Figure 7 Regression of operating profit in terms of past investments, net sales, and marginal costs of fuel sources

Source	SS	df	MS
Model	26.2285874	5	5.24571748
Residual	1.62715084	2	.813575418
Total	27.8557382	7	3.97939118

Number of obs	=	8
F(5, 2)	=	6.45
Prob > F	=	0.1397
R-squared	=	0.9416
Adj R-squared	=	0.7956
Root MSE	=	.90198

logprofit	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pastinvest2year	-.0094658	.0021301	-4.44	0.047	-.0186308	-.0003008
pastinvest	-.0015475	.0017219	-0.90	0.464	-.0089564	.0058613
investmentmature	-.0051706	.0024752	-2.09	0.172	-.0158206	.0054794
netsales	-.0002911	.0003904	-0.75	0.534	-.001971	.0013889
forwardco2price	.1935265	.1454749	1.33	0.315	-.4324017	.8194547
_cons	27.72554	8.304185	3.34	0.079	-8.00449	63.45556

Looking at these regressions, we see that past investments do seem to affect the current operating profit. Either examining the natural log of past investments or the past investments themselves, the profit is indeed affected by past investments. Despite this new information, the effects that past investments have on profit don't seem to go along with my hypothesis. Both investments made 2 years ago and 3 years ago have negative effects on operating profit. Although there can be doubt cast on the effect of investments made 3 years ago, the effect of investments made 2 years ago on operating profit in the present year can't.

With these findings, I re-examined my hypotheses to see if my assumptions before performing my analysis were correct.

Conclusion

The results of my regressions contradicted my predictions. Despite the contradictory results, I am still able to find some positive conclusions.

The effect of investments on the operating profits of the firms I examined in the time frame of 2005 to 2013 seems to disprove my hypothesis that investing in renewable energies is the most profitable strategy for energy firms. I suspect that this overall conclusion is chiefly because the time frame available to examine under the EU ETS is too short to show results of investments in renewable energy sufficient to impact the firms examined. The long time frame of investments in energy production means a significant shift towards renewable energy investment has not yet taken place or shown up in the financials of the majority of the firms I examined.

However, some important observations can be made that support a conclusion that investment in renewable energy is the most profitable response to an emissions cap. For example, when I examined how the make-up of fuel sources used to produce electricity affects operating profits, we did see that the financial results for hydropower and wind power are the same under the EU ETS as the results from using fossil fuels. This finding surprised me, given the significant price difference of the 3 fuel sources. Although fossil fuels are the cheapest energy production option, my results show fossil fuels generating the same operating profit as 2 more expensive fuel sources. This seems to indicate that the cost of carbon credits imposed under the EU ETS does, in fact, make investment in renewable energy sources more economically viable.

I must amend my hypothesis based on my findings. One theory I examined in my literature review was whether a firm facing a new marginal cost for carbon would switch fuel sources. In the short-term, switching fuel sources to a more carbon-efficient one is the most effective way to mitigate the new marginal cost of carbon. Taking this strategy into account with the knowledge that the financial outcome of wind power, hydropower, and fossil fuels are similar, we know that the optimal strategy is now to switch to the more emission-friendly sources. When a firm has access to more carbon neutral fuel sources such as hydropower or wind power, that firm should maximize their electricity production from that source over production from carbon intensive sources. In the short-term, if carbon credits are called for, fuel switching towards less carbon intensive methods will be the most profitable strategy.

Given that the EU ETS will reduce the supply of carbon credits over time, the marginal cost of carbon intensive production will also increase over that time. Although a firm can bank excess credits to allow for more emissions in the future, eventually carbon credits will run out and banking or trading credits will be a less profitable option for firms. If a firm wishes to not only remain profitable in the short-term, but also in the long-term, a firm must invest in more renewable energies.

The firm can be both profitable in the short-term and long-term by combining 2 strategies discussed in the literature I examined. By switching fuel sources to more carbon-friendly sources in the short-term while also investing in even more emission friendly fuel sources, such as hydropower or wind, the firm can insure that they will have to opportunity to switch fuel sources in the future. By reinvesting profits in renewable energy sources, the firm can increase their long-term profit potential.

Although my research leads me to draw these conclusions, further research is needed to determine the validity of my claims. In order to do this, future studies should wait several more years to have data better reflecting the realities of energy production investment schedules. Examining how investments made in previous time periods are informative. However, a more in-depth analysis of results after firms actually invest in renewable energy sources under a cap and trade scheme will be far more informative.

The results of my research were constrained by limited useful data, but I was able to conclude that Swedish energy production firms operating under the EU ETS cap and trade system can invest in carbon neutral fuel sources and maintain their profit levels. A more thorough examination of the actual effects of investments in renewable energy under the EU ETS should be performed once more investments in renewable energy sources have yielded sales.

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