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CERE Working Paper, 2011:14

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This version is of November 22, 2011

Abstract

With policies to promote power generation from renewable energy sources (RES) becoming important part of climate and energy policy worldwide, there is now considerable interest in understanding how these different market-based mechanisms affect power generating firms in practice. The existing theory provides conflicting guidance regarding profitability of Tradable Green Certificates (TGC) over Feed-in-Tariff (FIT) based policies. Thus, the main goal of this study is to empirically assess the performance of power generating firms operating in the TGC scheme environment relative to the performance of power generating firms operating under alternatives RES support mechanisms. The main finding of this study is that, in Europe, TGC schemes are associated with higher returns for power generating firms. This supports the hypothesis that higher investment uncertainty induced by the TGC policy nature coupled with some market imperfections lead to higher profits for electricity producers operating in TGC schemes.

Keywords: electricity, European Union, emission trading, feed-in-tariff, renewable energy, tradable green certificates

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1. Introduction and Literature Review

With policies to promote power generation from renewable energy sources (RES) becoming important part of climate and energy policy worldwide, there is now considerable interest in understanding how these different market-based mechanisms work in practice.

There exist two common policy instruments to promote renewable electricity: Feed-in-Tariff (FIT) and Tradable Green Certificate (TGC) systems. FIT policies are focused on setting the right *price* to drive RES deployment. In contrast, TGC policies set a *quantity* restriction that determines the market price of renewable electricity. In this respect, FIT and TGC policies resemble a pollution tax and a cap-and-trade system, respectively. This fundamental difference between FIT and TGC determines what effects each policy will have on the performance of power generating firms.

FIT policies and TGC systems can be compared in many dimensions, namely cost-efficiency, market distortions and transaction costs. According to the existing literature, one of the main advantages of TGC schemes over FIT systems is cost-efficiency. The EU Commission has favoured TGC schemes over FIT systems on the basis that TGC systems are more market orientated and, therefore, they should create more competitive markets for renewable electricity.[1] The Commission's working paper (European Commission, 1999), which is largely based on the theoretical assessment of various RES support mechanisms, suggests TGC as a system which is best suited to achieve the minimum cost for electricity generators and electricity consumers. In other words, TGC systems generate the least excess profits for power producing firms.

Markets for electricity might be distorted in many different ways. These distortions might mitigate or even reverse the expected effects of policies promoting renewable energy. The most apparent market distortion is the capital constraint. As TGC schemes imply a much higher risk level for investors in renewable power generation (a price of green certificate is uncertain), the availability of capital and its cost become an issue when compared to FIT systems, where a price for green electricity is fixed and known in advance (Mitchell et al.,

[1] In TGC schemes, power generating firms have to compete in two markets: common electricity markets and green certificate markets. In FIT systems, firms face guaranteed prices and the market demand, thus, firms may directly focus on internal cost minimisation.

2006). Higher capital costs determine higher expected returns for investors in TGC systems. Furthermore, the capital constraint also affects market entry decisions of small RES developers. Contrary, the FIT approach, by guaranteeing a price which is set so that both small and large firms may stay in business, helps firms to access cheaper capital. As a result, the number of firms can be smaller in TGC than in FIT systems. On that account, TGC markets might by characterised by higher market concentration that leads to higher profits.

Additionally, TGC systems are associated with higher transactions costs in the form of fixed administrative costs. This might create additional hurdles for smaller investors to enter the market (Dinica, 2006; Fouquet and Johansson, 2008; Jager and Rathmann, 2008). Again, this limits the potential number of investors and can result in less competitive TGC market.[2]

The main aim of this study is to test the above considerations empirically. The main hypothesis is that TGC systems, due to potentially higher market concentration and higher required capital returns, will be associated with ecxess profits for renewable energy generating firms. This hypothesis can be rephrased in the words of Nicholas Stern: „(pricing) mechanisms achieve larger deployment at lower costs. Central to this is the assurance of long-term price guarantees. (...) Uncertainty discourages investment and increases the cost of capital as the risks associated with the uncertain rewards require greater rewards (2007, p. 366)“.

As RES support mechanisms do not operate in isolation, the secondary aim of this study is to analyse the interactions between RES systems and other policies implemented to reduce greenhouse gas emissions and the resulting effects on power generating firms. In the European Union (EU), the EU-wide emissions trading system (EU ETS) plays a central role in achieving the EU's climate change targets. Hence our focus is on the interaction between the EU ETS and RES systems.

To the best of our knowledge, this study contributes to the existing literature on RES support mechanisms in two ways.[3] First, this is the pioneering *ex post* EU-wide analysis of this kind

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[2] See Cory, Couture, and Kreycik (2009) for more detailed discussion on transaction costs and firm size effects in TGC-based markets.

[3] We refrain from providing a detailed literature review on RES support mechanisms and their interactions with other environmental policies. The comprehensive reviews of relevant literature can be found in Menanteau et al. (2003), del Rio and Gual (2004), Agnolucci (2007) and Bergek and Jacobsson (2010). There are a number of

exploring RES support mechanisms' effects on firm performance, namely profitability. Second, the unique dataset of firms in the European power generating sector with identifications of EU ETS firms allows investigating interactions between RES support policies and the biggest emission trading programme in the world.

The rest of the paper is organised as follows: Section 2 introduces the empirical strategy; Section 3 describes the data; Section 4 presents and discusses the estimation results. A concluding summary is given in Section 5.

2. The Empirical Strategy

The empirical strategy is designed to analyse the effects of RES support mechanisms on firm performance. In particular, the relationship between Tradable Green Certificates and firms' profitability is investigated. It is assumed that a firm's profitability is a function of the renewable electricity generation support policy choice and other variables:

$$profit_{it} = f(TGC_i,\ X_{it}), \tag{1}$$

where $profit_{it}$ is the outcome of interest (firm profitability ratio, in particular, EBIT[4] margin over operating revenues); TGC_i is a RES policy dummy (1 is assigned for firms in the EU countries which adapted the TGC support mechanism and 0 is assigned for all other firms)[5]; X_{it} is a vector of firm characteristics (time and country dummy variables, age of the firm, firm category with respect to its size, firm size in terms of its assets etc.). X_{it} vector also contains the annual change in renewable electricity production (in MW).[6] The later variable is used not only to account for potential support level changes for renewable electricity generation but

studies which provide analyses of RES policies on the country-level, such as Lorenzoni (2003), Verbruggen (2004; 2009), Mitchell et al. (2006), Wang (2006) and Heinzel and Winkler (2011), just to mention few. The other stream of the literature focuses on interactions between RES policies and the EU ETS (e.g. Amundsen and Mortensen 2001; del Río González 2006; M. Rathmann 2007; Abrell and Weigt 2008; Böhringer and Rosendahl 2010). Johnstone et al.'s (2009) paper examines the effect of policy choice, such as FIT/TGC, on technological innovation.

[4] EBIT stands for Earnings Before net Interest and Tax.

[5] The analysed EU countries have implemented either TGC or FIT policies. The only exception is Finland, which implemented tax reduction incentives for promoting renewable electricity. The inclusion of Finland in the analysis does not affect the main findings of the study in any significant way. Table A1 in the Appendix provides information on what RES support mechanism each EU country adapted.

[6] Initially, to avoid endogeneity, we lagged this variable, but this did not affect the main results.

also to control for potential industry lobbying effects. For instance, Marques et al. (2010), who analyse the impact of several factors on the use of renewable energy sources in a set of European Union countries, suggest that the lobbying effect of the established industries may be related with the level of renewable energy use.

The analysis is commenced with a simple ordinary least squares (OLS) model. To control for the potentially high level of heterogeneity and possibly outlier-driven results, the iteratively reweighted least squares (IRLS) are used as an alternative to the OLS model.

Initially, the following model is estimated:

$$profit_{it} = \lambda_t + \varrho_c + \beta_1 TGC_i + \beta_2 BROWN_i + \boldsymbol{x_{it}\delta} + \varepsilon_{it}, \qquad (2)$$

where λ_t and ϱ_c are the time- and country-specific control variables, respectively; $\boldsymbol{x}_{it}$ is the vector of control variables mentioned earlier; $BROWN_i$ is a dummy variable for firms which were covered by the EU ETS. This dummy variable proxies *conventional* firms using combustible fossil fuels for energy generation.

Further, the panel nature of the dataset is exploited:

$$profit_{it} = \lambda_t + \varrho_c + \beta_1 TGC_i + \beta_2 BROWN_i + \boldsymbol{x_{it}\delta} + \varepsilon_{it} + \eta_i, \qquad (3)$$

where η_i are the firm-specific unobserved heterogeneity effects. However, as the policy variable of interest is time-invariant, the fixed effects model prevents identifying the policy effect. The random effects model is used instead.

The random effects model requires the random effects not to be correlated with the explanatory variables. This is a restrictive assumption, particularly in the context of the model we are attempting to estimate, where the firm-specific time varying variables, such as firm total assets and firm age, are likely to be correlated with the unobserved heterogeneity, e.g. managers' abilities.

To control for the potential correlation between the random effects and the other exogenous variables, Mundlak (1978) suggested modelling the unobserved heterogeneity (random effects) as a function of the means of the time varying explanatory variables:

$$\eta_i = a_0 + \boldsymbol{\bar{x}_i \psi} + a_i, \qquad (4)$$

where $\mathbf{\bar{x}}_{\boldsymbol{i}}$ is an average of $\mathbf{x}_{\boldsymbol{it}}$ time varying variables over time for each firm and a_0 is a constant term. We assume that time invariant a_i is uncorrelated with $\mathbf{x}_{\boldsymbol{it}}$. Since the Mundlak approach allows taking into account correlation between unobserved firm heterogeneity and firm characteristics, we use it to estimate the effect of TGC systems on firm profitability. The model can now be written as:

$$profit_{it} = \lambda_t + \varrho_c + \beta_1 TGC_i + \beta_2 BROWN_i + \boldsymbol{x_{it}\delta} + \varepsilon_{it} + a_0 + \boldsymbol{\bar{x}_i \psi} + a_i \qquad (5)$$

The next step is to explore the interaction between RES support policies and the EU ETS. This is done in two ways. Firstly, to understand whether TGC policies have a different effect on *conventional* fossil fuel power generating firms, we utilise the following model:

$$profit_{it} = \lambda_t + \varrho_c + \beta_1 TGC_i + \beta_2 BROWN_i + \theta_1 (TGC_i * BROWN_i) + \boldsymbol{x_{it}\delta} + \varepsilon_{it}, \qquad (6)$$

where θ_1 is a coefficient of the interaction term between the TGC policy dummy and the dummy identifying conventional energy producers which participate in the EU ETS. It indicates a TGC policy effect for *conventional* energy producers.

Secondly, we extend the last model by controlling for the actual introduction of the EU ETS in 2005:

$$profit_{it} = \lambda_t + \varrho_c + \beta_1 TGC_i + \beta_2 BROWN_i + \beta_3 Y05_t + \theta_1 (TGC_i * BROWN_i) +$$
$$\theta_2 (TGC_i * Y05_t) + \theta_3 (Y05_t * BROWN_i) + \theta_4 (TGC_i * BROWN_i * Y05_t) + \boldsymbol{x_{it}\delta} + \varepsilon_{it} \qquad (7)$$

$Y05_t$ is a dummy variable for the 2005-2007 period corresponding for the first phase of the EU ETS. θ_4 is a coefficient on the triple interaction term and it allows identifying a TGC policy effect for *conventional* firms after 2005, if any.

This model also allows investigating another interesting question. It is widely accepted that *conventional* electricity producers could make windfall profits in the first phase of the EU ETS because of the premium on electricity prices and the free allocation of emission permits (Sijm et al., 2006; Yu, 2011).[7] There exists a wide literature on how CO_2 price affects electricity prices, but there are very few empirical studies analysing how the EU ETS has affected the actual profitability of *conventional* energy producers. One exception is Yu's (2011) study that focuses on this issue using a sample of Swedish energy firms for 2005 and 2006. The study finds that the EU ETS had no or negative effects on the profitability of energy producers. Our cross-country firm level dataset allows us to explore this issue further. θ_3 coefficient in the last model (Equation 7) indicates the effect of the EU ETS on *conventional* energy producers and allows us to test the hypothesis of conventional electricity producers' windfall profits associated with the introduction of the EU ETS in 2005.

It is important to note that even though the policy measures are exogenous for individual firms, the potential country self-selection into implementing TGC or FIT policies might cause bias in the policy effect estimates if the particular countries' decision to adopt FIT or TGC type policies was based on expected firm profitability effects, in particular abnormal profits. To address this issue there is a scope for further research to overcome the strong policy causality assumption of this study.

3. Data Sources and Description

The Amadeus (Bureau van Dijk) database is a central data source of this study. This database includes firm level accounting and other data in standardised financial format. The general source for the Amadeus is national official public bodies in European countries. The Amadeus database is a very useful information source for cross-country comparisons as it provides harmonised accounts for large fraction of European firms.

Our sample covers EU-27 countries for the period 2002-2007. The data have been cleaned for obvious mistakes (e.g. negative values for assets). The analysis is restricted to the electricity generation sector (NACE 3511). This means that all electricity producers, irrespective of their utilised electricity generating technology, are considered. The Amadeus provides firms with

[7] See also Sijm et al. (2008) for literature review on how CO_2 price affects electricity price

both consolidated and unconsolidated financial accounts. To avoid a double-counting problem, unconsolidated financial accounts are used for the main policy analysis.

Several profitability measures are available and we use the EBIT margin over operating revenues as our main measure for profitability. Other profitability measures are also available such as ROA or ROE. Since in the Amadeus database the EBIT profitability measure is available for more firms than for any other alternative, EBIT margins are used as the main profitability indicator.

The asset-based variable and the categorical size variables are used to control for heterogeneity. There are also other possible proxies available to control for firm size, but as in the case of the profitability measure, the assets size measure is available for more firms. The usage of firm assets as a measure for firm size is a common practice in the empirical industrial organisation literature (see e.g. Geroski et al. 2003; Goddard, Tavakoli, and Wilson 2009).

Our dataset also contains information about EU firms in the EU ETS. The EU ETS data, obtained from the European Commission (Community Independent Transaction Log, CITL), were matched with the firm-level data from the Amadeus database. The addresses as well as the names of ETS firms were used as the matching identifiers.

Table 1 summarises the data and separates all variables according to the RES support mechanism (TGC or FIT). All monetary variables are deflated by the country-specific deflators from Eurostat. Of particular note is the fact that firms in the TGC and the FIT type groups are different in terms of size. On average, firms in the TGC group are almost 50 per cent bigger than firms in the FIT group in terms of their assets. As we may expect conventional ETS firms to be relatively bigger than other power generating firms, Table 2 presents the descriptive statistics on the data sample that excludes ETS firms. It is evident, that the same relationship also holds for the reduced sample. This suggests the importance of controlling for firm heterogeneity.

Table 1. Descriptive statistics of the variables according to the RES support mechanism (TGC or FIT), full sample, 2002-2007

	FIT			TGC		
Variable	Obs.	Mean	Std.	Obs.	Mean	Std.
EBIT margin	17 817	15.629	31.097	6 460	19.581	30.800
Firm assets, thou EUR	17 771	121 717	2 340 000	6 455	186 698	1 464 705
Size 1	17 817	0.473	0.499	6 460	0.429	0.495
Size 2	17 817	0.299	0.458	6 460	0.287	0.452
Size 3	17 817	0.157	0.364	6 460	0.163	0.369
Size 4	17 817	0.071	0.257	6 460	0.121	0.326
Payroll, thou EUR	9 444	9580	176 444	3 176	9 312	58 050
Added value, thou EUR	6 442	35 981	498 564	2 350	58 639	1 030 887
Return on Assets (ROA)	17 336	4.894	15.079	6 313	5.858	17.437
Return on Equity (ROE)	15 164	16.862	74.777	5 778	19.263	83.657
Return on Employed Capital (ROEC)	12 271	14.656	56.522	4 768	18.453	72.455
Age	17 280	12.113	15.225	6 292	15.102	21.143

Notes: All monetary variables are deflated by their country-specific deflators from Eurostat; Size1 to Size4 indicate the firm size category from the smallest to the largest as defined in the Amadeus database.

Table 2. Descriptive statistics of the variables according to the RES support mechanism (TGC or FIT), restricted sample (without ETS firms), 2002-2007

	FIT			TGC		
Variable	Obs.	Mean	Std.	Obs.	Mean	Std.
EBIT margin	16 296	16.478	32.078	5 977	20.409	31.333
Firm assets, thou EUR	16 257	52 950	657 648	5 973	99 259	757 427
Size 1	16 296	0.516	0.500	5 977	0.460	0.498
Size 2	16 296	0.305	0.460	5 977	0.302	0.459
Size 3	16 296	0.130	0.337	5 977	0.144	0.351
Size 4	16 296	0.049	0.216	5 977	0.094	0.292
Payroll, thou EUR	8 440	3 541	38 088	2 917	5 331	30 007
Added value, thou EUR	5 611	10 772	93 762	2 122	41 460	1 018 728
Return on Assets (ROA)	15 864	5.048	15.499	5 843	6.119	17.862
Return on Equity (ROE)	13 800	17.171	74.929	5 357	19.625	86.204
Return on Employed Capital (ROEC)	10 952	15.352	58.322	4 342	18.677	74.592
Age	15 805	12.006	15.104	5 809	14.684	20.836

Notes: All monetary variables are deflated by their country-specific deflators from Eurostat; Size1 to Size4 indicate the firm size category from the smallest to the largest as defined in the Amadeus database.

The econometric models specified above also include several country-specific variables: the annual change in electricity price and the annual change in renewable electricity production. These data are available from Eurostat and the International Energy Agency. The former variable controls the dynamics of electricity prices in each country. The latter variable indirectly controls the overall support for renewable energy. We may expect that countries with the higher growth in renewable electricity have more generous support systems for renewable energy.

4. Results

Table 3 summarises the TGC policy effects on the profitability (EBIT margins) of electricity generating firms.[8] In total, three types of models were estimated: the OLS model, the IRLS model, and the random effects model with the Mundlak terms. All models provide consistent evidence that power generating firms operating in EU countries that implemented green certificate trading were more profitable during the period 2002-2007. This finding does not identify the particular sources of this higher profitability, however, it supports our main hypothesis that TGC systems, due to potentially higher market concentration and higher capital returns required by investor, are associated with excess profits for renewable energy generating firms. This result that TGC schemes are linked with higher returns is in line with the earlier country-specific analysis (e.g. Verbruggen (2009); Bergek and Jacobsson (2010)).

The higher profits due to TGC are not different between conventional electricity producers and other electricity generating firms (*TGC*BROWN*).[9] However, the positive and significant coefficient for the interaction term between the TGC policy dummy and the time dummy representing the first phase of the EU ETS (*TGC*Y05*) suggests that the post-2005 period for electricity generating firms in TGC-based countries was associated with even higher profits. This result might be explained in two ways. First, the EU ETS has decreased the costs disadvantage of renewable electricity and, thus, renewable electricity has become more competitive. Second, the EU ETS has increased the demand for renewable electricity and this has induced the deployment of more and more expensive renewable electricity generating technologies. At each point in time, the certificate price will correspond to the most expensive technology induced in the system, and all power generators with lower costs, thus, receive an extra profit. However, this post-2005 effect is not different between conventional electricity producers and other electricity producers operating in TGC-based countries – the coefficient on the interaction term between the TGC policy dummy, the ETS firm dummy and the ETS period dummy (*TGC*BROWN*Y05*) is not significant.

The latter result provides the answer to the secondary objective of this study – the EU ETS had no effect on conventional power generating firms operating in countries with TGC

[8] The use of the other profitability measures (ROA, ROE) produced similar results.

[9] By inspecting Table 2 and Table A3 in the Appendix it is obvious that both conventional power generators and other power generating firms operating in TGC-base countries on average had significantly higher profits than firms operating in FIT-based countries.

schemes in place (*TGC*BROWN*Y05*). Also, although one might expect that power generators who must comply with the EU ETS and renewable quota restrictions might benefit from double regulation[10], the coefficient on the interaction term between the ETS period dummy and the conventional firm dummy is insignificant (*Y05*BROWN)*. The descriptive statistics for conventional power producers separated by the pre- and post-ETS period also do confirm this finding (see Table A2 in the Appendix). This result does not confirm common speculations about windfall profits due to the EU ETS.

Additionally, the estimation results show that power generators with larger assets had higher profitability. Also, the higher growth in renewable energy production (the proxy of the overall support level for renewable energy) led to higher profits (see Table 3, columns 7-9).

[10] It has been argued that the coexistence of RES support systems and emission trading may lead to differential treatment of large and small generators. This is so because electricity suppliers owning fossil-fuel-based generation plants can benefit twice if they invest in renewable electricity: they would receive the feed-in tariff/green certificate price and save tradable permits. In contrast, small independent producers would only receive one incentive: the feed-in tariff/green certificate price.

Table 3. The effects of RES support policies on the profitability of power generating firms, full sample

VARIABLES	OLS			IRLS			RE		
	1	2	3	4	5	6	7	8	9
TGC	5.944***	5.886***	3.979***	6.693***	6.470***	5.102***	5.889***	5.794***	4.745***
	(0.812)	(0.854)	(1.128)	(0.723)	(0.754)	(1.027)	(1.461)	(1.511)	(1.610)
BROWN	-12.09***	-12.20***	-11.74***	-12.37***	-12.73***	-11.74***	-11.23***	-11.44***	-10.76***
	(0.593)	(0.626)	(0.850)	(0.776)	(0.878)	(1.382)	(1.658)	(1.868)	(2.037)
TGC* BROWN	-	0.455	0.336	-	1.528	1.874	-	0.903	-0.831
	-	(1.339)	(2.181)	-	(1.683)	(2.751)	-	(3.654)	(4.010)
Y05*BROWN	-	-	-0.820	-	-	-1.659	-	-	-1.092
	-	-	(1.063)	-	-	(1.686)	-	-	(1.247)
TGC*Y05	-	-	2.958**	-	-	2.159**	-	-	1.601*
	-	-	(1.165)	-	-	(1.069)	-	-	(0.822)
Y05	-	-	-1.370	-	-	-0.153	-	-	-0.761
	-	-	(0.877)	-	-	(0.808)	-	-	(1.266)
TGC *BROWN*Y05	-	-	0.395	-	-	-0.363	-	-	2.800
	-	-	(2.621)	-	-	(3.371)	-	-	(2.488)
Renewable electricity (yoy change)	1.133	1.129	0.772	1.634	1.623	1.394	2.643***	2.641***	2.342**
	(1.406)	(1.406)	(1.412)	(1.329)	(1.329)	(1.335)	(0.997)	(0.997)	(1.003)
Firm age	-0.0166	-0.0167	-0.0162	-0.0237*	-0.0242**	-0.0236*	-0.343	-0.339	-0.362
	(0.0116)	(0.0116)	(0.0116)	(0.0122)	(0.0122)	(0.0122)	(0.416)	(0.416)	(0.417)
Lagged assets (log)	1.543***	1.542***	1.533***	2.470***	2.469***	2.456***	0.820***	0.819***	0.810***
	(0.167)	(0.167)	(0.167)	(0.124)	(0.124)	(0.124)	(0.165)	(0.165)	(0.165)
Electricity price (yoy change)	7.247	7.261	4.615	5.962	5.972	4.429	3.628	3.632	1.605
	(4.871)	(4.870)	(4.982)	(4.394)	(4.394)	(4.538)	(3.373)	(3.373)	(3.482)
Other industry dummy	yes	yes	yes	yes	yes	yes	yes	yes	yes
Time dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes
Size dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes
Regional dummies	yes	yes	yes	yes	yes	yes	yes	yes	yes
Mundlak terms	-	-	-	-	-	-	yes	yes	yes
No. of observations	17,045	17,045	17,045	17,045	17,045	17,045	17,045	17,045	17,045
No. of firms	5,704	5,704	5,704	5,704	5,704	5,704	5,704	5,704	5,704
R-squared	0.043	0.043	0.044	0.071	0.071	0.071	0.041	0.041	0.041

Notes: The robust standard errors are in the parentheses. *** p<0.01, ** p<0.05, * p<0.1.

5. Conclusions

Using the cross-country micro level dataset this study analyses how the choice of renewable energy promotion system affected the electricity production sector in Europe. In particular, we consider more closely Tradable Green Certificates vs. Feed-in Tariffs. The EU Commission has favoured TGC schemes over FIT systems on the basis that TGC systems are more market orientated (in TGC system green power generating plants have to compete not only in common electricity market but also in tradable green certificate markets) and, therefore, they should create more competitive markets for renewable electricity. In other words, TGC systems generate the least excess profits for power producing firms. We test this hypothesis against the alternative suggestion that due to market imperfections, namely because of higher risk, higher capital constraints and higher transactional costs, TGC schemes will be associated with excess profits for renewable energy generating firms.

The main finding of this study is that power generating firms, operating in EU countries that implemented green certificate trading, were more profitable compared to FIT-firms during the period 2002-2007. This result supports our alternative hypothesis of the presence of market imperfection in TGC type systems. However, this analysis is limited in that it cannot identify exact sources of this higher profitability. This aspect needs for further research.

Also we find that the introduction of the EU ETS had no effect on conventional power generating firms operating in countries with TGC schemes in place. The related results also do not confirm common speculations about excess profits in the energy sector due to the EU ETS.

Appendix

Table A1. The distribution of observations by country and RES support policy choice

Country	Freq.	Percent	TGC?
AT	47	0.19	-
BE	303	1.25	yes
BG	310	1.28	-
CZ	150	0.62	-
DE	1,956	8.06	-
DK	275	1.13	-
EE	107	0.44	-
ES	7,302	30.08	-
FI	623	2.57	-
FR	4,877	20.09	-
GB	1,275	5.25	yes
GR	385	1.59	-
HU	315	1.3	-
IE	99	0.41	-
IT	1,915	7.89	yes
LT	25	0.1	-
LU	8	0.03	-
LV	60	0.25	-
NL	107	0.44	-
PL	450	1.85	yes
PT	1,051	4.33	-
RO	603	2.48	yes
SE	1,914	7.88	yes
SI	88	0.36	-
SK	32	0.13	-

Table A2. Descriptive statistics of conventional firms before (2002-2004) and after (2005-2007) the EU ETS introduction

	2002-2004			2005-2007		
Variable	Obs	Mean	Std.	Obs	Mean	Std.
EBIT margin	924	7.821	15.515	1080	6.681	16.923
Firm assets, thou EUR	919	889232	6932192	1077	1018833	7156975
Size 1	924	0.024	0.153	1080	0.023	0.150
Size 2	924	0.221	0.415	1080	0.185	0.389
Size 3	924	0.419	0.494	1080	0.450	0.498
Size 4	924	0.337	0.473	1080	0.342	0.474
Payroll, thou EUR	569	64102	542511	694	54946	414672
Added value, thou EUR	499	185267	1361842	560	229863	1260849
Return on Assets (ROA)	897	2.637	9.561	1045	3.462	9.498
Return on Equity (ROE)	819	14.632	67.369	966	13.380	66.012
Return on Employed Capital (ROEC)	806	12.268	36.563	939	9.266	42.657
Age	903	14.221	19.264	1055	15.581	18.406

Notes: All monetary variables are deflated by their country-specific deflators from Eurostat; Size1 to Size4 indicate the firm size category from the smallest to the largest as defined in the Amadeus database.

Table A3. Descriptive statistics of conventional firms by RES policy choice

	FIT			TGC		
Variable	Obs	Mean	Std.	Obs	Mean	Std.
EBIT margin	1521	6.531	14.587	483	9.336	20.649
Firm assets, thou EUR	1514	860122	7685504	482	1270255	4515728
Size 1	1521	0.015	0.122	483	0.050	0.218
Size 2	1521	0.235	0.424	483	0.097	0.297
Size 3	1521	0.446	0.497	483	0.402	0.491
Size 4	1521	0.304	0.460	483	0.451	0.498
Payroll, thou EUR	1004	60341	527270	259	54148	170576
Added value, thou EUR	831	206193	1355069	228	218529	1127751
Return on Assets (ROA)	1472	3.229	9.268	470	2.615	10.318
Return on Equity (ROE)	1364	13.739	73.175	421	14.653	38.418
Return on Employed Capital (ROEC)	1319	8.871	37.969	426	16.169	45.235
Age	1475	13.262	16.431	483	20.122	24.002

Notes: All monetary variables are deflated by their country-specific deflators from Eurostat; Size1 to Size4 indicate the firm size category from the smallest to the largest as defined in the Amadeus database.

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