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Renewable energy use as environmental CSR behavior and the impact on firm profit

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Abstract

Firms buy renewable energy at premiums and report environmental concerns as motivation to do so. The bulk of the literature on environmental corporate social responsibility (CSR) suggests that this type of behavior even results in higher profit. From a microeconomic perspective, however, higher profit from environmental CSR activities is generally not expected. This paper investigates the relationship between firms' renewable energy use and profit by analyzing panel data for 920 firms over 2014–2018. We find no relationship between renewable energy use and profit. Hence, a win-win in the form of higher profit and a better environment does not seem to exist. In addition, it appears that firms do not have a positive willingness to pay for renewable energy as contribution to the environment.

Key words: Renewable energy use, Environmental CSR, Profit maximization, Theory of the firm, Product differentiation

1 Introduction

An increasing number of firms uses renewable energy with the intention to "combat climate change" (Apple, 2018), "contribut[e] to the reduction of carbon [emissions]" (Nestle, 2018) or "reduc[e] the environmental footprint" (Volkswagen, 2017). These public announcements seem to suggest that these firms are motivated by environmental concerns when they buy renewable energy, particularly considering that renewable energy is generally more expensive than non-renewable energy. For example, in the case of renewable electricity (applying to the three cited

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firms), firms that want to claim the use of renewable electricity typically acquire renewable electricity certificates in addition to the electricity itself. The wholesale price of European renewable energy certificates (Guarantees of Origin) was approximately €2 per MWh in 2018 (Greenfact, 2018). Prices of certain specific certificates are even much higher, such as Dutch wind certificates, which had a price of more than €7 per MWh in 2018.[1]

Considering that buying these renewable energy certificates does not affect at all firms' technological processes, the question emerges how renewable energy use is related to the general objective of the firm according to microeconomic theory, which is to maximize profit. More general, this question appears relevant for most corporate social responsibility (CSR) actions of firms. CSR may be referred to as actions that are beneficial to society, not directly beneficial to the firm and not required by law (McWilliams and Siegel, 2001). Environmental CSR can be considered the subgroup of actions which are related to environmental concerns, such as reducing the use of fossil energy in order to contribute to the mitigation of climate change. This paper regards renewable energy use as a specific type of environmental CSR: it benefits society through climate change mitigation while it generally does not provide direct benefits to the firm (i.e. lower costs) and is not required by law.

An extensive amount of papers empirically investigates the link between profit and (environmental) CSR. Although some of these papers find a negative or no linear relationship, most papers establish a positive linear relationship between profit and (environmental) CSR. This positive linear relationship is supported by several meta-analyses, both for CSR in general (Margolis *et al.*, 2009; Margolis and Walsh, 2001; Orlitzky *et al.*, 2003) and environmental CSR in particular (Dixon-Fowler *et al.*, 2013). A positive relationship seems to imply the existence of a win-win: CSR activities that benefit the environment are associated to higher firm profit as well. In contrast to the previous literature, based on stakeholder theory arguments, Barnett and Salomon (2012) theorize and empirically find a U shaped relationship between profit and CSR, i.e. that firms with low and high levels of CSR generate higher profit than firms with intermediate levels of CSR. They argue that, because firms require an adequate level of CSR expenditure before they can influence their stakeholders, firms are only able to profit from CSR expenditure when CSR expenditure reaches a sufficiently high level.

Taking on a microeconomic perspective, a positive relationship between profit and envi-

[1]See Hulshof *et al.* (2019) for more information on renewable energy certificate prices in Europe. For reference, the average wholesale electricity price was about €45 per MWh in the past decade in Northwest Europe.

ronmental CSR in general and renewable energy use in particular is not conform expectation (McWilliams and Siegel, 2001). On the one hand, renewable energy use can enable the firm to differentiate itself from competitors such that it can serve consumers with a higher willingness to pay and charge them higher prices. On the other hand, competition for those consumers is expected to drive down prices to the level of marginal costs. Furthermore, regarding firms' reported environmental concerns, it appears questionable as to whether firms are willing to use renewable energy at the expense of profit, as this directly contradicts the assumption that firms maximize profit. But if this would be the case, the decline in profit due to the use of renewable energy may be seen as the revealed willingness to pay of firms to contribute to climate-change mitigation.

The main question we address is: what is the relationship between profit and environmental CSR? In particular, we are interested in the relationship between profit and renewable energy use, a specific type of environmental CSR. The main contribution of this paper is that, rather than relying on indicator variables for environmental CSR (such as the KLD or ASSET4 score indicators), of which it is unclear whether they accurately reflect the true level of a firm's environmental CSR (e.g. Dixon-Fowler *et al.*, 2013), this paper relies on data regarding firms' renewable energy use, as a concrete measure for a specific type of environmental CSR.

This paper empirically investigates the relationship between profit and renewable energy use. Our analytical framework relies on the theory of product differentiation in a profit-maximization framework, as discussed in a seminal paper by Rosen (1974). This framework appears appropriate since, from a profit-maximization perspective, the only justification for using renewable energy is that the firm can differentiate itself from competitors (e.g. gain a better reputation) and serve consumers with a higher willingness to pay for this type of product quality, as renewable energy is more expensive and provides no technological advantages. Based on this analytical framework, we expect no relationship between profit and renewable energy use. If the empirical findings are not in accordance with this prediction, this might suggest that other explanations for renewable energy use by firms are more appropriate, such as altruistic environmental concerns.

The empirical analysis uses panel data for the period 2014–2018. The panel consists of 920 firms from 59 countries from a very large number of sectors. We find no evidence for a significant relationship between profit and renewable energy use, which is conform expectation based on microeconomic theory. From the results, there seems to be no win-win from renewable energy use in the form of higher profit and a better environment. In addition, the results suggest that firms do not use renewable energy at the expense of profit, which could have signaled a positive willingness to pay for the environment of firms. Instead, the relationship is neutral and firms are exactly compensated for their increased cost from using renewable energy. On the basis of using renewable energy as specific measure of environmental CSR, the findings of this paper do not corroborate the positive relationship between environmental CSR and profit (i.e. that it pays to be good/green), which is frequently established in the literature.

The remaining of this paper is organized as follows. The second section reviews the theoretical and empirical literature. The third section discusses the analytical framework. The fourth section describes the methods applied in this paper, in particular the empirical model, data and estimation method. The fifth section provides the results and discussion. A final section concludes.

2 Literature review

A central microeconomic assumption is that firms aim to maximize their profit and that firm behavior can be largely explained from this objective. For several decades, the (by now substantial) empirical CSR literature has been largely occupied with investigating how CSR expenditure relates to this central microeconomic assumption. We first discuss the link between profit and (environmental) CSR from a theoretical perspective. Consequently, we discuss the findings in the empirical literature. Finally, this section discusses renewable energy use by firms in particular. Considering the similarity between papers that focus on the general CSR-profit relationship and the environmental CSR-profit relationship, this section discusses papers from both the general CSR and environmental CSR literature.

2.1 Theoretical link between profit and environmental CSR

Economic theory has suggested two main theoretical explanations for the presence of (environmental-)CSR goods in firms' profit-maximizing bundle of inputs. First of all, (environmental) CSR can be part of profit maximization when it enables product differentiation. In contrast to firms active in markets with homogeneous goods, firms active in markets with differentiated goods may be able to charge a higher price than competitors (e.g. Rosen, 1974). Taking on a theory of the firm perspective, McWilliams and Siegel (2001) theorize that CSR expenditure can result in product attributes that are valued by consumers. The authors propose that firms, like for other inputs, trade-off the costs and benefits of CSR expenditure and select the quantity of CSR where the marginal costs and benefits are equalized. Considering the possibility to switch between CSR strategies, they theorize that no relationship between profit and CSR exists. A primary example of how firms differentiate themselves from competitors is reputation building through (environmental) CSR expenditure (e.g. Siegel and Vitaliano, 2007; McWilliams and Siegel, 2011).

Secondly, the profit-maximizing way to produce any quantity is where the production costs are minimized. Besides that several clean production technologies or inputs may be cheaper than polluting alternatives,[2] some authors have pointed out more subtle mechanisms through which environmental CSR can be part of cost-minimization. Porter and Van der Linde (1995) note that many types of environmental CSR investments are characterized by high initial investment costs which ultimately lead to cost reductions that offset the initial investment costs.[3] Another argument is that costly environmental CSR may prevent governments from imposing even more costly regulation (e.g. Davis, 1973; Carroll and Shabana, 2010).

2.2 Empirical evidence

A large empirical literature regarding the link between environmental CSR in particular or CSR in general and profit has emerged. The vast majority of these papers tries to relate measures of profit (e.g. net income, return on assets or Tobin's Q) to measures of (environmental) CSR (predominantly indicators of (environmental) CSR based on the KLD or ASSET4 scores). The difference between papers that focus on environmental CSR and papers that focus on all types of CSR is that the former generally measures CSR over environmental aspects only, whereas the latter measures CSR over all aspects. In other respects, the methodology in the two strands of literature is often similar. While the evidence is not fully consistent between studies, most papers appear to find a positive linear relationship between (environmental) CSR and profit (e.g. Waddock and Graves, 1997). This positive linear relationship is confirmed by several meta-analyses, for environmental CSR in particular (Dixon-Fowler *et al.*, 2013), and for CSR

[2] E.g. energy efficiency measures. It must be noted that it is somewhat doubtful whether these type of production inputs can be considered as CSR because, in addition to external benefits, they also generate direct private benefits to the firm. This is not the case for renewable energy considering that it is generally more expensive than non-renewable energy.

[3] Porter and Van der Linde (1995) also suggest that regulation is required for firms to be willing to invest in many types of CSR because they believe that firms generally fail at making optimal choices inter-temporally, i.e. fail at minimizing costs/maximizing profit over the long run.

in general (Margolis *et al.*, 2009; Margolis and Walsh, 2001; Orlitzky *et al.*, 2003).

Deviating from previous approaches, Barnett and Salomon (2012) theorize and empirically find a U shaped relationship between firm profit and CSR. They propose that, in order to profit from CSR actions, the level of CSR needs to surpass a certain threshold for otherwise the firm's stakeholders will not react in a profitable manner. Their argument is based on a stakeholder argument, namely that a firm's capability to influence their stakeholders depends on the level of CSR. The paper argues that, at low levels of CSR, a firm has few abilities to influence their stakeholders because those stakeholders will not perceive social actions by the firm as very credible and therefore not respond in a profitable manner. In contrast, at high levels of CSR, a firm has the ability to influence their stakeholders because those stakeholders will perceive social actions by the firm as credible and therefore respond in a profitable manner (in this case "such actions are in consonance with the firms character").

The majority of the papers in this literature have been criticized for the typical use of indicator variables for (environmental) CSR, often based on the KLD or ASSET4 scores. This type of indicator variable is usually based on ranking firms on a large number of CSR-related aspects which are then transformed into a single firm-level CSR score. These indicator variables have mainly become popular because it is difficult to measure CSR objectively. Inherently, there is a degree of subjectivity and arbitrariness present in the methodologies underlying such indicators (e.g. selection of aspects and aspect score calculation). Because of these problems, the validity of these indicators to represent actual environmental or social performance has been questioned (e.g. Dixon-Fowler *et al.*, 2013; Margolis and Walsh, 2001; Chatterji *et al.*, 2009; Semenova and Hassel, 2015). An exception is Konar and Cohen (2001), who use data regarding emissions of toxic chemicals and pending environmental lawsuits and also find a positive linear relationship with profit.

A second critique is the widespread (incorrect) use of ratio variables in this literature, both as dependent and independent variable (e.g. return on assets or toxic chemical emissions per dollar revenue) (Barnett and Salomon, 2012), which may lead to spurious results in regression analysis (e.g. Kronmal, 1993).

Another branch of papers has verified the direction of causality in the relationship between profit and CSR. The concern of these papers is that CSR expenditure may be determined by profitability, rather than the other way around, because it is "inessential" expenditure. If valid and unaccounted for, this reverse causality problem could lead to biased estimates from conventional estimation techniques. However, explicitly addressing the direction of causality, Kang *et al.* (2016) and Scholtens (2008) find evidence that causality runs from CSR to profit and not the other way around.

2.3 Renewable energy use by firms

Finally, this paper relates to the literature on renewable energy consumption by firms. In recent years, there has been a marked increase in the demand for renewable energy from firms. This can be seen for example from the steep increase in participation by firms in voluntary renewable energy programs in which they pledge or articulate their intention to increase their renewable energy use. Two primary examples are the U.S. EPA's Green Power Partnership (GPP) program and the RE100. The former experienced an increase in the number of participants from 656 in 2006 to 1532 in 2018. Collectively, participants consumed 55TWh of renewable electricity in 2018 (EPA, 2019). The RE100 experienced an increase from 50 participating firms in 2015 to 155 in 2018 with an aggregate renewable electricity consumption of 72TWh in 2017 (RE100, 2018).[4] Based on survey findings, PWC (2016) reports that meeting sustainability goals and reducing greenhouse gas emissions is the primary motivation for firms in the U.S. to buy renewable energy.

The primary tool for firms to consume renewable energy is the procurement of renewable energy certificates (RECs), which have become the dominant market mechanism for consumption of renewable electricity (Hulshof *et al.*, 2019). RECs are administered to renewable energy producers, which can then be sold separately from the energy to end-users who wish to claim the consumption of renewable energy. Firms buy RECs either (i) directly as unbundled product, i.e. separately from their electricity product, or (ii) as a bundled product consisting of both RECs and electricity from a retailer or producer. Method (i) accounted for 55% of the total renewable energy consumption of GPP partners in 2018 and for 46% of the total consumption of RE100 participants in 2017. Method (ii) accounted for 40% of the total renewable energy consumption of GPP partners in 2018 and 35% of the total consumption of RE100 participants in 2017 (EPA, 2019; RE100, 2018).

[4] For reference, total electricity consumption in Chile, Italy and the U.S. in 2017 was 75TWh, 315TWh and 4,098TWh respectively (IEA, 2019).

3 Analytical framework

This paper's analytical framework is based on the seminal paper about vertical product differentiation by Rosen (1974). Theory about product differentiation provides the suitable framework because it is the principal mechanism through which renewable energy relates to (economic) profit of the firm. Products are vertically (as opposed to horizontally) differentiated when, at a given price, everybody prefers a product (or is indifferent) when more of a particular characteristic is present. This seems to apply to renewable energy as well. It is clear that some individuals prefer goods with environmental-friendly attributes (e.g. Bjørner *et al.*, 2004) and, despite that some individuals may be indifferent, there is no reason to dislike the use of renewable energy in production. This section provides an interpretation of Rosen's model when goods are vertically differentiated on the basis of firms' renewable energy use with several assumptions that are specific to this case. We discuss the main insights and implications for the relationship with firm profit from adopting this framework.

A key element in Rosen's model is the dependence of the market price (p) on the presence of a number (n) of valuable characteristics ($z = (z_1, z_2, \cdots, z_n)$), which he refers to as the hedonic price function $p(z)$. Here, it is assumed that products are differentiated on the basis of a single attribute, renewable energy ($z = RE$). Firms are price takers but have some control over the price they can charge by using more or less RE. We will make the specific assumption that firms can modify the product's renewable energy characteristic by simply buying the desired amount of renewable energy certificates at the prevailing market price, reflecting actual practice. In terms of the firm's cost function $C(M, RE)$, where M is the quantity produced, this translates to assuming that the marginal cost of adding renewable energy is constant i.e. $\frac{\partial C}{\partial RE} > 0$ and $\frac{\partial^2 C}{\partial RE^2} = 0$. Moreover, buying renewable energy certificates does not lead in any way to changes in the physical production process and there are basically no interactions with other production inputs.[5] Further, we assume that firms have the same cost function. While this may not reflect reality for other product characteristics and inputs, it can be justified for the case of renewable energy on the basis that firms do not transform other inputs into the renewable energy characteristic but simply buy it from certificate retailers.

[5]The assumptions on the cost function are chosen to reflect differentiation on the basis of renewable energy in practice. This includes assuming there exist no entry barriers in the form of a fixed cost associated to choosing a certain renewable energy/quality level, as in Shaked and Sutton (1982, 1987). With renewable energy, firms merely change the desired amount of certificates and pay the associated marginal certificate price when choosing/changing the desired quality level instead of paying a significant fixed costs.

Firms then maximize profit $\pi = Mp(RE) - C(M, RE)$. The first order conditions that yield the optimum choices of $M = M^*$ and $RE = RE^*$ are given by:

$$p(RE) - \frac{\partial C}{\partial M} = 0 \tag{1}$$

and

$$M\frac{\partial p}{\partial RE} - \frac{\partial C}{\partial RE} = 0 \tag{2}$$

(2) gives the relationship between profit and renewable energy use, when evaluated at M^*. The first term ($M\frac{\partial p}{\partial RE}$) gives the marginal revenue of increasing RE whereas the second term ($\frac{\partial C}{\partial RE}$) is the marginal cost of increasing RE. Notice that the marginal cost of RE *per unit of output* is equal to $\frac{\partial C}{\partial RE}/M^*$. This is the firm's minimally required price increase to be willing to to increase its use of RE, i.e. the marginal reservation price for RE. Because of the assumption that firms have the same cost function, this is identical for all firms. According to (2), in the optimum, the marginal cost and revenue per unit should be equal, i.e. $\frac{\partial p}{\partial RE} = \frac{\partial C}{\partial RE}/M^*$. Furthermore, because we assume a competitive market, prices will equal the producers' reservation price. This implies that $\frac{\partial p}{\partial RE}$ is fully determined by $\frac{\partial C}{\partial RE}/M^*$.[6] Under these assumptions, the hedonic price curve and the producers' common RE marginal reservation price curve coincide and (2) is satisfied at any choice of RE. Moreover, since the marginal cost of certificates is constant, the slope of the marginal reservation price curve and therefore the hedonic price curve is also constant. In terms of (2), $\frac{\partial^2 p}{\partial RE^2} = 0$ because $\frac{\partial^2 C}{\partial RE^2} = 0$ by assumption.[7] Figure 1 draws the relevant producer reservation price curve ($p(RE)$) as a function of the renewable energy characteristic.[8]

From the perspective of some consumers, more of the renewable energy input may be preferred and the willingness to pay of these individuals increases with the amount of renewable energy accordingly. However, since buying a good with more renewable energy (at a higher price) means lower consumption of other goods, the marginal willingness to pay for the RE characteristic is decreasing, conform the usual properties of a utility function. In terms of figure 1, this can be shown by introducing a special type of consumer indifference curve, which

[6]Individual firms take the hedonic price curve and its slope as exogenous as they are assumed to be price takers.

[7]Assuming non-constant marginal cost of renewable energy merely changes the shape of the reservation price curve (e.g. convex), but not the qualitative conclusions regarding the expected relationship between profit and renewable energy from this theoretical framework.

[8]Where relevant refers to the reservation price curve corresponding to the competitive-industry profit level (π_{pc}). Rosen (1974) shows that a whole family of parallel reservations price curves exist (i.e. all with slope $\frac{\partial C}{\partial RE}/M^*$), each corresponding to a different profit level. From assuming a competitive market, the relevant reservation price is the one associated to π_{pc}.

Rosen calls the bid curve (θ). The bid curve reflects a consumer's willingness to pay for the good at different RE levels, while holding the level of utility constant.[9] As with conventional indifference curves, a whole family of parallel bid curves exist. Consumers prefer bundles to the south-east corner (i.e. a lower price for a given amount of RE) but are constrained by the market price. Their optimal choice is characterized by a tangency condition between their indifference curve and the hedonic price curve (essentially the budget constraint), corresponding here to the competitive firm's reservation price curve. Figure 1 draws the bid curves of two example consumers, which optimally choose two different levels of RE. When the preferences of consumers for the RE characteristics are very heterogeneous or "spread out", as is assumed in Rosen (1974) and here, the points of tangency with the producer reservation price curve occur at all levels of RE. In other words, at any choice of RE, firms can find consumers that prefer exactly that type.

What are the implications for the relationship between profit and renewable energy use? The outcome of the model is that the choice of RE does not matter for profit as firms are always exactly compensated for the increased costs of using more renewable energy. By increasing RE, costs increase but revenues also increases in an exactly offsetting manner because the good can be sold at a higher price.[10] In other words, this theoretical framework predicts that there exists no relationship between renewable energy use and profit.

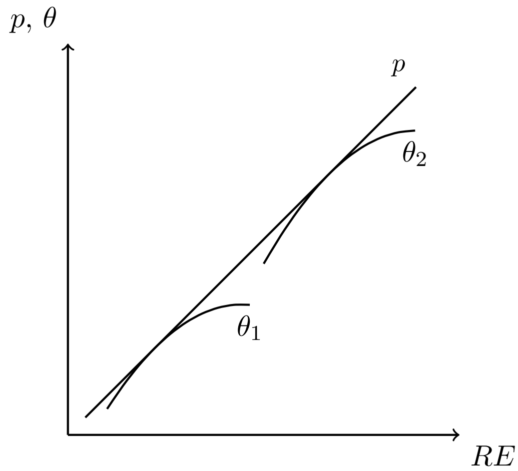

Figure 1: Producer (p) and consumer (θ_i) reservation prices for the renewable energy characteristic

[9]In figure 1, the vertical axis measures the amount spend on the good, as it is assumed that consumers buy one unit, which therefore equals the foregone expenditure on other goods. The bid curve is therefore an inverted conventional indifference curve (trading off consumption of the good with varying levels of the RE attribute versus consumption of other goods), with slope equal to minus the slope of a conventional indifference curve.

[10]Assuming consumers have perfect information on product qualities in terms of RE.

One of our critical (but arguably realistic) assumptions that drives this prediction is that firms have access to exactly the same technology/cost function to add the renewable energy characteristic, namely by simply buying the desired amount of certificates at a constant price. In contrast, assuming differences exist in firms' cost function, the general model in Rosen (1974) predicts that there will be a single optimal choice of RE for an individual firm and deviating in any direction from the optimum would hurt profit.

The subsequent empirical analysis tests this prediction that is derived from taking on a profit-maximization perspective with vertical product differentiation in a perfectly competitive environment. Given that alternative explanations of environmental CSR behavior cannot be true at the same time (e.g. one alternative explanation being that firms engage in green behavior for environmental reasons and at the expense of profit), we investigate the specific explanation that renewable energy use follows from profit maximization and that firms will only do so if they are compensated for it (in an offsetting manner due to competition).

4 Method

4.1 Empirical model

Using panel data, we estimate a regression model that relates firm profit (π) to renewable energy use (RE), in addition to several control variables that may correlate both with firm profit and renewable energy use. One specification allows for a curvilinear relationship between π and RE by including a quadratic term to test for the presence of a U shaped relationship, as found by Barnett and Salomon (2012). We estimate the following equation:

$$\pi_{ti} = \beta_0 + \beta_1 RE_{ti} + \beta_2 RE_{ti}^2 + \beta_3 TE_{ti} + \beta_4 D_{ti} + \beta_5 A_{ti} + c_i + \boldsymbol{\alpha}\mathbf{Y}_{ti} + \epsilon_{ti} \qquad (3)$$

where t refers to the time period and i to the firm.

The model includes total energy use (TE) as independent variable because it may correlate with both RE and π: renewable energy use is by definition a component of total energy use while the profitability of firms may also be related to the firm's (or industry's) energy intensity.[11]

Debt (D) is included as control variable as debt may influence managers' behavior for two reasons (e.g. Barnett and Salomon, 2012). On the one hand, higher debt may encourage decision

[11] The correlation coefficient between renewable and total energy use is 0.42.

making conform pure profit maximization. On the other hand, it may also reduce firms' ability to execute profitable investment opportunities due to possible capital constraints. When this affects firms' decisions to buy renewable energy, omitting debt would bias our estimate of the effect of renewable energy on profit. Assets (A) is included as independent variable to control for firm size. While total energy use may also be regarded as an indicator for firm size, it is an imprecise measure of firm size since larger firms may have a relatively low energy intensity (e.g larger firms in the financial and staffing sectors), which is therefore complemented with another measure of size.

c refers to an unobserved time-invariant firm-specific effect. In this case, this may capture differences in the unobserved ability of firms' management. $\mathbf{Y}$ is a vector of year-sector interaction dummies which are equal to one for firm i in year t if the firm belongs to the respective sector and zero otherwise. This may capture for example macroeconomic fluctuations pertaining to a specific sector. ϵ is an error term which is assumed to be independent and identically distributed with a mean of zero.

The model deliberately omits R&D expenditure as control variable, which is suggested to be included by McWilliams and Siegel (2000) for models linking CSR to profit. As the procurement of RECs from producers or retailers is a simple administrative act, renewable energy consumption is typically not expected to be relevant for firms' product innovations stemming from R&D expenditure. Including R&D expenditure does not materially change our conclusion regarding the relationship between profit and renewable energy. The first two columns in table A.1 in the Appendix report the results of the model with R&D expenditure included as control variable.

4.2 Data

The data for this analysis comes from firms' financial and environmental reports over the period 2014–2018, which we collect using Bloomberg. For this period, renewable energy use (in GWh) is reported for 971 firms in one or more years, resulting in a total number of annual firm-year observations for this variable of 2,696.[12] The data on renewable energy use is complemented with data for the other variables in (3): net income (in million US$) as a measure of profit,[13]

[12]Note that this includes all types of renewable energy, such as renewable electricity, renewable gas, renewable hydrogen etc.

[13]I.e. after taxes, interest payments, depreciation and all other expenses. Note that this is a measure of accounting profit and not economic profit.

total energy use (in GWh),[14] debt (in million US$, including short and long term debt) and assets (in million US$).

The final panel dataset is unbalanced due to one or more missing observations in most of the variables. In total, the final sample includes 2,581 firm-year observations for 920 firms. Firms from all continents and sectors are included in the sample, where sectors are distinguished according to the Industry Classification Benchmark (ICB) by FTSE Russell. The ICB classification encompasses 114 sub-sectors, 41 sectors, 19 super-sectors and 10 industries, out of which 104, 39, 19 and 10 are represented in the sample. The ICB sectors are used for construction of the year-sector dummy variables (195 in total of which one is omitted in estimation). Table 1 reports details about the geographical and industrial characteristics of the firms in our sample. Table 2 reports descriptive statistics of the variables.

Reporting about renewable energy use is voluntary and the incentive to report seems more obvious for firms that use considerable amounts of renewable energy (i.e. green firms) than for firms that do not. Therefore, a worry may be that firms that use hardly any renewable energy are not represented in the database. However, considering that 9% (34%) of the firms in the database have a renewable energy share (as percentage of total energy use) of less than 0.01% (1%), we are not highly worried about this selection effect.

Table 1: Number of firm-years in sample by geography and industry

	World	North America	South America	Europe	Africa	Asia	Oceania
All sectors	2,581	608	177	1,068	36	628	64
Oil & gas	87	21	9	32	0	25	0
Basic materials	323	84	35	93	5	88	18
Industrials	554	108	27	247	5	156	11
Consumer goods	440	74	26	182	10	144	4
Health care	124	46	3	47	2	26	0
Consumer services	180	51	8	92	10	19	0
Telecommunications	95	10	11	55	1	13	5
Utilities	135	24	46	51	0	14	0
Financials	466	115	12	243	3	67	26
Technology	177	75	0	26	0	76	0

Source: Bloomberg

[14] Including all types of energy.

Table 2: Descriptive statistics

	Mean	SD (within)	Minimum	Maximum
Net income (mln US$)	1,292	2,223	-16,265	94,209
Renewable energy use (GWh)	1,413	1,925	0	106,884
Total energy use (GWh)	10,582	4,763	0.2	563,957
Share of renewable energy	18.0%	6.9%	0%	100%
Debt (mln US$)	19,514	6,891	0	699,564
Assets (mln US$)	78,910	18,900	19	2,622,532

Source: Bloomberg

4.3 Estimation method

The analysis applies a within-estimation procedure to estimate the coefficients of the model in (3) because the unobserved time-invariant firm-specific affect may be correlated with both firm profitability and the decision to use renewable energy. This implies using only variation within the firm to estimate the effect of renewable energy on profit. Applying a random effects estimation procedure, such that also between-firm variation is considered, does not materially change our conclusion. The last two columns in table A.1 in the Appendix report the estimation results from a random effects model.

The model in (3) is estimated twice: (i) the primary model restricts $\beta_2 = 0$, in order to test for the presence of a linear relationship between profit and renewable energy. This entails testing the hypothesis that $\beta_1 = 0$ against the alternative that $\beta_1 \neq 0$; and (ii) the model without restrictions on β_2 in order to test for the presence of a U shaped relationship between profit and renewable energy. To test for the presence of a U shape, the analysis applies the test proposed by Lind and Mehlum (2010). Their formal test provides the necessary and sufficient conditions for the presence of a U shape. The test entails testing the null hypothesis that a monotone or inverse-U shape is present versus the alternative that a U shape is present.

Cluster-robust standard errors are computed because the autocorrelation test as proposed by Wooldridge (2010) indicates the presence of autocorrelation. In addition, from residual plots, it appears as if the predicted values become less accurate when the predicted value becomes larger, i.e. the models seem to suffer from heteroskedasticity. The standard errors are clustered at the level of the sub-sector based on the ICB classification (104 clusters).

5 Results and discussion

Table 3 reports the estimation results. Based on model (i), we estimate a negative but highly insignificant coefficient for renewable energy use (p=0.569), with a 95% confidence interval ranging from [-0.047, 0.026]. Regarding the estimated size of the effect, for an increase in renewable energy use of 10% for the mean firm (an increase of 141.3 GWh), this translates to an estimated effect on profit of [-6.6 mln US$, 3.6 mln US$], i.e. between -0.5% and 0.3% of mean profit. Hence, based on the full sample, we do not find evidence for a positive linear relationship between profit and renewable energy use, as has frequently been empirically established, including in meta analyses, for general indicators of (environmental) CSR (e.g. Orlitzky *et al.*, 2003; Dixon-Fowler *et al.*, 2013).

The coefficients for renewable energy and its square in model (ii) have the required signs for a U shaped relationship with profit but are not statistically significant (p=0.275 for RE and p=0.278 for its square). In addition, the formal test for a U shape fails to reject the null-hypothesis at conventional significance thresholds (p-value 0.142). These results do not support the presence of a U shaped relationship between profit and renewable energy use.

The results show that there is no relationship between profit and renewable energy use. This implies that firms are exactly compensated for an increase in costs when they use renewable energy. These results are in line with the predicted relationship in a profit-maximization framework. In contrast with most other papers in the CSR literature, this paper does not find evidence for a win-win in the form of a better environment and higher firm profit. In addition, the results imply that firms are not sacrificing profit in favor of renewable energy use. Hence, we do not find signals for a positive willingness to pay for renewable energy of firms in the sense that they accept lower profits.

With respect to the other variables, conform expectation, an increase in the level of assets is associated with a statistically significant increase in net income (p=0.026 and p=0.025 in models (i) and (ii) respectively). On average, an increase in the level of assets by one million US$ is associated to an increase in the level of profit by 0.02 million US$. For debt, we estimate a negative and marginally statistically significant coefficient (p=0.082 and p=0.084 in models (i) and (ii) respectively). We had no a priori expectation for this variable. The negative coefficients are in line with the findings of Barnett and Salomon (2012). For total energy use, we estimate a negative coefficient in model (i) and a positive coefficient in model (ii). These estimates are, however, highly insignificant (p=0.976 and p=0.864 in models (i) and (ii) respectively) and the 95% confidence intervals largely overlap ([-0.019, 0.019] and [-0.018, 0.021] in models (i) and (ii) respectively). It appears that changes in energy intensity within a firm are not associated to changes in net income. The estimated coefficients for the firm and year-sector fixed effects are not reported to facilitate readability and because they are of limited interest.

Table 3: Fixed effects estimation results. Dependent variable: net income

	Model (i)	Model (ii)
Renewable energy use	-0.010	-0.103
	(0.569)	(0.275)
(Renewable energy use)^2		0.000001
		(0.278)
Total energy use	-0.0003	0.002
	(0.976)	(0.864)
Debt	-0.022	-0.022
	(0.082)	(0.084)
Assets	0.020	0.020
	(0.026)	(0.025)
Constant	613.7	140.5
	(0.403)	(0.847)
Pseudo R^2	0.24	0.24
No. of observations	2,581	2,581
No. of firms	920	920
Year-sector dummies$^+$	Yes	Yes

P-value in parentheses.
$^+$ year-sector dummies are equal to one for firm i in year t if the firm belongs to sector s and zero otherwise.

6 Conclusion

Firms buy renewable energy, a specific type of environmental CSR, at premiums and typically report environmental as motivation to do so. The empirical environmental CSR literature seems to suggest that there even exists a win-win from this type of firm behavior: more environmental CSR is associated to higher profit levels.

From a microeconomic perspective, however, higher profit from environmental CSR in general and renewable energy use in particular are not expected (McWilliams and Siegel, 2001). On the one hand, firms may be able to differentiate themselves from competitors by using renewable energy, or another type of environmental CSR, and thereby charge higher prices. On the other hand, competition for those high-WTP consumers drives down prices towards the level of marginal costs. In addition, if we assume that the objective of the firm is to maximize profit, there is no scope for renewable energy use or environmental CSR at the expense of profit. Therefore, in this profit-maximization framework, we expect that there exists no relationship between profit and renewable energy use.

In this paper, we have analyzed the relationship between renewable energy use and firm profit by using panel data of 920 firms from various regions and sectors over the period 2014–2018. Also firms that use no or hardly any renewable energy are represented in the database.

The results suggest that there is no relationship between renewable energy use and profit. The interpretation of this result is twofold. Firstly, for renewable energy use by firms, there does not appear to exist a win-win in the sense that promoting social goals (a better environment) is not associated to benefiting private goals (firm profit). In relation to the broader CSR literature, our results do not corroborate the win-win relationship between (environmental) CSR and firm profit that has frequently been established, including in meta-analyses (e.g Orlitzky *et al.*, 2003; Dixon-Fowler *et al.*, 2013). Secondly, the results also imply that firms are not sacrificing profit when they use renewable energy, which could have been an indication for a positive willingness to pay for the environment by firms. These findings are in line with the expected relationship between renewable energy use and profit in a profit-maximization framework. This appears to indicate that firms do not have objectives beyond maximizing profit and that firms are only willing to contribute to climate change mitigation through the purchase of renewable energy when this contributes to the profit-maximization objective as well.

This paper's main contribution is that, rather than relying on indicator variables of which it is not clear to what extent they represent actual CSR levels, this analysis uses a more specific and concrete measure of environmental CSR in the form of renewable energy use. However, several caveats of the current study need to be mentioned. First, the data includes a highly heterogeneous group of firms in terms of industry and origin. Some factors that are not explicitly modeled could be related to the profitability of firms, particularly the competition intensity. Although we attempt to control for such factors (e.g. through industry-time and firm dummies), it can be valuable to study more homogeneous groups of firms. Secondly, the empirical analysis uses net income as measure for profit, which is a measure of accounting profit, whereas the theory concerns the relationship between economic profit and renewable energy use. Because firms increasingly play an important contribution in societies' efforts to mitigate climate change, further research is required to analyze how these firm contributions fit within the objectives of the firm.

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Appendix

Table A.1: Results of alternative specifications including R&D expenditure (ia and iia) and random effects (RE) estimations (ib and iib). Dependent variable: net income

	Model (ia) FE-estimation with R&D exp.	Model (iia) FE-estimation with R&D exp.	Model (ib) RE-estimation of eq. (3)	Model (iib) RE-estimation of eq. (3)
RE	-0.013	-0.135	0.001	0.017
	(0.511)	(0.210)	(0.877)	(0.536)
RE^2		0.000001		-0.0000002
		(0.213)		(0.421)
TE	0.0004	0.002	0.006	0.006
	(0.965)	(0.821)	(0.057)	(0.086)
Debt	-0.085	-0.084	0.0003	0.0003
	(0.369)	(0.374)	(0.955)	(0.955)
Assets	0.078	0.079	0.007	0.007
	(0.127)	(0.127)	(0.000)	(0.000)
R&D	-0.080	-0.055		
	(0.883)	(0.919)		
Constant	-623.4	-564.8	1084.8	1091.2
	(0.479)	(0.524)	(0.000)	(0.000)
Pseudo R^2	0.28	0.29	0.29	0.29
No. of obs.	2,117	2,117	2,581	2,581
No. of firms	769	769	920	920
Year-sector dummies$^+$	Yes	Yes	Yes	Yes

P-value in parentheses.
$^+$ year-sector dummies are equal to one for firm i in year t if the firm belongs to sector s and zero otherwise.

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