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The Role of R&D Expenses for Profitability: Evidence from U.S. Fossil and Renewable Energy Firms

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Abstract

This study investigates the relationship between R&D expenses and profitability for a panel of U.S. firms in the energy sector. The analysis, spanning the period 1990–2011, differentiates the energy sector into two groups: firms that sell fossil energy sources to generate electricity and firms that sell renewable energy sources to generate electricity. The empirical findings show that R&D expenses have a stronger impact on profitability in the group of firms that sell renewable energy sources.

Keywords: profitability, energy sector firms, R&D expenses, panel data

1. Introduction

This study investigates the relationship between R&D expenditures and profitability for firms in the energy sector. Considerable attention has been devoted to the relationship between R&D expenses and profitability. Roberts (2001) provides empirical evidence relative to the argument that as firms innovate, they generate new products across markets. In this manner, they enjoy a temporary monopolistic status, given that they are the only providers of such new products. According to the classical economic theory, the presence of profits in a product market, motivates external firms to enter the market (i.e., to enjoy those profits) and, thus, drive the market back to the equilibrium position, while excess profits disappear. However, the only way though which firms could continue experiencing persistent profits is either by continuing their innovation activities or by limiting their competitors' access to imitate their products by reinforcing the barriers to entry. For a great number of firms this goal can be achieved only through the protection patents offer.

This paper focuses on firms in the energy sector. Large energy firms spend a significant amount of money to have access in the inventories of oil, coal and gas or in renewable energy sources. These firms spend lots of money on R&D to achieve technological innovations that will make them more competitive. Over the last years, there have been significant changes in the energy sector. As the oil, coal and gas stocks are continuously depleting, more firms turn to renewable energy sources. In order to maintain efficient production standards they increase their spending on R&D. The strategy of this paper is to identify in which sector (i.e., traditional firms that sell fossil energy vs new energy firms that sell renewable energy) the relationship between R&D expenses and profitability is stronger, implying that investments in new technology related to energy lead to higher profits.

The remainder of this paper is organized as follows: Section 2 presents a brief review of the literature, while Section 3 displays the methodology followed. Section 4 presents the data used, while Section 5 reports the empirical results. Finally, Section 6 concludes the paper.

2. Literature Review

Firm profitability is usually measured through market value (Shah, 2008; Ehie, 2010; Chan, 2001). According to Chan (2001), "*The market value of a firm's shares ultimately reflects the value of all its net assets*." Chan (2001) argues that the association between the firm's market value and its tangible assets can be easily determined. By contrast, the nexus between that market value and its intangible assets is somewhat harder to be determined.

A number of papers in the relevant literature have attempted to determine the association between R&D expenses and firms' profitability (Hirschey, 1982; Roberts & Hauptman, 1987; Grabowski & Mueller, 1988; among others).

Moreover, Branch (1974) investigates seven industries and finds that changes in R&D expenses are significantly associated with firms' profitability, while Schoeffler (1977) determines that high R&D expenses are negatively associated with that profitability only in the case of rapidly growing markets. At the same time, R&D expenses turn to have a positive impact on the firms' performance only in the case that those firms have already established a strong position in the market and/or in their sector.

A number of studies show that R&D expenses have a consistent and positive effect on the profitability of a firm (Chan, 2001; Roberts, 2001; Shah, 2008; Ehie, 2010; Pindado, 2010). Shah (2008) makes use of a sample of U.K. manufacturing firms over the period 1998 to 2002; his empirical findings provide strong support for a positive association between R&D expenses and market values. Rzankhanov (2004) focuses on biotech firms. His empirical findings provide support to the presence of a positive relationship between patents and market values. Moreover, his results document that biotech firms tend to be more successful in their R&D efforts and for that reason they are valued higher than firms that fail to display a strong R&D record. Pindado (2010) argues on how a number of idiosyncratic firms' characteristics could affect the association between R&D expenses and firm values. His empirical findings highlight that although firms' size and stock prices display a positive association with R&D expenses, there are specific factors, such as external financial dependence, capital intensity, labor intensity, and free cash flows that display a negative association with R&D expenses.

A different strand in the literature points out that as R&D expenses increase, returns volatility follows the same path (Chan, 2001; Shah, 2008; Ehie, 2010). According to Chan (2001), returns show no differentiation for firms that spend highly or not on R&D, implying that R&D expenses do not affect a firm's performance. Chan (2001) concludes that with respect to firms with low R&D spending, in case they decide to spend more they may experience higher returns volatility.

3. Methodological Issues

The empirical goal of this paper is to investigate the associaiton between R&D expenses and profitability for a number of U.S. firms in the energy sector. To this end, we split the energy sector into two groups: traditional energy firms (i.e., they sell fossil energy) and energy firms that sell renewable energy. The justification for this splitting lies on our query to figure out in which group of energy firms the relationship between R&D expenses and profitability is stronger. The estimated equation yields:

$$ROA_{it} = a_i + b_1 RD_{it} + a_2 CF_{it} + \varepsilon_{it}$$

where ROA is the returns to asset profitability measure of each firm at the end of the financial year, sales defines sales revenues, RD represents R&D expenses and CF shows free cash flows, i = 1, …, N for each firm in the panel and t = 1, …, T refers to the time period. The parameter α_i allows for firm-specific fixed effects. Finally, ε_{it} denotes the estimated residuals which represent deviations from the long-run relationship. Our main research hypothesis is that R&D expenses have a positive impact on profitability, while this impact turns out to be stronger for those energy firms that sell renewable energy. According to theoretical arguments, free cash flows may have both a positive and a negative effect on market values. Pindado (2010) argues that cash flows are expected to have a negative impact on market values; his argument is based on the documentation that when firms experience high levels of cash flows, they use this type of funding for projects with a negative net present value, implying that these firms tend to undertake higher risks. By contrast, Chauvin and Hirschey (2001) show that cash flows have a positive impact on firms' market values.

4. Data

We collect quarterly data on returns to assets (ROA), returns on equity (ROE), R&D expenses (RD), capitalization (CAP), and free cash flows (CF) from energy firms that sell fossil energy and energy firms that sell renewable energy from the U.S. energy sector spanning the period 2000–2012. These data were obtained from the Bloomberg database. Fossil energy sources include energy from oil, coal, gas and nuclear power sources, while renewable energy sources include energy from hydropower, geothermal, solar, wind, biomass and biofuels. Our sample includes 183 firms, of which 39 are firms that sell fossil energy and 144 are firms that sell all types of renewable energy. The list of fossil and renewable energy firms can be found in Appendixes I and II, respectively. Finally, data are transformed in logarithms.

5. Empirical Analysis

5.1 Panel Unit Root Tests

There is a variety of panel unit root tests which include Levin et al. (2002), Im et al. (2003) and Fisher – ADF and Fisher – PP (Maddala & Wu, 1999). The results for fossil firms and renewable energy firms are reported in Tables 1 and 2, respectively. The results point out that the hypothesis that the levels of all the variables under study

contain a unit root is accepted at the 1% significant level across all tests. By contrast, when the tests are applied on the first differences, the results display that the unit root hypothesis is rejected.

Table 1. Panel unit root tests (Fossil energy firms)

	Levin et al.	Im et al.	Fisher-ADF square
ROA	-2.35	-1.47	15.09
ΔROA	-7.39*	-6.52*	87.64*
RD	-1.67	-1.17	14.39
ΔRD	-6.28*	-5.26*	90.37*
CF	-1.44	-1.21	20.64
ΔCF	-5.61*	-5.49*	94.35*
ROE	-1.38	-1.42	22.36
ΔROE	-5.74*	-5.73*	97.61*
CAP	-1.56	-1.63	18.71
ΔCAP	-6.13*	-6.37*	86.55*

Notes: Δ denotes first differences. * statistically significant at 1%.

Table 2. Panel unit root tests (Renewable energy firms)

	Levin et al.	Im et al.	Fisher-ADF square
ROA	-1.54	-1.62	17.55
ΔROA	-5.48*	-6.24*	88.71*
RD	-1.38	-1.53	20.78
ΔRD	-6.14*	-5.13*	90.06*
CF	-1.16	-1.18	16.93
ΔCF	-5.37*	-6.91*	87.62*
ROE	-1.24	-1.32	18.94
ΔROE	-5.83*	-6.78*	94.56*
CAP	-1.25	-1.32	19.05
ΔCAP	-6.31*	-6.52*	92.37*

Notes: Similar to Table 1.

5.2 Panel Cointegration Tests

Next, we make use of the Pedroni (1999; 2004) heterogeneous panel cointegration testing approach to determine whether a long-run equilibrium exists. Based on Pedroni's (1999; 2004) panel cointegration tests, i.e. the within dimension approach which includes four statistics as well as the group mean tests, i.e. the between dimension approach which includes three statistics, the empirical findings, reported in Table 3, reject the null hypothesis of no cointegration at the 1% significance level across all seven tests statistics.

Table 3. Panel cointegration tests (Profitability: ROA)

Panel cointegration tests (Fossil energy firms)			
Panel v-statistic:	52.75361	Group ρ-statistic:	-52.66983
Panel ρ-statistic:	-51.86232	Group PP-statistic:	-51.23962
Panel PP-statistic:	-50.46794	Group ADF-statistic:	-7.41517
Panel ADF-statistic:	-7.84264		
Panel cointegration tests (Renewable energy firms)			
Panel v-statistic:	46.87228	Group ρ-statistic:	-46.93857
Panel ρ-statistic:	-44.23963	Group PP-statistic:	-46.95269
Panel PP-statistic:	-45.69247	Group ADF-statistic:	-6.67476
Panel ADF-statistic:	-6.34782		

Notes: Both the panel and group mean panel tests are distributed asymptotically as standard normal. Both the panel statistic and the group statistics reject the null hypothesis of no cointegration.

5.3 Panel Cointegration Estimates

Next, the Fully Modified OLS (FMOLS) methodological approach is employed to determine the long-run equilibrium. As reported in Table 4, the results show that the coefficient of R&D expenses is positive and statistically significant at the 1% level. In particular, a 1% increase in R&D expenses increases profitability measured by ROA by 0.36%, for firms in the fossil energy sector, while for firms in the renewable energy sector we get that a 1% increase in R&D expenses leads to 0.74% percent in profitability. These findings imply that R&D expenses exert a stronger effect in profitability in the renewable energy sector, indicating the dominant role of such R&D investments in renewable energy. Finally, a number of model diagnostics indicates that the long-run estimates do not suffer from serial correlation (LM test), heteroscedasticity (HE test), and model misspecification (RESET test).

Table 4. FMOLS estimates (profitability: ROA)

Fossil energy firms			
ROA_{it} = 0.851	+ 0.361 Rd_{it}	+0.184 CF_{it}	
(4.61)*	(5.58)*	(4.97)*	
R^2 = 0.46	LM = 1.24	HE = 1.32	RESET = 1.65
	[0.20]	[0.36]	[0.26]
Renewable energy firms			
ROA_{it} = 0.647	+0.739 Rd_{it}	+0.226 CF_{it}	
(4.89)*	(8.62)*	(5.71)*	
R^2 = 0.59	LM = 1.12	HE = 1.25	RESET = 1.44
	[0.29]	[0.39]	[0.33]

Notes: t-statistics and probability values are reported in parentheses and brackets, respectively. LM is the Lagrange multiplier test for serial correlation. HE is White's heteroscedasticity test. RESET is Ramsey's regression equation specification error test.

In both cases, the control variable of cash flows turns out to have a positive and statistically significant effect on profitability.

5.4 Robustness Tests: Alternative Definitions of Profits

We replicate the above analysis for robustness purposes by using ROE as a proxy for profitability. The new results are reported in Table 5. These new findings confirm the robustness of the results reached in sub-section 5.3, indicating that R&D expenses exert (again) a stronger effect on renewable energy firms' profitability vis-à-vis its counterpart of fossil energy firms. In particular, a 1% increase in R&D expenses increases profitability by 0.32% in the case of fossil energy firms and by 0.66% in the case of renewable energy firms, supporting the argument that R&D expenses are characterized by higher value added technological advances in the renewable energy firms.

Table 5. Panel cointegration tests and FMOLS estimates (profitability: ROE)

Panel A. Cointegration tests

Panel cointegration tests (Fossil energy firms)			
Panel v-statistic:	48.26649	Group ρ-statistic:	-49.6369
Panel ρ-statistic:	-47.16094	Group PP-statistic:	-48.92254
Panel PP-statistic:	-45.56128	Group ADF-statistic:	-7.15893
Panel ADF-statistic:	-7.19084		
Panel cointegration tests (Renewable energy firms)			
Panel v-statistic:	45.26734	Group ρ-statistic:	-47.83482
Panel ρ-statistic:	-44.34099	Group PP-statistic:	-46.25481
Panel PP-statistic:	-44.92386	Group ADF-statistic:	-6.59873
Panel ADF-statistic:	-6.72359		

Panel B. FMOLS Estimates

Fossil energy firms			
ROEit = 1.462	+ 0.318 RD_{it}	+ 0.137 CF_{it}	
(4.25)*	(5.04)*	(4.52)*	
R2 = 0.41	LM = 1.45	HE = 1.50	RESET = 1.84
	[0.13]	[0.28]	[0.20]
Renewable energy firms			
ROEit = 1.449	+ 0.658 RD_{it}	+ 0.214 CF_{it}	
(4.52)*	(7.57)*	(5.36)*	
R2 = 0.52	LM = 1.42	HE = 1.64	RESET = 1.57
	[0.18]	[0.27]	[0.25]

Notes: Similar to Tables 3 and 4.

5.5 Robustness Tests: The Role of the Firm Size

The relationship between firm size and innovation is important for policy reasons. The competitive advantage in innovation for large firms is often highlighted in political discussions on the international competitiveness of small firms. Many governmental strategies are targeting small and medium-sized enterprises in order to help them to overcome their barriers for innovation. Further, Symeonidis (1996) suggests that this argument has policy implications for antitrust policies. If large firms possess more of the characteristics that lead them onto a higher innovation level, then increased competition or antitrust legislations could potentially tamper the technological progress. He highlights the relevance of his arguments claiming that they depend on whether such a hypothesis on the relationship between firm size and innovation holds.

A large amount of research has been formulated to examine the relationship between firm size and innovation, but no consensus has emerged. Most of the early research examines the role of size in R&D only using datasets for the U.S. Majumdar (2011) uses panel data on Indian firms to examine the effect of firm size on R&D expenses. He does not find a significant effect of firm size on R&D spending. This indicates that both small and large firms are just active in innovation. This part of the empirical analysis replicates the estimations by using an interaction term between capitalization and R&D expenses as an additional control variable. The new results are reported in Table 6.

Table 6. Panel cointegration tests and FMOLS estimates (the role of firm size)

Panel A. Cointegration tests

Panel cointegration tests (Fossil energy firms)			
Panel v-statistic:	43.28741	Group ρ-statistic:	-45.60932
Panel ρ-statistic:	-42.10562	Group PP-statistic:	-44.25723
Panel PP-statistic:	-42.62945	Group ADF-statistic:	-7.89427
Panel ADF-statistic:	-7.84382		
Panel cointegration tests (Renewable energy firms)			
Panel v-statistic:	44.34286	Group ρ-statistic:	-45.60932
Panel ρ-statistic:	-43.40285	Group PP-statistic:	-44.25723
Panel PP-statistic:	-43.23635	Group ADF-statistic:	-7.89427
Panel ADF-statistic:	-7.54958		

Panel B. FMOLS Estimates

Fossil energy firms			
ROA_{it} = 0.975	+ 0.277RD_{it}	+0.148 CF_{it}	+ 0.229 RD_{it} x CAP_{it}
(4.71)*	(5.85)*	(4.94)*	(7.36)*
R^2 = 0.49	LM = 1.29	HE = 1.36	RESET = 1.62
	[0.19]	[0.34]	[0.28]
Renewable energy firms			
ROA_{it} = 0.852	+0.733 RD_{it}	+0.236 CF_{it}	+ 0. 379 RD_{it} x CAP_{it}
(4.85)*	(7.94)*	(5.80)*	(8.36)*
R^2 = 0.58	LM = 1.35	HE = 1.52	RESET = 1.46
	[0.23]	[0.30]	[0.28]

Notes: Similar to Tables 3 and 4.

The results document the importance of firm size for R&D expenses as well as for firms' profitability. In particular, larger firms in both groups incur higher R&D spending, but the impact on profitability is stronger if these larger firms come from the renewable energy group.

6. Conclusions

This paper provided evidence in favor of a strong relationship between R&D expenses and firms' profitability for the energy sector in the U.S. and for firms that sell fossil energy and firms that sell renewable energy. The results documented that R&D expenses have a stronger impact on profitability in the latter group of firms. The findings remained robust after considering alternative profitability measures and the role of firm size. The interpretation of these results is that they are a sign of the importance of renewable energy and the money spend on R&D in this group of firms has higher value added in sold renewable energy. Moreover, fossil energy firms' technological innovations are slow to play a substantial role in their profitability, given the pressure on maintaining a clean environment.

Our results have implications for policy makers. In particular, a key issue is that of crowding out, in a sense that substantial increases in energy (and mostly in green technologies) R&D may come at a high cost, as these research efforts may draw away research funding and scientists from other productive sectors. However, crowding out effects appear to affect 'dirty' (i.e., in fossil energy sources) technologies. Thus, policies enhancing research incentives for green technologies have the additional desired effect of reducing incentives for research on 'dirty' technologies such as fossil fuels. However, investment in exploration of alternative fuels sources dwarfs investment in non-fossil alternative energy. Therefore, fossil fuel technologies may emerge the winners in the race for future energy. The risk from such a scenario is an increase in GHG emissions with its attendant implications for anthropogenic climate change. Policies that compensate for GHG benefits and for fuel security will improve the economics of renewable energy sources. Improvements in production efficiency of renewable energy will reduce competition to resources and improve the outlook for renewable energy. The renewable energy revolution is in its infancy and the future is uncertain, but policies can play an important role in delivering a sustainable renewable energy future. The economic principles we laid out will also be relevant in the future.

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Appendices

Appendix I. List of fossil energy firms in the US

Alliant Energy, Alon USA, American Electric Power, Anadarko Petroleum Corporation, Apache Corporation, BP, Chevron Corporation, ConocoPhillips, DC Energy, Defense Nuclear Facilities Safety Board, Devon Energy, Direct Energy, Dominion Resources, Duke Energy, EMCOR group, ENSCO International, Equitable Gas, ExxonMobil, Ferrellgas, First Energy, Hess Corporation, HKN Inc., Horizon Engineering LLP, Indian Mills Pump & Tank Company, Levant Power Company, Luminant, Marathon Oil Corporation, MidAmerican Energy Company, Oxy (Occidental Petroleum), PacifiCorp, Shell, Siemens, Southern California Edison, Southern Company Sunoco, United Refining Company, US Enrichment Corp., US EPA, Vaalco Energy Inc., Verenium, Westinghouse.

Appendix II. List of renewable energy firms in the US

Biomass

Algal Biomass Organization, Aventine Renewable Energy, Inc., Caletta, Clean Energy Generation, CRIMSON

Renewable Energy, DTE Biomass Energy, ESI Inc. of Tennesse, Ensyn, Forth Energy, General Biomass, Georgia Biomass, Golden Renewable Energy LLC, Helius Energy, LaidLaw Energy Group, MGT Power LTD, Nexterra, Renewable Energy Group, Inc, U.S. Department of Energy Biomass Progr, 808 Renewable Energy.

Energy efficiency

Enerquip, Enecsys, Fluor, GoGreenSolar.com, Green Mountain Energy Company, Grundfos Direct Sensors, Iberdrola Renewables, Johnson Controls, KACO New Energy, Inc., NV Energy, Rittal Corporation, Rotork , Schneider Electric, Tigo Energy, Waste Management, Zinc Air Inc.

Geothermal

Altren, Ambient Technologies, Inc., Chena Power, Florida Heat Pump, Geothermal Energy Association, Geothermal Resources Council, Gradient Resources, Ormat Technologies Inc., Maritime Geothermal, Nevada Geothermal Power Inc., WaterFurnace.

Hydropower

Brookfield, HydroWorld.com, National Hydropower Association, Ocean Renewable Energy Coalition, ORENCO Hydropower, Inc., Summit Hydropower, Inc.

Solar energy

Able Energy Co., Advanced Energy Industries, Inc., Affordable Solar Group, LLC, AllEarth Renewables, Alpha Technologies, American Renewable Energy, American Solar Energy Society, Apricus, Array Technologies, Birdseye Renewable Energy, Black & Veatch, Blue Sky Energy, Inc., Borrego Solar Systems, Inc., Brightergy, CivicSolar, Creotecc Solar Mounting Systems, Das Haus, Eaton, EMCORE Corporation, Enphase Energy, Green Power Labs Inc., Greenskies, Harrison Renewable Energy, HelioSage, Helios Solar Energy, Home Renewable Energy, LTD, Kipp & Zonen, Martifer Solar USA, Inc., Narenco, Netronex, Inc., Planet Solar, Power-One, Quick Mount PV, RED Group L3C, ReLI, ReneSola, Renewable Energy Alternatives, Renewable Energy Corporation, Renewable Energy Services, Renewable Energy Solutions, Renewable Energy Systems LLC, RevoluSun, Sharp Solar Energy Solutions Group, Sky Renewable Energy, SMA America, LLC, Solaire Generation, SolarEdge Technologies, Solart Group International, Solbright, Solectria Renewables LLC, Solmetric Corporation, Soventix GmbH, Standard Solar Inc., Sunetric, SunWork, Talesun Solar USA, Ltd., Unirac, Inc., United Renewable Energy.

Upsolar, Valentin Software, Inc, Verterra, Westinghouse Solar.

Wind power

American Wind Energy Association, EDF Renewable Energy, European Wind Energy Association, Ingeteam, Mersen, RES, Outland Energy Services, Southwest Windpower.

General/Other

AEG Power Solutions, Ameresco, American Council on Renewable Energy, Associated Renewable, AWS Truepower, LLC, Canadian Clean Energy Conferences, CleanEdison, Colorado Renewable Energy Society, DNV KEMA Energy & Sustainability, Grasslands Renewable Energy, LLC., GreenBrilliance, Greenpower Capital, Green Power Confereneces, ImagineSolar, Intertek, Interstate Renewable Energy Council, Karbone, Mannvit, Midwest Renewable Energy Association, Natural Power, Navigant, North American Board of Certified Energy, Renewable Energy Markets Association, Renewable Energy Vermont, Renewable Energy World Conferenence & Renewable Energy World Magazine, SAIC, Solar Electric Power Association, Solar Energy International (SEI), SolarInsure, Inc., SolarNexus, Solar POWER-GEN Conference & Exhibitions, Sol Systems LLC, SRECTrade, Inc., Stoel Rives LLP, Texas Renewable Energy Industries Assoc, The Stella Group, Ltd., Total Energy USA, UnThink Solar, WIP Renewable Energy Munich, 2GreenEnergy.com