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On the drivers of financial leverage for renewable energy projects: an empirical study on Spanish wind farms[+]

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Abstract

Financing renewable technologies is a critical element in the energy transition towards a decarbonized energy mix. The World Bank, the International Renewable Energy Agency and other multilateral institutions are developing new financing instruments to address the barriers and risks that hold back private investment in renewable energy technologies, while minimizing the possibility of crowding out the private sector. Within this context, this study explores the some of the drivers of external financing using a dataset of 318 wind farm projects commissioned in the period 2006-2013 in Spain. This dataset amounts to 80% of the total wind capacity installed in that period. Thanks to the granularity of this database, our analysis provides some results that explain why some projects are more attractive than others from a financial perspective. This study has two main takeaways: first the costs of a renewable project are the main drivers that determine the level of debt of the project while the capacity factor has a minor relevance. Second, the behavior of banks changed after the financial crisis of 2009. Before the crisis more expensive projects tended to have higher debt leverage ratio while after the financial crisis these projects were penalized in terms of access to external financing.

Keywords: Spanish wind farms, capital and operational costs, debt leverage ratio, LCOE

JEL codes: Q42, Q43, G32, C20

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1. Introduction

The anthropogenic accumulation of CO_2 and its impact on climate change is a well-known scientific evidence. According to NASA, carbon dioxide reaches the maximum level in the air of the last 650.000 years and the global average temperature is one degree Celsius higher than in 1880. In this context, in December 2015 195 countries adopted binding deal on global climate change, known as the Paris Agreement. A necessary condition to keep global warming below the “two degrees scenario” and in line with this agreement is a massive deployment of renewable energy. According to IRENA (2017), the share of renewables should raise to 65% of the world’s primary from 15% in 2016. However, it is not going to be easy to achieve this level of penetration of renewable technology.

Figure 1 shows that renewable energy investment at a global level is stagnated since 2010. The insufficient financing for renewable technology deployment, together with the cost of the technology, is perceived as one of the main obstacles toward a rapid decarbonization of the energy mix. For example, a World Bank report states that the high financial cost of renewable technologies, relative to fossil fuel generation technologies, is one of the main barriers to their deployment (Hussain, 2013). IRENA (2016) states that fundamental market barriers constrain the financing of renewable projects, especially in developing countries. In a report on the European renewable market, de Jager et al. (2011) develop recommendations for improving financing instruments and the access to capital and for closing the financing gap to reach the 2020 targets. In the case of the U.S., Mendelsohn and Feldman (2013) note that meeting a significant expansion of renewable sources will require access to broad new sources of financial capital. Justice (2009) points out that the financial sector approaches renewable energy in the same manner as any other investments, but this sector requires an additional level of understanding.

[Insert Figure 1]

It is important to highlight that financing is also a key element of the competitiveness of this type of technologies. Renewable technologies are characterized by extremely low operational costs and high initial capital costs, thus creating an atypical cost structure and making impossible to adopt the standard economic approach based on marginal costs. In economic terms, the marginal cost of renewable energy is close to zero, being the average total cost per MWh produced the relevant variable. The Leverage Cost of Electricity (LCOE) is a proxy of this variable and the standard way to assess the cost of the electricity produced by means of renewable sources (IRENA, 2018). As it is well-known, the LCOE is the sum of costs over the lifetime of the project divided by sum of the electricity produced during the same period of time, with the discount rate playing a critical role. As a result, the cost competitiveness of a renewable project is strongly affected by the discount rate that is used to assess its economic profitability. The Weighted Average Cost of Capital (WACC) is the standard discount rate used by renewable companies to calculate the LCOE and the Net Present Value (NPV) of investment projects (Short et al., 1995). The WACC is a weighted average of the cost of internal and external financing. In general, financial debt tends to be cheaper than equity because it has lower risk. The reason is that financial debts have priority claims in case of bankruptcy and liquidation of the company. As a result, companies with a higher level of debt tend to have a lower WACC and, consequently, a lower LCOE and a higher cost competiveness. Figure 2 shows the relationship between leverage (as debt over total capital costs) and LCOE for 318 Spanish wind projects commissioned in the period 2006-2013.

[Insert Figure 2]

The purpose of this study is shed some light on the drivers of external financing for renewable energy projects. Using granular data for Spanish wind projects commissioned in 2006-2013, this study tries to understand the relationship between the economic and technical variables of a project and the access to external financing. The analysis focuses on debt leverage, size of the project, capital and operational costs, and capacity factor, using an econometric approach.

The rest of the paper is organized as follows: section two discusses previous academic research in this topic, section 3 presents the data and methodology, section 4 discusses the results and section 5 concludes.

2. Literature review

In the economic and financial literature extensive work has been done to understand why and to what extent companies use external financing relative to internally-generated funds. At the theoretical level, alternative explanations have been offered to understand a firm's capital structure. Starting from the well-known irrelevance theorem (Modigliani and Miller, 1958), there are the trade-off and pecking order theories (Myers and Majluf, 1984) and the models emphasizing signaling (Ross, 1977), agency costs (Jensen and Meckling, 1976), and transaction costs (Williamson, 1988). At the empirical level, studies have generally focused on listed companies to study the determinants of leverage using cross sections or panel data. A host of explanatory variables have been included in econometric regressions, suggested by one or the other of the different theoretical explanations mentioned above (Rajan and Zingales, 1995). While a full list of variables and their expected impact on leverage is beyond the scope of this paper, the most important determinants are: firm size, age, asset tangibility, liquidity, profitability, growth opportunities, capital intensity, relative financing costs, probability of bankruptcy, tax benefits/shields.

Empirical studies on the determinants of leverage have typically focused on the capital structure of listed companies and corporations. These companies operate in various sectors, not limited to manufacturing. We are aware of only one published paper studying leverage in companies generating electricity from renewable sources, and wind energy in particular (Bobinaite, 2015).

What determines the amount of external financing and the use of debt is a question that, in principle, does not only apply to whole companies, but also to individual investment projects. The size and the structure of a company overall debt, of course, depends of the size and structure of debt for individual projects undertaken by the company over time. It is, therefore, of interest to analyze what determines a project's leverage size, and this will be a function of project-specific features as well as of company-related aspects. It should however be clear that the theories of corporate leverage and capital structure mentioned above, and the determinants emphasized therein, have only a limited application to the study of individual projects' leverage.

This paper empirically studies the determinants of leverage for a number of projects undertaken by firms active in the renewable energy sector. The focus on individual investment projects and the focus on the renewable energy sector is what makes our analysis new and interesting. To best of our knowledge, this is paper is the first one that explores the relationship between debt leverage and the economic and technical characteristics of individual renewable projects.

3. Data and methodology

Bean et al. (2017) is the main source of information and the description of the database can be found therein. However, a short description of the data is provided here.

Our dataset contains financial information on 318 onshore wind projects commissioned in Spain from 2006 to 2013 amounting around 11 GW of installed capacity. This represents around 85% of the new wind installed capacity in Spain during those years (BP, 2018). The database only includes projects with an installed capacity over 15 MW.

The company Bloomberg New Energy Finance is the primary source of information for each individual project and some data are estimates. For each project we have information on the year in which the project was commissioned, the capital cost in Euros per MW, the operational cost in Euros per MWh, the size in MW, the leverage (ratio of debt relative to total capital expenditure), the LCOE in Euros per MWh, the WACC, and the adjusted capacity factor. All Euro figures are expressed in constant 2013 prices. Table 1 presents some descriptive statistics.

[Insert Table 1]

This study also explores if there are differences in the financial drivers for leverage between projects with low and high LCOE. Bean et al. (2017) find that 83 Euros per MWh is the threshold that determines ‘economic’ and ‘uneconomic’ projects. For this reason, two subsamples are generated: one with projects with a LCOE below 83 Euros and other subsample with projects with a LCOE above 83 Euros per MWh. There are 186 economic projects and 132 uneconomic projects in the dataset. In addition and to explore if the financial drivers that determine the leverage of a project changed during the crisis financial crisis, two additional subsamples are defined: one for projects commissioned before the recession of 2006-2008 and other for projects commissioned during the crisis, 2009-2013. There are 191 projects commissioned before the crisis and 127 projects commissioned during the crisis. Table 2 reports descriptive statistics of projects with a LCOE above and below Euro 83 per MWh, and those initiated before and during the recessionary period.

[Insert Table 2]

Regarding the econometric approach, we estimate the leverage equations by ordinary least squares with heteroskedasticity-robust standard errors. The reason for this econometric approach is that our database is a set of 318 individuals projects commissioned in different years and there is only one observation per project. In other words, we cannot use a different econometric approach because these data are neither a panel nor a pseudo-panel.

4. Empirical results

The purpose of this study is to understand the economic and technical variables that make a project attractive for banks or lenders using an econometric approach. We estimate a set of equations where leverage is explained by the following variables: (i) the size of the project in terms of installed capacity in MW, (ii) the capacity factor of projects, (iii) the operating costs per MWh, and (iv) the capital costs per MW.

The LCOE is the standard way to assess the competitiveness of a renewable energy project, which makes it a potentially interesting explanatory variable to be included in the econometric analysis. The LCOE is a function of the discount rate used to evaluate future costs. The standard financial variable to discount these future costs is the weighted cost of capital (WACC). However, the weighted cost of capital depends on the leverage of the project. In order to avoid this circularity, we did not include the LCOE in the econometric analysis below. We want to reemphases that the empirical literature on the determinants of a company's leverage accounts for additional explanatory variables. However, we focus on individual projects and the available data are limited to the variables used here.

[Insert Table 3]

To assess the effect of the different variables on leverage we ran three different sets of regressions. Table 3 presents the estimation results. The first regression (column 1) uses the entire dataset, which is data from 318 projects. The second set of regressions (columns 2 and 3) differentiates projects with LCOEs below and above Euro 83 per MWh. Finally, the third set of regressions (columns 4 and 5) distinguishes two time periods: 2006-2008 and 2009-2013.

Before turning to the results, it is important to highlight that the debt is the final output of a negotiation process between the bank (or the lender) and the developer of the project (or the borrower). Banks try to minimize risks, offering debt to 'good' projects, that is, projects with low capital and low operating costs and, potentially, high revenues. In the case of 'bad' projects, developers try to minimize the equity and maximize the level of debt to reduce their own risk. This implies that the signs of the coefficients in the regression are not necessarily predetermined by economic theory.

The first regression (column 1) suggests that the leverage of a renewable energy project is explained by its cost. The higher the cost, the lower the debt and leverage. This finding has two implications. The first is that the relationship between leverage and costs is driven by supply, not by the demand for funds. Banks – the supply side – want to minimize risk and, for this reason, are more prone to lend money to 'good projects'.

The second finding is the economic implication of this result. It is well-known that the discount rate is critical to assess the LCOE of a project and, therefore, its competitiveness. The usual discount rate used in financial models is the WACC. Under ideal conditions there is no difference between the cost of debt or equity (Modigliani and Miller, 1958). However, external financing is generally considered to be cheaper than equity due to taxes and first claim on project assets in the case of bankruptcy. This result suggests that a reduction in the cost of the technology leads to a higher leverage, a lower WACC and, as a results these projects have a much lower LCOE.

The size of the project and, surprisingly, the capacity factor are not significant. The capacity factor is the variable that measures the productivity of the project in terms of electricity generation. According to these results, more productive projects do not seem to have a higher debt leverage. A potential explanation is that future revenues are subject to regulatory changes and, therefore, they are uncertain. For this reason, banks would focus mostly on costs to determine the risk of a project.

Regressions in columns 2 and 3 explore whether there are differences between 'economic' and 'uneconomic' projects. In both regressions the operating and capital expenses have a negative and significant coefficient, suggesting that projects with lower costs have access to a higher level of debt.

The main difference between the two types of projects is the capacity factor. In the case of uneconomic projects the capacity factor has a negative and significant coefficient. This implies that less productive projects in terms of electricity generation tend to have access to a lower level of debt. In the case of economic projects, this variable does not seem to be statistically relevant.

Finally, columns 4 and 5 analyze the potential differences before and after the financial crisis. Here the results show a relevant finding. There is a change in the parameter associated to capital cost. Previous to the crisis, the leverage and the capital cost had a positive and significant association. This implies that more expensive projects had access to higher debt. After the crisis, this parameter switches to a negative sign. This suggests that banks reduced substantially the access to financing and, as a result, more expensive projects tended to have lower debt ratio.

5. Conclusions

There is a growing consensus among policymakers and practitioners on renewable financing: it is considered as the most relevant bottleneck to accelerate the deployment of this technology. Multilateral institutions such as the World Bank or IRENA are developing new instruments to facilitate the financing of these types of projects. Within this context, this study has explored the relationship among financial leverage and the key characteristics of renewable energy projects, using data on Spanish wind farms for the period 2006-2013.

The most relevant findings were two. Firstly, capital and also operational costs of a project are the main determinants of the level of debt of a renewable project. This is an expected result, since renewable energy is a capital intensive industry. However, according to our results the capacity factor of the project has a minor relevance, despite this variable is the cornerstone to determine electricity generation and the flow of revenues along the maturity of the project. The lack of statistical significance of the capacity factor is an unexpected result. A possible reason is that these projects have a very long period of maturity and future revenues are subject to regulatory changes. Under these conditions, there is a lot uncertainty on future revenues. For this reason, banks would focus on capital and operational costs to assess the risk of the project and, therefore, to determine the level of debt. In any case, additional research on this finding is needed. Secondly, the behavior of Spanish banks towards renewable energy projects changed after the financial crisis of 2009. Before the crisis more expensive projects tended to have a higher debt ratio. This would suggest a relative abundance of financial credit in the period 2006-2009 or relaxed attitude towards the risk of the projects. After the financial crisis more expensive projects were penalized in terms of access to external financing.

Finally, the LCOE is not an adequate variable to understand the access to external financing. The reason is that the LCOE is a function of WACC. The higher the WACC the higher the LCOE and vice versa. However, the WACC depends on the leverage of the project. For this reason, the LCOE and the cost competitiveness of a renewable project can be only be evaluated after the financial conditions of the project are set.

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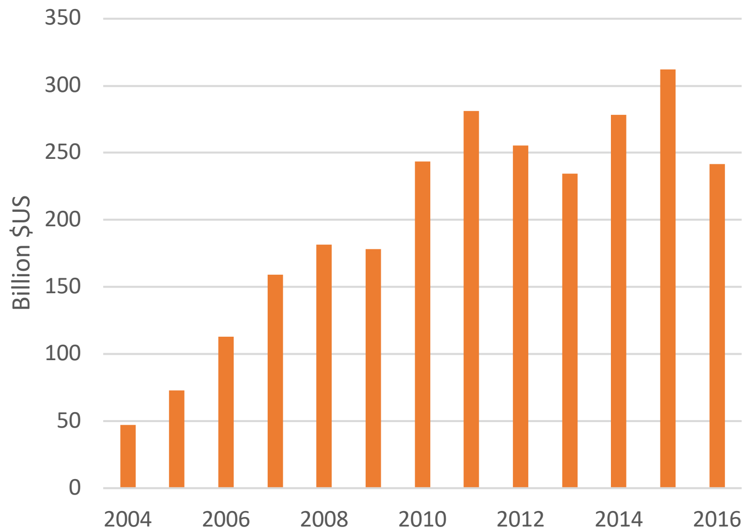
Figure 1: Global new investments in renewable energy excluding Hydro



Source: IRENA

Figure 1: Leverage and LCOE for Spanish wind projects

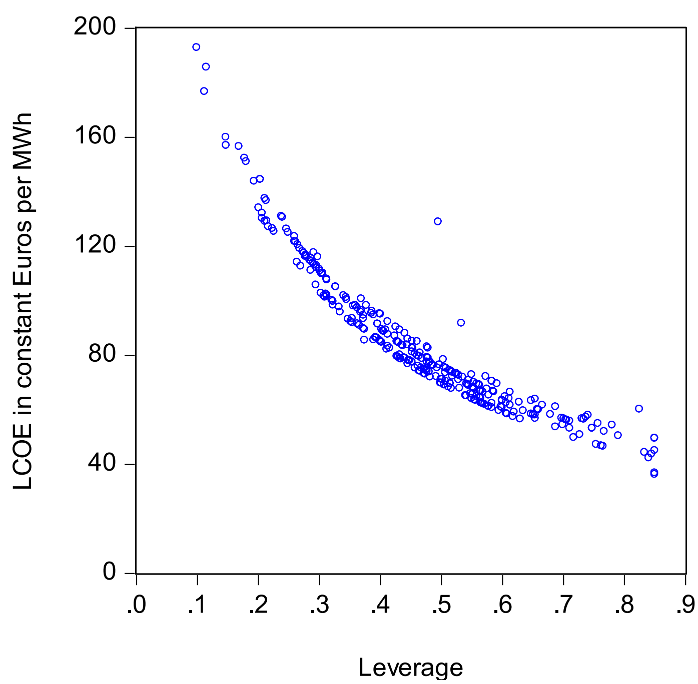


Table 1: Descriptive statistics

	Mean	Standard deviation	Maximum	Minimum
Capital cost	1,490,700	93,358	1,691,939	1,214,400
Operational cost	17.6	5.0	5.0	10.0
Size	33.7	12.0	94.0	16.0
Leverage	0.47	0.16	85	9.9
LCOE	83.6	25.8	192.8	36.2
WACC	0.06	0.01	0.08	0.04
Capacity Factor	0.24	0.06	0.46	0.11

Table 2: Descriptive statistics of subsamples

	LCOE < €83	LCOE > €83	Before Recession 2006-2008	Recession 2009-2013
Projects	186	132	191	127
Capital cost	1,485,341	1,498,252	1,470,481	1,521,108
Operational cost	14.53	21.93	17.36	17.96
Size	32.91	34.94	32.50	35.64
Leverage	0.57	0.33	0.48	0.46
LCOE	66.62	107.55	80.61	88.12
WACC	0.06	0.07	0.06	0.06
Capacity Factor	0.28	0.19	0.25	0.23

Table 3 : Estimation of determinants of leverage in Spanish wind projects

	(1)	(2)	(3)	(4)	(5)
	Whole sample	LCOE below Euro 83	LCOE above Euro 83	Before Recession 2006-2008	Recession 2009-2013
C	15.36	15.79	14.45	-2.54	19.75
	(11.82)	(9.66)	(6.04)	(-0.86)	(9.04)
Size	0.01	0.01	0.01	0.01	0.00
	(1.04)	(1.35)	(0.19)	(1.06)	(-0.10)
Capacity Factor	0.03	0.25	-0.40	0.19	1.13
	(0.18)	(0.98)	(-2.71)	(1.36)	(1.49)
Operating cost	-1.44	-1.10	-1.98	-1.27	-0.09
	(-6.13)	(-3.35)	(-12.11)	(-7.24)	(-0.10)
Capital cost	-0.85	-0.92	-0.73	0.40	-1.29
	(-10.76)	(-11.21)	(-4.28)	(2.04)	(-5.56)
Adjusted R^2	0.96	0.91	0.91	0.99	0.94
F test	2056.83	471.54	340.57	5703.66	488.25
Reset test	9.73	7.05	4.54	171.82	3.57
No. obs.	318	186	132	191	127

Notes: robust standard errors in parentheses.