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# Financing Early Stage Cleantech Firms

Seán O'Reilly<sup>1</sup>, Ciarán Mac an Bhaird<sup>1</sup>, and Damien Cassells<sup>1</sup>

**Abstract**—In this article, we analyze the financing of firms in the Cleantech sector that has successfully raised equity crowdfunding on platforms in 16 European countries. We find that firms with lower total assets and higher cash balances raise greater amounts of crowdfunding. In the period precrowdfunding, illiquid firms raise less finance and firms with greater assets raise more debt. In the postcrowdfunding period, crowdfunded firms raise significantly greater amounts of external equity, suggesting signaling effects. Our study highlights the ameliorating liquidity effects of crowdfunding, which are especially important in early stage firms developing new technologies.

**Index Terms**—Accounting ratios, cleantech, entrepreneurial finance, equity crowdfunding, innovation.

## I. INTRODUCTION

THE report by the Intergovernmental Panel on Climate Change [47] highlighted the need to reduce greenhouse gas emissions and strive for decarbonization in order to restrict global warming. The Paris Agreement, a legally binding international treaty on climate change, has a vision of accelerating technology development and transfer [92] in order to reduce harmful carbon emissions. The development of new and innovative disruptive technologies to ameliorate and reverse the harmful effects of carbon emissions is emphasized by governments and international agencies [6], [53], [59], [102]. Large incumbent firms are well resourced to conduct this research and development (R&D), although small early stage ventures also play a significant role in innovation and invention [67], [76]. New enterprises have the advantages of agility, testing, and implementing new business models quickly [73], although they typically lack sufficient resources to develop and scale their business successfully [37], [38], [44], [48].

Cleantech firms commercialize clean energy technologies, which entails developing, integrating, deploying, or financing new materials, hardware, or software, focused on energy generation, storage, distribution, and efficiency [36]. Many of these firms are in the early stages of development. In the U.K., for example, firms less than five years old constitute 90% of all Cleantech enterprises [65]. We define early stage Cleantech

firms as private for profit small- and medium-sized enterprises (SMEs) less than five years old whose aim is to develop and adopt innovative technologies to reduce carbon dioxide emissions in their products and processes [50]. Our sample of Cleantech firms operates in the energy efficiency, recycling and waste management, renewable energy, and transportation sectors.

Notwithstanding criticism of the lack of urgency of governments in addressing climate change [74], [82], the public sector has promoted investment in green technologies [66], a notable factor in increasing investment in the Cleantech industry, which peaked at \$301.7 billion globally in 2020 [89]. Considerable focus has been on larger scale projects funded by governments, such as developing Green Investment Banks and tackling larger infrastructural renewable energy projects, including wind farms [66]. By contrast, the financing requirements of early stage firms developing innovations in the Cleantech sector [76], [67], [84] have received less attention. There is a lacuna in the literature on empirical studies on financing new low carbon businesses and innovations [13], [67], [82]. While access to finance is a common obstacle for start-up firms, Cleantech start-ups experience particular challenges in raising finance [37], [66]. First, Cleantech firms may have long horizon R&D, subsequently struggling to obtain the sufficient levels of patient private investment to reach commercialization. This is exacerbated if the capital requirement is large [8], [73], [84]. Second, information asymmetries of start-up firms are particularly acute because of the newness and lack of a credit or trading history [64] and this is especially severe for Cleantech. Third, it is difficult to value new, untested technologies and intangible assets that have high obsolescence rates with unpredictable future success rates. Investors, thus, view early stage Cleantech investment as particularly risky [55], [79].

Crowdfunding has emerged as a new source of external equity finance that plays an increasingly important role in the financing of young entrepreneurial firms [3], [15], [26] and has a particular impact on growth opportunities [32]. The Crowdfunding market has increased dramatically over the past decade [89], second only to venture capital in the number of deals completed in 2020. The European Equity-Crowdfunding market was valued at \$2.3 billion in 2020 [89], of which \$189 million was directly attributable to Cleantech firms. According to the Crunchbase database, 2967 equity-crowdfunding campaigns between 2014 and 2019. Total 177 of these were Cleantech firms, representing 5.9% of all equity-crowdfunding campaigns. The number of Cleantech firms engaging in equity crowdfunding in Europe rose from 8 firms in 2014 to 51 firms in 2019. It is anticipated that this will continue to grow rapidly in the future with the global crowdfunding market expected to reach \$40 billion by 2026 [89].

Our study focuses on these 177 early stage Cleantech firms that have raised funding through European

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Equity-Crowdfunding platforms. The aim of our study is to obtain a deeper understanding of the financing of crowdfunded European Cleantech firms, which we investigate by posing the following research questions.

- 1) What are the potential determinants of the amount raised in Cleantech equity crowdfunding?
- 2) What are the potential determinants of debt and equity funding in the precrowdfunding period?
- 3) What are the potential determinants of debt and equity funding in the postcrowdfunding period?

This article seeks to contribute to our understanding of financing early stage Cleantech firms by analyzing the financing of firms that have successfully raised equity crowdfunding for the first time. A novel feature of our article is that we investigate the potential influence of accounting metrics on financial decision-making pre- and postcrowdfunding.

The rest of the article is organized as follows. In Section II, we review the related previous literature on crowdfunding and the financing of Cleantech firms. In Section III, we discuss our methodological approach. In Section IV, we discuss the results and major findings of our article. Finally, in Section V, the conclusion is presented and we suggest practical implications for Cleantech firms, investors, and policymakers in Section VI.

## II. PREVIOUSLY RELATED LITERATURE

### A. Financing Cleantech

Essentially, the development of new low-carbon businesses and innovations is an understanding of their resourcing requirements [23], [46], [82]. Cleantech firms differ slightly from other for profit SMEs insofar as on top of their commercial goal is the goal to develop innovative technologies that aim to reduce CO<sub>2</sub> emissions in their products and processes [50]. The financing gap is a greater problem for the diverse forms of Cleantech ventures, which are capital intensive, have a high technology risk profile, and uncertain exit opportunities for investors [37], [40], [72], [78], [85]. Early stage Cleantech firms are considered particularly vulnerable as they often exhibit long horizon intensive R&D with a long *valley of death* periods spanning proof of concept to early commercialization [66]. Additionally, they suffer from a higher *liability of newness* compared with other new ventures [56], [58] because of hybrid business models [81] that aim to combine commercialization with an environmental mission [29]. Since investors may not be rewarded for the full environmental-societal value, the risk-reward balance is often viewed as unfavorable [7], [13], [76]. As a result, there is resource scarcity in these ventures with large funding gaps within these firms [8], [55]. Kaminker and Stewart [49] question the role of institutional investors in financing clean energy and state the lack of suitable investment vehicles providing the risk-return profile investors requirement, suggesting that pension funds could provide patient capital required for such long-term projects. Gaddy *et al.* [36] suggest that the venture capital is the wrong model for energy innovation due to the long horizon of such projects and the return venture capital requires. Owen *et al.* [74] argue that Cleantech SME innovation financing should be an essential cornerstone of policies to tackle climate change

since they have the potential to develop significant technologies to address future low carbon economic requirements if they can successfully scale their business model [59], [60], [73], [80]. The need for a clear research and policy agenda to assist early stage Cleantech financing has never been greater [74].

### B. Crowdfunding

Crowdfunding has emerged as a new source of external equity finance that plays an increasingly important role in the financing of young entrepreneurial firms [31], [87], [94]. Equity crowdfunding is a form of financing in which entrepreneurs make an open call for funding on the Internet, hoping to attract a large group of investors. The open call and the investments take place on an online platform that provides the means for the transactions [3].

Crowdfunding in a variety of forms has greatly increased in use in the past decade [41], [54], [94]. Following continued growth, the global equity-crowdfunding market expanded to \$13.9 billion in 2019 [17]. Studies show it is important to differentiate between different crowdfunding types, including donation, peer-to-peer lending-based, reward-based, and equity-based crowdfunding [34], [66], [95] because the crowds' motives to back a campaign are significantly different between these crowdfunding types [19], [24]. Each type of crowdfunding has certain needs of the startup or project initiator [68]. Studies have increasingly examined the crowdfunding phenomenon that has primarily focused on the factors that lead to success on crowdfunding platforms [18], [22], [27], [28], [45], [69], [90].

We focus on equity-based crowdfunding, which entails investors pledging or investing money to become a beneficial shareholder of that company and receive the returns and the risks associated with being an equity shareholder. This coincides with other studies on crowdfunding that solely focus on equity-based crowdfunding [3], [88] due to the fact that investor motives are different between donation based and reward based to that of equity crowdfunding. We also know that equity-based crowdfunding platforms raise more than reward-based platforms [98]. The Cleantech firms we analyze are those providing shares in return for investment. The funding model on platforms we examine is known as "all or nothing" models of equity crowdfunding, where the firm sets a fundraising goal and only receives investment if the total funding target is achieved.

### C. Crowdfunding in Cleantech

Owen *et al.* [74] suggest that while crowdfunding is viewed as an important financing method within both developed and developing countries' innovation and finance ecosystems [42], [52], its potential is not sufficiently used in the context of environmentally oriented ventures. While there have been a number of studies on Cleantech and sustainable ventures in relation to other forms of crowdfunding, such as reward based [1], [14], [25], there is a scant amount of research undertaken on equity crowdfunding in Cleantech.

Specific to Cleantech firms, Cumming *et al.* [25] examined a reward-based platform, Indiegogo, and found that Cleantech crowdfunding is negatively related to individualism and is more common when oil prices are rising. Bonzanini *et al.*

[14] examined the crowdfunding of renewable energy projects across 13 different platforms on different types of crowdfunding. Their study explored the determinants of the campaign success. Bento *et al.* [10], using a reward-based platform, Kickstarter, also examined that the extent-specific project characteristics influence the ability to raise funds on a reward-crowdfunding platform and to explain their survival postcampaign, which showed an average survival rate over 70% after one year of operations suggesting the supporting sustainability effects of crowdfunding. Adhami *et al.* [1] examined a number of different specialized “green” platforms across Europe but did not focus solely on one type of crowdfunding. They found significant positive effects of green crowdfunding activity on two different indices of environmental performance and wellbeing at the local level. Bento *et al.* [9] assessed the risk and returns of crowdfunding across 17 different platforms but did not focus solely on one type of crowdfunding. They found that technological risks contribute to decreases in excess of returns of the projects and countries’ technological capacity and cultural dimensions explain variances in returns. They also concluded that larger average investments are associated with projects with superior return/risk profiles. Analyzing peer-to-peer lending platforms in France, Slimane and Rousseau [91] assessed the success factors of crowdfunding campaigns for renewable energy projects. Vismara [96] finds that being a sustainability-orientated firm does not increase the chances of success or of engaging professional investors, although it attracts a higher number of restricted investors. There is a significant gap in the crowdfunding and Cleantech pieces of literature of firm-specific analytic studies, and our article addresses this lacuna. It is worth noting that there are specific crowdfunding platforms that allow investment in “Green” projects only. However, these platforms are crowdlending and reward-based crowdfunding that differs from equity crowdfunding in the motivations of investors [25]. Cleantech firms are somewhat unique in equity-crowdfunding platforms in which they make up a small percentage of overall campaigns; this could be due to the large capital outlay that Cleantech firm’s experience in their early stage development that can be off-putting for investors. We do know that investment in the Cleantech industry is growing rapidly [89], and from our study, we see that there has been an increase in the amount of European early stage Cleantech firms turning to equity crowdfunding as an alternative source of financing.

#### D. Accounting Information in Crowdfunding

While most campaigns must disclose financial performance information, including future forecasts, there is limited research on the disclosure of this data and its effect on crowdfunding campaigns. Financial statements provide detailed data for investors considering equity-crowdfunding offerings [61] and have the potential to influence investing decisions. However, the potential effect of financial data for equity-crowdfunding campaigns has not been investigated [77]. Pattanapanyasat [77] states that the verified information in financial statements is likely the most credible channel for investors to evaluate firms’ viability and

the truthfulness of other disclosures. This article provides evidence that financial statements influence investors’ decisions and facilitate borderless capital formation and that the provision of financial statements appears to enhance how investors view other aspects of the disclosure, suggesting a positive reporting externality. Jo and Yang [101] find mixed evidence regarding crowd wisdom in accounting in the equity-based crowdfunding market. Focusing on forecasts, the study finds that the entrepreneurs systematically overestimate sales, earnings, profit margin, and assets, and underestimate the leverage suggesting investors to put more focus on future forecasts than past financial performance. Shafi [86] finds that financial metrics disclosed in campaign descriptions do not predict funding success for crowdfunded firms, stating that crowdfunding investors pay little attention to financial information contained in campaigns, consistent with the idea that they find financial information difficult to evaluate. However, when financial stakes in the form of equity offered in the campaign are high, crowd investors incur the costs of assessing complex financial information. Using a European database, Nitani *et al.* [71] suggest that the participants in the crowdfunding market are rational, interpreting signals derived from firm attributes and financial statements in appropriate ways to minimize risk and maximize returns. Donovan [30] finds that there is a positive association between financial reporting and capital raised, suggesting that accounting reduces information asymmetry with potential investors. The study also finds that financial reporting is indirectly associated with better ex-postperformance by increasing the likelihood of raising capital. It is clear that past financial performance is a key indicator as to why firms would seek crowdfunding and, for the first time, we incorporate accounting information for crowdfunded Cleantech firms.

We seek to add to the literature by investigating a number of the issues discussed above on our sample of Cleantech firms. For our tests on the amount raised, we propose that firms with higher premony valuation will raise more money for a smaller amount of equity [3], [5], [68]. We expect that firms with higher intangible assets will raise more money during the crowdfunding campaign. This is due to the fact that, if firms had more tangible assets, they would use this as collateral for debt financing that coincides with studies on tangible assets and debt financing [11], [70]. While firms with more intangible assets will be pushed to seek external equity financing [63], [93], including equity crowdfunding. Similarly, for financing precrowdfunding, we propose that older firms with higher tangible assets will raise more debt financing and those with higher intangible assets will raise more equity precrowdfunding. We also propose that liquidity thresholds could have an impact on the financing options and choices available to Cleantech firms before they embark on crowdfunding campaigns [99]. For financing postcrowdfunding, we propose that the previous amount of funding raised will have an impact on the financing options and choices available to Cleantech firms and expect that firms who have previously raised debt financing to continue this trend and raise additional debt financing [20]. Finally, we propose that the amount raised during a campaign can have positive signaling effects for financing postcrowdfunding [3], [20].

### III. METHODOLOGY AND DATA

Our article aims to investigate the role of equity crowdfunding in financing Cleantech firms across Europe. We compile a database of 177 Cleantech firms that have successfully raised equity on crowdfunding<sup>1</sup> platforms, for the first time, in the U.K., Finland, Sweden, Germany, Italy, Belgium, France, Estonia, Switzerland, Ireland, Austria, Denmark, Latvia, Netherlands, Norway, and Spain. We include all firms that have raised finance between 2014 and 2019 on the following crowdfunding platforms: Crowdcube, Seedrs, Syndicate Room, Invesdor, FundedByMe, Spreads, Symbid, OnePlanetCrowd, Spark, Seedmatch, BacktoWork, MamaCrowd, The Angel Crowd, Crowd for Angels, WiSeed, SoWeFund, FundWise, Funderbeam, and Companisto. Our data come from several sources. We first use the websites of European-based equity-crowdfunding platforms to identify and collect data on the firms that have successfully applied for and raised equity crowdfunding during the 2014–2019 period (inclusive). We undertook detailed checks on the validity of each of the equity-crowdfunding platforms used in this study by cross referencing them with the Crunchbase database ensuring completeness of all Cleantech firms that raised equity crowdfunding on European platforms. In terms of the countries selected as a part of this study, it was dictated by the validity of the equity-crowdfunding platforms cross referenced using the Crunchbase database. We gather data, including the amount raised, the number of investors, and the equity given to investors on the platforms' websites. We also examine the pitch in each campaign to get information on the purpose of funding and we classify the primary use of funding in each campaign. Then, we use multiple sources to collate data on each specific firm. We obtain accounting data from the Orbis Europe database managed by Bureau van Dijk. Orbis Europe contains the high-quality accounting data on privately held and publicly traded European firms [33], [99]. We then search each firm on the Crunchbase database to assess whether firms have raised equity financing before and/or after the crowdfunding campaign [43], [88].

The definitions of variables used to test our various models are provided in Table I. Summary descriptive statistics are presented in Tables II and III. We are solely focused on firms that are Cleantech specific [1], [10]. Our sector classification covers Cleantech firms that operate in energy efficiency, recycling and waste management, renewable energy, and transportation that coincides with the sectoral classification of the MIT energy initiative [36]. We focus on campaign-specific data, including the use of funds, financial accounting data, and equity financing data.

There has been limited research on accounting information and the role of past financial performance in crowdfunding. Drawing upon related studies that include financial data in their

methodologies [30], [77], [85], [99], we include key accounting ratios and indicators in our regressions. Accounting data variables investigated as a part of our research that include gearing ratio [99], total assets [30], [77], [99], intangible assets [30], [77], [99], cash [30], shareholder's funds [77], [85], and capital [77], [85], and are computed at  $T-1$  and  $T+1$ . We also have included liquidity ratios and drawing upon a study by Walthoff-Borm *et al.* [99], who measure excessive debt levels under three different criteria examining total debt to total assets. Cleantech firms tend to have long R&D cycles and may lack the required patient capital [76], [67], [84]. Given that little attention has been given to the financing gap of early stage Cleantech firms [8], [71], we measure and examine the short-term liquidity of these firms that could demonstrate the immediate impact of crowdfunding on these firms. We develop an "illiquid firms" variable based on the liquidity ratios computed at  $T-1$ , similar to previous studies [99]. We classify illiquid firms into two different dummy variables. We state that illiquid firms are those that have liquidity ratios less than 0.50:1 (we define liquidity ratio as current assets/current liabilities). We also classify another cohort of firms that have the liquidity ratios of between 0.51 and 0.75:1. The rationale behind this was to examine whether there would be any different outcome of those firms with very poor liquidity ratios (Illiquid <0.50) and those that have more manageable liquidity ratios (Illiquid <0.75), and whether financing employed would be different. We include the illiquid variables in our tests focusing on  $T-1$  to assess the short-term financial performance and the impact on financing before and after crowdfunding.

We empirically test our models, using ordinary linear regression, employing the amount raised in the equity-crowdfunding campaign as the dependent variable. Our base model is specified as follows:

$$Y = \beta_0 + \beta_1 \text{AGE} + \beta_2 \#\text{INVS} + \beta_3 \text{EQGIV} + \beta_4 \text{PREVAL} + \beta_5 \#\text{DIRS} + \beta_6 \text{PREV} + \beta_7 \text{GEAR}_{t-1} + \beta_8 \text{LIQ}_{t-1} + \beta_9 \text{ILLIQ}_{t-1} + \beta_{10} \text{INTAN}_{t-1} + \beta_{11} \text{TASS}_{t-1} + \beta_{12} \text{CASH}_{t-1} + \beta_{13} \text{SH}_{t-1} + \beta_{14} \text{CAPITAL}_{t-1} + \varepsilon.$$

We ran cross-sectional ordinary least squares (OLS) regressions using data collected for all firms, initially ignoring  $t$  sectoral, "purpose for which funding is sought," and country factors. The coefficients of this model are presented as our "base model" in Table V. We subsequently ran models to include country, sector, and use of funds control variables, which are presented as extended models 1–4 in Table V.

We also examine the funding of Cleantech firms pre and postcrowdfunding. Our second set of models employ debt and equity raised precrowdfunding as dependent variables, and coefficients for these tests are presented in Table VI. As with our previous approach, we test the base model, before running extended models to include country, purpose, and sectoral control variables. In our third and final set of models, we investigate the debt and equity raised postcrowdfunding as dependent variables. Consistent with our previous tests, we test the base model, which is computed at  $T+1$ , before running extended models to include country, purpose, and sectoral control variables, and coefficients for these tests are presented in Table VII. Although a number of variables are closely related, correlation tests do not suggest a high degree of first-order collinearity among the independent variables.

<sup>1</sup>We include firms who have successfully raised equity crowdfunding for the first time. We do not examine campaign specific variables on any other successfully funded campaigns beyond the first campaign. We exclude minibond offerings, offerings of convertibles bonds, and equity offerings by companies that have previously raised capital through equity crowdfunding.

TABLE I  
DEFINITIONS OF VARIABLES USED IN STATISTICAL MODELS

Country – Country in which firm is registered.
Firm Age at CF – Age of the firm from incorporation date to raising crowdfunding.
Firm Age Now – Age of the firm from incorporation date to current year (2020).
Investors – Number of Investors who contributed to crowdfunding campaign.
Amount Raised – Monetary amount (€) raised as part of crowdfunding campaign.
Equity Given – The amount of equity (%) that the firm released in crowdfunding campaign.
Pre-Money Valuation – The valuation of the firm prior to crowdfunding campaign.
Post-Money Valuation – A calculation of equity raised / equity given to suggest post-money valuation].
Dissolved/Failed – Number of firms who are no longer trading or who are in liquidation.
Number of Directors – The number of directors actively involved in the running of the firm at time of Crowdfunding.
Equity Funding Pre-CF – Monetary amount (€) of equity raised before crowdfunding campaign.
Debt Funding Pre-CF - Monetary amount (€) of debt raised before crowdfunding campaign.
Equity Funding Post-CF - Monetary amount (€) of equity raised after crowdfunding campaign.
Debt Funding Post-CF - Monetary amount (€) of debt raised after crowdfunding campaign.
Liquidity (T-1) – The liquidity ratio (current assets / current liabilities - expressed in x:1) one year prior to crowdfunding campaign.
Liquidity (T+1) - The liquidity ratio (currents assets / current liabilities - expressed in x:1) one year after crowdfunding campaign.
Illiquid (<0.75) – Firms with liquidity ratio's between 0.51:1 - 0.75:1
Illiquid (<0.50) – Firms with liquidity ratio's less than 0.50:1
Intangibles (T-1) – The monetary value of intangible assets (€) one year prior to crowdfunding campaign.
Intangibles (T+1) - The monetary value of intangible assets (€) one year after crowdfunding campaign.
Total Assets (T-1) – The monetary value of total assets (€) one year prior to crowdfunding campaign.
Total Assets (T+1) - The monetary value of total assets (€) one year after crowdfunding campaign.
Gearing (T-1) – The gearing level (total debt / total equity – expressed in %) one year prior to crowdfunding campaign.
Gearing (T+1) - The gearing level (total debt/ total equity – expressed in %) one year after the crowdfunding campaign.
Cash (T-1) – The monetary value of the cash balance (€) one year prior to crowdfunding campaign.
Cash (T+1) - The monetary value of the cash balance (€) one year after crowdfunding campaign.
Shareholder Funds (T-1) – The monetary value of the shareholder funds (€) one year prior to crowdfunding campaign.
Shareholder Funds (T+1) - The monetary value of the shareholder funds (€) one year after crowdfunding campaign.
Capital (T-1) – The monetary value of capital (€) one year prior to crowdfunding campaign.
Capital (T+1) - The monetary value of the capital (€) one year after crowdfunding campaign.
Use of Funds – The use of funds provided by the firms in their crowdfunding campaign (see classification below): <i>Use of Funds: Expansion, IT Development, Research &amp; Development, Sales &amp; Marketing and Working Capital</i>
Sector – The specific Cleantech sector (see classification below): <i>Sector Classification: Energy Efficiency, Recycling/Waste Management, Renewable Energy and Transportation.</i>
Country – The specific country in which campaign took place (see list below): <i>Countries: Austria, Belgium, Denmark, Estonia, Finland, France, Germany, Ireland, Italy, Latvia, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom</i>

#### IV. EMPIRICAL RESULTS AND DISCUSSION

##### A. Descriptive Statistics

In Tables II–IV, we present the summary statistics for the 177 firms in our sample. The average age of the firms from date of incorporation to crowdfunding was five years with an average of five directors, including founders. The average premoney firm valuation was €7.6 million. Firms operating in energy

efficiency (32%), recycling and waste management (17%), renewable energy (29%), and transportation sectors (22%) conducted equity-crowdfunding campaigns. The primary use of funds of these firms was R&D (37%) and expansion (29%), suggesting these Cleantech firms are in the development stages and require equity crowdfunding to develop their business further. Regarding equity-crowdfunding campaign characteristics, the average amount of capital raised during the campaign was

TABLE II  
SUMMARY DESCRIPTIVE STATISTICS OF VARIABLES

Variable	N	Mean	Median	SD	Min	Max
Age (Years)	177	5.05	4.00	3.80	0.00	26.00
Investors (N)	177	776	368	2,280	16	2,2712
Amount Raised (€)	177	828,918	450,000	1,392,670	50,000	11,200,000
Target Capital (€)	166	605,356	399,925	1,070,427	37,500	10,000,000
Equity Given (%)	166	0.11	0.09	0.08	0.01	0.58
Equity Offered (%)	166	0.09	0.07	0.05	0.01	0.25
Pre-Money Valuation	177	7,674,794	4,000,000	13,998,693	416,667	40,000,000
Post-Money Valuation	177	8,229,337	4,283,180	17,228,187	415,476	42,379,182
Number of Directors	177	5.16	4.00	4.77	1.00	34.00
Liquidity Ratio (T-1)	177	2.07	0.60	11.51	0.00	149.74
Liquidity Ratio (T+1)	177	3.61	1.26	9.76	0.00	110.24
Intangibles (€) (T-1)	177	270,327	0.00	1,725,775	0.00	21,464,000
Intangibles(€) (T+1)	177	373,920	0.00	2,221,695	0.00	24,946,000
Total Assets (€) (T-1)	145	1,715,566	560,000	3,817,914	1,000	31,905,000
Total Assets (€) (T+1)	143	2,035,972	693,000	4,814,116	3,000	42,499,000
Gearing Ratio (%) (T-1)	177	64.61	0.00	139.41	0.00	854.39
Gearing Ratio (%) (T+1)	177	63.63	3.13	126.94	0.00	812.40
Cash (€) (T-1)	145	317,793	45,000	739,146	0.00	672,3000
Cash (€) (T+1)	143	283,902	52,000	662,168	0.00	498,2000
Shareholder Funds (€) (T-1)	145	610,344	117,000	1,526,243	-1,813,000	12,009,000
Shareholder Funds (€) (T+1)	143	832,881	214,000	2,158,487	-1,765,000	20,484,000
Capital (€) (T-1)	145	253,779	10,000	767,570	0.00	6,125,000
Capital (€) (T+1)	143	272,104	10,000	806,488	0.00	6,500,000

TABLE III  
DESCRIPTIVE FIRM STATISTICS

Panel 1			Panel 2			Panel 3		
Age of Firm	N	%	Type of Cleantech Firm	N	%	Use of Funds	N	%
Start-Up	6	3.39	Energy Efficiency	56	31.64	Expansion	51	28.81
1-3 years	61	34.46	Recycling/Waste Management	30	16.95	IT Development	18	10.17
4-9 years	95	53.67	Renewable Energy	52	29.38	Research & Development	66	37.29
10-15	12	6.78	Transportation	39	22.03	Sales & Marketing	29	16.38
<15	3	1.69				Working Capital	13	7.34
	177	100%		177	100%		177	100%

€828 918<sup>2</sup>; the average number of investors was 776 and the average equity given was 11%. Overall, 105 firms (59%) obtained follow-up funding after their equity-crowdfunding campaign, and 24 firms (13.5%) went insolvent, were liquidated, or were dissolved.

In terms of funding pre and postcrowdfunding, we find that 68 firms raised equity funding precrowdfunding (38%) with an average investment of €1 167 000 and 75 firms raised debt funding precrowdfunding (42%) averaging €872 287. In postcrowdfunding, we find that 35 firms raised equity (20%) with an average investment at €2 584 000 and 89 firms raised debt funding (50%), averaging €735 845 per firm, which indicates that debt funding remained stable before and after crowdfunding

campaigns. This is because older firms with greater total assets sought debt funding; see summary statistics on funding pre and postcrowdfunding in Table IV.

The accounting data provide good insight into the financial performance of firms pre and postcrowdfunding campaigns. Median liquidity ratios are at 0.60 before crowdfunding and 1.26 after crowdfunding, showing the immediate positive impact of receiving additional funding. In total, 54% of firms had liquidity ratios of less than 0.75, which would suggest that these firms were illiquid or suffering from liquidity issues prior to the crowdfunding campaign. To further this point, cash balances improve immediately after crowdfunding; precampaign the median cash balance was €45 000 and after the campaign rose to a median of €52 000. In relation to total assets, the median total asset value is €560 000 and €693 000 for pre and postcrowdfunding, respectively. This suggests that firms used the funding raised to invest immediately and to expand. As expected, shareholder

<sup>2</sup>To ensure comparability of firms from Europe and the United Kingdom, we use the EUR/GBP exchange rate as of the date of the campaign end and convert the volumes from GBP to EUR.

TABLE IV  
DESCRIPTIVE STATISTICS ON FUNDING PRE AND POSTCROWDFUNDING

Debt Funding Pre-crowdfunding		Debt Funding Post- crowdfunding	Equity Funding Pre-crowdfunding	Equity Funding Post- crowdfunding
Average Age (Yrs) (at CF)	6.3	6.6	6.2	4.5
Number of Firms	75 (42%)	89 (50%)	68 (38%)	35 (20%)
Total Raised (€)	65,421,000	65,490,000	75,936,000	90,450,000
Average Raised (€)	872,287	735,845	1,167,000	2,584,000
Average Total Assets (T-1 Pre) / (T+1 Post)	2,300,000	2,512,000	1,900,000	2,761,000
Average Intangible Assets (T-1) / (T+1 Post)	490,000	715,685	550,000	1,216,000
<i>Sector</i>				
Energy Efficiency	20 (27%)	25 (28%)	23 (34%)	14 (40%)
Recycling/Waste Management	9 (12%)	13 (15%)	8 (12%)	5 (14%)
Renewable Energy	24 (32%)	27 (30%)	19 (28%)	11 (31%)
Transportation	22 (29%)	24 (27%)	18 (26%)	5 (14%)
<i>Use of Funds</i>				
Expansion	20 (27%)	26 (29%)	24 (35%)	12 (34%)
IT Development	6 (8%)	5 (6%)	1 (1%)	3 (9%)
R&D	27 (36%)	36 (40%)	23 (34%)	14 (40%)
Sales & Marketing	17 (23%)	16 (18%)	14 (21%)	3 (9%)
Working Capital	5 (7%)	6 (7%)	6 (9%)	3 (9%)

funds' also increases positively in the year proceeding the campaign. Median shareholder funds' were €117 000 prior to the campaign and increases to €214 000 after the campaign.

### B. Amount of Crowdfunding Raised

In Table V, we report coefficients for our models investigating potential determinants for the amount raised through crowdfunding. Coefficients for our base model are presented in column 1. We find a positive relationship between the amounts raised and firm age. Older firms in Cleantech tend to raise more funding, and this is possibly due to the nature of their business in which it takes time to develop their concepts and reach a viable commercialization stage, so naturally, they will seek crowdfunding after a number of years and pose a lesser perceived risk for investors. We find a negative relationship between the amount raised and the number of investors; this could suggest that there are more institutional investors investing in Cleantech firms or that individual investors are, in fact, investing greater amounts in Cleantech firms than other firms due to the "social good" of doing so. Looking at previous studies, Hornuff *et al.* [43] examine 413 firms from the U.K. and Germany that raised equity crowdfunding and find that the average amount raised was €424 438 with an average of 366 investors. A study on crowdfunding for Green Projects in Europe [1] shows that on specialized "green" project platforms, the average value of the investment on a given campaign was €452 491. Slimane and Rousseau [91] examine French Crowdlending platforms specializing in

renewable energy projects that show average amounts raised of €229 725 across 167 projects. Our study shows a greater average amount raised (€828 918) which could suggest that institutional investors are investing in these projects or that there is a positive sentiment for Cleantech firms, along with the fact that equity-crowdfunding firms raise more in comparison with reward-based crowdfunding [25], [98].

Unsurprisingly, firms who were prepared to give more equity away raised greater absolute amounts. We find that for every additional 0.56% equity given, firms raise €100 000. We estimate the price of 2% of firm equity at €400 000. Firms that had a greater premoney valuation raised more money during their campaigns [4], [12], [16]. Firms that had previously raised financing before embarking on crowdfunding also raised more finance. This suggests that they are slightly older firms and further along in their development. In the majority of cases, firms were seeking funding for the purpose of R&D and expansion, rather than working capital or marketing.

In relation to accounting data and past financial performance, firms with lower tangible assets raised greater amounts through crowdfunding. This is an important factor for Cleantech firms and the sector in which they operate. In our sample, energy efficiency firms were the most represented (32%) firms that sought equity crowdfunding. As the majority of these firms are developing unique and new technologies, including software development, to enhance the usage of energy efficiency, this is to be expected that firms would not necessarily have large tangible assets. This indicates that investors invest greater amounts in



TABLE V  
POTENTIAL DETERMINANTS OF AMOUNT RAISED IN EQUITY CROWDFUNDING

Dep. Var.	Amount Raised			
	Base Model	Ext Model 1	Ext Model 2	Ext Model 3
Firm Age	.0300* (.0186)	.0201 (.0180)	.0222 (.0185)	.0237 (.0188)
Investors	-.0002*** (.0000)	-.0002*** (.0000)	-.0002*** (.0000)	-.0002*** (.0000)
Equity given	5.6833*** (.7909)	5.3259*** (.8328)	5.4486*** (.8675)	5.4850*** (.8758)
Pre-Money Valuation	8.0000*** (1.0900)	8.0000*** (1.0400)	8.0000*** (1.0700)	7.0000*** (1.0000)
Number of Directors	.0078 (.0167)	.0276 (.0181)	.0264 (.0186)	.0268 (.0191)
Raised Financing Pre-Crowdfunding	.1081 (.1393)	.3070** (.1377)	.3160** (.1408)	.3159** (.1431)
Gearing (T-1)	-.0000 (.0004)	.0000 (.0004)	-8.000 (.0004)	.0000 (.0004)
Liquidity (T-1)	.0010 (.0049)	-.0005 (.0046)	-.0000 (.0047)	-.0002 (.0048)
Illiquid (<0.75)	-.1128 (.1302)	.0429 (.1295)	.0455 (.1312)	.0421 (.1359)
Intangible Assets (T-1)	-2.0000 (4.0000)	3.0400 (4.0000)	2.0000 (4.0000)	2.0000 (4.0000)
Total Assets (T-1)	-1.0000*** (4.0000)	-1.0000*** (4.0000)	-1.0000*** (4.0000)	-1.0000*** (4.0000)
Cash (T-1)	2.0000** (1.0000)	1.1200 (9.0000)	1.0100 (9.0000)	1.0000 (9.0000)
Shareholders' Funds (T-1)	3.0000*** (1.0000)	2.0000*** (1.0000)	2.0000*** (1.0000)	3.0000*** (1.0000)
Capital (T-1)	-1.6300* (9.2600)	2.0000 (1.0500)	1.2900 (1.0000)	-5.0000 (1.0000)
Constant	11.6754*** (.1815)	11.8105*** (.2080)	11.7555*** (.2296)	11.7881*** (.2688)
Country		Yes	Yes	Yes
Sector			Yes	Yes
Use of Funds				Yes
# Obs.	166	166	166	166
Adj. R2	55.77	62.83	62.13	61.53
F	15.86	10.62	9.46	8.33

Table V reports the results of the amount raised regression models. The base regression model specifications are as per (2) and (3), respectively, with the full model extending the base model with the country, sector, and purpose fixed effects. All variables are defined in Table III. Standard errors are in parentheses. \*\*\*, \*\*, and \* denote the statistical significance at the 1%, 5%, and 10% levels, respectively.

firms with greater intangible assets, new ideas, or patents than those with tangible assets. When investigating further, we also find this in certain renewable energy and transportation firms that are at the early stages of their development with emphasis on the development of a specific software or battery engineering, which ties in with the lack of tangible fixed assets. Equally important for investors was the current financial position within a given firm as there is a positive relationship between the amounts raised and cash balances and shareholders' funds. The ability to have a positive cash position along with positive shareholders'

funds was a contributing factor to raise more funds. Specific to accounting ratios, such as gearing, liquidity, and illiquid firms, we do not find any evidence suggesting that the investors pay particular attention to this.

In testing for country, purpose, and sectoral control variables, we find no statistical significance between any specific sector, use of funds, and amount raised. In terms of country-specific variables, however, we find significant differences between the U.K. and all other countries. A large number of previous studies conducted on the U.K. crowdfunding market [94], [97], [99]

TABLE VI  
POTENTIAL DETERMINANTS OF DEBT AND EQUITY FUNDING PRECROWDFUNDING

Dep. Var.	Debt Funding Pre-Crowdfunding		Equity Funding Pre-Crowdfunding	
	Base Model	Ext Model	Base Model	Ext Model
Firm Age	.4373*** (.1370)	.3702*** (.1422)	.2487* (.1465)	.1877 (.1536)
Number of Directors	-.2010* (.1221)	.0913 (.1495)	.1034 (.1287)	.0795 (.1597)
Raised Debt Funding Pre Crowdfunding			1.3505* (1.017)	1.2581 (1.1135)
Raised Equity Funding Pre Crowdfunding	1.712* (.9479)	1.5609 (1.0116)		
Liquidity (T-1)	.0341 (.0382)	.0327 (.0380)	.0412 (.0401)	.0351 (.0405)
Illiquid (<0.75)	1.5954 (1.3049)	2.1303 (1.3448)	-3.2155** (1.3518)	-2.959** (1.4176)
Illiquid (<0.50)	-3.4814*** (1.2729)	-4.8244*** (1.3711)	1.3789 (1.3636)	1.0296 (1.5215)
Intangibles (T-1)	2.0100 (3.6100)	4.1400 (3.8700)	3.7500 (3.7900)	3.8500 (4.1400)
Total Assets (T-1)	1.1000*** 3.2700	8.1800*** (3.3400)	-1.900 (3.5000)	-3.8200 (3.5800)
Cash (T-1)	-1.1400 (7.5900)	-1.1700 (7.6800)	-2.9600 (8.0200)	5.5500 (8.2400)
Shareholders' Funds (T-1)	-1.7400** (7.8800)	-1.3000* (7.9300)	2.8300 (8.3700)	7.5900 (8.4800)
Capital (T-1)	8.0100 (7.0500)	-1.2400 (8.5600)	1.4000* (7.3700)	1.8700** (9.0800)
Constant	3.6409*** (1.017)	-.8895 (1.7156)	3.4825*** (1.0736)	5.2571*** (1.775)
Country		Yes		Yes
Sector		Yes		Yes
Use of Funds		Yes		Yes
# Obs.	177	177	177	177
Adj. R2	20.13	26.05	12.03	16.18
F	5.03	2.88	3.19	2.03

Table VI reports the results of the funding precrowdfunding regression models. The base regression model specifications are as per (2) and (3), respectively, with the full model extending the base model with the country, sector, and purpose fixed effects. All variables are defined in Table III. Standard errors are in parentheses. \*\*\*, \*\*, and \* denote the statistical significance at 1%, 5%, and 10% levels, respectively.

indicate that the U.K. is one of the world's most advanced and established crowdfunding markets [95]. Our results reaffirm that the U.K. crowdfunding market is one of the most developed in Europe, as we find that U.K. firms raise more funding than their European counterparts with statistical significance for all countries in our sample.

### C. Funding Precrowdfunding

In this section, we analyze debt and equity funding raised by our sample firms in the precrowdfunding period. In Table VI, we report regression coefficients for debt and equity funding precrowdfunding. We use lagged accounting variables ( $T-1$ ). A standout finding is that the liquidity and asset structures have

TABLE VII  
POTENTIAL DETERMINANTS OF DEBT AND EQUITY FUNDING  
POSTCROWDFUNDING

Dep. Var.	Debt Funding Post-Crowdfunding		Equity Funding Post-Crowdfunding	
	Base Model	Ext Model	Base Model	Ext Model
Firm Age Now	.9965*** (.2587)	1.1056*** (.3111)	.5943** (.2849)	.5201 (.3494)
Investors	.0002 (.0004)	.0000 (.0005)	-.0005 (.0004)	-.0002 (.0005)
Amount Raised	4.0000 (8.0000)	8.0000 (8.0000)	1.0000* (8.0000)	1.0000* (9.0000)
Equity Given	4.0000 (8.0000)	4.5981 (6.6621)	-4.0000 (6.0000)	-10.000 (7.0000)
Pre-Money Valuation	6.0000 (1.0000)	-2.0000 (1.0000)	-1.0000 (1.0000)	-2.0000 (1.0000)
Post-Money Valuation	-1.0000 (1.0000)	2.0000 (1.0000)	-5.0000 (1.0000)	-7.0000 (1.0000)
Number of Directors	-.0838 (.1066)	-.2666** (.1333)	.2552** (.1120)	.2799* (.1447)
Raised Debt Funding Pre-Crowdfunding	6.7691*** (.8467)	7.4014*** (.9181)	-3.2113*** (1.049)	-2.979*** (1.1911)
Raised Equity Funding Pre-Crowdfunding	.8557 (.8997)	1.2066 (.9812)	1.0136 (.9588)	.4478 (1.0655)
Debt Funding Post-Crowdfunding			1.6745 (1.0504)	2.1474* (1.1404)
Equity Funding Post-Crowdfunding	1.2694 (1.0407)	1.6398 (1.1084)		
Liquidity (T+1)	-.0030 (.0390)	-.01268 (.0398)	-.0250 (.0416)	-.0159 (.0431)
Intangibles (T+1)	-1.0000 (2.0000)	-4.0000 (3.0000)	9.0000 (2.0000)	1.0000 (3.0000)
Total Assets (T+1)	4.0000 (2.0000)	5.0000* (2.0000)	-4.0000 (2.0000)	-3.0000 (3.0000)
Cash (T+1)	2.0000 (7.0000)	3.0000 (7.0000)	-6.0000 (8.0000)	-6.0000 (8.0000)
Shareholders' Funds (T+1)	-2.0000 (5.0000)	-4.0000 (6.0000)	1.0000** (6.0000)	8.0000 (6.0000)
Capital (T-1)	3.0000 (5.0000)	-1.0000 (7.0000)	-1.0000* (6.0000)	-3.0000 (7.0000)
Constant	-.6766 (1.1764)	.2434 (1.9821)	.8203 (1.2563)	1.7689 (2.1396)
Country		Yes		Yes
Sector		Yes		Yes
Use of Funds		Yes		Yes
# Obs.	166	166	166	166
Adj. R2	37.91	40.37	16.12	17.16
F	7.30	3.94	2.98	1.90

Table VII reports the results of the funding postcrowdfunding regression models. The base regression model specifications are as per (2) and (3), respectively, with the full model extending the base model with the country, sector, and purpose fixed effects. All variables are defined in Table III. Standard errors are in parentheses. \*\*\*, \*\*, and \* denote the statistical significance at 1%, 5%, and 10% levels, respectively.

a significant effect on the types of funding Cleantech firms avail of. In relation to debt financing, we find that the liquidity ratios of less than 0.50 are negatively related to the amount of debt funding precrowdfunding. However, liquidity ratios between 0.51 and 0.75 are negatively related to the amount of equity funding precrowdfunding. When we examine this further, we find greater debt and lower equity funding for firms with higher liquidity ratios. This indicates that the debt financing providers will not finance firms with poor liquidity ratios, in this case, being <0.50. It also suggests that firms with poor liquidity ratios are more likely to seek equity financing and it is likely that equity

investors will fund these types of projects based on the future outlook and potential, rather than current short-term liquidity. In total, 96 out of the 177 firms (54%) fall under the illiquid targets we have set, which is a liquidity ratio of less than 0.75:1. One could argue that the reason Cleantech firms have sought equity crowdfunding is that they are not in a position to secure debt financing and will revert to an alternative option.

We also find a positive relationship between firm age and tangible assets. This stands to reason as older firms will have a track record and time to accumulate tangible fixed assets as collateral on borrowings. Shareholders' funds are negatively related to debt funding precrowdfunding, suggesting that debt providers are more concerned with assets and collateral requirements than on the past financial performance, which is a key component of shareholders' funds. This suggests that asset structure is a significant issue for Cleantech firms when it comes to their early stage financing. In summary, firms with tangible assets fulfill the collateral requirements of debt providers, and firms with high levels of intangible assets are attractive investments for equity providers. In relation to capital introduced in firms from incorporation, this is favorable for equity investor's precrowdfunding, suggesting that they wish to invest in founders who have "skin in the game" and have been willing to invest their own funds into their business at incorporation. As previously stated, asset structure in Cleantech firms is significant when making the capital structure decision, and our findings highlight the challenges Cleantech firms with good ideas, patents, and potential face in trying to raise debt financing unless they have the required collateral.

Firms that had raised debt or equity financing precrowdfunding often raised the alternative type of funding. An example of this is that firms who raised debt financing also had the likelihood of raising equity financing, all of this before they raised on crowdfunding platforms. This suggests signaling for firms who already had some method of financing and, therefore, had better prospects at obtaining additional financing.

In terms of country-specific variables, we find that U.K. Cleantech firms raise more equity funding precrowdfunding than firms in other countries, apart from Finnish and Danish firms. We reaffirm this when analyzing debt funding precrowdfunding where we find that U.K. Cleantech firms raise less debt than those of all other countries apart from Finland and Germany. Looking at sector-specific variables, we find no statistical significance of funding choice precrowdfunding campaigns. Finally, when including the use of funds, we find that firms who sought funding for IT development raised less equity precrowdfunding than firms who sought funding for Expansion purposes, suggesting that equity investors precrowdfunding would rather invest in firms who are further along in their development stage.

#### D. Funding Postcrowdfunding

In this section, we analyze the debt and equity funding raised by our sample firms in the postcrowdfunding period. In Table V, we report regression coefficients for debt and equity funding raised postcrowdfunding as dependent variables. We employ campaign-specific and accounting variables at  $T+1$  to examine the postcrowdfunding impact on accounting data. Similar to

debt funding precrowdfunding, we find a positive relationship between the firm age and total tangible assets with the amount of debt funding raised. This further highlights the nexus between asset tangibility and capital structure of Cleantech firms. When we examine equity funding postcrowdfunding, we find that tangible assets are negatively related to the amount of equity financing raised postcrowdfunding. This suggests that the financing decisions of Cleantech firms are influenced by the asset type and sector they operate in. Firms that raised debt financing precrowdfunding also raised more debt and equity funding postcrowdfunding. Specific to debt financing postcrowdfunding, we find that firms that have previously used bank finance are more likely to continue that trend and build upon the relationship they have with their debt provider [70]. It could be argued that they have used crowdfunding to test the market, signal for future investment at a later stage, and do not wish to give any more equity away now, therefore, continuing with debt financing. We also find that, for equity funding postcrowdfunding, those who raised debt financing precrowdfunding raised more equity postcrowdfunding. When we isolate these firms and examine their capital structure pre and postcrowdfunding, we find that precrowdfunding these firms had substantially larger assets than most other firms averaging €2.2 million. However, their intangible assets were quite small with 50% of firms having no intangible assets and the remaining firms' intangible assets averaging at €340 000. This leads us to believe that firms' had used tangible assets to secure debt funding precrowdfunding and required much higher amounts later, so resorted to financing by way of equity postcrowdfunding. There is also the possibility that all assets were already committed to other loans. When we examine the debt financing precrowdfunding, we find the average borrowing was just over €200 000; while these firms raised equity funding postcrowdfunding, they also increased their debt funding to an average of €620 000 postcrowdfunding.

An interesting finding on closer examination of firms that raised equity funding postcrowdfunding is the fact that the average equity obtained precrowdfunding was €280 000 but rose substantially to just over €2.5 million after the crowdfunding campaign. This makes a clear distinction that firms that raised equity-funding postcrowdfunding required significantly greater amounts. A striking finding from firms that raised equity-funding postcrowdfunding was in the year following a crowdfunding campaign, intangible assets rise significantly from €340 000 to €620 000. This coincides with our findings on funding precrowdfunding that debt providers require collateral in the form of tangible assets, while equity investors require growth opportunities, particularly the high levels of intangible assets. It also indicates that the additional equity funding required was primarily used for further development and creation of intangible assets; this is something we do not witness with debt-funded firms. When we examine the specific sectors of firms that raised equity-funding postcrowdfunding, we find that the majority of them are in energy efficiency (40%) and renewable energy (31%), with the use of funding for the crowdfunding campaign focused on R&D (40%) and expansion (34%). This indicates the preference of external equity holders to invest in firms with more intangible assets and those focused on development.

Another finding suggesting the importance of a successful crowdfunding campaign for firms seeking further equity investment is that there is a positive relationship between the amount raised on a campaign and postequity financing. We find that, for each unit of finance raised during the equity-crowdfunding campaign, firms raise X10 of equity postcrowdfunding. This indicates a positive signaling effect of crowdfunding to equity investors, providing them with validation from the crowd who believe in the firm as to the potential for their business model. This provides us with an extension of the "wisdom of the crowd" view, suggesting that there is a reputational effect gained from crowdfunding that further increases the firm's potential for attracting additional equity. The amount raised through crowdfunding has a positive effect on the postmoney valuation of the firm, which is greatly beneficial to firms seeking to raise additional financing externally. This highlights the importance of the initial premoney valuation and the decision on the amount of equity given as a part of the campaign.

Of the firms that raised equity postcrowdfunding, 51% of these firms raised equity financing from corporate venture capital. The 25% of firms who raised equity postcrowdfunding from our sample raised finance, subsequently, through equity-crowdfunding platforms. The average equity investment on crowdfunding, subsequent to the first round, rose substantially to an average of €1.5 million from an average of €828 918 in the first campaign, thus, showing the confidence firms had to return to equity crowdfunding, suggesting that their experience was positive and see it as a valuable method of raising finance.

In analyzing funding postcrowdfunding, there appears to be a positive effect of larger entrepreneurial teams [2], [3], [35]. We find a positive relationship between firms with a greater number of directors and the amount of equity funding postcrowdfunding. This highlights the importance of directors and the social networks they have [21], [62], [100], which suggests that the more directors involved in a firm, the better opportunities available to raise external equity financing. We find the opposite for firms that raise debt funding postcrowdfunding. Debt funding postcrowdfunding and the amount of debt raised are positively related that further demonstrates the importance of entrepreneurial teams for raising external financing.

In terms of country-specific variables, we find that U.K. Cleantech firms are more likely to raise equity funding postcrowdfunding, and apart from German and Swedish firms, receive more equity funding postcrowdfunding than any other country. The opposite is observed when analyzing debt funding postcrowdfunding, where we find that U.K. Cleantech firms raise less debt than those of all other countries apart from Finland, Italy, and Sweden. Looking at sector-specific variables and use of funds, we find no statistical significance for debt and equity funding postcrowdfunding.

## V. CONCLUSION

In this article, we provided new evidence of potential determinants of the amount of finance raised by early stage Cleantech firms through equity crowdfunding in Europe. We also analyzed the financing patterns of Cleantech firms before and after crowdfunding. We used a dataset of 177 Cleantech firms

that ran first time equity-crowdfunding campaigns in Europe across 19 platforms. We found out that firms raised substantially more amounts of external equity postcrowdfunding, suggesting signaling effects. We provided evidence that firms that raised financing before the campaign raised more money during the campaign itself. We found that the asset structure was important for raising equity crowdfunding for Cleantech firms, insofar as firms with lower tangible assets raised more money. This suggested that the investors were willing to invest in firms with greater intangible assets and future prospects. We also found investors were more willing to invest in firms with positive cash positions and a proven track record by examining their shareholder's funds. In terms of accounting ratios, such as liquidity and gearing, our findings suggested that the investors focused more on the crowdfunding campaign, previous financing arrangements, and future potential rather than accounting information. In analyzing financing of Cleantech firms in the precrowdfunding period, we found that debt providers were more willing to finance firms with greater tangible assets, while equity investors were more willing to invest in firms with greater intangible assets. Regarding the level of liquidity within firms and their financing patterns, we found that the debt providers were less likely to finance firms with poor liquidity ratios but that equity investors were willing to finance them. Finally, in analyzing the postcrowdfunding period, we found that firms that had raised debt financing precrowdfunding were more likely to raise debt and equity funding after the crowdfunding campaign. We also showed the positive impact of a successful equity-crowdfunding campaign on equity investment postcrowdfunding in which the average amount of equity funding had increased substantially to just over €2.5 million. We know that 25% of firms who obtained equity financing postcrowdfunding returned to equity crowdfunding, suggesting their experience was positive and see it as a valuable method of raising finance. Overall, we found that equity crowdfunding for early stage Cleantech firms was a very valuable method of financing with positive impacts on financial performance and the ability to raise financing postcampaign.

Our study also had clear limitations. First, we had examined firms who obtained crowdfunding from 2014 to 2019 with some of those firms yet to be in a position to raise financing postcrowdfunding and we examined the year before and the year after the campaign. A dataset with a longer timeframe and a re-examination of those firms in the future would be beneficial to examine financial patterns and decision making over a longer period and to assess whether many of these firms have had any major changes, such as acquisitions or liquidation. Second, other legal and regulatory factors might lead to differences in the number and amount of investors of our coefficients for European platforms compared with those in the U.K. The U.K. equity-crowdfunding market is one of the most advanced in the world and perhaps more needs to be known about the differences and the impact of pre and postfunding on these firms. Potential explanations could be the U.K. tax advantage<sup>3</sup> and

London as a financial central hub [98]. Third, we examined European firms that raised equity crowdfunding on European platforms only. There was a possibility they may have raised equity crowdfunding in other markets, in particular, the U.S. Further studies may aim to add to this by using a dataset with a longer time span, investigate firms who also raised outside of European platforms, and compare Cleantech firms with that of other firms in different industries.

## VI. PRACTICAL AND POLICY IMPLICATION

Our study adds to the literature in several ways. First, the determinants of the amount raised can assist Cleantech firms seek equity crowdfunding and highlight the significance of correct business valuation and the importance of financial management. Second, we acknowledge the different financing options available to Cleantech firms based on their asset structure and show a clear pathway for firms with greater tangible assets as opposed to intangible assets. Third, funding postcrowdfunding can assist policymakers to evaluate whether equity crowdfunding is an efficient and worthwhile form of financing for Cleantech firms. From our article, we know that for each unit of crowdfunding raised, there is a tenfold increase in equity postcrowdfunding that shows the positive signaling effects.

For Cleantech firms contemplating equity crowdfunding, it would be beneficial to ensure that they are at a developed stage and have sufficient assets in existence, including intangible assets, that they will more than likely have achieved if commercialization is reached after the number of years of incorporation. Furthermore, it is important to highlight in the campaign pitch the exact use of funds and those requiring the funds for expansion and R&D purposes will be more successful. If possible, it would also be beneficial to seek crowdfunding on the U.K.-based platforms. Specific to investors, based on their risk-taking profile, firms who have a steady financial position who have reached commercialization are good prospect regardless of liquidity ratios in the short term. It would be advisable to examine the financial statements in detail and be conscious of the premoney valuation and the forecasts set out in the campaign pitch itself.

In terms of policy implications for government, and in order to put greater emphasis on the immediate climate crisis by supporting innovative Cleantech firms, they could increase crowdfunding cofinancing programs along with public-private principally venture capital cofinancing [75] arrangements for Cleantech firms. The early and long horizon innovations of Cleantech firms represent uncertainty, which needs further funding to develop. It is refreshing to see the British Business Bank recently launched the Future Fund, which can further assist businesses and investors. In some U.K. crowdfunding platforms, the opportunity to invest via the Future Fund is available, which provides investors with further tax incentives. While the U.K. has advanced tax incentives for investors, other countries around Europe could follow to improve investment efficiency and interest from prospective investors. The European Commission, along with other partners, has also established an ambitious *European Green Deal*, which aims to ensure that the EU will be carbon neutral by 2050. This will require huge policy implementations

<sup>3</sup>The United Kingdom provides two tax reliefs for investors. Both the enterprise investment scheme and the seed enterprise investment scheme offer tax relief of up to 30% and 50%, respectively.

and funding, and with this in mind, it will be important for innovative SMEs to obtain some of this funding to ease the patient capital gap burden that exists.

With the global crowdfunding market expected to reach \$40 billion by 2026 [89], it is clear that this alternative method of financing is now becoming a stable source of finance for innovative SMEs and has a positive impact on Cleantech firms, something that is sure to grow into the future.

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