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Factors Affecting the Development of Clean-tech Start-Ups: A Literature Review

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Abstract

In this paper, we carry out a literature review of the studies investigating the factors that affect the performance and growth of clean technology start-up firms. The importance of clean-tech start-ups lies in their mission to protect the environment by facilitating the increased use of clean energy and environmentally friendly solutions. At the same time, the entrepreneurial nature of many of these firms enables introduction of radical innovations necessary for making breakthroughs in the industries of renewable energy and environmental technology that in turn are essential for the industry development. Given their significance, there are surprisingly few studies with the focus on the factors affecting the growth of clean-tech start-ups. Our search in leading management, entrepreneurship and energy journals has yielded a total of 13 articles, almost all of which focus on such external factors as policies. We argue that this gives us an incomplete picture of the factors enabling a clean-tech firm's development. As clean-tech firms are a subset of the population of new technology-based firms (NTBFs), we draw on the literature dealing with the factors that promote growth of NTBFs in order to build our framework for structuring the results. The analysis uncovers what future research areas can be pursued in order to gain a more balanced understanding of what enables the development of a clean-tech start-up. We suggest that in addition to the macro-studies of policies and regulations, future research needs to examine the individual and firm-specific factors, e.g. characteristics of the clean-tech entrepreneurs, teams, governance mechanisms and network structures. Furthermore, the existing focus on the environmental and innovative performance of clean-tech start-ups should be complemented by examining the alternative firm outcomes related to e.g. financial performance, social identity, alliance portfolio and internationalization.

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1. Introduction

In recent years there has been a growing interest in the debate regarding climate changes, specifically human-induced changes. Companies, and their investments in green technology, will therefore play an important role in the upcoming climate cleanup fight [1]. However, the extent to which the existing research addresses the real environmental innovators is limited. This is surprising given the dependence on firms that are able to provide radical innovations to sufficiently solve the problems [2]. Innovative companies are important facilitators of green strategies that average firms are enforced to use to gain sustainable development, for example, an increased use of energy generated from renewable sources or a more environmentally friendly handling of wastes. The companies providing such technologies group together in the clean-tech industry. In this paper we adopt the definition of a "clean tech" by Pernick and Wilder [3]. A clean-tech firm delivers any product, service, or process that delivers value using limited or zero nonrenewable resources and/or creates significantly less waste than conventional offerings. Clean-tech companies help to protect the environment by facilitating the increased use of clean energy and environmentally friendly solutions [4]. A wide variety of technologies fall into this industry ranging from solar, wind and hydropower to biofuels, green transportation and green buildings.

We specifically focus on entrepreneurial clean-tech firms that exploit technological knowledge to create new technical solutions. Given the importance of such firms in shaping the clean technologies of the future, the aim of the paper is to review the literature dealing with clean-tech firms to shed light into what factors affect their growth. This, in turn, should improve our understanding of how to sustain the life of these companies that are expected to contribute to increased technological and environmental impact of the clean-tech industry. As early-stage entrepreneurial clean-tech firms are a subgroup of new technology-based firms (NTBFs), we also draw on the literature which addresses the factors affecting the NTBF's growth and performance. Thus, we contribute to the research on clean technology and renewable energy by showing what factors influence the growth of entrepreneurial clean-tech firms. Additionally, we identify promising future research directions to further develop this research stream.

This paper is structured as follows. In section 2 we outline our theoretical framework for structuring the results and subsequent discussion. Section 3 describes the methodology used in this literature review. In section 4 we present the descriptive findings. Section 5 contains the discussion of the findings and suggestions for future research followed by the final section with conclusions.

2. Theoretical framework

We choose to build our study upon a theoretical framework that is intended to aid in structuring the results of our literature review and subsequent discussion. The factors that promote new technology-based firm growth can roughly be divided into three categories: individual, firm-specific and external factors [5]. Individual factors relate to the personality, skills and competences of the entrepreneur or entrepreneurial team. Firm-specific factors cover a range of factors specific to the firm entity including the financial and human resources of the firm, its network and its strategic choices etc. The external factors comprise all industry-wide or nation-wide factors, such as environmental organizations, national policies and the general availability of financing. All of these factors are shown to be important for the growth of NTBFs [5-11].

3. Methodology

The aim of this study is to systematically review the growing research on clean-tech start-up companies in major business, management and entrepreneurship journals. First, we searched for articles in the ISI Web of Science database, which covers a wide range of leading journals. The search criteria was a combination of three terms 'growth', 'drivers', 'firm performance' with the following key words: new technology based firms, high-tech firms, clean-tech firms, renewable energy, green tech firms, SME, sustainable entrepreneurship, environmental technology,

eco-innovation. Also, it had to be an article within either business or management. For instance, growth AND clean-tech firm* AND article AND business. In total this search has returned a set of 1.720 articles.

Next, we chose to limit the search to fifteen leading journals within management, business and entrepreneurship studies [4]: Academy of Management Journal, Academy of Management Review, Administrative Science Quarterly, American Economic Review, Entrepreneurship Theory and Practice, Industrial and Corporate Change, Journal of Business Venturing, Journal of Technology Transfer, Management Science, Organization Science, R & D Management, Research Policy, Small Business Economics, Strategic Management Journal, and Technovation. The second search has yielded a total of 492 articles. These articles were added to the database and gone through systematically to decide their relevance for this study. Each article's abstract was read. As a result, 393 articles turned out to be irrelevant, while only 13 articles were highly relevant addressing the clean-tech firm issues. The remaining 86 articles were included in our review because they dealt with the growth factors in NTBFs in general.

To assure full coverage, we have also searched for the articles in the Energy Policy journal and used a snow-ball method, i.e. checked the references in the articles identified in the previous step. The articles that seemed relevant focused on the policies to support environmentally friendly technologies rather than factors facilitating growth of the firms developing these technologies. As such, the final result was still 13 clean-tech studies.

From the articles we have recorded the following information: authors' names, journal, theory, country, industry, research question(s), data, dependent variable(s), independent variable(s), control variable(s), method, key findings and proposed future research. The table is available upon request to the authors.

4. Descriptive findings

This section presents the descriptive findings of our literature review. Figure 1 shows the distribution of the clean-tech firm articles across leading management, business and entrepreneurship journals with the majority of the articles published in the Research Policy. Figure 2 shows the increasing research interest in this topic. Ten articles are empirical, while three are conceptual.

The majority of research focuses on American companies. The "worldwide" category also includes American companies. We did not find any studies that examine the development of the clean-tech industry in emerging regions, such as China, Japan, Africa or South America, even though there is wide acceptance that these regions, China in particular, are becoming increasingly important for the clean-tech industry as a whole [1,3].

In terms of the power industry, the two largest groups are aggregated focusing on the clean-tech- and renewable energy technologies/industries as a whole, rather than focusing on specific technologies and their development. These are followed by the solar and wind power industries that are the two largest clean-tech industries if one excludes hydropower [1].

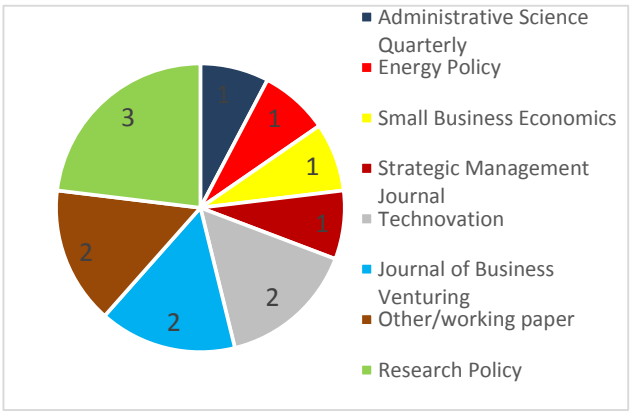

Figure 1: Number of articles published per journal

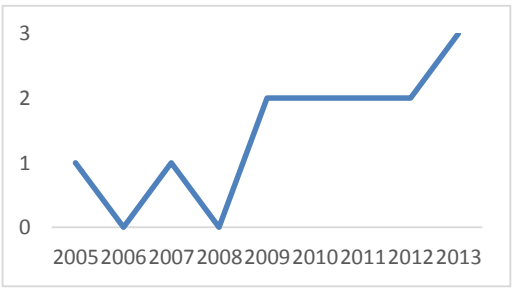

Figure 2: Number of articles published per year

4.1. Individual factors

While eleven articles examine the effect of at least one external variable on the firm, only one article incorporates the effect of individual characteristics of entrepreneurs. Even in this article the primary focus is on firm-specific factors, whereas the background of the entrepreneurs is controlled for [12].

4.2. Firm-specific factors

Three articles in this category investigate the impact of firm partners and networks on a firm's performance, either financial or environmental [13-15]. The study by Lettice et al. [12] finds that higher levels of commercial risk seem to increase the chance of receiving research funding.

4.3. External factors

External factors have been most widely studied. This concerns especially the use of policies and regulations in order to enhance the competitiveness of firms in the clean-tech industry. The authors suggest what policies can facilitate the fastest possible rate of adoption of clean technologies [16-18]. Seven studies focus on policies, and their general findings are that current policies have a strong potential to improve a clean-tech firm's growth and performance.[15,19]. Nevertheless, the negative effects of strong regulations and policy dependency are also evaluated, including their effect on firm innovativeness and on the capability and willingness to supply radical innovations [2,13,20]. As such, policies seem to be a two-edged blade; on the one hand they are essential for making clean technologies economically viable [19], on the other hand there is a risk of diverting firms' focus from the radical innovations necessary to aid our battle against the climate changes [2].

As to policies supportive of firm growth, Tsoutsos and Stamboulis [19] suggest that three factors are especially important in this regard: learning processes across the value chain, cooperation within the industry and flexible financing mechanisms. York and Venkataraman [21] emphasize the importance of entrepreneurial firms in bringing about the necessary environmentally benign changes, and suggest this will be best achieved if the entrepreneurs are incentivized to focus on ethically motivated, environmentally superior innovations.

Other external factors were also examined. Eyraud et al. [1] explores a long range of external factors and their influence on the rate of "green investments". Walsh [22] investigates what external country-specific factors affect the commercialization of renewable energy innovations. Meek et al. [23] study whether social norms of a society have an effect on the creation of new clean-tech enterprises, while Sine and Lee [24] examines the effect of social movement organizations on the creation of market opportunities and the stimulation of entrepreneurial activity.

5. Discussion and suggestions for future research

In this section we discuss the findings of our literature review. To enrich the discussion we draw on the literature about the factors affecting the growth of new technology-based firms on the individual, firm and external levels accordingly. We further suggest future research avenues (including the discussion of the firm growth and theories) that are interesting to pursue and that would hopefully be helpful in developing future research on clean-tech entrepreneurial firms.

5.1. Individual factors

We found virtually no studies that examine individual characteristics of the founding entrepreneurs and how they may affect the performance and growth of a clean-tech start-up. A distinctive feature of the clean-tech industry is that it is highly regulated by various policies [19]. Hence, we can assume that founders or managers with former political experience may be better able to affect the political agenda and interpret political decisions, and thus give their firms a competitive advantage.

Specifically, future research into clean-tech start-ups could build on the findings for NTBFs, e.g. that the activity and involvement of the firm's management, including the board of directors, strongly influences its growth [25]. An

interesting research question could focus on how the clean-tech management team and board work together to achieve growth. Often clean-tech businesses have been founded not only to exploit a market potential, but also to aid in developing a new technology which can potentially save the world from climate changes [26]. As such, another future research avenue is to explore the incentives that drive managers and board members to establish clean-tech businesses. Similarly, the reasons why a public fund and a venture capital fund invest in a company might be fundamentally different. While the venture capitalist may aim at achieving financial gains, the public institution representative may be more interested in the creation of local (community) growth and employment. It could be interesting to see whether such diverging interests create tensions that inhibit clean-tech venture growth or serve as catalysts for fruitful strategy discussions in the boardroom.

5.2. Firm-specific factors

Few studies have examined firm-specific factors. The results show varying effects of partnerships and networks on a firm's bottom line [13-14], as such, contradicting previous research on NTBFs, where a strong relationship has mainly been found between a firm's networks and its performance [9-10]. This makes it an interesting aspect, which deserves more research attention.

Beyond the studies on networks, we know extremely little about the influence of firm-specific factors on the growth of clean-tech start-ups. The fact that the clean-tech sector is still a sector with limited profitability which depends on government incentives [27] might suggest that the positive effect of available financial capital on a NTBF's growth will also hold for clean-tech firms. Furthermore, Maine et al. [28] find that being located in a cluster or science park is beneficial for biotech firms. Such effect can be expected to be positive also for clean-tech start-ups, but needs empirical testing.

Similar to the research on individual factors, there are a number of firm-specific factors that have been found to influence NTBF growth positively. Testing these factors in a clean-tech setting may therefore bring valuable contributions to the field. For example, due to distinct nature of the clean-tech industry, both on the demand side and related to policies and regulations, the strategic landscape of clean-tech firms may differ significantly from that of other firms [19,27]. One might therefore expect that clean-tech start-ups should focus more on such strategic aspects e.g. gathering political influence. Studies analysing the effects of firm's strategic orientation, location, financial and human capital, etc. could broaden our knowledge about this topic.

5.3. External factors

External factors are relatively well studied in current clean-tech literature. Policies have received greatest attention, including their positive influence on creating the necessary demand for clean technology [15,19] and their potentially negative effect on clean-tech firm innovativeness [2,13,20]. One factor that has not been considered yet is the availability of venture capital. In the NTBF literature it has been established that venture capital financing has a strong positive effect on a firm's growth [11]. As the clean-tech industry is very capital intensive [1], one might expect this positive effect to be even stronger for clean-tech start-ups. Bürer & Wüstenhagen [29] show that investors perceive feed-in tariffs to be the most effective renewable energy policy, and that the overall preference for feed-in tariffs is even more pronounced among investors based in Europe (versus US) and with higher exposure to clean energy (e.g. more experience). Similar survey among the clean-tech firms being invested in or searching for venture capital funding is an exciting future research direction.

5.4. The growth of the firm

Current clean-tech studies have predominantly measured growth and performance in terms of innovative or environmental performance [2, 20]. A large proportion of entrepreneurial clean-tech firms are founded because of a desire of the entrepreneur to help protect the environment [26], and it is therefore reasonable to argue for the use of environmental measures of firm performance. However, Bennett [30] emphasizes the need for using financial and other traditional business measures in addition to environmental measures, because of the fact that, as the author says, if one wants to save the planet, one can't do it without making a profit.

A potential compromise may be the “triple bottom line” [13-14]. The triple bottom line refers to a concept where the traditional financial bottom line of a company – that is the financial profit – is supplemented by two additional “bottom lines”, one measuring the company's social responsibility and one measuring the company's environmental responsibility [31]. Overall, no measure of growth is perfect, and one needs to use a combination of measures to fully explain the firm growth as phenomenon [32]. Consequently, other relevant firm performance measures could be developing an international alliance portfolio [33], reaching international sales [34] coupled with the social identity of the founder (social entrepreneur) [40]. Most recent research on growth calls for studies on how the firms grow rather than how much [32].

5.5. Theoretical and methodological considerations

We found that the studies were primarily empirical, and this calls for a theoretical development of the field. There are several theories that could be drawn upon. One such theory is the resource-based view, which has been a popular theory for evaluating business action for several decades [35-37]. The resource-based view focuses on the resources of the firm, and how these can lay the basis for a sustainable competitive advantage. This view could be fruitfully applied to clean-tech start-ups. One could investigate, for instance, whether obtaining truly inimitable and non-substitutable resources, and thereby sustainable advantage is possible and necessary in the rapidly changing clean-tech industry, and to which degree these advantages can be exploited to achieve firm growth.

Another interesting theoretical perspective to build upon could be the internationalization of clean-tech start-ups. The international potential for delivering clean technology is huge and growing [1,15] and it would thus be interesting to evaluate which theories of internationalization will hold for clean-tech start-ups. Specifically one might expect companies in older, more established industries, such as the hydropower industry, to internationalize in a stage-wise way, similar to that described in the Uppsala model [38,39]. However, with younger and more revolutionary industries, such as solar photovoltaics or tidal energy, the nature of the industry might lead new firms to behave more like International New Ventures, where the entire world is considered as the firm’s potential market from early on in the firm's development [34]. Exploring these theories in a clean-tech setting could offer new knowledge about various ways that different clean-tech firms may internationalize and the factors that facilitate firm’s internationalization.

As to methodologies, we call for a multi-level analysis of individual, firm-specific and external factors as well as cross-country comparisons to gain a more balanced understanding of what enables the development of a clean-tech start-up.

6. Conclusion

We have reviewed the literature dealing with factors affecting the growth of clean-tech firms. While we found many studies focusing primarily on policies that support the development of clean-tech industry and growth of clean-tech firms, we found very few studies that consider the characteristics of the founders (managers) and the firm itself. We contribute to the research on clean-tech and renewable energy by showing what factors affect and may be expected to affect the growth of entrepreneurial clean-tech firms as well as what future research directions can be pursued to further develop this research stream.

References

[1] Eyraud, L., B. Clements and A. Wane (2013). "Green investment: Trends and determinants." Energy Policy 60(0): 852-865.
[2] Nemet, G. F. (2009). "Demand-pull, technology-push, and government-led incentives for non-incremental technical change." Research Policy 38(5): 700-709.
[3] Pernick, R. and C. Wilder (2007). The Clean Tech Revolution: The Next Big Growth and Investment Opportunity, HarperCollins.
[4] Rasmussen, E., O. Bulanova, A. Jensen and T. Clausen (2012). "The Impact of Science-Based Entrepreneurial Firms - a Literature Review and Policy Synthesis." NF-rapport nr. 3/2012.
[5] Gilbert, B. A., P. P. McDougall and D. B. Audretsch (2006). "New venture growth: A review and extension." Journal of Management 32(6): 926-950.

[6] Almus, M. and E. A. Nerlinger (1999). "Growth of new technology-based firms: Which factors matter?" Small Business Economics 13(2): 141-154.
[7] Colombo, M. G. and M. Delmastro (2002). "How effective are technology incubators? Evidence from Italy." Research Policy 31(7): 1103-1122.
[8] Lindelof, P. and H. Lofsten (2003). "Science Park location and new technology-based firms in Sweden - Implications for strategy and performance." Small Business Economics 20(3): 245-258.
[9] Wynarczyk, P. and R. Watson (2005). "Firm growth and supply chain partnerships: An empirical analysis of UKSME subcontractors." Small Business Economics 24(1): 39-51.
[10] Zeng, S. X., X. M. Xie and C. M. Tam (2010). "Relationship between cooperation networks and innovation performance of SMEs." Technovation 30(3): 181-194.
[11] Bertoni, F., M. G. Colombo and L. Grilli (2011). "Venture capital financing and the growth of high-tech start-ups: Disentangling treatment from selection effects." Research Policy 40(7): 1028-1043.
[12] Lettice, F., P. Smart, Y. Baruch and M. Johnson (2012). "Navigating the impact-innovation double hurdle: The case of a climate change research fund." Research Policy 41(6): 1048-1057.
[13] Doblinger, C., M. Dowling and R. Helm (2013). "Does Public Policy Stimulate Firm Entrepreneurial Behavior and Innovative Activities?" Working paper presented at the 73d Academy of Management Annual Meeting, San-Antonio, Texas.
[14] Meyskens, M. and A. L. Carsrud (2013). "Nascent green-technology ventures: a study assessing the role of partnership diversity in firm success." Small Business Economics 40(3): 739-759.
[15] Menon (2011). En kunnskapsbasert fornybar energi- og miljønæring. Et kunnskapsbasert Norge. L. A. Grünfeld and A. Espelien, Menon Business Economics.
[16] Kaplan, A. W. (1999). "From passive to active about solar electricity: innovation decision process and photovoltaic interest generation." Technovation 19(8): 467-481.
[17] Veugelers, R. (2012). "Which policy instruments to induce clean innovating?" Research Policy 41(10): 1770-1778.
[18] Jacobsson, S. and V. Lauber (2006). "The politics and policy of energy system transformation - explaining the German diffusion of renewable energy technology." Energy Policy 34(3): 256-276.
[19] Tsoutsos, T. D. and Y. A. Stamboulis (2005). "The sustainable diffusion of renewable energy technologies as an example of an innovation-focused policy." Technovation 25(7): 753-761.
[20] Hoppmann, J., M. Peters, M. Schneider and V. H. Hoffmann (2013). "The two faces of market support-How deployment policies affect technological exploration and exploitation in the solar photovoltaic industry." Research Policy 42(4): 989-1003.
[21] York, J. G. and S. Venkataraman (2010). "The entrepreneur-environment nexus: Uncertainty, innovation, and allocation." Journal of Business Venturing 25(5): 449-463.
[22] Walsh, P. R. (2012). "Innovation Nirvana or Innovation Wasteland? Identifying commercialization strategies for small and medium renewable energy enterprises." Technovation 32(1): 32-42.
[23] Meek, W. R., D. F. Pacheco and J. G. York (2010). "The impact of social norms on entrepreneurial action: Evidence from the environmental entrepreneurship context." Journal of Business Venturing 25(5): 493-509.
[24] Sine, W. D. and B. H. Lee (2009). "Tilting at Windmills? The Environmental Movement and the Emergence of the US Wind Energy Sector." Administrative Science Quarterly 54(1): 123-155.
[25] Zhang, J. J., C. Baden-Fuller and J. K. Pool (2011). "Resolving the Tensions between Monitoring, Resourcing and Strategizing: Structures and Processes in High Technology Venture Boards." Long Range Planning 44(2): 95-117.
[26] Parrish, B. D. (2010). "Sustainability-driven entrepreneurship: Principles of organization design." Journal of Business Venturing 25(5): 510-523.
[27] Průša, J., A. Klimešová and K. Janda (2013). "Consumer loss in Czech photovoltaic power plants in 2010– 2011." Energy Policy 63(0): 747-755.
[28] Maine, E. M., D. M. Shapiro and A. R. Vining (2010). "The role of clustering in the growth of new technology-based firms." Small Business Economics 34(2): 127-146.
[29] Bürer, M. J. and R. Wüstenhagen (2009). "Which renewable energy policy is a venture capitalist's best friend? Empirical evidence from a survey of international cleantech investors." Energy policy 37: 4997-5006.
[30] Bennett, S. J. (1991). Ecopreneuring: the complete guide to small business opportunities from the environmental revolution, Wiley.
[31] Elkington, J. (1997). Cannibals With Forks: The Triple Bottom Line of 21st Century Business, Capstone Publishing.
[32] McKelvie, A. and J. Wiklund (2010). Advancing Firm Growth Research: A Focus on Growth Mode Instead of Growth Rate. Entrepreneurship Theory and Practice. 34(2): 261-288.
[33] Lee, Y. and S. T. Cavusgil (2006). "Enhancing alliance performance: The effects of contractual-based versus relational-based governance." Journal of Business Research 59(8): 896-905.
[34] Oviatt, B. M. and P. P. McDougall (2005). "Toward a theory of international new ventures." Journal of International Business Studies 36(1): 29-41.
[35] Penrose, E. T. (1959). The Theory of the Growth of the Firm, New York: John Wiley.
[36] Wernerfelt, B. (1984). "A Resource-Based View of the Firm." Strategic Management Journal 5(2): 171-180.
[37] Barney, J. (1991). "Firm Resources and Sustained Competitive Advantage." Journal of Management 17(1): 99-120.
[38] Johanson, J. and J. E. Vahlne (1977). "Internationalization Process of Firm - Model of Knowledge Development and Increasing Foreign Market Commitments." Journal of International Business Studies 8(1): 23-32.

[39] Johanson, J. and J. E. Vahlne (2009). "The Uppsala internationalization process model revisited: From liability of foreignness to liability of outsidership." Journal of International Business Studies 40(9): 1411-1431.

[40] Dean, T. J. and J. S. McMullen (2007). "Toward a theory of sustainable entrepreneurship: Reducing environmental degradation through entrepreneurial action." Journal of Business Venturing 22(1): 50-76.