The combined effect of success factors in crowdfunding of Cleantech projects

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Abstract

Cleantech projects can significantly contribute to the reduction of greenhouse gas emissions globally. However, they often lack investments from the conventional finance sector. Crowdfunding represents an alternative for financing cleantech projects. By using a Qualitative Comparative Analysis, this paper explores the combinational effect of the six success factors identified in the general crowdfunding literature for cleantech projects published on Kickstarter platform. The results indicate that crowdfunding success of cleantech projects is highly contextual, and identify a set of core conditions that cleantech entrepreneurs are advised to consider for their crowdfunding campaign design.

Keywords: Crowdfunding, cleantech projects, climate change, Qualitative Comparative Analysis, entrepreneurs

1. Introduction

Climate change is a global threat characterized by extreme weather patterns, that put at risk food security, biodiversity, human and ecosystem health (IPCC, 2019). Governments around the world have committed to the Paris agreement to reduce greenhouse gas (GHG) emissions and keep global warming below 2°C above pre-industrial levels (UNFCCC, 2020). One of the ways to achieve this goal is through a wide implementation of clean technologies (cleantech) projects (Polzin, 2017), i.e. projects providing positive externalities in terms of a cleaner environment.

However, one crucial constraint for implementing such projects is the lack of finance (Polzin, 2017). First, these projects are usually characterized by high uncertainty, regulatory dependency and capital intensity, which makes them less attractive for private investors (Polzin, 2017). Second, they are often based on novel technology, while investors prefer to invest in familiar technologies (Leete et al. 2013). Third, many entrepreneurs launching cleantech projects have limited business experience, which can make it difficult to obtain sufficient investments (Maehle et al. 2020).

Crowdfunding – pooling financial contributions from a potentially large number of interested backers, where each of them provides a relatively small amount of money (Shneor & Maehle, 2020) – complements traditional forms of entrepreneurial financing (Short et al. 2017), and can represent an alternative for cleantech projects.

Crowdfunding has gained wide popularity in recent years, with transaction value projected to reach US$1,082.9m in 2021 (Statista.com, n.d.). Since in crowdfunding backers invest smaller amounts of money, they tend to take into consideration not only tangible benefits but also societal ones, e.g. projects' environmental impact (Cumming et al. 2017). This makes crowdfunding highly relevant for cleantech projects.

There is a growing focus among researchers on crowdfunding of sustainable projects, such as for example Tenner & Hörisch (2021) studying investor characteristics in sustainable crowdfunding; Maehle et al. (2021) analyzing the use of climate frames in crowdfunding campaigns; Maehle (2020) studying the distinctive features of sustainable crowdfunding; and Testa et al. (2019) connecting sustainable crowdfunding with Multi Level Perspective (MLP). Despite this there is still a lack of studies analysing the success factors for such projects with a systematic comparative approach (Koch & Siering, 2019).

While many researchers address individual success factors of crowdfunding campaigns in general such as for example the role of female co-founders and perceived sustainable mission of campaigns (Bento et al. 2019); project duration, funding goal, dollar amount contributed per day (Cordova et al. 2015) on crowdfunding success; it is important to understand how the interrelations of these factors and their combined effect influence the success of environmental, climate related crowdfunding campaigns (Hörisch, 2014). In addition, more qualitative studies are needed that can increase understanding of underlying causal mechanisms, processes and dynamics of crowdfunding success (Testa et al. 2019: 71).

Understanding crowdfunding success of cleantech project can help cleantech entrepreneurs to finance their initiatives, and in the long-term contribute to the transition towards cleaner production, which is a prerequisite for a zero-emission society and achieving the international climate goals.

This paper addresses the abovementioned issues by applying a Qualitative Comparative Analysis (QCA) to explore the combined effect of the success factors identified in the general crowdfunding literature in the case of cleantech projects. The combined effect is defined as specific combinations of attributes enabling a certain outcome. In this study, it concerns the combined effect of success factors for crowdfunding as outcome.

The paper is structured as follows: Section 2 provides a concise overview of prior identified success criteria for crowdfunding campaigns, which builds the theoretical framework. Section 3 introduces the methodological approach and research design applied in this study. Sections 4 and 5 present and discuss the combined effect of success factors in crowdfunding of Cleantech projects. Section 6 addresses the limitations of this study. Section 7 presents the scientific and practical contributions of this study and some concluding remarks.

2. Success factors for crowdfunding campaigns

The previous literature identifies a wide range of factors influencing the success of crowdfunding campaigns (Shneor & Vik, 2020;).

This study investigates the relevance and interrelations of six success factors– 1) target amount, 2) emotional appeal, 3) campaign duration, 4) communication with backers, 5) entrepreneur's gender, and 6) location of backers. The number of factors was reduced to these six to secure a variety of categories (heterogeneity) in relation to the number of cases, which is a prerequisite for conducting a meaningful QCA analysis (Berg-Schlosser et al. 2009).

In the following, it is discussed how each of the chosen factors can influence the crowdfunding success and why they were included in the research design.

Target amount

Cleantech projects are often very costly (Cumming et al. 2017) and require higher target amounts than conventional crowdfunding campaigns. Therefore, it is interesting to include target amount in the research design to explore whether its combined effect with other conditions is relevant for the success of cleantech crowdfunding. Ferreira and Pereira (2018) argue that a high amount is more difficult to get crowdfunded since it would require more people to crowdfund the project (larger social network). Large projects might also appear unreasonable, and therefore discourage potential backers (Lagazio & Querci, 2018). Findings from several studies on reward-based crowdfunding demonstrate that higher funding goals are negatively associated with success (Clauss et al. 2018;). Moreover, evidence from crowdfunding of technology projects confirms the same trend (Cordova et al. 2015).

Locality of backers

Previous research suggests that support of local communities can influence the crowdfunding success. Pabst et al. (2021) argue that regional bonds can lead to more trust from potential funders, while Josefy et al. (2017) show that crowdfunding success depends on the communities which the campaign belongs to, and culture is an important community attribute influencing crowdfunding success. In addition, the climate literature argues that the focus on the local impacts increases people's willingness to act (Stoknes, 2014). Moreover, compared to distant funders, local ones are more likely to support crowdfunding projects at an earlier stage (Agrawal, et al. 2015). Their early contributions can determine the pattern of subsequent contributions by distant backers responsive to others' investment decisions (Cordova et al. 2015). Since cleantech crowdfunding projects address climate change, and a local connection becomes important for people to act on climate change (Stoknes 2014), the location of backers can become important for the success of cleantech projects.

Compelling emotional appeal of the campaign/narrative

Several studies demonstrate that using emotional appeals increases a campaign's chances for crowdfunding success. Emotional appeal is especially important in sustainable crowdfunding as social and psychological motivations may be equally or more important than economic ones in this case (Testa et al. 2019). While studying pro-social campaigns, Rhue and Robert Jr. (2018) demonstrate that using emotional language (i.e. positive or negative sentiment) increases crowdfunding success. Moreover, research shows that emotions are an important factor to motivate and support climate change solutions (Salama & Aboukoura, 2018).

Communication with backers – campaign updates

Communication with backers is extremely important for crowdfunding success, especially for sustainable projects due to their high ambiguity and intangibility of some of the sustainability claims (Maehle, 2020). Providing information about the project during the campaign reduces information asymmetries by disclosing additional details about the project and explaining ambiguous information (Ahlers et al. 2015). This increases the credibility and legitimacy of the project (Clauss et al. 2018), signals its quality, and reduces investor confusion (Lagazio & Querci, 2018). Moreover, regular communication with backers increases entrepreneurs' trustworthiness and may motivate backers to provide positive word-of-mouth, which can attract more interest towards the project (Efrat & Gilboa, 2019). Updates on the project given by entrepreneurs during the campaign period is a common way of communicating with backers. Several studies show a positive relationship between updates and crowdfunding success, as updates act as an indicator of project quality. Mollick (2014) demonstrates the effect of early updates on crowdfunding success, while Block et al. (2017) find that in equity-based crowdfunding updates have a positive effect on crowd participation. Moreover, Kuppuswamy and Bayus (2018) show that project support is positively related to updates at any point in the funding cycle and successful projects have more frequent updates then unsuccessful ones. Lagazio and Querci (2018) also confirm a positive influence of updates on crowd-investors.

Duration of crowdfunding campaign

There is mixed evidence about the optimal duration of a crowdfunding campaign. Zheng et al. (2014) find a significant positive effect of campaign duration in rewards-based campaigns in China. In addition, other studies on crowdfunding success of technology projects (Cordova et al. 2015) and environment-oriented crowdfunding campaigns (Hörisch, 2015) demonstrate that longer campaign duration increases the chance of success, e.g. due to higher project visibility (Burtch et al. 2013). On the contrary, Lukkarinen et al. (2014) find that longer campaigns have

lower success chances. Shorter campaigns create a sense of urgency (Boeuf et al. 2014), while longer campaigns may indicate entrepreneurs' lack of confidence (Mollick, 2014). Moreover, backers may forget about the campaign if it is too long (Härkönen, 2014). The duration is included as an important condition for cleantech projects because of the complex value proposition they entail (Maehle, 2020). Based on the previous literature (Boeuf et al. 2014), it is assumed that longer cleantech crowdfunding campaigns can take away the sense of urgency for mitigating climate change and make these projects more intangible and less feasible for potential backers.

Entrepreneur's gender

In crowdfunding, female entrepreneurs are seen as more trustworthy and therefore have higher chances to be funded than men (Johnson et al. 2018). Some studies also suggest that women use a more vivid and emotional language, which increases trust among backers and makes female entrepreneurs more successful (Majumdar & Bose, 2018). Female entrepreneurs outperform male ones in crowdfunding, all other things being equal, especially while proposing technological projects (Greenberg & Mollick, 2017). To see how this becomes relevant for cleantech projects combined with other conditions, it was decided to address entrepreneur's gender as one of the success factors.

3. Methods

3.1 Background on Qualitative Comparative Analysis (QCA)

This study employs a QCA, a comparative research method that enables a systematic case comparison and that can be applied for theory testing and development (Marx & Dusa, 2011). It originates from macrosociology and comparative politics, and was developed by Charles Ragin in the 1980s to bridge variable- and case-oriented approaches in social science research

(Ragin, 1987). QCA has experienced exponential growth in usage since 2007 and become a widely accepted research methodology (Roig-Tierno et al. 2017:22) QCA has also been applied in crowdfunding research for assessing sponsor satisfaction (Xu et al. 2016), contingency factors leading to the success of equity crowdfunding (De Crescenzo et al. 2020), and delivery performance of rewards in reward-based crowdfunding (Tuo et al. 2019). In this study, QCA is employed to explore the combined effect of six factors influencing crowdfunding success of cleantech projects.

Cleantech projects are characterized by complex value propositions (Maehle, 2020) and therefore their crowdfunding success is often the result of different combinations of factors rather than one individual factor. Hence, this study requires a holistic approach to allow identifying the causal complexity of factors enabling the success of cleantech crowdfunding projects. QCA is a set-theoretic, case-sensitive, configurational method that builds on causal complexity (Berg-Schlosser et al. 2009) and thus appropriate to employ in this study.

In QCA's terminology, cases consist of configurations of attributes (called conditions), where combinations of conditions can be causally linked to a certain outcome (Rihoux, 2020). In this case, linking previously identified factors enabling the success of cleantech crowdfunding campaigns.

Three important concepts underlie QCA. The first one is *conjunctural causality*, stating that the causal role of a single factor may unfold only in combination with other conditions (configurations). Furthermore, the same factor can produce a different outcome, depending on the context it operates in, which is called *multifinality*. Last but not least, QCA is anchored in *equifinality*, which means that one outcome can have mutually non-exclusive explanations represented by different paths of combined conditions (Berg-Schlosser, et al. 2009).

QCA assists in the identification of necessary and sufficient (combinations of) conditions for a certain outcome. A necessary condition is always present when the outcome is present, but it alone does not cause the outcome (Schneider & Wagemann, 2012). Sufficiency entails that a set of conditions on its own causes an outcome.

3.2 Data collection and operationalization

A crisp set QCA was conducted where each condition and outcome were operationalized in a binary way. Explanatory conditions are calibrated with [1] if the condition is present and [0] if it is absent in the data set. Outcome [1] represents successfully crowdfunded cleantech projects, where success is defined as being fully crowdfunded in their given time period. Outcome [0] represents not successfully crowdfunded projects[1]. A crisp set QCA was chosen over a fuzzy set approach because of the explorative, qualitative nature of the research. The interest in this study lies in "differences in *nature* or *kind* rather than differences in *degree*" (Ragin 2002 in De Meur et al. 2009:149), meaning that it lies more in investigating meaningful differences in the data with less focus on degree, even though interval-level data is used for dichotomizing some of the conditions.

3.3 Case selection

To carry out a meaningful QCA analysis, cases must be comparable, which means they must share enough background characteristics, which then can be considered as constant for the analysis (Berg-Schlosser & De Meur, 2009). It was therefore chosen to focus on cleantech crowdfunding campaigns on one crowdfunding platform, Kickstarter. Kickstarter is an internationally known crowdfunding platform with a large variety of projects. It does not have a particular green, climate profile, which was considered as an advantage since such a platform

[1] Due to the set relational and asymmetric principle of QCA, [0] outcome is not considered as unsuccessful but only "not" successful (Rubinson et al. 2019).

would not exclusively attract a climate-concerned crowd and therefore provide a much broader public, so that this external factor could be controlled for. Kickstarter makes use of reward-based crowdfunding.

For identifying cases, search words "technology projects" and "on Earth" were used, which means that projects from all parts of the world were included; among those the projects tagged with the label "environmental" were selected, which was the closest to selecting cleantech projects[2]. As a result a list of 80 projects was obtained of which 20 projects were not successful, meaning that they reached less than their inquired amount of funding in their given campaign period, and 60 successful projects, obtaining 100 percent of their inquired funding or more in their specified campaign period. From this original list, projects that could not be affiliated with one of the Cleantech categories were excluded. Cleantech categories include projects related to the use of advanced materials, agriculture and forestry, air and environment, biofuels and biochemicals, biomass generation, conventional fuels, energy efficiency, energy storage, fuel cells and hydrogen, geothermal, hydro and marine power, nuclear, recycling and waste, smart grid, solar, transportation, water and waste water, and wind (Cumming et al. 2016: 86). Projects where the campaign was cancelled prior to the campaign end or lacked information on some of the conditions included in the dataset were also excluded.

The final sub-population included 38 projects, with 27 successfully funded projects and 11 not successfully funded ones[3]. The intermediate (medium size) number of cases is very suitable since it ensures empirical intimacy/sufficient familiarity with each case, which is important for conducting a good QCA analysis (Berg-Schlooser & De Meur, 2009). A large N design as in

[2] The search was conducted in June 2020 and thus included all registered projects on Kickstarter at this time.
[3] The case selection process resulted in a higher success rate than Kickstarter's average (39.4%, https://www.kickstarter.com/help/stats. Higher success rates of cleantech projects can be explained by their extended value proposition including environmental and social values. This allows the projects to appeal to different target groups with various motivational reasons.

quantitative research would make it difficult to interpret the individual case information that is important for QCA.

3.4 Calibration of conditions

The six chosen success conditions satisfy the methodological requirements for a QCA analysis. They combine easily quantifiable information and qualitative richness. They were calibrated (operationalized) in the following way. Communication with backers was operationalized as the condition UPDATE. Based on crowdfunding statistics (Nonprofitssource.com, (2020); Startups.com, (2018)), the average number of updates that a successful campaign owner posts is four. All campaigns that included at least four updates by the entrepreneur during the campaign period were calibrated with [1]. All campaigns with fewer than four updates during the campaign period were calibrated with [0].

In order to calibrate the duration of campaigns (LOWDURATION), the threshold recommended by Kickstarter was applied. Kickstarter advises entrepreneurs to set campaigns for not more than 30 days (Kickstarter, 2020). Thus, cleantech campaigns that took place 30 days or less were calibrated with [1] and campaigns with more than 30 days with [0].

The condition LOCAL indicates whether backers come from the same country as the entrepreneur or not. On Kickstarter, this information is found under the label “community” on the campaign website. The community label shows how many people have crowdfunded the campaign and the top cities and countries they come from. Campaigns with a majority of backers from the same country as the entrepreneur were calibrated with [1] and campaigns where most of the backers originate from other countries than the entrepreneur were calibrated with [0].

A compelling emotional appeal of the campaign (EMOTION) was calibrated based on the inclusion of emotional ques in the main text of the campaign. These include words like

"passionate", "fun", "happy" but also emotional pictures that arouse backers' conscience and feelings. Campaigns with an emotional appeal were calibrated with [1]. Campaigns with the absence of an emotional appeal were calibrated with [0]. EMOTION was the condition that required a more nuanced calibration approach. A double coding process (Saldaña, 2015) was applied, meaning that both authors went through each single case individually and calibrated these individually. The chosen calibrations were then compared and negotiated/discussed where the calibrations differed.

LOWAMOUNT was calibrated based on the average size of crowdfunding campaign for cleantech projects that was identified in a previous study, 26,095 USD (Cumming et al. 2017). This means that all projects seeking funding up to 26,095 USD were calibrated with [1] and all campaigns seeking funding above 26,095 USD were calibrated with [0].

The condition FEMALE was calibrated based on the name of the entrepreneur who registered the campaign. Campaigns designed by women were calibrated with [1] and campaigns designed by men were calibrated with [0].

Table 1 illustrates the theoretical expectations about the influence of each condition on the success of cleantech crowdfunding campaigns based on the literature review presented in Section 2. For the data presentation, the design by Pagliarina et al. (2019) was adapted.

[Insert table 1 somewhere here]

Cases in QCA are considered as configurations of conditions (Marx & Dusa, 2011). In this study, each condition is expected to be a potential necessary condition but that will have to be combined with some other conditions to produce the outcome (success of crowdfunding).

Table 2 presents the selected cleantech crowdfunding campaigns with their assigned set membership values (calibrations) for each condition.

[Insert table 2 somewhere here]

4. Results: Enabling conditions for cleantech crowdfunding

4.1 Truth table and most parsimonious solution

To comply with good QCA practice, a test of necessity (Schneider & Wagemann, 2012) was first conducted for [1] outcome (successfully crowdfunded cleantech projects). Necessary conditions display a high consistence value of 0.9 or more (Schneider & Wagemann, 2012). Table 3 shows the test of necessity conducted with the fsQCA 3.0 software.

[Insert table 3 somewhere here]

No condition was identified as necessary, meaning that no single condition has to be individually present or absent for the occurrence of success in cleantech crowdfunding. However, EMOTION and UPDATE come very close to being a necessary condition. A truth table was then designed, which sorts cases with the same configurations of conditions into one row. The 38 cases in Table 2 are represented in the truth table in Table 4. With six conditions in this data set a total of 2^6=64 combinations are logically possible. A value of [1] (presence) or [0] (absence) was assigned to the outcome for each configuration, based on the consistency values. The consistency value was set to 0.75 as recommended in the literature (Schneider and Wagemann, 2012). The truth table shows 22 different configurations with empirical information on the outcome (Rows 1-22) and good levels of empirical diversity.

Three configurations in rows 4, 7 and 11 display a low consistency value as they are part of a contradictory configuration, meaning that the same combination of conditions implies in some cases a positive outcome [1] and in others a negative outcome [0]. These configurations were configurated as a [0] outcome since it becomes difficult to maintain the statement, where a

subset relation exists (explaining success of crowdfunding), due to the low consistency value (ibid). Ragin's approach was followed for treating contradictory cases as "unclear" and thus accept a reduction in the number of minimizable configurations in exchange for more consistency in the case/outcome relationship (Ragin 1987). 42 other logically possible combinations were left, where empirical data (logical remainders; non-observed cases) was lacking, which means it is unclear whether these combinations are sufficient for the outcome. However, they become relevant for the minimization process in the specified QCA analysis.

[Insert table 4 somewhere here]

The truth table indicates that there are many different configurations leading to the outcome [1] often represented by just one case instead of clustering many cases into a few configurations. This shows the unique path of each configuration for achieving success with their crowdfunding campaign and a potential high diversity among cases included in this dataset. QCA allows for capturing the complexity of the phenomena (successful crowdfunding) under study.

A standard analysis was conducted with fsQCA 3.0 for the outcome [1] successfully crowdfunded cleantech campaigns and outcome [0], not successfully crowdfunded cleantech campaigns. QCA is asymmetric which means that the negative outcome cannot be logically derived from the revised solution paths for the [1] outcome (Rubinson et al. 2019) and requires conducting two separate analyses. The standard analysis in fsQCA includes three different solutions (complex, intermediate and most parsimonious). These solutions differ in their application/treatment of logical remainders (logically possible configurations without empirical data).

As applying QCA to the success factors of crowdfunding is still a new field of research (De Crescenzo et al. 2020), there is a lack of the more in-depth theoretical knowledge needed to determine the easy logical remainders and their attributed outcome value (Schneider &

Wagemann, 2012). Therefore, for interpretation, the most parsimonious solution was used that will help to identify the core conditions for successful crowdfunding (Fiss, 2011). The other two solution paths (complex and intermediate) are presented in appendices 1-4.

In the parsimonious solution, it is possible to identify four sufficient configurations for successfully crowdfunded cleantech campaigns and two for not successfully crowdfunded campaigns represented in form of a configuration chart (Fiss, 2011) in Table 5. Filled circles indicate the presence of the condition and blank circles the absence of a condition. Blank cells indicate that the presence or absence of the condition is not relevant. Raw coverage, unique coverage and consistency cover the so-called parameters of fit. *Raw coverage* represents the proportion with cases of a positive outcome covered by this term of the solution. *Unique coverage* indicates how much of the outcome is covered by a specific solution term in proportion to the other ones (Schneider & Wagemann, 2012:133). Solution coverage indicates the degree to which an entire solution term covers the outcome (Schneider & Wagemann, 2012).

The last row in Table 5 shows the cases that include a membership in the solution path. Cases can be a part of different solution terms due to QCA's underlying logic (non-exclusionary logical OR) that allows the same case to be a part of different sufficient configurations (Schneider & Wagemann, 2012). The value of unique coverage becomes relevant to illustrate this overlap (Schneider & Wagemann, 2012). For example, configuration 6 has a very low unique coverage since only one case (Solar car) is exclusively part of this solution path.

[Insert table 5 somewhere here]

In order to interpret the data, there is a need to go back to the cases to conduct a systematic qualitative comparison. In the following section, the cases and combinations of conditions for each configuration implying SUCCESS and not SUCCESS are analysed.

5. Discussion: The combined effect of success factors in crowdfunding of Cleantech projects

The analysis leads to four non-mutually exclusive combinations of conditions associated with successful crowdfunding (see Table 5). Configurations 1 to 4 represent paths to successful crowdfunding, while configurations 5 and 6 represent paths to not successful crowdfunding. Configurations 2 and 3 represent the highest number of cases (both 8 cases), which suggests that cleantech projects are successful if entrepreneurs frequently communicate with backers and stick to short campaign duration or use an emotional appeal. Configurations 1 and 4 are covered by fewer projects. None of the configurations are technology specific. They capture a wide range of projects including recycling, solar and green energy.

Some of the conditions (LOWAMOUNT, LOWDURATION and FEMALE) do not provide more in-depth qualitative information since they are numerically calibrated. However, the conditions UPDATE, EMOTION and LOCAL contain qualitative information reflecting the case-oriented nature of QCA, and therefore there is a need to examine the meaning of these conditions in the dataset. In the following, the contextual meaning of these conditions will be analysed before discussing the interrelations of the conditions in each configuration for successful crowdfunding.

5.1. The effect of communication with backers (campaign updates) on successful cleantech crowdfunding

Communication with backers is especially important for sustainable projects (including cleantech), as they often have higher risk perceptions and therefore a higher need for legitimacy (Maehle, 2020). In this study, communication was measured through campaign updates. The QCA results indicate that in configurations 1, 2 and 3 frequent updates combined with other conditions such as emotional appeal and a short campaign duration are enabling contexts for

successful crowdfunding. Campaigns included in these configurations vary highly in their number of updates (from 4 to 12) suggesting that above the necessary minimum the content of the updates is more important than the quantity.

Previous research has shown that updates can serve as signals of project quality, and may solve information asymmetry problems and reduce investor confusion, which can positively influence investor decisions (Lagazio & Querci, 2018). When analysing all the successful cases with the presence of UPDATE, five different types of updates used by cleantech entrepreneurs are identified. First, there are updates caused by external events, e.g. special offers at Boxing day or International women's day, or during the COVID 19 pandemic:

> The world is facing difficult times. Since the last days, we are all invited to stay in our homes and take advantage of technology to be near the ones we love the most […] As a way to support everyone staying at home in the most comfortable and beautiful way, we removed the quantity limit of the Earlybird "Tech & Comfy Homeware Set" reward (Knit art, 2020).

Second, updates can also include special offers to backers who spread the word about the campaign. For example, the Solar backpack campaign offered 5 percent of every dollar to backers who share the campaign with their friends:

> The journey has just started! Now share our campaign with your friends and we will give you 5% of every dollar you help raise. All you have to do is click the button below to register, and we will give you a unique link to share. The more you share, the more you earn!" (Solar backpack, 2020)

Third, entrepreneurs use updates to announce public events. This includes webinars or livestreams with a Q&A session, demo presentations of technologies at fairs, workshops and Skype consultations. Some entrepreneurs use very creative ways to interact with backers, e.g.

the project ‘Monitor plastic’ makes it possible for backers to send in their own microplastic samples and get them analysed by an expert.

Fourth, updates can refer to external acknowledgements received by the entrepreneur that can strengthen trust in the promoted cleantech products, and overall improve the entrepreneur’s reputation and legitimacy. This can be a reference to a Kickstarter nomination (e.g., nomination as ‘a project we love’) or other external awards, such as a small business of the year award:

> ‘Solar cooker’[4] has been awarded CTA's Small Business of the Year award for 2017. CTA's Innovation Entrepreneur Awards program recognizes executives and leading businesses with revenues under $30 million and the contributions they make to the U.S. economy. (Solar cooker, 2020).

Fifth, a last type of update relates to the technical details of the cleantech product, e.g. discussing the recent developments and improvements of the technology:

> As we head into the home stretch, with just two weeks left in this campaign, we are going through all kinds of engineering and manufacturing details. We are always amazed at the complexity in the final phases of design execution. It is easy to think you are finished, only to discover a tiny detail leads you down a rabbit hole (Solar cooker, 2020)

5.2. The effect of emotional appeal on successful cleantech crowdfunding

Entrepreneurs use emotional appeal to evoke positive emotions and arouse affective responses from the backers (Xiang et al. 2019).

The campaigns included in configuration 2 often make use of a positive emotional appeal to convince backers that they make a difference by supporting their product:

[4] Name anonymized.

> I am not the best self promoter and in general an introvert. I am however very proud of the 'technology'[5] and already surprised at how far it has come. It was just an idea made out of desperation, because I honestly dislike static in my clothes. Then I realized the positive environmental impact of the 'technology' and thought little me, just a little guy, can make a difference in the environment. (Dryer sheet replace, 2020).

Entrepreneurs also describe how using their cleantech products can increase a feeling of well-being:

> Live healthier, sleep better and breathe easier with the world's most sustainable air purifier (Air purifier, 2020).

> We are on a mission to bring solar energy education across the country and empower people of all ages to envision and start realizing a brighter future (Solar education, 2020).

Positive emotions also relate to simplicity of the cleantech technologies compared to conventional ones:

> Solar power is the future and at 'Solar cooker'[6], we're making it more easy, fun and accessible than ever (Solar cooker, 2020).

In addition, some entrepreneurs use feelings related to guilt, which have been proven to serve as a motivational factor for donation intention (Majumadar & Bose, 2018):

> Don't we all want to save energy, even if we aren't so efficient ourselves?... with [NAME OF PRODUCT], you can go green and save green... the best of both worlds! (Energy saving device, 2020).

[5] Replaced original name with 'technology' for anonymity.
[6] Replaced original name for anonymity.

5.3. The effect of local support

Configuration 1 states that the absence of a strong local support combined with frequent communication with backers can enable successful cleantech crowdfunding. This is a surprising finding contradicting the original expectations; however, locality can be less relevant in cleantech crowdfunding than in general crowdfunding as the reduction of greenhouse gas emissions achieved through cleantech projects has global importance and is beneficial for backers despite their location.

Still, this configuration has a limited explanatory power. Kickstarter is a US-based crowdfunding platform that operates internationally. All cases included in this configuration path are initiated outside the US including two cases from Canada, one from Italy, one from Portugal, one from Israel and one from Sweden. In 17 of all successfully funded cases, backers came from the US, which can be explained by Kickstarter's origin.

5.4. Enabling context for not successful crowdfunding campaigns

The analysis of the negative outcomes (not successful) leads to two solution terms with configuration 5 (table 5) clearly covering the largest amount of cases. This configuration indicates that cleantech crowdfunding campaigns are not successful if they lack communication with backers, and at the same time run for more than 30 days. These findings are consistent with the expectations that longer crowdfunding campaigns with limited communication will reduce chances for success.

An illustrative case where lack of communication limited the success of a project is Solar race car. Backers posted comments on the campaign website where they encouraged the entrepreneur to have more media coverage and inquired access to some of the designs. However, the entrepreneur did not provide access, or information, which backers inquired.

As for the length of the campaign, it is not possible to identify a clear pattern. The duration of not successful campaigns varies from 33 days to 60 days.

6. Limitations and future research

Due to the methodological constraints, the empirical analysis is based on an intermediate (medium) sample size. Future research is encouraged to include more cases into their research design. A higher number of sufficiently diverse cases would also allow including additional success factors and increasing the explanatory power of this study. For example, future studies could include entrepreneur's trustworthiness measured through prior conducted crowdfunding campaigns and their success as research (Zheng et al. 2014) shows the importance of trust in crowdfunding . Furthermore, to expand the sample and secure higher sample representativeness, researchers could compare different crowdfunding platforms and see whether the overall profile of the crowdfunding platform and type of crowdfunding (donation, reward, loan and equity) influence the success of cleantech crowdfunding campaigns.

Further qualitative case study research is also encouraged. For instance, it could be interesting to conduct an in-depth study of the typical success cases identified in this study through causal process tracing (PT) to gain more knowledge on the within-case causal mechanisms that link these conditions to the outcome (Beach, 2018). It could also be interesting to study how the number of concurrent cleantech cases matter for success, for example whether a higher number of cases can result in a cluster effect with positive externalities across campaigns.

Moreover, the current study does not address the policy context as a relevant condition. The sample included a variety of cleantech projects from different countries that might entail different types and stringency of environmental policies that can influence investor's interest in crowdfunding these projects (see Bianchini and Croce (forthcoming). Future research can

include stringency of environmental policies as an additional condition to see how the presence of this condition interacts with the other conditions and influences the success of cleantech crowdfunding projects.

7. Conclusion and contribution

This study contributes to the growing literature on the crowdfunding success factors by investigating their combined effects with a novel methodological approach (Qualitative Comparative Analysis – QCA) instead of considering them individually. Moreover, it highlights the complexity of the crowdfunding process for cleantech projects, which represent a relatively new crowdfunding context of increasing importance. This study therefore provides useful theoretical and practical implications. Theoretically, the analysis demonstrates that there is no one single condition or combination of conditions that guarantees the success. The findings align with previous research arguing for complex combinations of success factors in crowdfunding. The current study however provides new knowledge on the nature of these interactions and the combined effect of different factors, while prior research has mainly focused on success factors individually. The results indicate that crowdfunding success of cleantech projects is context dependent and some core conditions crucial for cleantech entrepreneurs can be identified. As for practical implications for cleantech entrepreneurs, it is recommended to actively communicate with backers through frequent and targeted updates. This strategy is especially effective in combination with other conditions, e.g. emotional appeal making the campaigns more personally attractive for backers. Overall, increased use of crowdfunding in cleantech projects can foster their realization and therefore contribute to more cleaner production and achieving international climate goals.

Declaration of conflicting interests

The authors have no conflict of interest.

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Tables

Table 1 Operationalization of the six conditions and respective theoretical expectations

Condition	Reference	Expectation	Calibration
EMOTION	Chen et al. (2016); Gorbatai and Nelson (2015); Khut (2016); Mitra and Gilbert (2014); Rhue and Robert Jr. (2018); Wang et al. (2018)	The inclusion of EMOTION has a positive impact on the success.	Campaigns with an emotional appeal were calibrated [1]. Campaigns without an emotional appeal were calibrated [0].
UPDATE	Efrat and Gilboa (2019); Kuppuswamy and Bayus (2018); Lagazio and Querci (2018); Clauss,et al. (2018); Maehle (2020); Mollick (2014); Ahlers et al. (2015)	The use of UPDATES has a positive impact on the success.	Campaigns that included at least four updates during the campaign period were calibrated [1]. Campaigns that included less than four updates during the campaign period were calibrated [0][1].
LOW DURATION	(Kickstarter, 2020); Boeuf et al. (2014); Härkönen, (2014); Lukkarinen et al. (2016); Mollick (2014)	LOWDURATION has a positive impact on the success.	Crowdfunding campaigns with a period of 30 days or less were calibrated with [1] and campaigns with more than 30 days were calibrated with [0].
LOW AMOUNT	Lagazio and Querci (2018); Clauss, et al. (2018); Ferreira and Pereira (2018); Cordova et al. (2015); Cumming et al. (2020); Mollick (2014); Zheng et al. (2014)	LOWAMOUNT has a positive impact on success.	Campaigns with goal amount up to 26,095 USD and lower were calibrated [1] and campaigns over 26,095 USD were calibrated with [0].[2]
FEMALE	Greenberg and Mollick, (2017); Johnson et al. (2018); Majumdar and Bose (2018)	FEMALE initiated campaigns have a positive impact on success.	Projects with female entrepreneurs were calibrated [1] and projects with no female entrepreneurs were calibrated [0].
LOCAL	Josefy et al. (2017); Agrawal et al. (2015); Cordova et al. (2015)	LOCAL has a positive impact on success.	Campaigns where most of the backers originate from the same country as the campaign owner were calibrated with [1]; campaigns where most of the backers do not originate from the same country as the entrepreneur were calibrated with [0].

Table 2 Dichotomized data matrix - Selected Cleantech crowdfunding campaigns with assigned set membership values

ID	Type	Label	Description	EMOTION	UPDATE	LOWDURATION	LOCAL	FEMALE	LOWAMOUNT	SUCCESS (outcome 1)
1	Re-cycling	Air purifier	Biodegradable air filter for homes and offices	1	1	0	1	0	0	1
2	Forestry	Tree drones	Drones that fire germinating tree seeds into the soil	1	1	0	0	1	0	1
3	Green Energy	Biogas system	Machine that turns organic waste into clean, renewable cooking gas and fertilizer	1	1	1	0	0	0	1
4	Environment	Impact app	App to calculate personal GHG emissions and environmental impact	1	0	1	0	0	1	1
5	Agri-culture	Indoor garden	Indoor home gardening system	1	0	1	1	0	0	1
6	Recycling	Knit art	Reusing yarn for a software that turns a picture into a knitted piece	1	1	1	0	1	1	1
7	Agri-culture	Vertical farming	vertical farm concept to teach companies and schools in Liverpool about where their food comes from	1	1	1	1	1	1	1
8	Green Energy	Faucet	Water fountain for bathroom that saves water	1	1	1	1	0	1	1
9	Re-cycling	Dryer sheet replace	Re-usable, eco-friendly, dryer sheet replacement.	1	1	0	1	0	1	1
10	Re-cycling	Monitor plastic	DIY research net for monitoring plastic pollution in surface water	1	1	1	0	0	1	1
11	Solar energy	Window Solar	Window solar charger	1	1	1	1	1	0	1
12	Green transport	Portable e-Motor	Portable e-motor for bicycles	1	1	1	1	0	1	1
13	Energy effi-ciency	Energy Analyzer	Precision DC Energy Analyzer to become more energy efficient	0	1	1	1	0	0	1
14	Agri-culture	Ecosystem garden	Smart miniature greenhouse	1	1	1	0	0	0	1
15	Re-cycling	3DPrinter	Recycled plastic pellet 3D printer	1	1	0	1	1	0	1

16	Solar Energy	Solar backpack	Backpack with solar charger	1	1	0	1	1	1	1
17	Re-cycling	Analog camera	Tool that makes digital photos and videos with analog cameras	1	1	1	0	0	0	1
18	Environ ment	Robot	Robot that cleans trash from Chicago river	1	0	1	1	0	0	1
19	Solar energy	Solar car	Solar powered car	0	0	1	1	0	1	1
20	Environ ment	Litter app	App to track and reduce litter	1	1	1	1	0	0	1
21	Solar energy	Solar cooker	Portable solar cooking device	1	1	0	1	0	0	1
22	Energy Effi-ciency	Energy Tracker	Energy tracker that shows energy consumption at home	1	1	0	1	0	0	1
23	Energy Effi-ciency	Energy saving device	Device that attached to AC unit and uses evaporative cooling to pre-cool the intake air	1	1	0	1	0	0	1
24	Re-cycling	Phone case	Phone cases made from recycled ocean plastic	1	0	0	1	0	1	0
25	Re-cycling	Recycle camera	instant film camera that uses thermal paper/receipts as film	1	0	1	1	1	0	0
26	Re-cycling	3D Plastic	3D Printing of recycled plastic waste	1	0	0	1	0	1	0
27	Green transport	Bike electricity	Biker trainer that produces own electricity	1	0	0	1	0	0	0
28	Solar Energy	Solar race car	Family-sized solar powered car	1	1	1	1	1	1	0
29	Solar energy	Folding solar panel	Folding Solar Panel System for Backup and Temporary Power	0	0	0	1	0	0	0
30	Green transport	Electric vehicle	Electric car that aims to achieve new speed record	0	0	0	1	0	0	0
31	Solar Energy	Solar speaker	Solar powered speaker system	0	1	0	1	0	0	0
32	Solar Energy	Solar education	Solar powered van that delivers solar education across the USA	1	1	0	1	1	1	1
33	Re-cycling	Surfboard	high performance surfboards that are recyclable	1	0	0	1	0	0	0

34	Environment	Smart shower	smart shower head that saves water	1	0	1	1	0	0	0
35	Solar energy	Solar power module	Integrated electronic module to continuously power a solar panel	0	0	0	0	0	1	0
36	Wind energy	Wind turbine	Portable wind power station	0	1	0	1	0	0	1
37	Green energy	Food energy converter	Food waste to energy converter	1	1	1	1	0	0	1
38	Solar energy	Solar energy plug	smart grid solar delivery device	1	1	1	1	0	0	1

Table 3 Analysis of Necessary Conditions with fsQCA 3.0

Outcome: SUCCESS		
Conditions tested	**Consistency**	**Coverage**
EMOTION	0.851852	0.766667
UPDATE	0.851852	0.920000
LOWDURATION	0.629630	0.850000
LOCAL	0.740741	0.666667
FEMALE	0.222222	0.750000
LOWAMOUNT	0.370370	0.714286

Table 4 Truth table with case configurations

Row	EMOTION	UPDATE	LOW DURATION	LOCAL	FEMALE	LOW AMOUNT	SUCCESS	Number of cases	Raw Consistency	Cases
1	1	1	0	1	0	0	1	4	1	Air purifier [1], Solar cooker [1], Energytracker [1], Energy saving device [1]
2	1	1	1	0	0	0	1	3	1	Biogas system [1], Ecosystem garden [1], Analog camera [1]
3	0	0	0	1	0	0	0	3	0	Folding solar panel [0], Electric vehicle [0]
4	1	0	1	1	0	0	0	3	0.666667	Indoor garden [1], Robot [1], Smart shower [0]
5	1	1	1	1	0	0	1	3	1	Litter app [1], Food energy converter [1], Solar energy plug[1]
6	1	0	0	1	0	0	0	2	0	Bike electricity [0], Surfboard [0]
7	0	1	0	1	0	0	0	2	0.5	Solar speaker [0], Wind turbine [1]
8	1	0	0	1	0	1	0	2	0	Phone case [0], 3DPlastic [0]
9	1	1	1	1	0	1	1	2	1	Faucet [1], Portable e-motor [1]
10	1	1	0	1	1	1	1	2	1	Solar education [1], Sun backpack [1]
11	1	1	1	1	1	1	0	2	0.5	Vertical farming [1], Solar race car [0]
12	0	1	0	0	0	0	1	1	1	Tree drones [1]
13	1	1	0	1	1	0	1	1	1	3D printer [1]
14	1	0	1	1	1	0	0	1	0	Recycle camera [0]
15	1	1	1	1	1	0	1	1	1	Window Solar [1]
16	0	0	0	0	0	1	0	1	0	Solar power module [0]
17	1	0	1	0	0	1	1	1	1	Impact app [1]
18	1	1	1	0	0	1	1	1	1	Monitor plastic [1]
19	1	1	0	1	0	1	1	1	1	Dryer sheet replace [1]

Table 5 Analysis of sufficient conditions for successfully [1] and not successfully [0] crowdfunded Cleantech campaigns (design adapted from Fiss, 2011)

	Successful crowdfunding				Not successful crowdfunding	
Configuration number	1	2	3	4	5	6
UPDATE	●	●	●		○	○
EMOTION		●				
LOCAL	○					
LOW DURATION		○	●	●	○	
LOW AMOUNT			○	●		
FEMALE				○		○
Raw coverage	0.222222	0.296296	0.296296	0.185185	0.636364	0.0909091
Unique coverage	0.0740741	0.296296	0.185185	0.148148	0.636364	0.0909091
Consistency	1				1	
Solution coverage	0.851852				0.727273	
Solution consistency	1				1	
Cases with membership	Biogas system [1], Knit Art [1], Tree drones [1], Monitor plastic [1], Eco garden [1], Analog camera [1]	Air purifier [1], Dryer sheet replace [1], Solar education [1], 3D Printer [1], Solar backpack [1], Solar cooker [1], Energy tracker [1], Energy saving device [1]	Biogas system [1], Window solar [1], Energy Analyzer [1], Eco garden [1], Analog camera [1], Litter app [1], Food energy converter [1], Solar energy plug [1]	Impact app [1], Faucet [1], Monitor plastic [1], Portable e-motor [1], Solar car [1]	Phone case [1], 3D Plastic [1], Bike electricity [1], Folding solar panel [1], Electric vehicle [1], Surfboad [1], Solar power module [1]	Recycle camera [1]

Appendices

Table A1 Complex solutions for [1] successfully crowdfunded Cleantech projects

Solution term (configuration)	**Raw coverage**	**Unique coverage**	**Con-sistency**	**Cases with membership**
EMOTION*UPDATE* LOWDURATION*~FEMALE	0.333333	0.185185	1	Biogas system [1], Faucet [1], Monitor plastic [1], portable e-motor [1], Eco garden [1], Analog camera [1], Litter app [1], Food energy converter [1] , Solar energy plug [1]
EMOTION*UPDATE*LOCAL*~ LOWAMOUNT	0.333333	0.0370371	1	Air purifier [1], Window solar [1], 3D printer [1], Litter app [1], Solar cookers [1], Energy tracker [1], Energy saving device [1], Food energy converter [1], Solar energy plug [1]
EMOTION*UPDATE* ~LOWDURATION*LOCAL	0.296296	0.111111	1	Air purifier [1], Dryer sheet replace [1], Solar education [1], 3D printer [1], Solar backpack [1], Solar cooker [1], Energy tracker [1], Energy saving device [1]
UPDATE*LOWDURATION* LOCAL*~FEMALE* ~LOWAMOUNT	0.148148	0.0370371	1	Energy analyzer [1], Litter app [1], Food energy converter [1], Solar energy plug [1]
EMOTION*LOWDURATION* ~LOCAL*~FEMALE *LOWAMOUNT	0.0740741	0.0370371	1	Impact app [1], Monitor plastic [1]
EMOTION*UPDATE* LOWDURATION*~LOCAL *LOWAMOUNT	0.0740741	0.0370371	1	Knit art [1], Monitor plastic [1]
~EMOTION*UPDATE* ~LOWDURATION*~LOCAL* ~FEMALE*~LOWAMOUNT	0.037037	0.0370371	1	Tree drones [1]
~EMOTION*~UPDATE* LOWDURATION*LOCAL* ~FEMALE*LOWAMOUNT	0.037037	0.0370371	1	Solar car [1]
Solution coverage	0.851852			
Solution consistency	1			

Table A2 Intermediate solutions for [1] successfully crowdfunded Cleantech projects

Solution term (configuration)	**Raw coverage**	**Unique coverage**	**Con-sistency**	**Cases with greater membership**
UPDATE*~LOCAL	0.230769	0.0769231	1	Biogas system [1], Knit art [1], Tree drone [1], Monitor plastic [1], Eco garden [1], Analog camera [1]
EMOTION*UPDATE* ~LOWDURATION	0.307692	0.307692	1	Air purifier [1], Dryer sheet replace [1], Solar education [1], 3D printer [1], Solar backpack [1], Solar cooker [1], Energy tracker [1], Energy saving device [1]
UPDATE*LOWDURATIO N* ~LOWAMOUNT	0.307692	0.192308	1	Biogas system [1], Window solar [1], Energy analyzer [1], Eco garden [1], Analog camera [1], Litter app [1], Food energy converter [1], Solar energy plug [1]
EMOTION*LOWDURATI ON*LOWAMOUNT*~FEM ALE	0.153846	0.0384615	1	Impact app [1], Faucet[1], Monitor Plastic [1], Portable e-motor [1]
LOWDURATION*LOCAL* ~FEMALE* LOWAMOUNT	0.115385	0.0384615	1	Faucet [1], Portable e-motor [1], Solar car [1]
Solution coverage	0.851852			
Solution consistency	1			

Table A3 Complex solutions for [0] not successfully crowdfunded Cleantech projects

Solution term (configuration)	**Raw coverage**	**Unique coverage**	**Con-sistency**	**Cases with membership**
~UPDATE*~LOWDURATION* LOCAL*~FEMALE* ~LOWAMOUNT	0.363636	0.181818	1	Bike electricity [1], Folding solar panel [1], electric vehicle [1], Surfboard [1]
EMOTION*~UPDATE* ~LOWDURATION*LOCAL* ~FEMALE	0.363636	0.181818	1	Phone case [1], 3D Plastic [1], Bike electricity [1], Surfboard [1]
~EMOTION*~UPDATE*~LOW DURATION*~LOCAL*~FEMALE*L OWAMOUNT	0.0909091	0.0909091	1	Solar power module [1]
EMOTION*~UPDATE* LOWDURATION*LOCAL* FEMALE*~LOWAMOUNT	0.0909091	0.0909091	1	Recycle camera [1]
Solution coverage	0.727273			
Solution consistency	1			

Table A4 Intermediate solutions for [0] not successfully crowdfunded Cleantech projects

Solution term (configuration)	**Raw coverage**	**Unique coverage**	**Con-sistency**	**Cases with greater membership**
~UPDATE* ~LOWDURATION	0.636364	0.636364	1	Phone case [1], 3D plastic [1], Bike electricity [1], Folding solar panel [1], Electric vehicle [1], Surfboard [1],
~UPDATE*FEMALE	0.0909091	0.0909091	1	Recycle camera [1]
Solution coverage	0.727273			
Solution consistency	1			