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Microfinance and Green Energy Lending: First Worldwide Evidence

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Abstract

The increasing requirement for action on climate change in developing countries has led to the inclusion of environmental aspects in microfinance objectives, in addition to social and financial performance, and hence to the appearance of green microfinance. To date, financing for modern energy service has proven to be an attractive option to offset adverse climate change related effects for the poor. This article sheds some light on factors predicting clean energy finance involvement of MFIs. By using a worldwide survey among microfinance institutions on rural lending and IT solutions implemented by YAPU Solutions, this study investigates how institutional characteristics and economic growth relate to green energy micro-credit. The findings provide evidence of a significantly positive relationship between the maturity and business sustainability of an MFI and the likelihood of offering green energy loans. Moreover, MFIs managed by female managers and located in wealthy countries are less willing to commence the finance of green energy.

Keywords: Microfinance institutions, Green energy financing, Clean energy, Sustainable Development Goals

JEL Classification: G21, Q01, Q42

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I. Introduction

Over the past decades, the enhancement of negative environmental issues such as global warming, increasing air pollution, and rising sea levels, have presented notable global threats to economic growth and sustainable development. This universal problem is also reflected in the UN Sustainable Development Goals (SDGs) and the COP21 Paris agreement for climate change (UN 2015; UNFCCC 2015), whereby here, exceptional emphasis on environmental performance in addition to social and economic objectives should be taken into account (UNFCCC 2015). Consequently, the importance of a triple bottom line in the financial sector is also highlighted due to its notable importance and its broad impact to various elements of development (*Taghizadeh-Hesary*/*Yoshino* 2019; *Sachs* et al. 2019). In this context, the microfinance industry plays a pivotal role for the following reasons. Microfinance clients, especially those who live in rural areas, are indeed some of the most vulnerable people despite their modest impact on the environment (*Dowla* 2018; *Harrold* et al. 2002). The reason for this could be their great reliance on natural resources and their high level of exposure to environmental threats. Moreover, negative impacts on the operation of microfinance institutions (MFIs) are directly or indirectly linked to the consequences of climate change. While MFIs feasibly encounter physical harm and operational interruption due to disasters, environmental-related losses faced by their clients possibly trigger the increase of debt defaults, which in turn adversely impact MFIs performance and sustainability (*Pantoja* 2002).

These issues urge MFIs to reaffirm their objectives and to take proper actions in adapting to the consequences of climate change and environmental degradation (*Allet* 2014; *Rippey* 2012). This development is accompanied by the emergence of green microfinance as a response toward increasing environmental awareness of businesses and organizations in order to maintain sustainable economic growth. Green microfinance encourages microfinance service providers and clients to engage in more environmentally-friendly practices, such as green businesses, renewable energy projects, green loans, climate smart agriculture, and the assessment of environmental risks (*Huybrechs* et al. 2015). Through the increased support of their clients in combating environmental related losses, MFIs could benefit from a higher repayment probability and thus a reduction of the credit risk of the socio-environmental vulnerable beneficiaries (*Abdur Rouf* 2012; *Moser* et al. 2016).

When discussing the need for environmental management, one subject to be considered is the energy sector. According to IEA (2019), two-thirds of greenhouse gas emissions, which are considered to be the main culprit of global warming, are generated by power systems. Moreover, energy poverty is responsible for further problems such as lowering one's livelihood, since most of the daily activities (lighting, appliances, cooking, and transportation) require the frequent use

of energy. Therefore, energy is considered to be essential in achieving a sustainable social and economic development and in protecting the environment (*Goldemberg* et al. 2000). In other words, there is a need for promoting the transition to environmentally-friendly energy, i. e. green energy, which comprises both the deployment of renewable sources and energy efficiency measures. The increase of renewable energy and energy efficiency (RE & EE) contributes to achieving many targets of the SDGs such as combating climate change, eliminating poverty and hunger, promoting sustainable economic growth, and improving public health and well-being (*Inglesi-Lotz* 2016; *Haseeb* et al. 2019; *Del Rio*/*Burguillo* 2009; *Bhattacharya* et al. 2017; *Colombo* et al. 2013). However, modern energy generation is often more expensive than the traditional biomass-related approach and thus imposes a relatively high cost burden on the poor. Thus, the allocation of sufficient finance of low carbon energy plays an important role in breaking the poverty cycle and in sustaining human development (*Brunnschweiler* 2010; *Lewis* 2010; *Baker* 2015; *Rao* et al. 2009). The story is not only about the use of renewable energy, but also about the mobilization of finance to further develop the use of sustainable renewable energy. This is particularly a problem for the clients of MFIs, who are often financially excluded by traditional finance systems.

In this context, microfinancing mechanisms for clean energy are particularly important for closure of the finance gap, which consequently boosts the deployment of RE & EE (*Surendra* et al. 2014; *Allderdice* et al. 2007). MFIs are perceived to be in an advantageous position in their ability to adapt green energy lending due to the following reasons. First, one of the prominent features of microfinance is the tight relationship between MFIs and their clients (*Stiglitz* 1990). The nature of this relationship allows MFIs to better understand the energy needs of their beneficiaries and to develop suitable products and services and thus to foster the adaptation of clean energy at a local level (*Nepal*/*Amatya* 2006; World Bank 2012). Second, microfinance beneficiaries are more vulnerable from climate change and power crises than other parts of the population. By providing sustainable financial and non-financial support to them, individuals and small businesses are able to invest in green energy technologies, which in turn boosts their awareness of environmental issues and sustainable development (*Rao* et al. 2009; *Walekhwa* et al. 2009). Furthermore, the role of MFIs is also important since providing this kind of business to financially-excluded population is commercially inadvisable, henceforth drawing less motivation from traditional banking systems or private investors (UNEP FI 2012; *Allderdice* et al. 2007).

Surprisingly, microcredit for green energy purposes remains limited and appears to lack motivational factors by many institutions despite its promising benefits. The question of what drives the inadequate interest of MFIs in green energy finance requires closer examination. One possible explanation could be that while there is a growing body of literature on general green microfinance (*Allet*/*Hudon* 2015; *Forcella*/*Hudon* 2016) and sustainable energy finance in gen-

eral (*Mazzucato*/*Semieniuk* 2018; *Yildiz* 2014), the integration of microfinance and RE & EE appears to only have been modestly studied. The lack of information paints an ambiguous picture of sustainable energy lending. A broader knowledge-base needs to be developed to better understand what factors affect the small-scale lending for green energy purposes, as well as to facilitate the MFIs' response to this new field of business investment.

This study is one of the first to determine several factors that influence the involvement of MFIs in sustainable energy finance. To analyze this matter, we employ a unique dataset, which is composed of a rural lending and IT solutions survey implemented by YAPU solutions and the MIX Market database, comprising a cross-sectional sample of 969 MFIs in 2015. With this dataset, we examine a set of variables with regard to the question of whether they are related to an MFIs provision of green energy lending. These variables are constituted by MFI-specific variables such as the maturity of an MFI or business sustainability as well as country-specific variables.

The key findings of our article confirm the explanatory power of the maturity and customer retention of sustainable energy loans. Specifically, more mature MFIs, as measured by age and the debt-to-equity ratio, tend to engage more frequently in green energy lending practices. We identify a positive significant impact of the active borrower retention rate on the provision of green energy loans. Moreover, our results show evidence of the fact that MFIs with a high percentage of female managers are less likely to grant loans to sustainable energy projects. Furthermore, MFIs located in poorer countries show more willingness to foster green energy. Remarkably, the depth of outreach and financial performance of an MFI are not significantly correlated to an MFI's capacity to engage in green energy issues, suggesting that this relatively new field of business may not require a better financial performance or a strong focus on social objectives.

The remainder of our article is structured as follows. While section II. describes related literature and deduces the hypotheses, the data collection and the methodology are presented in Section III. The discussion of descriptive statistics and several empirical results are displayed in Section IV., followed by recommendations and a brief conclusion in the final section.

II. Related Work and Hypotheses

1. Sustainable Development Goals and Green Energy Finance

In September 2015, the SDGs, which comprise 17 targets including combating poverty, climate change, improving living standards, achieving gender equality, and the empowerment of women were first adopted by the United Nations Gen-

eral Assembly as the most important plan to create a better society. Importantly, 'sustainable energy' is not only one of the critical goals (namely SDG 7), but can also be regarded as a key factor for the success of other sustainable development goals (*Allen* et al. 2016; *Nerini* et al. 2018). Therefore, increasing the use of RE & EE products contributes to the achievement of the SDGs, which then drive additional demand for financing energy production. Given the importance of green renewable energy finance in obtaining the SDGs, an interesting question concerns how to facilitate the engagement of institutions in this field of business. The existing body of literature on sustainable energy investments, both in theoretical and in empirical regards, has hitherto focused on the role of governmental support, private investors, capital markets, and traditional banks as opposed to the microfinance sector. In this literature, many factors are evidenced to be determinants of low carbon energy finance. *Mazzucato*/*Semieniuk* (2018) conduct an exploratory study on the directionality of renewable energy project investments among the financing parties (private and public banks, utility companies) and determine that the risk level is the key factor leading to financial decision making. The influence of appropriate governmental policies is examined in the study by *Cárdenas Rodríguez* et al. (2014), which confirms the positive impact on the financing of private sector. Besides, other factors such as the financial actors' preferences, apt policy instruments, the borrowers' RE awareness, technology-related management abilities, and the availability of capital resources have also been investigated (*Masini*/*Menichetti* 2012; *Martinot* 2001; *Narbel* 2013).

Regarding the microfinance sector, although some analyses of various dimensions of green management and its impact factors exist (*Allet*/*Hudon* 2015; *Forcella*/*Hudon* 2016; *Forcella*/*Huybrechs* 2016; *Forcella* et al. 2015), only very little is known about analysis of clean and sustainable energy finance. Nonetheless, several studies focus on the status quo and finance mechanisms of RE and EE. *Allderdice* et al. (2007), in their study (for Latin America and the Caribbean), report that energy related loans play a minor role for MFIs and that these are frequently embedded in other financial products such as enterprise loans, housing improvement loans, etc. The authors also highlight the cooperation between energy providers and MFIs, the role of government support, and donor programs in favor of MFIs in order to boost the expansion of energy conversion. Moreover, *Allderdice* et al. (2007) consider a strategic approach and proper awareness of MFIs and clients to be helpful in constructing an energy loan portfolio. *Forcella* et al. (2017), in their survey-based research conducted in the same region, investigate the lending activities of MFIs related to green projects. Approximately 20 percent of respondents of their survey confirm having had RE and/or EE loans in their portfolio, albeit with a high rate of green practice involvement.

So far, these findings have not provided clear evidence of the question concerning whether and when an MFI engages in green energy lending. In the next part, we develop our hypotheses by further discussing existing work related to our factors of interest. Subsequently, the four hypotheses are investigated in the empirical analysis to explore whether these hypotheses can be supported by real-world evidence.

2. *Maturity of Institutions*

Among the wide range of determinants of an MFI's environmental performance, the age of the institution as a measure for maturity is mentioned as having been the key factor in several previous studies. According to *Allet*/*Hudon* (2015), there exists a particularly positive and significant relationship between an MFI's age and the provision of green microcredit prevails. This finding is derived from an investigation of a sample of 160 global MFIs. Following *Allet*/*Hudon* (2015), *Forcella*/*Hudon* (2016) provide the same evidence, yet with a smaller sample of 59 MFIs operating in Europe. These results suggest that the maturity of an MFI may influence the likelihood of providing RE & EE finance.

As a further proxy for maturity, *Mersland*/*Urgeghe* (2013) and *Dorfleitner* et al. (2017) employ the capital structure of an MFI with an interpretation based on the business life cycle theory. In more specific terms, these authors argue that MFIs initially operate as non-regulated institutions with their sources of funding originating from retained earnings or external donations such as the granting of subsidies. As the MFIs mature and transform into a more regulated form, they are able to gain access to commercial debt, which, in turn, enables them to reach more clients as well as to seize the advantage of economies of scale (*Kyereboah-Coleman* 2007). Renewable energy projects are associated with various types of risk, such as political, market, technical risk, and a low rate of return (*Liu*/*Zeng* 2017; *Lee*/*Zhong* 2015). Young institutions are considered to be less risk-inclined than their older counterparts, which can make them less motivated to manage a green energy loan portfolio. Because of economies of scale, which have a tendency to be available for mature MFIs, they are better equipped to deal with these risks.

Summarizing the arguments of the mentioned literature, we expect that the stage of the life cycle of an MFI has a crucial impact on engaging in small scale RE & EE lending, representing a dimension of green performance. In other words, we expect more mature MFIs (in terms of age and debt to equity) to engage more frequently in green energy lending. Hence, our hypothesis is stated as follows.

Hypothesis 1 (H1). The maturity of an MFI is positively related to the likelihood of green energy lending.

3. Female Leadership

Along with maturity, another important factor which is frequently documented in the literature with respect to environmental governance of an organization is the gender diversity of leadership (*Ben-Amar* et al. 2017; *Liao* et al. 2015; *Cucari* et al. 2018; *Birindelli* et al. 2018). Building on theoretical foundations, namely the critical mass theory and the stakeholder theory, researchers provide mixed evidence on the direction of the relationship. While a positive link can be found in the studies of *Ben-Amar* et al. (2017) and *Liao* et al. (2015), different results are evidenced by *Cucari* et al. (2018) and *Birindelli* et al. (2018). According to *Strøm* et al. (2014), female leadership is positively associated with having more females clients. However, focusing on a female clientele possibly places a burden on an MFI, which then worsens its performance (*D'Espallier* et al. 2013). The interpretation is that women are associated with smaller loans, which are costly to monitor and to process, suggesting a negative impact on financial performance. Consequently, MFIs may lack appropriate funding sources for other initiatives such as green energy lending.

Furthermore, women are commonly found to be more risk-averse than men in making decisions (*Charness*/*Gneezy* 2012; *Byrnes* et al. 1999). As shown by *Ertac*/*Gurdal* (2012) in their experimental study, women not only show a more risk-averse behavior when making decisions on their own, but also tend to be less prone to risky options for their groups compared to men. Similarly, *Bogan* et al. (2013) demonstrate that the share of males in the management is positively associated with a higher likelihood of engaging in risky investments. Taking into account the fact that finance for energy projects is related with high levels of risk, this evidence suggests a lower willingness to involve in energy lending if the share of female managers is high.

Summarizing, the discussed literature suggests that female-managed MFIs are less likely to focus on the mission of supplying loans for green energy purposes. We, therefore, formulate the following hypothesis.

Hypothesis 2 (H2)**.** The variable female leadership is negatively related to an MFI's involvement in green energy lending.

4. Customer Retention

The term customer retention generally refers to the situation in which customers return to organizations in order to demand further products and services.

Therefore, maintaining a high rate of customer retention is essential for institutions in the attainment of smooth operations and financial sustainability (*Reichheld*/*Kenny* 1990). In their research, the authors point out that the positive relationship between retention rate and a bank's margins and growth is not only true in the case of deposit services, but also in other financial services. Later on, research by *Reichheld* (1993) also confirms the influence of a high level of customer loyalty on the improved economic performance of firms. *Zahorik*/*Rust* (1993) additionally suggest that retained market share increases economic benefits far more than market share growth gained from new customers. In general, it is widely agreed that increasing retention rate, i.e the reduction of the customer defection rate, is an important factor that strengthens an organization's performance. The explanation is that acquiring new clients costs more than retaining the existing ones (*Buchanan*/*Gillies* 1990; *Reichheld* 2001). Furthermore, the retention rate is particularly important since it reflects how good an institution's service quality is, i. e. whether customers are supported well. *Reichheld* (1993) emphasizes the importance of delivering superior values to the customer as one of the key strategies responsible for the retention of customer's loyalty. Analogously, *Oyeniyi*/*Abiodun* (2010) also remark the interdependent link between these two factors. Applying to the microfinance context, where the ultimate goal is customer's welfare, a high rate of customer retention implies better social performance. We argue that higher retention rates signal more efficient performance due to reduced transaction costs, and may also result in an improvement of the capacity for new lending products such as green energy. Indeed, the influence of sufficient human and capital resources on the new product development performance has been investigated in several studies (*Vermeulen* et al. 2005; *Chang* 2016). Following these considerations, we conjecture the positive effect of the customer retention rate on green energy lending. Accordingly, we formulate the third hypothesis.

Hypothesis 3 (H3)**.** The rate of customer retention is positively correlated with MFI's involvement in green energy lending.

5. The Economic Status of the Destination Country

Besides the possible influences on MFI level, reflected by the Hypotheses 1 to 3, the tendency to offer green energy lending may also be a matter of regional differences, and thus of the country in which an MFI is located. There are several reasons why green energy microfinance could vary across countries with different economic welfare status. One could think that in advanced economies with high levels of urbanization, there is a high level of electricity penetration, which can lead to low demand of RE as another source of electricity generation. Consequently, less MFIs in such countries will veer toward support of renewable energy solutions. As opposed to this, the need for renewable energy remains high in less urbanized countries due to the great reliance in these

areas on traditional biomass such as wood used for lighting, cooking, and heating. According to *Allderdice* et al. (2007), the bottleneck of insufficient green energy solutions in rural areas in Latin America can be explained by the extreme concentration of MFIs in urban areas, leaving the rural poor population behind. While the traditional energy sources boost man-made global warming, they also remain in short supply. According to *Aguirre*/*Ibikunle* (2014), commitments to renewable energy tend to be reduced in nations with a paucity of potential resources, particularly in the case of biomass and solar energy. Thus there is a high need for green energy in less developed countries. Given the benefits of green energy, the aim of tackling the lack of sustainable energy could prove to be a portfolio optimization strategy of MFIs with particularly high social benefits. The association of social preferences and microfinance lending decisions has been discussed in previous research (*D'Espallier* et al. 2013; *Allet* 2014) in which focusing on specific types of lending (woman lending and environmental lending) becomes a method of reaffirming MFIs' social objectives.

Furthermore, when studying the cases of Asian countries, which are characterized by a bank-dominated financial market, *Peimani* (2018) identified the unwillingness of the banking sector to fund clean energy projects. The authors conclude that the lack of appropriate financial support is the main challenge to the expansion of green energy in these countries. The reason for this situation is that RE & EE projects are considered to be high risk and yield a low return rate, triggering the reluctance of banks to engage in green energy lending. It is, therefore, reasonable to assume that in more developed countries with superior financial systems, the mobilization of funding is more efficient, possibly leading to a low requirement for support from MFIs. As opposed to this, due to the lack of access to bank finance and the inefficient capital markets, microcredit mechanisms can be considered a potential solution in tackling financial barriers to green energy in developing nations. In other words, MFIs could play the pivotal role of a complementary actor in closing green energy finance gap. This argument is consistent with previous findings of *Vanroose*/*D'Espallier* (2013) in the sense that MFIs fulfill the needs that the traditional financial system fails to support. Therefore, the last hypothesis makes a statement on the provision of green energy loans in less developed countries. In our study, we measure the development status by the GDP per capita to capture the pure economic development, but also by an index measuring the development according to the SDGs.

Hypothesis 4 (H4)**.** MFIs operating in less developed countries are more likely to engage in providing green energy loans.

III. Data and Methodology

1. Data

Our unique dataset comes from several sources. The first part of the data comes from a survey designed and implemented by the company YAPU Solutions (https://www.yapu.solutions). The data have been provided in an anonymized way for academic research purpose only. YAPU obtained these data by individually sending an online survey to MFIs worldwide during the time frame from November 2017 to March 2018. In order to enhance the response rate and assure the quality of responses, the survey was written in three languages, namely English, Spanish and French, being the world's most prevalent ones. The questionnaire generally concentrates on climate smart finance, agriculture and rural lending, as well as the deployment of IT solutions to facilitate green businesses. Participants were also asked to provide some institution-specific information, e. g. number of employees and number of offices. The questionnaire also included questions on the financing of renewable energy and energy efficiency technologies, which is the main focus in this study. After three reminders, the number of responses amounted to 179. However, we were able to use 90 questionnaires for the purpose of our analysis due to the incompleteness and inconsistency of some of the responses.

The second dataset was derived from the MIX Market database, which today is a part of the World Bank data platform. MIX Market is the largest transparent and public data source for the financial and social performance of MFIs worldwide, as well as for general profile information such as year of establishment, legal status, etc. One limitation is that all the financial information is self-declared by the institutions, which mostly lack reasonable auditing. Therefore this source of information could contain some unrealistic data. The MIX Market set of MFIs was also used as an address list for sending out the questionnaire to a worldwide sample of MFIs.

Aligning with *Dorfleitner* et al. (2017), we eliminated institutions with the following criteria: percentage of female managers or borrowers is larger than one, return on asset is larger than one or smaller than –1.5, gross loan portfolio to total assets larger than one, and average loan balance per borrower is larger than $ 15,000. Following *Allet*/*Hudon* (2015), to mitigate the potential of reverse causality, especially regarding the effect of energy microlending on variables related to the social and financial performance of MFIs, we use lagged MFI-specific variables. For the year 2015, 969 MFIs reported realistic and consistent data to MIX Market. In addition to this, other macroeconomic indicators are also included in order to examine the power of effects of economic status and environmental policy. These data were obtained from World Development Indicators and Sustainable Development Solutions Network (SDSN). The final sample con-

tains 969 MFIs, of which 90 have responded to YAPU Solutions survey questions relating to the provision of credit products dedicated to RE/EE.

Table 1 presents detailed definitions of the employed variables of our study. Our dependent variable is Energyloan, which refers to the involvement of MFIs in small-scale credit provision for green energy purposes. It is an ordinal variable that takes the value of 1 if MFIs do not declare any activities for energy services. If institutions do not offer explicit green energy loans, but some of their loans are also used for projects dedicated to RE or EE, the dependent variable takes the value of 2. Finally, it equals 3 if the MFI states that it is doing this type of business or plans to do so within the following year. In this paper, renewable energy refers to all sources of energy generated from natural processes (solar, wind, biomass, geothermal, hydropower and ocean resources, solid biomass, biogas, and liquid biofuels) that are continually replenished (*Mandil* 2005). According to IEA (International Energy Agency), the capability of managing energy consumption in an efficient way is subsumed as being energy efficiency. In a technical sense this means either reducing the use of energy for the same type of service or producing more services with the same amount of energy.

The hypothesis-related predictor variables we use in our set-up are *Age* and debt-to-asset ratio of the MFI, the percentage of female managers, the retention rate, and the gross domestic product per capita (GDPpc) of the country in which the MFI operates. The evolution of stage of life and funding structure are commonly used in the existing literature as an indicator of an MFI's maturity (*Dorfleitner* et al. 2017; *Allet*/*Hudon* 2015; *Mersland*/*Urgeghe* 2013). Therefore, we employ the age of the MFI (number of year functioning as an MFI) and debt to equity to proxy for the maturity of MFIs. To capture the effect of female leadership, we include a variable for the percentage of female managers. The variable *Retention* is included to account for the ability of maintaining existing customers of MFIs. The number of active borrower retention provides a positive implication for the financial sustainability of institutions. Finally, to assess the effect of the pure economic development status, the logarithm of gross domestic product per capita is taken into account. Additionally, the SDGs score of a country is employed as an alternative measure to represent the effect of the level of development.

Furthermore, we use ITintensity, OSS, log(GLP), Rural, and Region as MFI-specific control variables. More specifically, we employ a dummy variable indicating whether or not more than one IT solution is used by the MFI. We define IT solution deployment as being the use of one of the distinct IT products: specialized desktop software, software/app for tablets or smartphones in the field, tablets in the field, and smartphones in the field. Furthermore, operational self-sufficiency serves as a proxy for financial performance of the MFI based on the logic that the higher this quantity is the better the business manage-

Table 1

Definition of Variables

Variable	*Description*
Energyloan	Indicator for whether MFIs have specific loan products dedicated to RE/EE. It equals 1 if MFIs do not have, 2 if MFIs do not have but with their loans, they also invest in RE/EE, and 3 if they have or will launch within next year (RE/EE).[1]
Answer	Dummy variable refers to response status of MFIs. It takes the value of 1 if MFIs replied to the survey. Otherwise, it equals 0.
ITintensity	Dummy variable indicates whether MFI uses more than one IT solution (exclude excel). If yes, it takes the value of 1 and 0, otherwise. IT solutions are: Specialized desktop software; Software/App for tablets or smartphones in the field; Tablets in the field, Smartphones in the field by MFIs.[1]
Age	Indicator for number of year institution has functioned as an MFI, as of 2017.
log(GLP)	Logarithm of gross loan portfolio.
ALSGNI	Indicator for average loan size, obtained by dividing average loan balance per borrower by gross national income per capita (GNI).
DTE	Indicator for debt to equity ratio.
Retention	Indicator for retention rate, obtained by dividing number of active borrowers at the end of the reporting period by the sum of active borrowers at the beginning of the reporting period and new borrowers during the reporting period.
FEMMAN	Indicator for the percentage of female managers.
OSS	Indicator for operational self-sufficiency, obtained by dividing financial revenue by operation cost, including financial and operating expense, and impairment losses on loans.
Rural	Indicator for the percentage of number of rural loan portfolio.
Diamonds	Rating score of MFIs defined by MIX. It is categorized into 3 groups, namely Unrated (not ranked yet), Low (MFIs are ranked 1 – 3 diamonds), and High (ranked 4 – 5 diamonds). The based category is Unrated.
CPIA	Policy and institutions for environmental sustainability rating (1 = low to 6 = high). It ranks how environmental policies foster the protection and sustainable use of natural resources and the management of pollution.

Variable	*Description*
log(GDPpc)	Logarithm of gross domestic products per capita of the country, in which the MFI is located.
SDGs score	Indicator for the level of sustainable development of a country.
Region	Categorical variable for the geographical location of the MFI. The regions are Africa and the Middle East and North Africa (MENA), East Asia and the Pacific (EAP), Eastern Europe and Central Asia (EECA), Latin America and the Caribbean (LAC), and South Asia. The reference category is Africa and MENA.
Type	Categorical variable for the legal status of MFIs. There are MFIs of type Bank and Others, Credit Union/Cooperative, Non-bank financial institutions (NBFI), and Non-government organization (NGO). The reference category is Bank and Others.

Note: Sources of data

Variables "Energyloan" and "ITintensity" are derived from the survey on Rural Lending and IT Solutions.

Variable "Rural" is computed based on the MIX Market database.

Data for GDPpc and CPIA are collected from the World Development Indicators.

Data for SDGs scores is collected from SDG Index and Dashboards prepared by Sustainable Development Solutions Network (SDSN) and the Bertelsmann Stiftung.

Data for all other variables are collected from the MIX Market database.

[1] : Detailed questions and answer options constructed to these variables can be founded in Appendix A.

ment of the institution. The *log(GLP)* variable, measuring the size of the organization, is employed to control for the effect of economies of scale. Following *Mersland*/*Urgeghe* (2013) and *Allet*/*Hudon* (2015), the focus on rural areas can be seen as a proxy for business orientation. Therefore, we construct the variable to represent the fraction of the loan portfolio in rural areas. We expect that MFIs with a greater concentration in rural areas will be more highly motivated in addressing energy needs than the remainders.

Additionally, a set of dummy variables is included to manage the effect of geographical locations. Specifically, there are five different regions, including Africa and the Middle East and North Africa (MENA), East Asia and the Pacific (EAP), Eastern Europe and Central Asia (EECA), Latin America and the Caribbean (LAC) and South Asia.

2. Methodology

To investigate which factors are related to an MFI's decision to offer green energy lending, we conduct various analyses with ordered probit models with

Eicker-Huber-White heteroskedastic-consistent standard error by applying the following regression equation:

$$y_i^* = \alpha + \beta_1 x_i + \beta_2 c_i + \in_i$$

where y_i^* represents the outcome variable which comprises the provision of green energy lending of an MFI *i*. While x_i stands for a vector of hypothesis-related variables of an MFI *i*, a vector of control variables is denoted by c_i.

Three different levels are assigned for MFIs' involvement in green energy lending and the scores refer to the order within this involvement (see Table 1). In the model, it is assumed that y_i^* is an unobserved variable and only involvement level can be observed. Thus, the first step is to map the categories of the involvement levels y_i into a partition of the latent variable y_i^* as follow:

$$y_i = \begin{cases} 1, \text{ if } y_i^* \leq \mu_1 \\ 2, \text{ if } \mu_i^* < y_i^* \leq \mu_2 \\ 3, \text{ if } y_i^* > \mu_2 \end{cases}$$

where μ_r ($r = 1, 2$) represents the partitions of the range of y_i^* linked with each value of level of involvement.

For the reason that MFIs are not obligated to declare every piece of information to Mix Market, our dataset encompasses a number of missing values. In order to mitigate this problem, we substitute missing observations with their arithmetic mean of the variable. More specifically, we employ the mean imputation technique to overcome the problem. One of the limitations of YAPU Solutions survey is the self-reporting of the respondents, which feasibly triggers the potential of bias. The survey could have the potential to attract more MFIs with an interest in energy loan provision, which then leads to higher response rate of them. Even though we obtain 33.67 % of respondents (33 out of 90 MFIs – see Table 3) who stated that they did not provide green energy loans, we still address potential selection bias. In particular, we employ the Heckman endogeneity ordered probit model and follow a two-step procedure. In the first step, the selection equation, we assess the likelihood of MFIs responding to YAPU Solutions survey. We are then able to use the obtained result in the second step, the ordered probit model, to estimate the actual regression of interest. In the selection regression, *Answer* is a binary dependent variable indicating whether or not an MFI replied to our survey. Determinants of response decision include the variables of *Age, log(GLP), log(GDPpc)*. CPIA and Type are employed as additional predictor variables. According to *Helgeson* et al. (2002), the respondent's perspective towards research plays an important role in determining the probability of response. Based on this finding, we argue that green energy interest

groups are more likely to react to our questionnaires. As demonstrated by *Allet*/*Hudon* (2015), there is an interdependent relationship between an MFI's legal status and environmental performance. Therefore, we assume that there are certain types of MFI that are more likely to be in favor of green energy credit, and are more willing to participate in the survey. Additionally, several scholars emphasize the influence of appropriate policy design on inducing renewable energy (*Rodríguez* et al. 2015; *Mazzucato*/*Semieniuk* 2018). Specifically, well-designed policies play an important role in attracting financial actors. Subsequently, we assume a link between the effectiveness of policies, measured by CPIA policy and institutions for environmental sustainability rating, and the likelihood of an MFI's response to the survey.

IV. Results

1. Descriptive Analysis

Table 2 and Table 3 present the frequency distribution of the categorical variables with respect to the response status and the green energy loan status of the MFIs. In the data sample, 34.57 % MFIs are from LAC, thus dominating other regions regarding the number of these MFIs. This, however, corresponds to the study by *Allet*/*Hudon* (2015). The same holds true (32.22 % of MFIs) for the sub-sample of those 90 MFIs for which we can verify whether they offer energy loans. Additionally, MFIs of the type NBFI account for a large proportion of the total sample with a share of 37.56 %, while in the sub-sample of 90 MFIS the type NGO prevails. Remarkably, the percentage of unrated MFIs that did not answer the survey is higher than that of the rated MFIs (18.32 % versus 7.78 %), confirming, to some extent, the quality of the survey is confirmed. Table 3 shows that many MFIs are unwilling to deploy more IT solutions as only 27.78 % MFIs in the sub-sample use more than one software application. When taking a closer look at each category of engagement in green energy lending, we observe a dominance of MFIs using less than two IT solutions. Moreover, MFIs located in LAC appear to outweigh their peers from other regions regarding the provision of green energy loans as 35.36 % MFIs offer these products or plan to do so within the next year.

The descriptive statistics of the metric variables can be found in both Table 4 and Table 5. The results reveal that the average proportion of female managers is 37 % and 32 % in the total and in the respondent sub-sample respectively, which are comparably low figures, suggesting that female-managed institutions are less likely to favor clean energy technologies. The OSS of both response and non-response groups are higher than 1, indicating that, on average, MFIs generate sufficient income to cover their operating costs. The statistics also indicate

Table 2

Frequency Table by Response Status

	Reply to survey					
	No		*Yes*		*Total*	
	Obs	%	Obs	%	Obs	%
Region						
Africa and MENA	202	22.98	19	21.11	221	22.81
EAP	114	12.97	13	14.44	127	13.11
EECA	118	13.42	11	12.22	129	13.31
LAC	306	34.81	29	32.22	335	34.57
South Asia	139	15.81	18	20.00	157	16.20
Type						
Bank and others	180	20.48	9	10.00	189	19.50
Credit Union/Cooperative	121	13.77	6	6.67	127	13.11
NBFI	333	37.88	31	34.44	364	37.56
NGO	245	27.87	44	48.89	289	29.82
Diamonds						
Unrated	161	18.32	7	7.78	168	17.34
Low	307	34.93	31	34.44	338	34.88
High	411	46.76	52	57.78	463	47.78
N	879		90		969	

that the average loan size adjusted to GNI per capita is 0.45 among the respondents, which is lower than that of non-respondents (0.59). This variable is often used as a proxy for the outreach efficiency in the microfinance institutions based on the logic that the lower the quantity, the better the outreach. Therefore, this observation could signal that the respondents tend to those MFIs that place more emphasis on social objectives. However, the difference is not significant.

2. Regression Analysis

This section provides the empirical results obtained for the straightforward ordered-probit model and the Heckman selection regression (see Table 6). We first

Table 3

Frequency Table by Energy Lending Response Status

	(1)		*(2)*		*(3)*		*Total*	
	Obs	%	Obs	%	Obs	%	Obs	%
IT intensity								
No	23	69.70	8	66.67	34	75.56	65	72.22
Yes	10	30.30	4	33.33	11	24.44	25	27.78
Region								
Africa and MENA	8	24.24	2	16.67	9	20	19	21.11
EAP	5	15.15	3	25.00	5	11.11	13	14.44
EECA	5	15.15	0	0.00	6	13.33	11	12.22
LAC	9	27.27	4	33.33	16	35.56	29	32.22
South Asia	6	18.18	3	25	9	20	18	20
Type								
Bank and others	2	6.06	3	25.00	4	8.89	9	10.00
Credit Union/Cooperative	4	12.12	0	0.00	2	4.44	6	6.67
NBFI	12	36.36	2	16.67	17	37.78	31	34.44
NGO	15	45.45	7	58.33	22	48.89	44	48.89
N	33		12		45		90	

(1): MFIs offer no specific loan products dedicated to RE/EE.

(2): MFIs offer no specific loan products dedicated to RE/EE, but with its loan products, it also finance investments in RE/EE.

(3): MFIs offer specific loan products dedicated to RE/EE or plan to introduce them within the next year.

run ordered-probit regressions to test the impact of maturity, measured by age and debt-to-equity ratio (model specification (1)). The model specification (2) focuses on the effect of performance variables while our baseline model with a full set of included variables is represented in the model specification (3). The models (5) and (6) exhibit the estimation results for the Heckman two-stage model.[1]

The Wald test of independence displays an insignificant result, and thus there is no clear sign of a sample selection bias. Regarding our first hypothesis on the maturity of an MFI, we find substantiation in the results of model specification

[1] Note that while the Heckman model is presented in two stages, we implement the ordered-probit Heckman model with a maximum likelihood approach, in which both stages are estimated simultaneously.

Table 4

Descriptive Statistics of Metric Variables by Response Status

	No		Yes		Total	
	Mean	SD	Mean	SD	Mean	SD
Age	19.41	10.35	21.02	9.69	19.56	10.30
DTE	3.51	8.68	4.44	4.26	3.60	8.37
FEMMAN	0.38	0.25	0.32	0.22	0.37	0.25
log(GDPpc)	7.84	0.95	7.65	0.88	7.83	0.94
SDGs score	61.74	7.38	60.32	7.57	61.61	7.41
log(GLP)	16.07	2.24	16.18	1.99	16.08	2.22
OSS	1.13	0.29	1.13	0.26	1.13	0.28
ALSGNI	0.59	1.18	0.45	0.55	0.58	1.13
Retention	0.83	0.21	0.79	0.14	0.82	0.21
CPIA	3.29	0.32	3.24	0.35	3.28	0.32
Observations	879		90		969	

Table 5

Descriptive Statistics of Metric Variables by the Provision of Energy Loan

	(1)		*(2)*		*(3)*		*Total*	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	17.94	9.34	22.75	9.19	22.82	9.70	21.02	9.69
DTE	3.66	2.63	4.31	3.88	5.04	5.21	4.44	4.26
FEMMAN	0.38	0.18	0.41	0.34	0.26	0.19	0.32	0.22
log(GDPpc)	7.80	0.88	7.88	0.63	7.47	0.91	7.65	0.88
SDGs score	60.72	7.74	61.61	6.26	59.67	7.86	60.32	7.57
log(GLP)	15.82	2.02	17.51	2.88	16.09	1.55	16.18	1.99
OSS	1.13	0.28	1.30	0.38	1.08	0.19	1.13	0.26
ALSGNI	0.37	0.50	0.55	0.86	0.48	0.48	0.45	0.55
Retention	0.77	0.17	0.85	0.18	0.80	0.11	0.79	0.14
Rural	0.58	0.31	0.55	0.28	0.55	0.25	0.56	0.27
CPIA	3.23	0.36	3.20	0.47	3.26	0.32	3.24	0.35
Observations	33		12		45		90	

(1): MFIs offer no specific loan products dedicated to RE/EE.

(2): MFIs offer no specific loan products dedicated to RE/EE, but with its loan products, it also finance investments in RE/EE.

(3): MFIs offer specific loan products dedicated to RE/EE or plan to introduce them within the next year.

(1) and (3), in which the variable age has a 1 % significant positive coefficient. A similar observation can be made with respect to debt to equity. We also observe a positive sign of the proxies for maturity in the Heckman model, but here, age is significant at a lower level, namely 5 %. Summarizing, the hypothesis on the impact of maturity is strongly supported with respect to both proxy variables age and debt-to-equity ratio. In addition, the results from model specification (2) and (3) reveal that the variable of female managers is negatively related to green energy loans even in the case of the Heckman selection model. This result suggests that female managers have a lower chance to engage in the topic of green energy. Therefore, we are also able to find supporting evidence for our second hypothesis. However, note that this variable could also be a proxy for a specific type of MFI being rather dedicated to classical micro-lending instead of green energy lending.

Regarding hypothesis 3, we find that the retention rate has a significantly positive coefficient in all three regressions, which generally supports our third hypothesis. One possible explanation for this finding could be that the establishment of green energy finance requires more upfront costs and thus more stability in operations to reduce the risks associated with the provision of such a new service. Finally, our regression results show significant evidence related to the economic status of the respective country. The positive coefficient of the variable GDPpc is in line with the argument that in less developed regions, the role of MFIs in green energy lending is more important. Furthermore, we employ the SDGs score, which measures the yearly SDGs performance of a country, as an alternative proxy for development status. Replacing *log(GDPpc)* by this additional measure to run the full ordered probit and Heckman model yields regression results (model specification (4) and (6), respectively), which are consistent to our above main findings. To be more specific, we observe the same signs of the coefficients and similar significance levels as in the case of *log(GDPpc)*. A low SDGs country score represents a lack of engagement in sustainable activities, such as the use of RE and EE. Our finding indicates that the MFIs in a country with a low SDGs index may also be affected by that tendency. Ostensibly, the forth hypothesis can also be supported with corresponding evidence.

In addition to our main findings, we detect a significant correlation between green energy lending and several other variables. The regression results reveal that MFIs in Latin America and the Caribbean are more likely to offer green energy lending products. This finding was subsequently explained by the high potential of renewable energy sources in these regions. A similar, but weaker effect can be observed in the case of EECA. This is, to some extent, in line with the findings of *Forcella/Hudon* (2016), which shows that MFIs from Eastern Europe are in superior position to those in Western European regarding environmental management.

Table 6

Estimation Results

	Odered probit model				Heckman model			
	(1)	(2)	(3)	(4)	(5)		(6)	
					Energy loan	Answer	Energy loan	Answer
Age	0.060*** (0.016)		0.058*** (0.018)	0.067*** (0.020)	0.057** (0.023)	0.008 (0.006)	0.068*** (0.021)	0.007 (0.006)
Debt to equity	0.092*** (0.032)		0.120*** (0.043)	0.126*** (0.042)	0.120*** (0.041)		0.124** (0.052)	
Female managers		−1.614** (0.684)	−1.992*** (0.634)	−2.181*** (0.648)	−1.982*** (0.593)		−2.169*** (0.815)	
Average loan size/GNI		−0.184 (0.218)	−0.078 (0.247)	0.186 (0.217)	−0.079 (0.255)		0.183 (0.206)	
Retention rate		1.799** (0.871)	1.932** (0.822)	1.706** (0.818)	1.920** (0.812)		1.710* (0.948)	
OSS		−0.413 (0.555)	−0.098 (0.665)	−0.398 (0.531)	−0.095 (0.645)		−0.394 (0.593)	
Gross loan portfolio (ln)	0.019 (0.060)	0.073 (0.071)	−0.014 (0.076)	−0.030 (0.080)	−0.013 (0.080)	0.003 (0.030)	−0.032 (0.095)	0.002 (0.031)

	Odered probit model				Heckman model			
	(1)	(2)	(3)	(4)	(5)		(6)	
					Energy loan	Answer	Energy loan	Answer
IT intensity	−0.546 (0.355)	−0.221 (0.346)	−0.458 (0.362)	−0.463 (0.352)	−0.465 (0.378)		−0.445 (0.402)	
Rural	−0.346 (0.546)	−0.307 (0.597)	−0.566 (0.590)	−0.514 (0.574)	−0.559 (0.596)		−0.522 (0.584)	
GDP capita (ln)	−0.921*** (0.233)	−0.656*** (0.252)	−0.901*** (0.273)		−0.891*** (0.278)	−0.162** (0.067)		
SDGs score				−0.095*** (0.032)			−0.096*** (0.032)	−0.016* (0.008)
Region								
EAP	0.486 (0.450)	0.325 (0.487)	0.605 (0.486)	0.975* (0.536)	0.593 (0.480)		0.992* (0.542)	
EECA	1.059* (0.549)	0.947* (0.542)	1.470** (0.610)	2.025*** (0.755)	1.462** (0.590)		2.022** (0.789)	
LAC	1.199** (0.499)	1.373*** (0.507)	1.489** (0.580)	1.419** (0.552)	1.485** (0.602)		1.415*** (0.520)	
South Asia	0.144	0.240	0.068	0.332	0.055		0.354	

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(Table 6 continued)

	(0.428)	(0.412)	(0.445)	(0.439)	(0.442)		(0.467)	
CPIA environmental policy						–0.136 (0.184)		–0.134 (0.222)
MFI type								
Credit Union/Cooperative						–0.037 (0.288)		–0.036 (0.287)
NBFI						0.281 (0.193)		0.278 (0.189)
NGO						0.561*** (0.199)		0.546*** (0.192)
Diamonds								
Low						0.291 (0.222)		0.285 (0.225)
High						0.414** (0.209)		0.406* (0.208)
Observations	90	90	90	90	90	969	90	969
Pseudo R^2	0.156	0.110	0.204	0.181				

Model specifications (1)-(4) are ordered probit model with *Energyloan* as dependent variable. Model (5) and (6) present the results of Heckman estimations with Answer and Energyloan being dependent variables in the first and second stage of Heckman model, respectively. Variables are defined in Table 1.

Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 7

Frequency Table by Energy Lending – Extended Sample

	(1)		*(2)*		*(3)*		*Total*	
	Obs	%	Obs	%	Obs	%	Obs	%
IT intensity								
No	28	63.64	8	66.66	37	75.51	73	69.52
Yes	16	36.36	4	33.33	12	24.49	32	30.48
Region								
Africa and MENA	11	25.00	2	16.67	10	20.41	23	21.90
EAP	7	15.91	3	25.00	5	10.20	15	14.29
EECA	5	11.36	0	0.00	8	16.33	13	12.38
LAC	14	31.82	4	33.33	16	32.65	34	32.38
South Asia	7	15.91	3	25.00	10	20.41	20	19.05
Type								
Bank and others	3	6.82	3	25.00	4	8.16	10	9.52
Credit Union/Cooperative	7	15.91	0	0.00	3	6.12	10	9.52
NBFI	13	29.55	2	16.67	20	40.82	35	33.33
NGO	21	47.73	7	58.33	22	44.90	50	47.62
N	44		12		49		105	

(1): MFIs offer no specific loan products dedicated to RE/EE.

(2): MFIs offer no specific loan products dedicated to RE/EE, but with its loan products, it also finance investments in RE/EE.

(3): MFIs offer specific loan products dedicated to RE/EE or plan to introduce them within the next year.

To confirm the reliability of our findings, we also conduct robustness checks for the employed empirical method. First, there are 15 MFIs that answered the questionnaire but refrained from answering the question upon green energy lending. For these MFIs, we further explore their involvement in energy lending by researching their websites and other officially public documents. This leads to a larger sample of 105 MFIs, but with a little less accuracy. Table 7 and Table 8 show summary statistics for categorical and metric variables, respectively. Overall, we observe relatively similar descriptive statistics to those of based samples (90 MFIs).

Second, we implement the Heckman model with full information maximum likelihood (FIML) to address the missing data issue in an alternative way and

Table 8

Descriptive Statistics of Metric Variables by the Provision of Energy Loan – Extended Sample

	(1)		*(2)*		*(3)*		*Total*	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	17.95	8.54	22.75	9.19	22.39	9.55	20.57	9.28
DTE	3.60	2.77	4.31	3.88	5.00	5.08	4.34	4.14
FEMMAN	0.38	0.17	0.41	0.34	0.26	0.19	0.33	0.21
log(GDPpc)	7.86	0.91	7.88	0.63	7.45	0.89	7.67	0.89
log(GLP)	15.91	2.04	17.51	2.88	16.16	1.59	16.21	2.00
OSS	1.16	0.29	1.30	0.38	1.09	0.22	1.15	0.27
ALSGNI	0.36	0.47	0.55	0.86	0.48	0.47	0.44	0.53
Retention	0.78	0.15	0.85	0.18	0.79	0.10	0.79	0.13
Rural	0.61	0.29	0.55	0.28	0.56	0.24	0.58	0.26
CPIA	3.28	0.35	3.20	0.47	3.25	0.33	3.26	0.35
Observations	44		12		49		105	

(1): MFIs offer no specific loan products dedicated to RE/EE.

(2): MFIs offer no specific loan products dedicated to RE/EE, but with its loan products, it also finance investments in RE/EE.

(3): MFIs offer specific loan products dedicated to RE/EE or plan to introduce them within the next year.

obtain unbiased parameter estimations with a more correct standard error. However, due to the limited number of observations without missing values, the problem of convergence occurs when the model is estimated. To deal with this issue, we exclude the variable with the most missing values in the selection model, namely CPIA.

The results of the re-estimated models provided in Table 9 show the consistency with previous findings. The model specification (1) to (4) replicate the estimations presented in Table 6, yet with an extended sample of 105 MFIs. Meanwhile, the results of the Heckman model with FIML are given in the model specification (5). At first glance, the signs remain largely unchanged compared with Table 6, but the significance levels are overall lower in these cases. Even the control variables show the same results. Therefore, the extended response sample and estimation with FIML can be considered to yield robust results.

Table 9

Robustness Checks

	Odered probit model			Heckman model			
	(1)	(2)	(3)	(4)		(5)	
				Energy loan	Answer	Energy loan	Answer
Age	0.063*** (0.016)		0.062*** (0.017)	0.063*** (0.022)	0.003 (0.006)	0.045*** (0.012)	0.007 (0.006)
Debt to equity	0.099*** (0.031)		0.130*** (0.043)	0.125* (0.069)		0.057** (0.026)	
Female manager		−1.708** (0.749)	−2.180*** (0.680)	−2.151** (1.005)		−1.504*** (0.531)	
Average loan size/GNI		−0.201 (0.212)	−0.073 (0.270)	−0.076 (0.310)		0.101 (0.183)	
Retention rate		1.822** (0.877)	2.089** (0.841)	2.079 (1.492)		1.054* (0.559)	
OSS		−0.511 (0.510)	−0.174 (0.629)	−0.184 (1.016)		−0.474 (0.375)	
Gross loan portfolio (ln)	0.041 (0.060)	0.098 (0.072)	0.003 (0.078)	0.001 (0.095)	0.018 (0.029)	−0.054 (0.059)	0.026 (0.035)

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(Table 9 continued)

	Odered probit model			Heckman model			
	(1)	(2)	(3)	(4)		(5)	
				Energy loan	Answer	Energy loan	Answer
IT intensity	−0.631*	−0.385	−0.542*	−0.514		−0.075	
	(0.323)	(0.320)	(0.327)	(0.421)		(0.274)	
Rural	−0.761	−0.700	−0.979*	−0.960		−0.482	
	(0.519)	(0.555)	(0.554)	(0.640)		(0.465)	
GDP capita (ln)	−1.029***	−0.767***	−1.006***	−1.008***	−0.140**	−0.494***	−0.152**
	(0.226)	(0.241)	(0.266)	(0.382)	(0.064)	(0.18)	(0.076)
Region							
EAP	0.554	0.412	0.657	0.674		0.553	
	(0.439)	(0.462)	(0.468)	(0.689)		(0.362)	
EECA	1.567***	1.378***	1.973***	1.937**		0.894**	
	(0.543)	(0.522)	(0.589)	(0.976)		(0.421)	
LAC	1.260**	1.405***	1.541***	1.521**		0.796*	
	(0.492)	(0.482)	(0.564)	(0.647)		(0.445)	
South Asia	0.368	0.434	0.233	0.256		0.279	
	(0.406)	(0.388)	(0.423)	(0.491)		(0.333)	

CPIA environmental policy					–0.056 (0.177)		
MFI type							
Credit Union/Cooperative					0.184 (0.257)		0.133 (0.287)
NBFI					0.279 (0.183)		0.336 (0.218)
NGO					0.617*** (0.188)		0.623*** (0.218)
Diamonds							
Low					0.310 (0.204)		0.029 (0.236)
High					0.402** (0.196)		0.271 (0.221)
Observations	105	105	105	105	984	68	868
Pseudo R^2	0.193	0.141	0.244				

Model specifications (1)–(3) are ordered probit model with *Energyloan* as dependent variable. Model (4) and (5) present the results of Heckman estimations with extended response sample and FIML, correspondingly. Answer and Energyloan are dependent variables in the first and second stage of Heckman model, respectively. Variables are defined in Table 1.

Standard errors in parentheses: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

V. Conclusion

MFIs are notably important as they are instrumental in attaining human sustainable development. The triple bottom line in microfinance specifically emphasizes that not only the social mission, i. e. the focus on low-income beneficiaries, especially women, but also financial objectives must be pursued in an environmentally friendly manner. Regarding the environmental perspective, green energy is one of today's most prevalent issues due to its high demand and a lack of sustainable finance possibilities. This paper investigates the conditions under which MFIs are likely to engage in green energy lending and to what extent they engage. The employed data cover the years 2015 and 2017 for explanatory and predicted variables, correspondingly. Statistics on MFI level and macroeconomic level are provided by World Bank data platform.

This study provides results derived from several ordered-probit and Heckman selection model regressions. The first main result is a positive relationship between green energy finance and maturity. The more mature the MFIs, the deeper their engagement in green energy lending is. Considering green energy lending as a remarkable feature of environmental concerns, this finding reinforces the previous statements from *Allet*/*Hudon* (2015), and *Forcella*/*Hudon* (2016), in the sense that an MFI's maturity is associated with improved environmental performance. The second key conclusion provides a suggestion on the relationship between the share of female managers and green energy lending. Contrary to previous literature dealing with the link between the management gender diversity and an institution's response to environmental issues (*Ben-Amar* et al. 2017; *Liao* et al. 2015), our results show that a higher share of female managers tends to be associated with weaker support for green energy lending projects. However, this finding should not be over-interpreted as the share of female managers may be a proxy for some structural features of the respective MFI. Third, the ability to retain existing customers is another pivotal characteristic that is likely to have a positive influence on the provision of green energy loans. Finally, credit products for green energy appear to be more attractive to MFIs in less developed countries. Taking into account the fact that poor countries suffer energy crises and have a higher number of microfinance clients, it can be postulated that the effectiveness of green energy lending could be more powerful in developing countries than in developed ones.

The policy implications of our results are straight-forward, as they show the characteristics of MFIs which offer green energy lending. If these types of financial services are to be expanded on a global scale, we show which MFIs can be allured more easily toward offering these services. This also helps to identify challenges and obstacles in spreading finance and thus the use of green energy.

One limitation of this study lies in the employed data. Almost all of the key input data are collected from the MIX Market database, which contains self-reported data, and may thus encounter the problem of being biased. With dependent and independent variables collected in one specific year, the analysis could be refined if the covered period of time is longer and a panel data set is utilized. Therefore, a more advanced study could focus on capturing institution-specific and timedependent effects. Additionally, it may be useful to further research the question of how strong these RE & EE energy microfinance services affect sustainable development activities in different demographic groups, e. g. rural versus urban low-income population or female versus male. Due to the distinct characteristics of each group, the effects are also expected to vary. Everything considered, this paper takes a decisive step forward in academic discussion on the question of how to foster appropriate finance sources of green energy for the poor.

Appendix A. Rural Lending and IT Solutions Survey

Here we display those original questions and answer options of the employed questionnaire that are related to the variables Energyloan and ITintensity.

Energyloan

"Does the institution offer specific loan products dedicated to renewable energy (e. g. solar panels, biodigesters, etc.) and/or energy efficiency (e. g. efficient cookstoves, etc.)?

- Yes
- No, my institution does not offer credit products specifically dedicated to renewable energy or energy efficiency, but with its loan products it also finance investments in renewable energy or energy efficiency
- No, but my institution plans to introduce credit products specifically dedicated to renewable energy or energy efficiency within next year
- No"

ITintensity

"By digital solutions we mean any software support that contributes to digitalise the processes and/or activities of your financial institution: collection of client's information, credit assessment, credit management, monitoring, reporting, etc. Examples are dedicated software solutions for desktop computers, Apps for tablets or smartphones, etc.

…

Does your institution use any digital support solutions for data collection, analysis, reporting on lending activities? (multiple answers are possible)

- No
- Yes, desktop: excel

- Yes, specialized desktop software (not excel)
- Yes, software/App. for tablets or smartphone in the field
- Yes, tablets in the field
- Yes, smart phones in the field
- Other (please specify)"

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