



Constraints and Incentives in Using Renewable Energy Technology in MSMEs: A Mexican Case

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Authors' contributions

This work was carried out in collaboration between all authors. Author FJS designed the study, wrote the protocol, carried out the analysis and wrote the first draft of the manuscript. Authors BR, PR, HDLR and JAZ managed the literature searches and reviewed the draft manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/BJEMT/2016/27238

Editor(s):

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Complete Peer review History: <http://www.sciencedomain.org/review-history/15490>

Short Research Article

Received 25th May 2016
Accepted 14th July 2016
Published 24th July 2016

ABSTRACT

This paper shows the results of an investigation aimed to determine if some organizational and market variables are related to the propensity of micro, small and medium enterprises (MSMEs) to use renewable energy. The methodology of the study is correlational, and uses statistical techniques such as contingency tables and Analysis of Variance (ANOVA) to analyze the relationships between the dependent and independent variables. We included 160 micro, small and medium enterprises. The sample included 86 percent of companies with fewer than 10 workers; 11% of 10 to 50 workers; and 3% 50 to 250 workers. The method of data collection involved the application of a survey of owners and managers of companies. Significant relationships between the dependent variable intention to invest in renewable energy and geographic dispersion of market variables and level of information on renewable energy were also found. Among the main findings we conclude that the factor most related to the adoption of behaviors associated with sustainable consumption, would be the level of information they have access to MSMEs, which suggests the

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importance of designing programs to improve the quality and quantity of information available for the different business segments, especially for those who meet other characteristics associated with the adoption of these technologies, such as greater vertical integration, more dispersed markets and higher levels of income.

Keywords: Renewable energy; clean energy; energy consumption; social responsibility; technological modernization; technology transfer; MSME's.

ABBREVIATION

XLSTAT: Is leader of the Statistical Analysis Software.

1. INTRODUCTION

Climate change is a factor that strongly pressed government agendas, especially in emerging economies. In the Mexican case, this factor led to an ambitious energy reform aimed on the one hand to modernize the oil industry, and secondly, to reduce energy dependence on fossil fuels. The target for 2018 is going from 0.456 to 0.350 tons of CO₂ (tCO₂) equivalent emitted per megawatt hour was set generated, and by 2030, the Mexican government has set a goal of reducing emissions of greenhouse gases by 25% (Secretaría de Medio Ambiente y Recursos Naturales [1]).

MSMEs make an important contribution to the energy consumption of the Mexican economy because they spend 47% of electricity and 11% of thermal energy (Ruiz & Rivera [2]). For this reason, if MSMEs increase renewable energy use will significantly advance in meeting the objectives of mitigating climate change in Mexico.

However, many companies, especially MSMEs may have various constraints in investing in this technology because they have trouble getting funding (Zevallos [3]), asymmetry in access to information technology (Viniegra & Viniegra [4]), and the fact that currently dirty energy is cheaper than clean energy (Arreola [5]).

Some research has explored the role profile of microentrepreneurs and the type of administration in the adoption of clean energy (Justo, Olazábal, Orbegozo y López [6]). They emphasize that the owner of this business, is responsible for production, but also performs functions of marketing, sales, legal representation and purchases, which keeps its focus on issues that have little or nothing to do with the issue of renewable energies. However,

the authors point out that once you have managed to attract the attention of business managers, receive information and understand the benefits of such projects, your perspective change and then engage in such activities.

Other authors (Pintor, Lera, Garcia and Faulín, [7]) point out that in regions where many companies and users of renewable energy (low dispersion of the market) are concentrated a process of specialization of human capital which develops the competitiveness of the sector and improve growth prospects.

The investment for technology development is another important factor in which MSMEs are generally at a disadvantage compared to large compañías. Bakiewicz (cited by Viniegra [4]) suggests that a strategy for technological development of MSMEs it would aim to create symmetry in an environment where they learn "doing technology", with the participation of universities and research centers.

1.1 MSMEs Contribution to the Millennium Development Goals

Summit on Sustainable Development of 2015 generated a new development agenda will help to complete the achievements of the Millennium Development Goals in the fight against poverty and sustainable development. Among the elements of the sustainability report of companies, it highlights the environmental aspect, which translates as the impact of processes, products and services on the environment, as shown in Table 1.

The commonly accepted definition of Corporate Social Responsibility (CSR) is the Green Paper of the Commission of the European Communities [8] defined as "... the voluntary integration of social and environmental concerns of businesses into their commercial activities and their relations with its stakeholders, "which takes as its starting point a definition of voluntary CSR as a means for companies to contribute to social

Table 1. Companies report on sustainability elements

Economic	Environmental	Social
Payroll expenses, R & D, human capital formation.	Impact of processes, products and services on the environment.	Health and safety in the workplace. Stability employees Labor, human rights etc.

Source: Prepared based on the GRI guidelines

improvement and cleaner environment, and in turn express this responsibility to the workers and all other stakeholders of the company. (Vargas [9]).

In Mexico, the micro, small and medium enterprises play a key role in job creation and can also do so in meeting the Millennium Development Goals, given their economic contribution. Currently they exist in the country 5.6 million economic establishments, of which 94.3 percent are micro, 4.6 percent are small, 0.9 percent are medium and 0.2 percent are large companies (Instituto Nacional de Estadística y Geografía [10]). Micro, small and medium enterprises contribute 52 percent of GDP and 72 percent of formal employment (Ruiz & Rivera, 2013). The power consumption of MSMEs amounted to 92 367 GWh / year, according to estimates by Deutsche Gesellschaft für Internationale Zusammenarbeit [11]. This subsector has a potential energy savings of 14.6 percent, representing 13,514 Gw / h 6.8 million tCO₂ avoided.

However, this important segment of the economy has slowly incorporated the use of renewable energies. This seems to be related to regulatory, economic and organizational factors. Among the reasons of regulatory type, highlight the existence of a restrictive and complex legislation that still encourages investment in technologies for clean energy production in a distributed, despite the recent approval of a major energy reform that includes a substantial change in the national electricity market. Among the reasons for market are the high prices of equipment and especially the fact that for the moment remain cheaper energy produced from clean energy hydrocarbons. One might also mention among market factors, the asymmetry in access to finance and relevant information on the subject. Finally, among the reasons for such organizational factors are associated with size, professionalizing management, capacity for absorbing new technologies, and perceptions of managers on the energy issue.

This study will help show through a quantitative methodology, the importance of variables such as access to information to accelerate energy transition in Mexico.

2. RESEARCH METHODS AND DATA COLLECTION

The study was conducted during the months of January and February 2016. It included a random sample of 160 micro, small and medium businesses located in the metropolitan area of San Luis Potosi and Soledad de Graciano Sanchez, San Luis Potosi State, Mexico, within a total population of 55 314 economic units (Instituto Nacional de Estadística y Geografía [10]). The sample is simple random and provides a confidence level of 94% and an error of 6%. The method of data collection involved the application of a survey of owners and managers of companies. Additional information and secondary data were collected by consulting official sources and scientific articles related to the topic.

The research objective is identify organizational and market variables that can affect the adoption of technology to produce renewable energy or clean energy buy in micro, small and medium-sized Mexican companies.

2.1 Method of Data Analysis Tools and Use Statistics

Once the data is collected, these were tabulated and edited manually. The analysis was performed using Microsoft Office Excel program and the application program XLSTAT. First a contingency table was developed in order to determine the dependence / independence between the variables. Subsequently, for each of the independent variables subsamples defined and analysis of variance (ANOVA) was applied to determine if there is difference in mean intergroup, and therefore a variation associated with an independent variable, with a significance level $p = .05$.

2.2 Area, Location, Demographic and Economic Characteristics

The study was conducted in the metropolitan area San Luis Potosi - Soledad de Graciano Sánchez, located in the central area of the state of San Luis Potosi. An indicator of economic dynamism of San Luis Potosi is the rate of growth of state GDP, compared to the national average. For example, from 1993 to 2006, the average annual growth rate was 3.47 percent, while the national indicator for the same period stood at 2.98 (Torres & Del Valle [12]). For 2011, the growth rate of economic activity was 6.5 percent, which placed the company in the fourth nationally (Government of the State of San Luis Potosi [13]).

It should be noted that San Luis Potosi is one of the leading regions in Mexico for the generation of renewable energy, because to date are in operation or soon to start activities 19 renewable energy projects, including the second wind farm nationwide.

2.3 Hypotheses

2.3.1 Detailed instruction

H1. The propensity of MSMEs to consume clean energy is related to organizational and market factors. Among the factors that influence the propensity to consume are:

- H1a. Company size
- H1b. Company Age
- H1c. Type of administration
- H1d. Degree of professionalism in the administration
- H1e. Investment
- H1f. Frequency of Investment in Technology
- H1g. Level of spending on electric power
- H1h. Level of spending on gas
- H1i. Grade level of vertical integration
- H1j. Level of information on renewable energy
- H1k. Opinion on renewable energy

H2. The priority level that MSMEs provide investment in renewable energy is related to organizational and market factors. Among the factors that influence the propensity to invest are:

- H2a. Company size
- H2b. Company Age
- H2c. Type of administration
- H2d. Degree of professionalism in the administration
- H2e. Investment
- H2f. Frequency of Investment in Technology

- H2g. Level of spending on electric power
- H2h. Level of spending on gas
- H2i. Grade level of vertical integration
- H2j. Level of information on renewable energy
- H2k. Opinion on renewable energy

3. RESULTS AND DISCUSSION

The sample included 86 percent of companies with fewer than 10 workers; 11% of 10 to 50 workers; and 3% 50 to 250 workers. Of these companies, 68% are engaged in trade, 8% to 24% manufacturing and services. For its age, the sample included 51% of companies with more than 5 years of operation; 38% 1 to 5 years and 11% less than a year. 85% of companies have lower incomes than one million pesos (55,000 USD); 12% turnover of between 1 and 10 million pesos (55 thousand and 550 thousand USD); and 3% turnover of more than 10 million pesos (550,000 USD).

3.1 Crosstabulation 1

XLSTAT statistical software using a contingency table was developed in order to determine whether there is a relationship between independent variables and the variable propensity of companies to buy clean energy. This analysis allowed us to identify three independent variables that have a dependency relationship with the variable propensity of companies to buy clean energy, with a significance level of $p < 0.05$: Sales of the company, level of vertical integration and level of information on energy renewable.

Chi square statistic shows the relationship between variables, while the level of significance p indicates the probability of rejecting the null hypothesis of independence being true. In the underlined variables, the alternative hypothesis is accepted because the level of significance $p < 0.05$ and therefore we say that the variables are interdependent.

3.1.1 ANOVA 1

Subsamples of the population under natural categories of each of the variables defined (for example, regarding the Financing Variable two subsamples were established: a) receive funding and b) not receive funding). Data produced each subsample for the variable propensity of companies to buy clean energy is extracted, and then a Levene test was applied to determine which groups there is equal variances (H_0), and which are different (H_1) with a significance level of $\alpha = 0.05$.

Table 2. Dependent and independent variables under study

Variable	Indicator	Dependent variables	Indicator
Company size	No. of employees	Priority of the investment in renewable energy	Place of investment in renewable energy among the priorities of investment by businesses
Company age	Company sales		
Company age	Year since the company was created		
Type of administration	Degree of professionalism in the administration		
Dispersal enterprise market	Degree of geographical dispersion of business customers		
Investment	Use financing funding sources		
Frequency of Investment in Technology	Frequency with which companies invest in new technology		
Level of spending on electric power	Bimonthly Power Consumption in kw / h	Availability of clean energy companies to buy clean energy	Intention to buy regardless of price
Level of spending on gas	Gas consumption in USD		
Grade level of vertical integration	Grade level in which companies participate in supply chains		
Level of information on renewable energy	Degree of information that companies have on renewable energy		
Affinity towards renewable energy	Opinion on renewable energy		

Source: Made by self

Table 3. Relationship between the independent and the variable propensity's companies to buy clean energy

Variable	Chi square	P	Alpha significance level	Test of the hypothesis H1
No. of employees	2.352	.671	.05	Rejected
Company sales	9.952	.041	.05	Accepted
Company age	2.666	.615	.05	Rejected
Degree of professionalism in the administration	6.380	.173	.05	Rejected
Degree of geographical dispersion of business customers	9.056	.170	.05	Rejected
Use Financing funding sources	0.478	.787	.05	Rejected
Frequency with which companies invest in new technology	6.497	.370	.05	Rejected
Bimonthly Power Consumption in kw / h	5.428	.490	.05	Rejected
Gas consumption in USD	5.026	.541	.05	Rejected
Level in which companies participate in supply chains	10.527	.032	.05	Accepted
Level of information on renewable energy	17.427	.008	.05	Accepted
Opinion on renewable energy	6.230	.621	.05	Rejected

Source: Made by self

Table 4. Variances' analysis between subsamples independent's variables at its intersection with the variable propensity's companies to buy clean energy

Variable	F	P	Alpha significance level	Test of the hypothesis H1
No. of employees	1.305	.274	.05	Rejected
Company sales	3.733	.026	.05	Accepted
Company age	0.913	.341	.05	Rejected
Degree of professionalism in the administration	3.976	.021	.05	Accepted
Degree of geographical dispersion of business customers	3.519	.016	.05	Accepted
Use Financing funding sources	0.309	.579	.05	Rejected
Frequency with which companies invest in new technology	1.819	.146	.05	Rejected
Bimonthly Power Consumption in kw / h	1.851	.140	.05	Rejected
Gas consumption in USD	0.744	.528	.05	Rejected
Level in which companies participate in supply chains	0.850	.429	.05	Rejected
Level of information on renewable energy	5.366	.002	.05	Accepted
Opinion on renewable energy	1.123	.348	.05	Rejected

Source: Made by self

Table 5. Relationships between independent variables and the priority to investment in clean energy

Variable	Chi square	P	Alpha significance level	Test of the hypothesis H1
No. of employees	9.901	.449	.05	Rejected
Company sales	6.417	.779	.05	Rejected
Company age	12.126	.277	.05	Rejected
Degree of professionalism in the administration	15.937	.101	.05	Rejected
Degree of geographical dispersion of business customers	20.222	.164	.05	Rejected
Use Financing funding sources	3.638	.603	.05	Rejected
Frequency with which companies invest in new technology	6.955	.959	.05	Rejected
Bimonthly Power Consumption in kw / h	14.179	.512	.05	Rejected
Gas consumption in usd	16.122	.374	.05	Rejected
Level in which companies participate in supply chains	7.445	.683	.05	Rejected
Level of information on renewable energy	17.112	.312	.05	Rejected
Opinion on renewable energy	24.731	.212	.05	Rejected

Source: Made by self.

It was determined that there is a difference of variances in the sub-samples corresponding to the independent variables Sales Company, type of administration, dispersion enterprise market and level of information on renewable energy, which would suggest to us that you can existing relationship between these variables and changes in the variable Propensity to buy clean energy.

In the underlined variables, the F value exceeds the critical value F, with a lower level of significance at $p < 0.05$. This means that changes among the factors that determine the subsamples had a statistically significant effect on the results of the variable propensity to buy clean energy.

Table 6. Analysis of variance between samples of independent variables its intersection with the priority variable to investment in clean energy

Variable	F	P	Alpha significance level	Test of the hypothesis H1
No. of employees	0.959	.386	.05	Rejected
Company sales	1.032	.995	.05	Rejected
Company age	0.913	.688	.05	Rejected
Degree of professionalism in the administration	1.202	.304	.05	Rejected
Degree of geographical dispersion of business customers	6.066	.001	.05	Accepted
Use Financing funding sources	0.109	.742	.05	Rejected
Frequency with which companies invest in new technology	2.077	.106	.05	Rejected
Bimonthly Power Consumption in kw / h	2.337	.077	.05	Rejected
Gas consumption in USD	1.599	.195	.05	Rejected
Level in which companies participate in supply chains	0.654	.522	.05	Rejected
Level of information on renewable energy	3.337	.038	.05	Accepted
Opinion on renewable energy	2.690	.034	.05	Accepted

Source: Made by self

3.2 Crosstabulation 2

Subsequently, the analysis using the same subsample, but now with the data for the corresponding priority of renewable energy among investment options for companies replicated item.

In this case, it could not confirm that there is any relationship of dependence between the dependent and independent variables, so we proceeded to replicate the process of analysis of variance.

3.2.1 ANOVA 2

This analysis tool indicates that there is a difference of variances corresponding to the variable dispersion enterprise market and level of information on renewable energy, at its intersection with the referred variable dependent subsamples, as shown in Table 6 above.

4. CONCLUSION

As can be seen in data analysis, there are indications that some of the organizational variables analyzed exert a greater influence on the propensity to consume clean energy and renewable energy investments in micro, small and medium enterprises. Among the variables that stand out is the level of information on

renewable energy, which appears in the first contingency table as both analysis of variance, while other variables such as sales of the company, level of vertical integration and dispersion of the market, it appear to be related more with the propensity to consume clean energy. This leads us to conclude that a factor that appears to be strongly related to the adoption of behaviors associated with sustainable consumption, would be the level of information they have access to MSMEs, which suggests the importance of designing programs to improve the quality and quantity of information available for the different business segments, especially for those who meet other characteristics associated with the adoption of these technologies, such as greater vertical integration, more dispersed markets and higher levels of income. An information strategy to consider the advantages of adopting sustainable business practices, showing the economic medium and long term for the company benefits but also by awareness of the importance of mitigating climate change, is key to accelerating this process in a business segment accounting for more than half of employment and wealth produced in the country.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
<http://sciedomain.org/review-history/15490>