Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 5, 9830-9840

Effective Factors in the Acceptance and Success of Green Technologies in Iran: Examination and Analysis using Grounded Theory

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Abstract

This research aimed to extract the effective factors in the acceptance and successful implementation of green technologies in Iranian society. The current research is an applied qualitative study that employs exploratory-descriptive design and grounded theory (GT) for its purposes. The research population includes experts and specialists in green technologies. Eight experts were selected as the research population using purposive sampling. First, the effective variables for the penetration of green technologies were determined by reviewing the literature on technology penetration models and previous studies on green technologies. The output information was then used to develop and implement a semi-structured interview with the experts to extract their opinions in this regard. The interview results were coded and hence categorized to extract potential relationships between variables, from which a hypothetical model for the penetration of green technologies in Iran was developed. Hence, the Delphi method was employed to extract the categorized components based on those extracted from the interviews. The results from coding indicate that there are 6 main categories affecting the penetration and success of green technologies in Iranian society: environmental, economic, cultural, individual, institutional, and social factors.

Keywords: Technology Penetration, Green Technology Success, Sustainable Development, Grounded Theory

INTRODUCTION

Today, green technology, with its particular emphasis on environmental protection, has become a notion of pivotal significance for customers, shareholders, governments, employees and competitors, as users around the globe, are increasingly pushing organizations to produce environmentally friendly products and services. It is rightfully deemed one of the more influential ingredients for the enhanced performance and survival of organizations. The greatest challenge of organizations of all sorts is the issue of change and transformation, the management of which is arguably a key factor in the sustainability and relevance of the organization. In the current dynamic market brimming with competition, innovation is the key to any organization's survival. Today, the environmental performance of companies and compliance with environmental laws is considered a competitive advantage (Sarnube et al., 2015).

Venkatesh (2003) argues that one of the rather significant determinants for evaluating the probability of success of any newly-introduced technology is the “perceived ease of use” of that technology. It can lead to the required motivation in users who may otherwise be less willing to use new systems, and can be further used in training and marketing new technology. The first technology acceptance model is widely considered to be the multi-attribute model developed by Fischbein (1979) - and later modified by Fischbein and Ajzen (1980) - which

presents a complex model of the relationships between beliefs, attitudes, intentions and consumer behavior. According to this model, a person's attitude towards any service received is based on his/her evaluation of the same service. Fischbein's rational grounds for this model was the behavioral learning theory, stating that the inclination towards a technology happens more or less automatically.

Although technology acceptance models have been developed mainly to analyze the extent and manner of information technology penetration on users, they have also been extensively considered for examination. For instance, Farozanfar et al. (2016) proposed a novel hypothetical model using quantitative data, arguing that the previous models were focused on the concept of technology rather than that of sustainable development and its role in technology acceptance. The authors further showed that technology awareness is key to accepting technologies based on sustainable development. Atif Ali et al. (2021) also developed a hypothetical model for the acceptance of green technologies based on the theory of rational action, in which knowledge about green technology plays a mediating role in the formation of beliefs thereon, thus forming an attitude towards the acceptance and subsequent use of green technology. Moreover, De Xia et al. (2021) studied the role of regulation in environmental fields, the adoption of green technologies by organizations and the mediating role of government ownership therein. They concluded that all three models of command and control regulation, economic incentives and voluntary cooperation positively affect the acceptance of technologies. In contrast, the state of the organization being governmental only has a positive effect on the command and control regulation model while having a negative effect on the other two.

Overall, the successful implementation of any given technology is perceived to be influenced by the level of penetration of the technology in the target society and hence the public favor of that technology. As such, closely examining the factors affecting the penetration and acceptance of technology can (1) help identify the reasons for any potential setbacks in the quest to implement some technologies and (2) help the main players of technology transfer better understand the controllable factors to enhance the chances of successful technology transfer. Technology acceptance models (TAM) have been extensively studied in various information technology fields. Also, some studies have further employed the notion to examine the acceptance rate of the so-called green technologies, that is, those about new and renewable sources energies. Nevertheless, no model has been developed to examine the penetration and acceptance of new energy technologies (such as solar energy) and the factors influencing the acceptance of these technologies in Iran. As such, this research aimed to identify the factors effective in the penetration and success of green technologies in Iran.

Theoretical foundations of research

Green technology innovation

Process innovation is the implementation of a new or significantly improved production or delivery method software to reduce uncertainty and increase the efficiency and effectiveness of processes internal to the organization. The application of green knowledge to promote and guide innovation in organizational processes is often referred to as “green process innovation,” perceived to have the capacity to the highly enhanced environmental efficacy of the organization. As such, corporate-level managers are left with no choice but to evaluate and improve processes such as recycling, reuse and re-production of raw materials while seeking a thorough understanding of manufacturing approaches that lead to optimal energy consumption and minimal environmental contamination (Song et al., 2017).

Green technology innovation involves investing in green equipment and machinery and applying advanced green technologies. Also, developing new solutions for storing goods, conserving material consumption and managing documentation are all deemed part of green technology innovation. As such, green technology innovation is producing technical knowledge to mitigate negative environmental consequences. Since most state-of-the-art technologies bring-upon serious environmental consequences and irreversible damages to the ecosystem, organizations are no anymore interested in the sole attribute of novelty. Rather they seek out those that have been proven to be sustainable,

hence the notion of social responsibility of organizations (Sholihin et al., 2017).

Sustainable development

A development is called a sustainable one if it realizes the needs of the current organization without compromising the ability of future generations to meet their needs. By this definition, the right of each generation to enjoy the same amount of natural capital that was available to other generations is recognized, and the use of natural capital is allowed to the extent of its consumption. Sustainable development is a significant academic point of interest in management and public policy that has emerged widely outside the United States (Shahivand and Payab, 2016). It seeks to focus more clearly on the future results of current behaviors. Sustainable development considers various fields: the effect of greenhouse gases, climate change, ozone layer destruction, land degradation, depletion of non-renewable resources, and air pollution in towns and cities, among others. Sustainability is a state in which the utility and existing facilities do not lose potential over time and hence corresponds to the ability of ecosystems to continue functioning in the indefinite future without falling into the depletion of resources or excessive use of such. "Sustainability is a condition through which social and natural structures perform synergically. However, it is still employed by some international organizations such as the World Bank for growth prospects." Sustainable development is a broad idea that may convey different connotations, provoking different reactions in this regard. Sustainable development is best defined as an attempt to integrate the emerging notions of environmental issues with socio-economic ones. It is introduced as a shift in the understanding of the relationship between humans and nature and humans with each other, which completely contrasts with the views of the past two centuries (Rahmati Dehkordi and Raisi Dehkordi, 2017).

Views on technology acceptance

The original technology acceptance model (Davis, 1989) was designed to envisage the acceptance of information technology by a user and the extent of its use. Today, it is one of the highly popular and solid models for predicting the acceptance of various classes of users. Based on the model above, the motivation to use a system is determined by two variables: (1) the perceived extent to which a certain technology improves the performance of systems, also known as perceived usefulness and (2) the perceived extent by which the task at hand becomes easier to perform, also known as perceived ease of use. The usefulness and ease of use that comes from the user's attitude towards technology lead to the behavioral intention to use that technology (prediction of acceptance). Useful and easy-to-use technologies will positively affect the user's attitude and motivation toward using that technology in the future, enhancing the chances of its actual use.

Later, Nysveen et al. (2005) sought to integrate different models to better predict the acceptance of mobile phone technologies and propose several methods to explain the motivation of technology consumers. They claimed that the technology acceptance model is not sufficient for technologies used in everyday life, and the model should be developed based on the concept of perceived control in the theory of planned behavior because there are other internal or external constraints on human behavior that are not included in the previously established technology acceptance models. Other studies also confirmed this, e.g., Teo and Pok (2003) showed that subjective norms should be considered part of the acceptance study model for mobile phone technologies. Nysveen et al. (2005) developed an integrated information systems technology model that explains the desire to use mobile technology. This finding implies that different models can be implemented for different technologies, in each of which the influence of factors on enhancing the acceptance of a particular technology is examined. Findings from Nysveen et al. (2005) indicated that perceived expressiveness, customers' understanding of the pleasure of using technology, the usefulness of technology for users, the ease of using technology for users and positive attitude are among the influential factors for using mobile phone services. Also, mental norms and factors controlling behavior are effective as consumers' intention to use mobile phone services.

Research Methodology

The current research is an applied qualitative study that employs exploratory-descriptive design

and grounded theory (GT) for its purposes. The research population includes experts and specialists in green technologies. Eight experts were selected as the research population using purposive sampling. First, the effective variables for the penetration of green technologies were determined by reviewing the literature on technology penetration models and previous studies on green technologies. The output information was then used to develop and implement a semi-structured interview with the experts to extract their opinions in this regard. The interview results were coded and hence categorized to extract potential relationships between variables, from which a hypothetical model for the penetration of green technologies in Iran was developed.

Findings

According to the results, out of the selected samples, six participants (75%) were men, and two participants (25%) were women. Moreover, one participant (12.5 percent) was less than 35 years old; one participant (12.5 percent) was in the 35-40 age group, three participants (37.5 percent) were aged in the range 41-45 years, and three participants (37.5 percent) were over 45 years old. Also, two participants (25%) had working experience of fewer than 5 years, four participants (50%) had working experience of 5-10 years, one participant (12.5%) had 11-15 years of working experience, and one participant (12.5%) had more than 15 years of working experience under his belt.

By reviewing the interviews and getting familiar with the basic concepts, initial identifiers were created, and the identifications of the respondents were done. Then, searching and recognizing the themes at this stage to formulate a comprehensive model.

Table 1: Themes extracted from the interviews

Aim	Main theme	Sub-theme
Factors and effective factors in the acceptance and success of green technologies in Iran	Environmental	Conservation of non-renewable natural resources Using available and free resources such as water, wind and sun Diversification of resources Mitigating pollution to protect the environment Having a clean environment and preserving it for future generations Using solar energy to generate electricity
	Economical	Low price Cost-effectivity Tax exemption Economic impact and negative effects of elimination of fossil fuels on the economy Using incentive options Free green technology Government support Low costs Financial and economic incentivization
	Cultural	Offering public education Persuading the public to use resources Giving the necessary and practical training for the products Supporting the provider company Creating a cultural portfolio Generating a sense of need at the community level by seeking help from environmental activists and social media influencers Informing people about the advantages of green technology Advertising Popular people in the society using green technology Offering an incentive to people who consume green technology from the government Education

		Habituation of green technologies High understanding of society
	Institutional	Failure to create suitable infrastructure for use Studying and getting statistical information from social networks High quality of services provided High-quality equipment provided Long life with consumables Not needing much space to install this equipment Providing diverse support services Providing the necessary ingredients for waste separation from the government Providing conditions for using public transportation or organic food Lack of resources and expensive other resources Polls and surveys Enhancing the acceptance of technology Having resources in proper volumes Lack of complexity Availability of storage facilities The volume and extent of use of green technology Availability of infrastructure in the market Government support
	Individual	Having a sense of responsibility for the future generation Education Knowledge of the benefits of these technologies Attitudes of people inner beliefs about the need to use new technologies Conscience of people
	Social	Ease of access General Acceptance Making people aware of the positive effects of using green energy Individual Health Good product support Easy to use green technology Adoption and use by many people Usefulness to society Being moral in the eyes of society Being prestigious in the eyes of society Trends in the use of green technology

By examining the themes, the common dimensions of concepts are emerged in the main themes, a part of which, as an example, is shown in Table 2.

Table 2: Common dimensions of concepts in the main themes

Components	Concepts	Identifier	Frequency

Environmental	Conservation of non-renewable natural resources Using available and free resources such as water, wind and sun Diversification of resources Mitigating pollution to protect the environment Having a clean environment and preserving it for future generations Using solar energy to generate electricity	A1+A2+A3+A4+A5+A6	4A1+2A2+5A3+5A4+A5+A6
Economical	Low price Cost-effectivity Tax exemption Economic impact and negative effects of elimination of fossil fuels on the economy Using incentive options Free green technology Government support Low costs Financial and economic incentivization	A7+A8+A9+A10+A11+A12+A13+A14+A15	6A7+7A8+2A9+2A10+3A11+4A12+2A13+2A14+3A15
Cultural	Offering public education Persuading the public to use resources Giving the necessary and practical training for the products Supporting the provider company Creating a cultural portfolio Generating a sense of need at the community level by seeking help from environmental activists and social media influencers Informing people about the advantages of green technology Advertising Popular people in the society using green technology Offering an incentive to people who consume green technology from the government Education Habituation of green technologies High understanding of society	A16+A17+A18+A19+A20+A21+A22+A23+A24+A25+A26+A27+A28	2A16+3A17+8A18+4A19+5A20+6A21+2A22+2A23+3A24+4A25+5A26+6A27+3A28
Institutional	Failure to create suitable infrastructure for use Studying and getting statistical information from social networks High quality of services provided High-quality equipment provided Long life with consumables Not needing much space to install this equipment Providing diverse support services	A29+A30+A31+A32+A33+A34+A35+A36+A37+A38+A39+A40+A41+A42+A43+	4A29+6A30+3A31+2A32+4A33+5A34+6A35+2A36+3A37+4A38+A39+3A40+A41+5A42+3A43+4A44+5A

	Providing the necessary ingredients for waste separation from the government Providing conditions for using public transportation or organic food Lack of resources and expensive other resources Polls and surveys Enhancing the acceptance of technology Having resources in proper volumes Lack of complexity Availability of storage facilities The volume and extent of use of green technology Availability of infrastructure in the market Government support	A44+A45+A46+	45+A46+4A47+5A48+3A49+4A50+5A51+3A52
Individual	Having a sense of responsibility for the future generation Education Knowledge of the benefits of these technologies Attitudes of people inner beliefs about the need to use new technologies Conscience of people	A47+A48+A49+A50+A51+A52	5A47+4A48+5A49+3A50+3A51+A523
Social	Ease of access General Acceptance Making people aware of the positive effects of using green energy Individual Health Good product support Easy to use green technology Adoption and use by many people Usefulness to society Being moral in the eyes of society Being prestigious in the eyes of society Trends in the use of green technology	A53+A54+A55+A56+A57+A58+A59+A60+A61+A62+A63	7A53+5A54+6A55+5A56+4A57+5A58+3A59+A60+3A61+2A62+3A63

Analysis of interviews with 8 experts resulted in 63 factors deemed effective in the acceptance and success of green technologies in Iranian society, each classified in individual, cultural, economic, social, environmental and institutional factors.

The Delphi method was used in the next phase to extract the components based on the contents extracted from the interviews. In the first round of Delphi, the list of categories, subcategories and concepts was provided to experts to comment on and confirm or reject their prevalence. They were also asked to offer comments and suggestions to the model. In the second round, the set of factors collected together with the results of the first stage was given to the second group of experts to determine the importance of each category, subcategories and concept. At each stage, the researcher suggested modifications to the concepts, subcategories and categories. Finally, after the second round of Delphi, the categories, subcategories and concepts with higher means per the opinion of the experts were selected.

In the first round of the Delphi method, items 32, 33, 48, 62 and 63 were removed from the questionnaire due to having fewer than 3, and the rest were inputted into the second round. In the

second stage (round), no item was excluded from the research process as all had means of higher than 3. Therefore, based on the third round results, the most important factors affecting the acceptance and success of green technologies in Iran were identified and ranked.

Table 3: results from third round Delphi

Components	Mean	SD	Mean rank
1. Conservation of non-renewable natural resources	4.3750	.74402	34.94
2. Using available and free resources such as water, wind and sun	3.1250	1.88509	26.63
3. Diversification of resources	4.1250	.83452	29.56
4. Mitigating pollution to protect the environment	4.0000	.92582	26.31
5. Having a clean environment and preserving it for future generations	4.5000	.75593	37.50
6. Using solar energy to generate electricity	4.2500	.70711	32.44
7. Low price	3.6250	1.18773	22.63
8. Cost-effectivity	4.7500	.70711	43.56
9. Tax exemption	4.1250	.83452	30.00
10. Economic impact and negative effects of elimination of fossil fuels on the economy	4.0000	.75593	27.06
11. Using incentive options	4.5000	.53452	36.13
12. Free green technology	4.2500	.70711	32.44
13. Government support	4.0000	.75593	25.69
14. Low costs	4.1250	.83452	29.25
15. Financial and economic incentivization	4.1250	.83452	29.63
16. Offering public education	4.1250	1.12599	32.25
17. Persuading the public to use resources	4.2500	.88641	33.13
18. Giving the necessary and practical training for the products	4.3750	.74402	34.31
19. Supporting the provider company	3.7500	1.28174	26.38
20. Creating a cultural portfolio	4.2500	.70711	31.31
21. Generating a sense of need at the community level by seeking help from environmental activists and social media influencers	3.7500	.70711	22.63
22. Informing people about the advantages of green technology	3.6250	.91613	21.69
23. Advertising	3.8750	.64087	24.06
24. Popular people in the society using green technology	4.0000	.92582	27.38
25. Offering an incentive to people who consume green technology from the government	4.1250	.83452	28.31
26. Education	3.7500	.70711	22.63
27. Habituation of green technologies	4.5000	.75593	37.56
28. High understanding of society	4.5000	.75593	36.25
29. Failure to create suitable infrastructure for use	4.2500	.70711	32.00
30. Studying and getting statistical information from social networks	4.3750	.74402	34.56
31. High quality of services provided	4.0000	.92582	25.81
32. Not needing much space to install this equipment	4.1250	.99103	29.38
33. Providing diverse support services	4.0000	.92582	25.81

34. Providing the necessary ingredients for waste separation from the government	4.2500	.70711	31.44
35. Providing conditions for using public transportation or organic food	4.1250	.64087	29.44
36. Lack of resources and expensive other resources	4.3750	.51755	34.44
37. Polls and surveys	4.2500	.88641	32.56
38. Enhancing the acceptance of technology	4.5000	.53452	35.13
39. Having resources in proper volumes	4.2500	.70711	31.44
40. Lack of complexity	4.5000	.53452	36.13
41. Availability of storage facilities	4.2500	.70711	31.44
42. The volume and extent of use of green technology	4.1250	.64087	28.44
43. Availability of infrastructure in the market	4.1250	.83452	29.56
44. Government support	3.8750	.99103	24.94
45. Having a sense of responsibility for the future generation	3.3750	1.84681	26.88
46. Knowledge of the benefits of these technologies	4.5000	.75593	36.25
47. Attitudes of people	4.0000	.75593	26.25
48. Inner beliefs about the need to use new technologies	3.8750	.64087	22.69
49. Conscience of people	3.5000	.75593	16.88
50. Ease of access	3.7500	1.03510	21.75
51. General Acceptance	3.8750	.83452	23.81
52. Making people aware of the positive effects of using green energy	4.1250	.99103	29.38
53. Individual Health	3.8750	.83452	23.81
54. Good product support	3.7500	1.16496	23.88
55. Easy to use green technology	4.1250	.99103	29.94
56. Adoption and use by many people	3.8750	.83452	23.38
57. Usefulness to society	4.2500	1.03510	33.44
58. Being moral in the eyes of society	4.6250	.74402	38.56

The results from coding revealed 6 main categories affecting the acceptance and success of green technologies in Iranian society: environmental, economic, cultural, individual, institutional, and social. Therefore, the following research model can be devised based on the findings of the study:

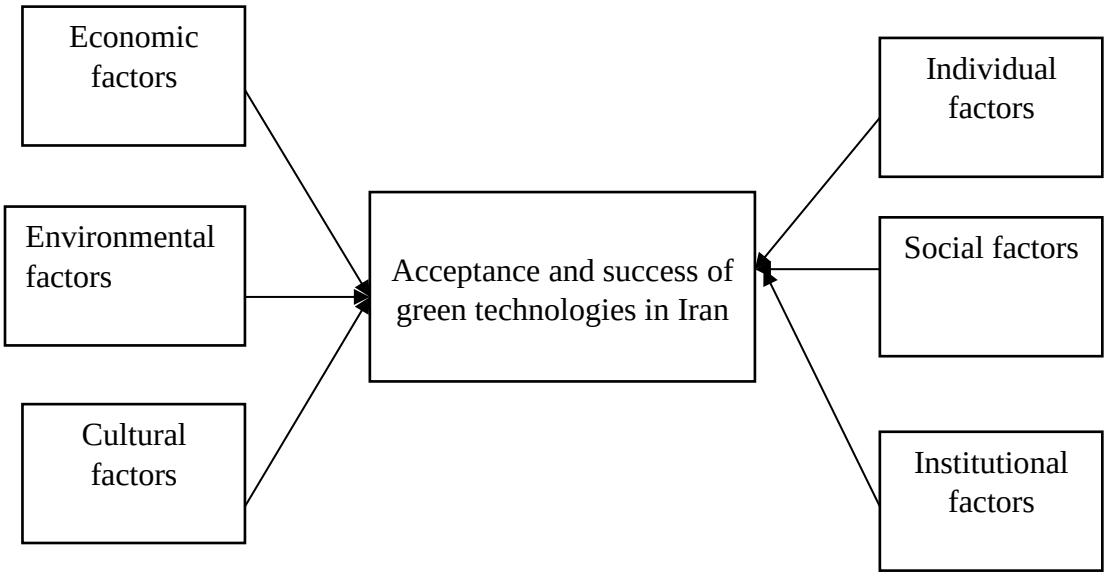

Figure 1: Research model

Conclusion

This research aimed to determine the effective factors in the acceptance and success of green technologies in Iranian society. Today, the ever-increasing growth of the population of cities and the limitations caused by the consumption of fossil fuels on the one hand, and nature-related challenges such as global warming, climate change, and the destruction of the ozone layer, among others, have led to a plethora of high-cost environmental problems and shifts in natural dynamism of many ecosystems on the surface of the earth. As such, owing to the excessive growth of the population in the contemporary era and the congruently high consumption of non-renewable resources and fossil fuels, the depletion of the environment-originated resources and the lack of proper management in planning to meet the needs of future generations have become extremely alarming for governments and economic planners all around the globe. What makes it further threatening is that such issues are not just economically applicable to the present era, as the limited non-renewable energy resources in the world often lead to highly strategical and political challenges.

Galbreath et al. (2017) stated that green technology aims to reduce adverse environmental effects through measures adopted in the entire value chain from supplier to consumer. Previous research has established that green innovation consists of four main dimensions: green process innovation, green product innovation, green managerial innovation, and green technological innovation. In the "Earth Conference 1992", sustainable development was defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. The World Environment Commission defines sustainable development as "a process of change in the use of resources, the direction of investments, the direction of technology development and institutional change that is compatible with present and future needs." Brundland Commission argues that "Sustainable development as a process is necessary to improve and progress the situation and eliminate the social and cultural shortcomings of advanced societies and should be the main driver of balanced, proportionate and harmonious economic, social and cultural progress of all societies, especially those of developing countries.

The authors sought to conduct a literature study to identify factors that can be effective in the acceptance and success of green technologies in Iranian society, based on the results of which semi-structured interviews were conducted with a select group of experts. Hence, the hypothetical acceptance model of green technologies in Iranian society was developed. The results from coding ultimately indicated that there are 6 main categories affecting the acceptance and success of green technologies in Iranian society: environmental, economic, cultural, individual, institutional, and social factors.

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