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Research Article

Investigating the Impact of Green Information Technology on the Performance of Large Organizations (Case Study: Kerman Graduate University of Advanced Technology)

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Abstract
Large organizations such as universities face many challenges in managing green and moving toward energy efficiency. Government subsidies, support schemes, and energy support budgets in these organizations in recent decades have led to an inadequate cultural foundation in the organizational force and insufficient attention to how to spend and pay attention to green management. In recent years, with the expansion of automation and electronics infrastructure in universities, electricity consumption has increased. The present study was conducted to investigate the factors affecting green information technology in the Kerman Graduate University of Advanced Technology (KGUAT). First, using field studies and similar research, indicators affecting green information technologies were collected and proposed. To review the status of indicators and prioritize them using data collection tools through questionnaires and interviews in KGUAT among the staff. Data analysis is performed using SPSS software and the Smart PLS model. A total of 13 indicators affecting green information technology management were proposed. Based on the prepared questionnaires, focusing on reducing costs, increasing efficiency, and improving statistical analysis quality were analyzed. The model results showed that the fit indices of the model were all in the desired range and can be relied on the model and future organizational decisions to maximize the effect of reducing energy consumption in the future. According to the results of management factors, product and process and infrastructure factors affect the efficiency of green management.
Keywords: Green University, Green Information Technology, Statistical Analysis, Smart PLS, SPSS Software

Introduction

The topic of green information technology (GIT) is currently one of the most important topics in the world today due to the increasing development of information and communication technology in all aspects of human life. Green information technology is crucial both economically and environmentally, and it also counts as social responsibility. Organizations are legally, ethically,

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and socially responsible for promoting their IT products, programs, services, and practices with green and environmental approach.

Information Technology (IT) is one of the most up-to-date and sensitive industries that has provided many benefits to various companies and organizations. However, at the same time, the industry is one of the largest consumers of energy in the world (Capra and Merlo, 2009). IT products have significant effects on the environment. They contain known chemicals threat to human health and the environment (Capra and Merlo, 2009). IT accounts for only about 3% of greenhouse gas emissions, so most of these emissions come from non-IT sources. It is possible to improve energy efficiency and reduce environmental pollution by using more intelligent information technology (Porter, 1996).

Organizations use IT extensively to develop and accelerate performance and increase productivity and competitive advantage. Organizations use the latest IT technologies to provide more facilities to employees and customers without knowing the environmental consequences of these tools. Now that excessive use of IT tools and equipment can cause damage to the environment, what better way than IT to find and apply the right solution. In fact, since the use of information technology tools is unavoidable, the appropriate solution is to protect the environment (Chang and Chen, 2013).

Green University is a university that in all its activities, including education and research and services, health, safety, and environmental protection perspective and efficient and optimal use of resources and consumables, can move towards achieving sustainable development goals (Pegus et al., 2016). Universities are a prominent organization that is highly dependent on IT due to their activities' structure. The infrastructure in universities is more extensive than other governmental and non-governmental organizations. Therefore, its effects and consequences can be seen more clearly. However, any action to improve the university's environmental performance in the university will lead to an immediate and effective improvement of green management (Genta et al., 2019).

For example, the University of Isfahan (Iran) has been one of the top universities in green management for several years (Isfahan, 2020). The program conducted in this university is based on nine indicators of green management, including lighting control systems, heating systems, air conditioning, office equipment, water consumption, waste management, paper consumption, and consumer items, clean technology usage, renewable energies in transportation.

Another effective measure in this field in Iran is the presentation of management and green model by the Iranian Green Management Association to develop the acceptance of responsibility in organizations' social and environmental areas and its convergence with economic responsibility. This model was designed based on the superior experiences of successful national and international organizations and top models. Through the European Green Management Association (EAGM) based in Lausanne, Switzerland, a modern approach to Global senior executives was introduced after ten years and global maturity. This model is a good guide for determining improvement projects and helps organizations measure their capabilities in integrating social, environmental, and economic responsibility (Ramayah et al. 2010).

In a study conducted by Azadnia et al. (2014) entitled “The role of information and communication technology ICT in estimating the indicators of sustainable development from environmental, economic, social and cultural dimensions,” the role of ICT on development provision of rural sustainability from various dimensions was studied (Azadnia et al., 2014). In a study conducted by GolTabar and Sattari in 2013, ICT's economic and environmental effects in Iran’s young organizations were evaluated and studied (Gol Tabar and Sattarifar, 2013).

Ghareh Bigloo, in 2013 conducted a study to investigate the relationship between the dimensions of knowledge management and organizational performance in Rasht municipality, which has enormous human resources in the organization and the level of the ICT is low and week. The results obtained from testing the hypotheses indicate a significant relationship between the dimensions of knowledge management and organizational performance (Ghareh Bigloo, 2013).

Studies and organizational measures for the development of green management in universities in other countries have been followed more seriously. Some related research is provided below:
A study by Mu et al. (2009) examined the impact of green product innovation on organizational performance and competitive advantage in 140 companies operating in Turkey's various industries. This study showed that green product innovation has a positive and significant effect on the performance and competitive advantages of the organization. Also, this effect on the organization's competitive advantages is more than performance (Mu et al., 2009).

Another study examined the impact of environmental innovations on the export performance of European organizations. This study also showed that the capability and performance of research organizations in the field of environmental or green innovation has a positive effect on their competitive advantages in global markets (Costantini and Mazzanti, 2012).
Hassan Zohara et al. (2015) examine the literature on green marketing and two factors of green innovation and green promotion that affect the performance of the companies. Despite the potential and benefits and marketing of green products, it became clear that there were challenges in green refinancing later. Their results showed that green innovation and promotion have a positive effect on the work of corporate companies. Extensive studies have been conducted on the Malaysian government's agenda to improve the situation of green companies (Hasan and Ali, 2015).

In 2010, Yuan et al. examined the role of a company's green marketing and internal environmental sustainability practices. They also identified the interaction between green marketing strategy and internal application issues in a company. In this research, using marketing strategy records, the relationship between green marketing strategy and supporting the company's internal environment operations has been studied according to 4 main axes:

1) Green Supplier
2) Environmental resource management
3) Green Research and Development
4) Environmental processes and stages produced

Statistical methods, parallel analysis, factor analysis, and multiple regression were used to analyze the collected data from 332 companies. The results led to identifying four applications in the company to adopt a green marketing strategy (Yuan et al., 2010).

Molla et al. (2010) introduced a new integrated hub model of green marketing integration and sustainable supply chain management with six dimensions: product, advertising, planning, process, people, and a project called PS6. Their experimental study in the industry has been tested the integrated PS6 model in many companies. The new integrated model allows the flow of resources such as information, materials, and funds between green marketing and sustainable supply chain management through multiple direct routes and can achieve overall business performance (Molla and Abareshi, 2011).

The IT Governance Institute has developed a framework called COBIT (Control Objectives for Information and Related Technologies), a well-known model for controlling information, information technology, and risks, and is used to implement and audit. This framework incorporates the best hands-on experience in ICT governance and provides a set of acceptable processes, benchmarks, and metrics for the environment's physical management (Wati and Koo, 2011).

In 2019, Juiz et al. presented and discussed the green indicators of IT governance through balanced scorecards in the data center (Juiz et al., 2019). According to him, different types of functions and departments of information technology have been developed in organizations that sometimes these functions are not related to the rest of the organization and to solve this problem, a solution is proposed by building a Balanced Scorecards (BSC) with a generalizable example based on the virtualization of a data center in order to minimize the negative impact of IT operations on the environment.

As mentioned, green management in Iranian universities is still not considered, and the main activities carried out so far have been scattered and cross-sectional. It is also essential to develop comprehensive and targeted programs based on university infrastructure and local conditions. Therefore, in this study, by examining the indicators affecting the development of green management in information technology, a better understanding of the conditions and how the relationship and the importance of the indicators using the structural equation method were achieved.

Materials and methods

First, a field visit was made to the university, its various units, and its information technology infrastructure to conduct this study. Individuals and experts related to information technology were identified. During the interview with them and reviewing previous related research, structural equation models and research hypotheses were formed. The statistical community completed model questionnaires, and then the results were statistically analyzed.

In this research, the research method is based on applied results and descriptive purpose because we will seek to describe the practical components of Green Information Technology (GIT) on the organization of the KGUAT. In this method, interview and questionnaire techniques and library studies have been used to extract hypotheses and reject or influence them with the organization's experts' help. The research method of this research is analytical, which a descriptive-exploratory type is, and in terms of the purpose of the research, it is considered an applied type.

Methods and tools of data collection through questionnaires and interviews distributed among the staff of the KGUAT and data analysis are done using SPSS and Smart PLS software (version 3).

Statistical steps and sampling method include the following steps:

The statistical population is 600 people. The sample number is 50 experts and managers with at least five years of experience, familiar with GIT topics, and aware of the field of technology and information.

After determining the sample size and referring to experts, the questionnaire was given to them, and a total of 50 questionnaires were returned. It is noteworthy that the sampling was done randomly, and the statistical samples had the following conditions:

- At least five years of work experience
- At least a bachelor's degree
- Familiarity with the field of GIT

Descriptive and inferential statistics have been used to analyze the research data. The structural equation model has been used to test the hypotheses. In this study, the structural equation method by PLS software was used to analyze the data. The descriptive statistics of the data (statistical index and dispersion and preparation of tables and graphs) and the questionnaire's reliability were used by SmartPLS software.

Study area

The KGUAT was established on the campus of Mahan with an area of 2000 hectares. The campus includes the Kerman Graduate University of Advanced Technology, the institute of advanced science and technology, and the environmental science and technology Park. KGUAT has three faculties of science and technology, electrical and computer engineering, and civil engineering and surveying. The university also has five research centers (environmental sciences, photonics, materials and energy, IT and computer) and 33 advanced laboratories. The Science and Technology Park has a growth center and eight sub-growth centers across the Kerman province (KGUT, 2019).

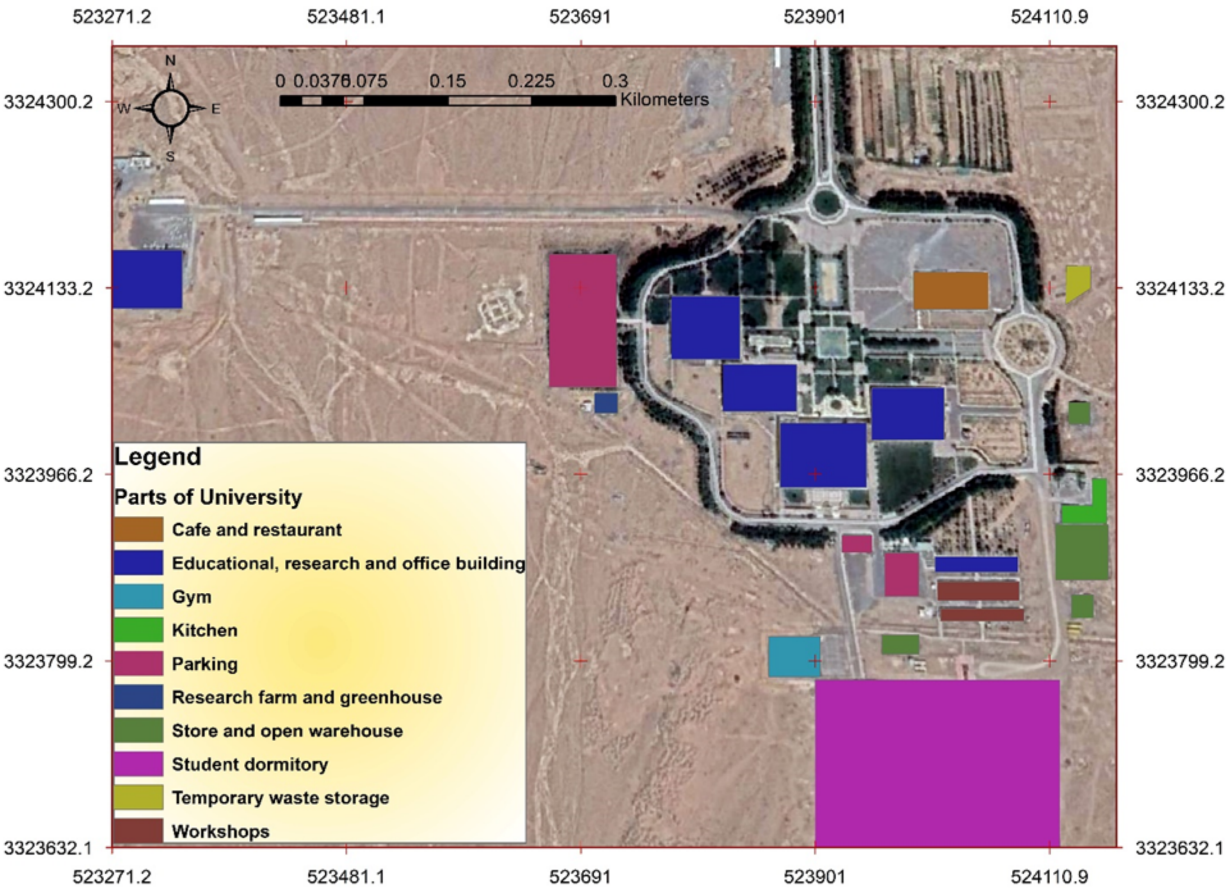

Figure 1. KGUAT map

Structural equation modeling (SEM)

Structural equation modeling, introduced in the late 1960s, provided a tool in researchers' hands to examine the relationships between several variables in a model (Kline, 2015; Lin et al., 2020). Structural equation analysis is done according to a process with a precise and uniform format. Meanwhile, structural equation modeling, introduced in the late 1960s, provided a tool in researchers' hands to study the relationships between several variables in a model (Kline, 2015). This technique's power in the development of theories has led to its widespread application in various sciences such as marketing, human resource management, strategic management, and information systems.

Structural equation modeling (SEM) analysis using SmartPLS software was performed to test the research model. Often loosely termed causal modeling, SEM was applied to test multivariate models with empirical data (Zain et al., 2005). It is a statistical modeling technique widely used in the behavioral sciences (Lin et al., 2020; Sarstedt and Cheah, 2019). SEM using LISREL, EQS, PLS, AMOS, and other second-generation data analysis software is often applied in MIS (Shiau et al., 2019). Such software is essential because it provides powerful techniques to address key IS research problems. SEM goes beyond traditional statistical approaches because it can confirm relationships and even help gain insights into the relationships' causal nature and strength (Sarstedt et al., 2017).

Goodness of Fit index

To examine the model's fit in PLS, the global quality criterion proposed by Amato et al. In 2004 was used (Amato et al., 2004).

$$\text{GoF} = \sqrt{\overline{communality} \times \overline{R^2}} \tag{1}$$

Communality is the average subscription of each variable and measures the quality of the external model. R^2 The average of the coefficients of determination is related to each endogenous latent variable, measures the quality of the internal model, and is calculated for each endogenous variable according to the latent variables that explain it (Khan et al., 2019). Three values of 0.01, 0.25, and 0.36 are introduced as a weak, medium, and strong values for Goodness of Fit (GoF).

Results and discussion

Sample and procedure

The status of different respondents in terms of opinion and their classification is presented in Table 1. According to the results, 21.4% were under 35 years old, 42.7% were between 35 and 45 years old, 31.1% were between 45 and 55 years old, and 4.9% were over 55 years old.

Table 1. Assessing the respondents' age status

Age	Frequency	Cumulative frequency
Under 35 years	21.4	21.4
Between 35 and 45	42.7	64.1
Between 45 and 55	31.1	95.2
More than 55	4.9	100
Total	100	-

The table of the frequency distribution of respondents based on their education is given below. As can be seen from the data in Table 2, 37.9% had a bachelor's degree, 47.9% a master's degree, and 14.5% a doctorate.

Table 2. Frequency distribution/respondents in terms of education

Education	Frequency	Cumulative frequency
Bachelor	37.9	37.9
Masters	47.6	85.5
P.H.D	14.5	100
Total	100	-

Research hypotheses

Three research hypotheses were enunciated as follows:

Hypothesis 1. Infrastructure reforms and changes resulting from the development of GIT have a positive and significant effect on improving the university's organizational performance.

Hypothesis 2. Reducing the costs of developing GIT has a positive and significant effect on improving the university's organizational performance.

Hypothesis 3. Reforms and changes in the management process resulting from the development of GIT have a positive and significant effect on improving the organizational performance of the university.

Operational measures of study variables

The proposed indicators are based on the model assumptions. These indicators are divided into three general categories, each includes its sub-categories, which are presented in detail below:

Table 3. Proposed indicators in the model of confirmatory structural equations

	Criteria	Sub-Criteria
1	Managerial	Culture building
2		Strategy
3		Education
4		Monitoring and performance evaluation
5	Product and process	Process reengineering
6		Design green products and services
7		Teleworking
8		Health, Safety, and Environment
9	Infrastructure	Datacenter management
10		Energy consumption management
11		virtualization
12		Intelligent information systems
13		Data integration
14	Performance	Reduce energy costs and maintain the system
15		Improving the quality of the environment and indoor air
16		Increase system efficiency

In the following, the structure of the proposed model in order to examine the importance of GIT in the KGUAT is presented:

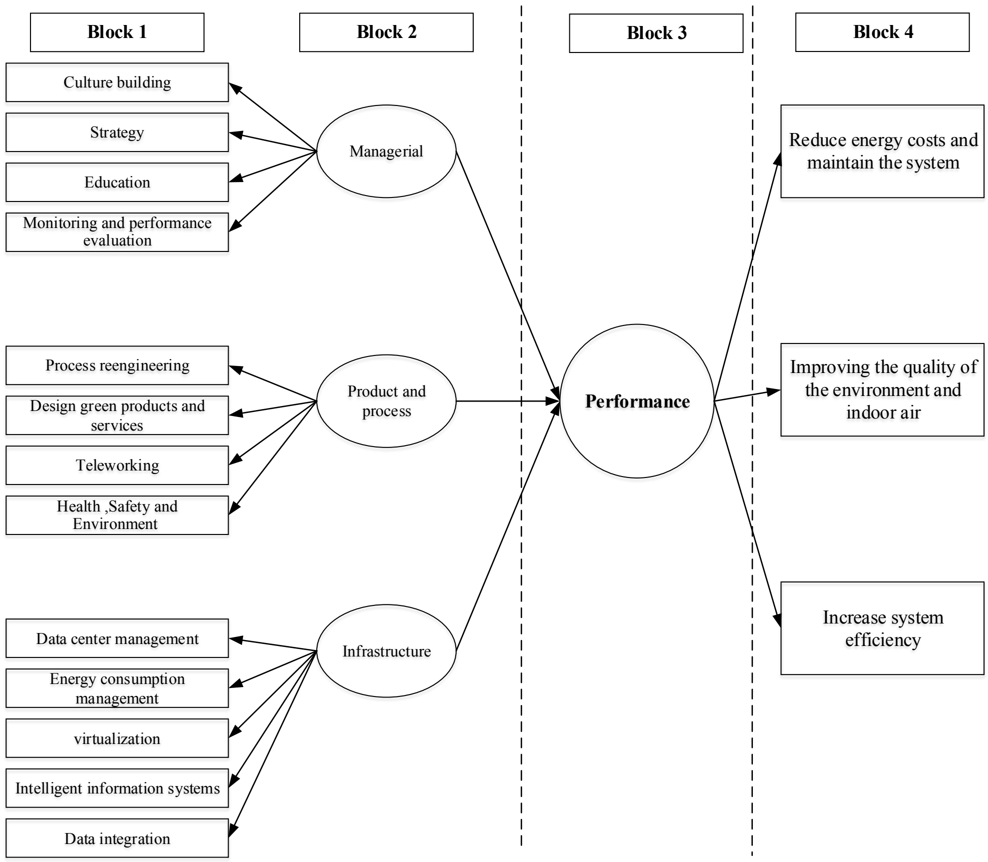

Figure 1. Structure of the proposed model

Data analyses

In Table 4, descriptive statistics can examine each of the research variables, including mean, standard deviation, maximum, minimum, skewness, and elongation.

Table 4. Descriptive statistics of research variables

Variable	Number	Min	Max	Mean	Standard deviation
Managerial	50	1.5	4.5	3.1	0.75424
Product and process	50	1	4.25	3.16	0.82493
Infrastructure	50	2	4.6	3.756	0.45766
Performance	50	2	5	3.64	0.75545

According to the table 4, it is clear that the highest average is relate to the variable of infrastructure factors with a value of 3.75 and the lowest average is relate to the variable of organizational factors with a value of 3.10.

In this part of the research, it is necessary to determine the normality of the distribution of variables. The one-sample Kolmogorov-Smirnov test compares the observed cumulative distribution function with a sequential variable's expected cumulative distribution function. If the data have a normal distribution, parametric statistics can be used and if the data do not have a normal distribution, non-parametric statistics can be used. The following statistical hypotheses have been proposed to perform this test:

H_0: Data is normally distributed.

H_1: Data is not normally distributed.

If the significance level of the research variables (Sig) is more significant than 0.05, the null hypothesis is confirmed, and the claim of normal distribution of the research variables is accepted.

Table 5. The significance level of Kolmogorov–Smirnov test for research variables

Variable	Significant amount	Normality status
Managerial	0.043	abnormal
Product and process	0.012	abnormal
Infrastructure	0.001	abnormal
Performance	0	abnormal

According to Table 5, the significance levels of all variables are less than 0.05. Therefore, the research variables do not have a normal distribution.

In performing factor analysis, one must first make sure that the research data can be reduced to several hidden factors. For this purpose, two tests, Kaiser-Meyer-Olkin (KMO) and Bartlett, are used. The KMO index examines the smallness of the partial correlation between variables. It thus determines whether the variance of the research variables is affected by the expected variance of some latent and fundamental factors. This index is in the range of zero to one, and values close to one indicate that the sample size data is appropriate. Three spectrums can be defined for this oscillation, and for each case, a decision can be gained whether or not to perform factor analysis:

- Values of 0.49 and less: Factor analysis is not recommended.
- Values 0.50 to 0.69: Factor analysis is recommended in case of data corrections.
- Values of 0.70 and above: Factor analysis is recommended.

The Bartlett test examines when the correlation matrix is mathematically known (identical and unit matrices). If the Bartlett test's significance level is less than 5%, factor analysis is suitable to identify the factor model because the assumption that the correlation matrix is unique is rejected. There is a significant relationship between the variables, and it is possible to discover the data structure.

Table 6 shows the KMO value, Bartlett statistic value, degree of freedom, and sig Bartlett test. Since the KMO index value is 0.731 (above 0.7), the number of samples is sufficient for factor analysis and path analysis with structural equation modeling. Also, Bartlett's sig value is less than 5%, which indicates a significant relationship between the variables, and factor analysis is appropriate to identify the structural model.

Table 6. KMO index and Bartlett test for sample adequacy

KMO	Bartlett's test	Degrees of freedom	Significance level
0.731	300.759	120	0

For this purpose, confirmatory factor analysis was performed on the items of the questionnaire. All questions have a factor load above 0.5 and significant values above 1.96 and accurately measure the variables predicted in the questionnaire. You can see the model for measuring research variables in two modes of significance and standard coefficients in the following.

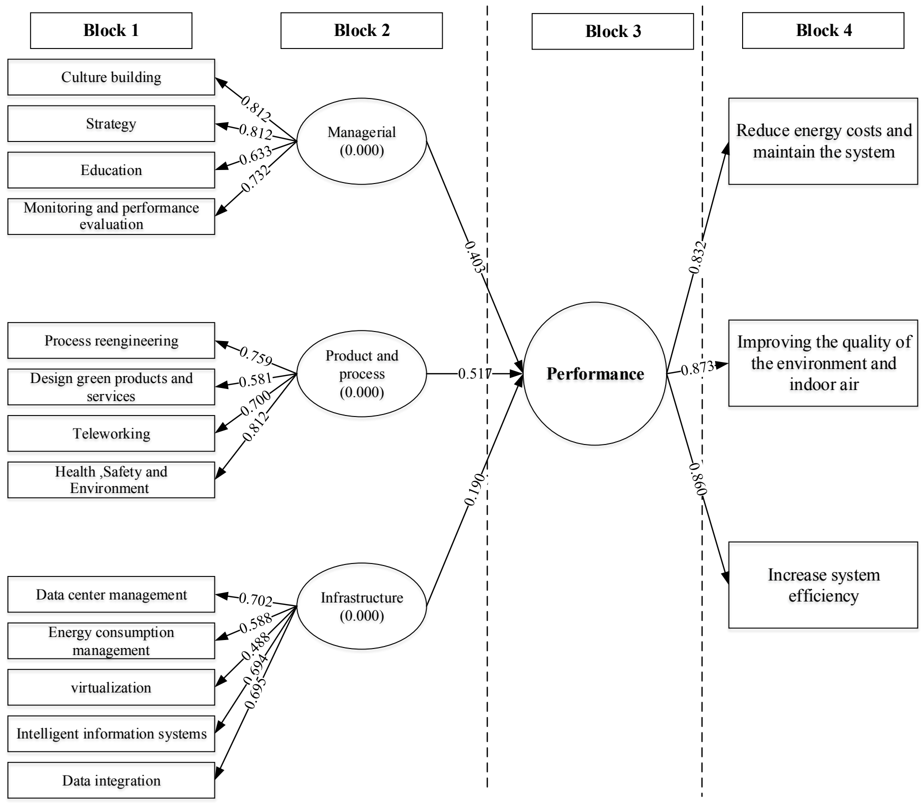

Figure 2. Standard measurement model

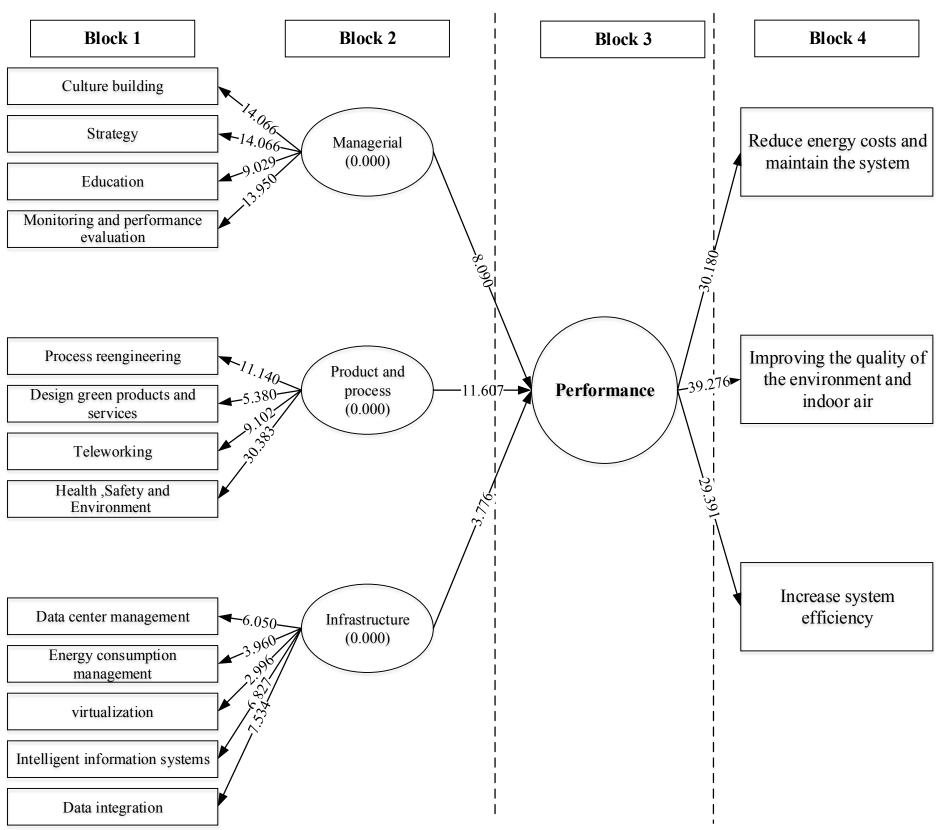

Figure 3. Measurement model in a significant state

Based on the values of Table 7, the calculated Average Variance Extracted (AVE) for all structures have the mean values of the extracted variance higher than 0.5, so the items explain more than 50% of the variance of their respective structures. The desirability of the values of this index indicates the existence of convergent validity in the tests used.

The correlation between the variables with the Spearman correlation method is presented in Table 8. According to Table 9, the items or markers of all structures have the highest factor load on their structure; That is, they have the least cross-loading on other structures. Some research suggests that each item's factor load on its structure should be at least 0.1 more than the same item's operating load on other structures (Schober et al., 2018). According to Table 8, the correlation between the structures is less than the square of the mean of the extracted variance of each structure, which shows that no two variables are completely correlated with each other, and the composition of the items is such that all structures are well separated from each other. Therefore, the measurement tool has a divergent validity.

Due to the confirmation of convergent and divergent validities, the measuring instrument has structural validity. On the other hand, all structures have combined reliability higher than 0.7. Therefore, there is an internal consistency between the indicators related to each variable.

Table 7. Measurement model parameters

Criteria	Sub-Criteria	Factor analysis	Significant amount	CR	Cronbach's alpha	AVE
Managerial	1	0.812	14.066	0.877	0.833	0.546
	2	0.633	9.029			
	3	0.812	14.066			
	4	0.732	13.95			
Product and process	5	0.812	30.383	0.937	0.916	0.75
	6	0.7	9.102			
	7	0.581	5.38			
	8	0.759	11.14			
Infrastructure	9	0.588	3.96	0.923	0.896	0.706
	10	448	2.996			
	11	0.694	6.827			
	12	0.695	7.534			
	13	0.702	6.05			
Performance	14	0.832	30180	0.817	0.703	0.53
	15	0.872	39.278			
	16	0.86	29.391			

In Table 9, regarding the relationship between research variables, it can be stated that:

- The significance level for variables that are less than 0.05 indicates a significant relationship between the two variables.
- The significance level for variables that are obtained more than 0.05 indicates that there is no significant relationship between the two variables.

Table 8. Correlation between variables by Spearman correlation method

Correlations					
		Managerial	Product and process	Infrastructure	Performance
Managerial	Correlation coefficient	1	0.574**	0.353*	0.539**
	Significance level		0	0.012	0
	No.	50	50	50	50
Product and process	Correlation coefficient	0.574**	1	0.219	0.392**
	Significance level	0	-	0.126	0.005
	No.	50	50	50	50
Infrastructure	Correlation coefficient	0.353*	0.219	1	0.520**
	Significance level	0.012	0.126	-	0
	No.	50	50	50	50
Performance	Correlation coefficient	0.593**	0.392**	0.520**	1
	Significance level	0	0.005	0	-
	No.	50	50	50	50

* Correlation is significant at the 0.05 level (2-tailed). ** Correlation is significant at the 0.01 level (2-tailed).

Table 9. Divergent validity

Criteria	Managerial	Infrastructure	Product and process	Performance
1	0.857	0.406	0.612	0.506
2	0.797	0.723	0.535	0.473
3	0.744	0.454	0.633	0.573
4	0.743	0.540	0.501	0.560
5	0.538	0.812	0.555	0.505
6	0.140	0.800	0.349	0.407
7	0.694	0.810	0.188	0.441
8	0.101	0.881	0.334	0.317
9	0.157	0.786	0.212	0.506
10	0.448	0.221	0.703	0.171
11	0.402	0.284	0.807	0.359
12	0.588	0.286	0.827	0.279
13	0.106	0.559	0.823	0.475
14	0.377	0.514	0.232	0.706
15	0.370	0.488	0.235	0.832
16	0.695	0.183	0.301	0.789

As shown in Table 10, the value of the goodness-of-fit index is 0.346, indicating an above-average overall fit for the structural model. It means the internal model has enough power to test the hypotheses, and the test results can be considered 100% statistically reliable. Also, the criterion

R^2 or coefficient of determination indicates the effect of exogenous variables on an endogenous variable. This criterion is calculated only for endogenous structures, and its value is zero for exogenous structures. The higher the coefficient of determination of a model, the better the fit of the model. Three values of 0.19, 0.33, and 0.67 have been introduced as criteria for weak, medium, and strong values.

Based on the model obtained from the test of research hypotheses, the confirmation or rejection of hypotheses is examined. To confirm or reject the hypotheses, the significance coefficient (t-statistic) is used. If the t-statistic is more than 1.96 or less than -1.96 (at the level of 5% error), the hypothesis is confirmed, and a significant relationship between the two hidden variables is obtained.

According to Table 11, the status of confirmation or rejection of each of the research hypotheses is examined. According to the table, it is clear that:

- Management factors positively and significantly affect performance as much as 40.3% (because the significant value of the t-statistic is greater than 1.96).
- Product and process factors as much as 51.7% have a positive and significant effect on efficiency (because the significant value of t-statistic is greater than 1.96).
- Infrastructural factors positively and significantly affect efficiency as much as 19.0% (because the significant value of the t-statistic is greater than 1.96).

Table 10. Calculation of internal model fit

Criteria	Communality	R^2
Managerial	0.76	-
Product and process	0.8	-
Infrastructure	0.83	-
Performance	0.89	0.85
Goodness of Fit index (GOF)	0.346	

Table 11. Results of partial least squares analysis for research hypotheses

Hypothesis	Path coefficient (Beta coefficient)	Significant amount
1. Management factors affect performance.	0.403	8.09
2. Product and process factors affect performance	0.517	11.607
3. Infrastructure factors affect performance.	0.19	3.77

Data adequacy analysis test was used to check the suitability of the data for factor analysis. In the next step, the normality of the variables was examined, and it was concluded that the variables were not normal. However, an SEM test was used to test the research hypotheses. The model results showed that the model's fit indices were all in the desired range and can be relied on by the model.

Conclusion

Large organizations such as universities face many challenges in green management and moving towards energy efficiency. Government subsidies, support schemes, and energy support budgets in these organizations in recent decades have led to an inadequate cultural foundation in the organizational force and insufficient attention to how to spend and pay attention to green management. In recent years, with the expansion of automation and electronics infrastructure in universities, electricity consumption has increased. On the other hand, the elimination of some subsidies and the increase in energy costs have forced universities and large organizations to reform their consumption patterns, create a culture of green management and reform their structure to reduce energy consumption.

Based on the model obtained from the test of research hypotheses, the hypotheses were confirmed or not. According to the management factors model results, 40.3% had a positive and significant effect on efficiency (because the value of t is more significant than 1.96). Also, 51.7% of product and process factors positively and significantly affected performance (due to being more prominent). Significance of t (from 1.96) and finally infrastructure factors had a 19.0% positive effect on efficiency (because the significance of t was more significant than 1.96).

Also, according to the model results, the value of the goodness-of-fit index is equal to 0.346, which indicates a high overall average fit for the structural model. The internal model has enough power to test hypotheses, and the test results can be considered 100% statistically reliable. Also, the criterion R2 or coefficient of determination indicates the effect of exogenous variables on an endogenous variable. This criterion is calculated only for endogenous structures, and in the case of exogenous structures, its value is zero. The higher the coefficient of determination of a model, the better the fit of the model. Three values of 0.19, 0.33, and 0.67 are introduced as criteria for weak, medium, and strong values. According to the results of management factors, product and process and infrastructure factors affect the efficiency of green management. In general, the model results showed that the model fit indices were all in the desired range, and the mode is reliable.

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