Presenting a Model of Intelligent Transportation Systems Considering the Energy Crisis and Sustainable Development

Seyyed Mohammad Gharibian Lavasani[1], Mohammadali Keramati[2*] Hossein Moinzad[3] , Azadeh Mehrani[4]

[1] Department of Technology Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.
[2] Department of Industrial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran(Corresponding Author).
[3] Department of Industrial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran.
[4] Department of Financial Management, Nowshahr Branch, Islamic Azad University, Nowshahr, Iran.

*** Corresponding author email address**: mohammadalikeramati@yahoo.com

Received: 2024-01-15 **Reviewed:** 2024-01-20 **Revised:** 2024-03-14 **Accepted:** 2024-03-20 **Published:** 2024-03-31

Abstract

The objective of this research was to identify and evaluate the model of intelligent transportation systems considering the energy crisis and sustainable development. The research was conducted in an exploratory and survey-based manner. In the qualitative section, the Delphi method was employed, while in the quantitative section, the Interpretive Structural Modeling (ISM) and Structural Equation Modeling (SEM) methods were used. In the qualitative section, as well as in the ISM method, the target population consisted of managers and experts in the field of transportation, from which 15 individuals were selected using the purposive sampling technique. The influential components of the model were identified through a literature review technique. First, the identified components were filtered and assessed using the Delphi technique. Subsequently, modeling was conducted using the Delphi method and ISM. The software used for this purpose included EXCEL and MICMAC. The quantitative population consisted of an unlimited number of employees from transportation companies, with 384 individuals selected as the sample based on Cochran's formula. Data analysis was performed using coding and path analysis based on a researcher-made questionnaire and qualitative analysis. To fit the proposed model, the structural equation modeling technique in SMARTPLS software was employed. According to the Delphi technique, the identified categories included: electronic network management, route management, environmental factors, transparency of regulations, trust management, technical infrastructure, information standardization, and daily transportation forecasting. These, along with the main research component, were analyzed by experts. Based on the interpretive structural model, a five-level model was identified.

Keywords: *Intelligent Transportation System, Energy Crisis, Sustainable Development.*

How to cite this article:

Gharibian Lavasani S.M, Keramati, M., Moinzad3, H., Mehrani, A. (2024). Presenting a Model of Intelligent Transportation Systems Considering the Energy Crisis and Sustainable Development. Management Strategies and Engineering Sciences, 6(1), 31-42.

1. Introduction

The Intelligent Transportation System (ITS) plays a vital role in sustainable development, as it utilizes advanced technologies such as the Internet of Things (IoT), Big Data, and Artificial Intelligence (AI) to improve the efficiency, safety, and sustainability of transportation systems. These systems provide real-time information to passengers and transportation managers, enabling better route planning, reducing traffic, and optimizing vehicle usage [1]. For instance, traffic management systems can adjust traffic signals based on traffic flow, reducing waiting times and subsequently lowering fuel consumption and greenhouse gas emissions [2-4].

Another critical aspect of ITS in sustainable development is improving road safety and reducing accidents. Using advanced sensors and cameras, ITS can continuously monitor road conditions and driver behavior, issuing necessary warnings when needed. These technologies also enable better coordination between vehicles and road infrastructure, allowing vehicles to move at appropriate speeds automatically, thus preventing accidents. Enhancing safety not only helps save lives but also reduces the costs associated with accidents [5].

ITS can also promote the use of clean vehicles and public transportation. By creating integrated transportation systems that include buses, trains, bicycles, and other public vehicles [6], the overuse of personal vehicles can be reduced, contributing to lower air pollution and urban traffic (Haghshenas et al., 2022). These systems, by providing accurate and up-to-date information to passengers, can facilitate travel planning, reduce waiting times, and enhance the travel experience. In this way, ITS acts as a comprehensive and sustainable solution for improving urban and intercity transportation systems, contributing to sustainable development [7].

Digital technologies are transforming contemporary life, including the energy and transportation sectors (Iftikhar et al., 2023). Digitalization is a key trend offering options for energy demand and carbon emission reductions, although there are concerns about whether the energy savings from networked digital devices can offset the energy consumption of the devices themselves. Digital technologies can also help shape next-generation transportation systems toward smart and sustainable design [8].

Intelligent transportation is undergoing rapid evolution today, with numerous applications featuring diverse functions being found in heterogeneous networks [9, 10]. In general, ITS today represents advanced research development that uses connectivity and automation to optimize mobility and deliver a wide range of transportation services. However, the increasing availability and affordability of ITS have heightened interest in smart energy management within these applications. It is estimated that ITS accounts for more than 40% of global energy consumption due to rising greenhouse gas emissions across the environment. However, with the continual evolution of modern computing and technology, transportation trends in the future may lead to increased exploitation of energy resources, potentially resulting in an energy crisis. Furthermore, the scope of ITS is rapidly changing due to the influence of intense competition and innovation [11].

A sustainable energy management system provides an ideal solution for ITS to effectively manage energy resources for various transportation-related activities in real-time. Achieving sustainable energy management goals across ITS is often time-consuming and requires further innovative research and exploration. Consequently, there is a growing need to develop sustainable energy management solutions from both market and environmental perspectives. Energy management has also become a crucial evaluation criterion when dealing with various aspects of ITS devices. Despite the increasing use of energy resources, global carbon dioxide emissions continue to rise gradually. In this context, the research aims to investigate a model of sustainable energy management practices for ITS applications [12].

With the growing demand for energy and the limitations of fossil resources, optimizing energy consumption in all sectors, including transportation, is more critical than ever. ITS, by utilizing modern technologies such as IoT, Big Data, and AI, can significantly reduce energy consumption in transportation [13]. These systems, through solutions like route optimization, traffic management, and the use of electric and hybrid vehicles, help reduce fossil fuel consumption and greenhouse gas emissions, which aligns with the goals of sustainable development [14].

The role of ITS in sustainable development is not only limited to improving efficiency and reducing energy consumption but is also connected to enhancing the quality of life for citizens and reducing the negative impacts of transportation on the environment [15, 16]. By reducing traffic, travel time, and increasing road safety, ITS reduces stress and increases individual satisfaction. Moreover, by reducing pollutant emissions and noise pollution, ITS can improve air quality and reduce noise in cities, which is crucial for public health and the environment. Ultimately, presenting a model for ITS as a comprehensive and sustainable solution helps develop transportation infrastructure and adopt advanced technologies. This model can serve as a blueprint for other cities and developing countries to move closer to achieving sustainable development goals. Through collaboration between governments, companies, and research institutions, the widespread development and implementation of ITS can be promoted, leveraging its benefits to improve energy crisis management and achieve sustainable development. Therefore, the research seeks to answer the question: What is the model of ITS considering the energy crisis and sustainable development?

2. Methodology

The research was conducted in an exploratory and survey-based manner. In the qualitative section, the Delphi method was utilized, while in the quantitative section, Interpretive Structural Modeling (ISM) and Structural Equation Modeling (SEM) methods were employed. In the qualitative section, as well as in the ISM method, the population under study consisted of managers and experts in the field of transportation management, and 19 participants were selected using a purposive sampling method. The influential components of the model were identified using a literature review technique. Initially, the identified components were filtered and assessed using the Delphi technique. Subsequently, modeling was performed using both the Delphi method and ISM. The software used included EXCEL and MICMAC. The quantitative population consisted of an unlimited number of employees from transportation companies, with a sample of 384 participants selected using Cochran's formula.

Based on a researcher-made questionnaire and qualitative analysis, data were analyzed using coding and path analysis. Data analysis was conducted using ISM and path analysis. ISM is a method for analyzing qualitative data commonly used in social sciences and management. In this method, various factors in a research phenomenon are identified through interviews or other qualitative sources. Then, using the interpretive structural method, the relationships between these factors are determined, and structural diagrams are created to display these relationships. This method allows for the analysis of complexities, relationships, and patterns within qualitative data. SEM, on the other hand, is a quantitative data analysis method used to examine the relationships between variables and to confirm or reject research hypotheses (Alizadeh & Nazarpour, 2023). This method employs statistical modeling to examine the relationships between variables and their impacts on each other. SEM enables the analysis of causal relationships resulting from the direct or indirect effects of variables and allows for hypothesis testing to confirm or reject the results of the analysis. To fit the proposed model, SEM techniques were used in SMARTPLS software.

3. Findings and Results

The qualitative section of this study was conducted based on the views of 15 managers and experts from the transportation industry and academic faculty members in transportation management. Regarding gender, 13 participants were male and 6 were female. Ultimately, 8 participants had between 10 and 15 years of work experience, and 11 participants had over 15 years of work experience.

In this study, a total of 9 main components were identified through the literature review. To ensure the validity of the identified dimensions and components and to answer the research questions, the Delphi technique was employed. The Delphi method was conducted as follows (Table 1).

Table 1. Delphi Analysis of Identified Components

Component	Symbol	Mean	Median	Mode	Standard Deviation	Range	1st Quartile	2nd Quartile	3rd Quartile	Status
Electronic Network Management	C1	3.325	3	4	0.747	2	3	3	4	Approved
Route Management	C2	3.488	4	4	0.735	3	3	4	4	Approved
Environmental Factors	C3	3.907	4	4	0.894	3	2	3	4	Approved
Transparency of Regulations	C4	3.930	3	3	0.768	2	2	3	4	Approved
Trust Management	C5	3.279	3	4	0.796	3	3	3	4	Approved
Technical Infrastructure	C6	3.558	4	4	0.628	2	3	4	4	Approved
Information Standardization	C7	3.465	4	4	0.735	2	3	4	4	Approved
Daily Transportation Forecasting	C8	3.441	4	4	0.665	2	3	4	4	Approved
ITS Considering Energy Crisis and Sustainable Development	C9	3.372	4	4	0.578	2	4	4	5	Approved

Kendall’s coefficient: 0.703, Significance level: 0.000, Degrees of freedom: 8.

Based on the results obtained from the Delphi technique, all components scored above 5. Therefore, no components were eliminated, and all were approved. The Kendall’s coefficient of 0.703 confirms the results, validating the first round of Delphi.

For further data analysis, ISM was used in the MICMAC software. ISM is a method for evaluating the effect of each variable on other variables. This design is a comprehensive approach to measure relationships and is used to develop the model’s framework, ensuring that the overall objectives of the research are achievable.

The first step in ISM is calculating the internal relationships of the indicators. Expert opinions are used to reflect the internal relationships among the indicators. The matrix obtained from this step shows which variables affect others and which are influenced by them. Typically, symbols such as those in Table 2 are used to identify the pattern of relationships between elements.

Table 2. Symbols Used to Indicate the Relationships of Identified Indicators

V	A	X	O
Variable i affects j	Variable j affects i	Mutual relationship	No relationship

The structural self-interaction matrix (SSIM) of dimensions and indicators is constructed and compared using the four conceptual relationships. The information obtained is summarized using the ISM method, and the final structural self-interaction matrix is created. Based on the symbols in Table 2, the structural self-interaction matrix is presented in Table 3.

Table 3. Structural Self-Interaction Matrix (SSIM)

Variable	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1		X	A	A	V	A	A	V	V
C2			A	A	V	A	A	V	V
C3				X	V	A	X	V	V
C4					V	A	X	V	V
C5						A	A	X	V
C6							V	V	V
C7								V	V
C8									V
C9									

The resulting matrix is transformed into a binary matrix (0 and 1). In the binary matrix, the main diagonal elements are set to 1. The received matrix using the ISM technique is presented in Table 4.

Table 4. Received Matrix of Identified Indicators

Variable	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	1	1	0	0	0	0	0	1	
C2	1	1	0	0	0	0	0	1	
C3	1	1	1	1	1	0	1	1	1
C4	1	1	1	1	1	0	1	1	1
C5	1	1	0	0	1	0	0	1	1
C6	1	1	1	1	1	1	1	1	1
C7	1	1	1	1	1	0	1	1	1
C8	1	1	0	0	1	0	0	1	1
C9	0	0	0	0	0	0	0	0	1

The method for obtaining the reachability matrix uses Euler’s theory, where the adjacency matrix is added to the identity matrix.

Table 5. Final Reachability Matrix of Identified Indicators

Variable	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	1	1	0	0	0	0	0	1	1
C2	1	1	0	0	0	0	0	1	1
C3	1	1	1	1	1	0	1	1	1
C4	1	1	1	1	1	0	1	1	1
C5	1	1	0	0	1	0	0	1	1
C6	1	1	1	1	1	1	1	1	1
C7	1	1	1	1	1	0	1	1	1
C8	1	1	0	0	1	0	0	1	1
C9	0	0	0	0	0	0	0	0	1

To determine the relationships and level categorization of the criteria, the set of outputs and inputs for each criterion must be extracted from the received matrix.

The reachability set (row elements, outputs, or impacts) includes variables that can be reached through this variable.

The antecedent set (column elements, inputs, or influences) includes variables through which this variable can be reached.

The output set includes the criterion itself and the criteria it influences. The input set includes the criterion itself and the criteria that influence it. Subsequently, the mutual relationships of the criteria are identified.

Table 6. Input and Output Sets (Impacts) for Each Variable

Component	Symbol	Input	Output
Electronic Network Management	C1	3	8
Route Management	C2	3	8
Environmental Factors	C3	8	4
Transparency of Regulations	C4	8	4
Trust Management	C5	3	8
Technical Infrastructure	C6	9	1
Information Standardization	C7	8	4
Daily Transportation Forecasting	C8	3	8
ITS Considering Energy Crisis and Sustainable Development	C9	9	1

For variable C_i, the reachability set (output or impacts) includes the variables that can be reached through C_i. The antecedent set (input or influences) includes the variables through which C_i can be reached. After determining the reachability and antecedent sets, the intersection of the two sets is calculated. The first variable for which the intersection equals the reachability set is categorized as the first level. Thus, the first-level elements have the most influence in the model. Once the level is determined, the criterion is removed from all sets, and the input and output sets are reformed to determine the next level.

Table 7. Determining the First Level in the ISM Hierarchy

Symbol	Input	Output	Intersection	Level
C1	C1-C2-C3-C4-C5-C6-C7-C8	C1-C2-C9	C1-C2	2
C2	C1-C2-C3-C4-C5-C6-C7-C8	C1-C2-C9	C1-C2	2
C3	C3-C4-C6-C7	C1-C2-C3-C4-C5-C7-C8-C9	C3-C4-C7	4
C4	C3-C4-C6-C7	C1-C2-C3-C4-C5-C7-C8-C9	C3-C4-C7	4
C5	C3-C4-C5-C6-C7-C8	C1-C2-C5-C8-C9	C5-C8	3
C6	C6	C1-C2-C3-C4-C5-C6-C7-C8-C9	C6	5
C7	C3-C4-C6-C7	C1-C2-C3-C4-C5-C7-C8-C9	C3-C4-C7	3
C8	C3-C4-C5-C6-C7-C8	C1-C2-C5-C8-C9	C5-C8	4
C9	C1-C2-C3-C4-C5-C6-C7-C8-C9	C9	C9	1

Thus, variable C6 is classified at level 5. After identifying the first-level variables, these variables are removed, and the input and output sets are recalculated without considering the first-level variables. The common set is then identified, and variables for which the intersection equals the input set are selected as second-level variables.

Variables C1-C2 are second-level variables.

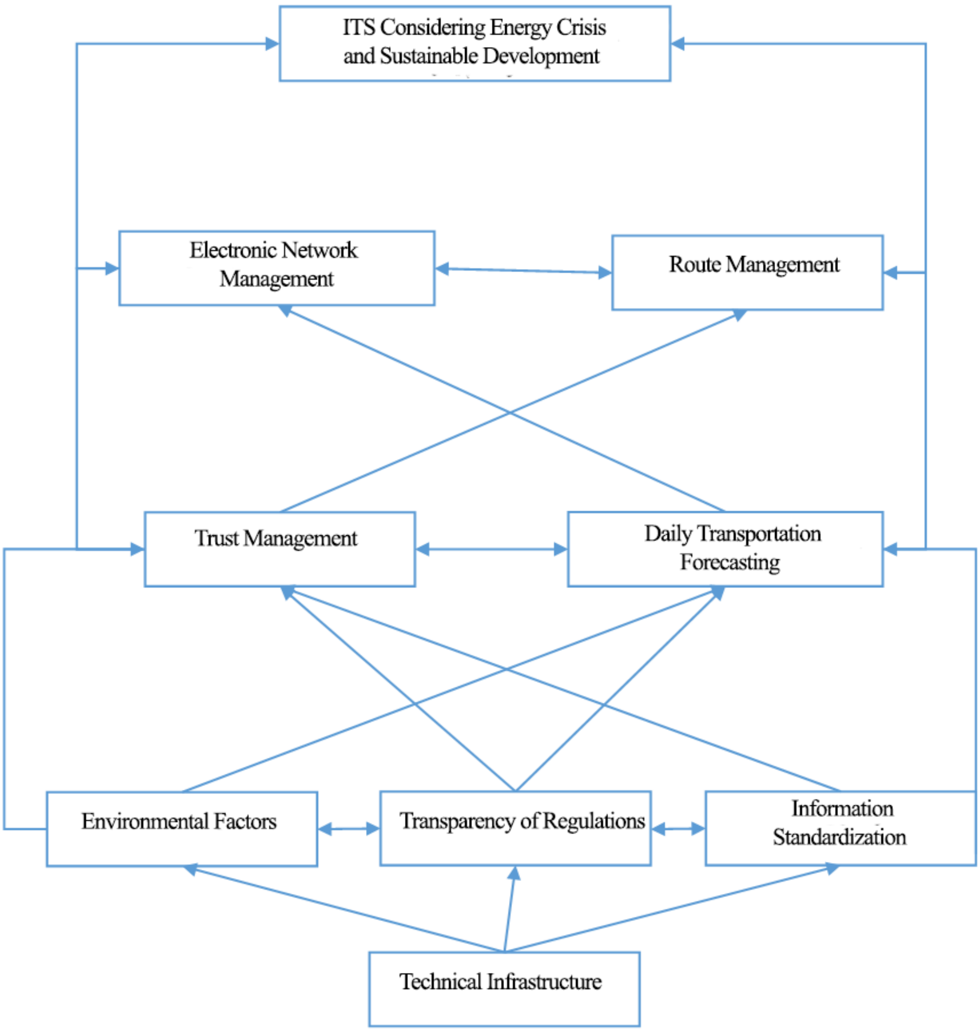
Variables C5-C8 are third-level variables.

Variables C3-C7 are fourth-level variables.

Variable C9 is the first-level variable.

The final hierarchy of the identified variables is presented in Figure 1. In Figure 1, only significant relationships between elements at each level and the underlying levels, as well as meaningful internal relationships within each row, are considered.

Figure 1. Structural Model of Intelligent Transportation System Considering Energy Crisis and Sustainable Development



Based on the calculations of the interpretive structural modeling (ISM), 9 categories were classified according to these concepts. Descriptive statistics of the identified criteria are shown in Table 8.

Table 8. Mean and Standard Deviation of the Model Components

Statistic	Variable	Mean	Skewness	Kurtosis	Variance	Minimum	Maximum
Electronic Network Management	3.6729	-0.496	0.314	0.339	2.75	5	
Route Management	4.2229	-0.625	-0.47	0.358	3	5	

Environmental Factors	4.0938	0.018	-0.032	0.192	2.75	5
Transparency of Regulations	3.8734	-0.883	0.163	0.465	2.5	5
Trust Management	3.7405	-0.301	-0.171	0.473	2	5
Technical Infrastructure	4.3938	-0.241	-0.621	0.302	3	5
Information Standardization	4.1	-0.938	0.134	0.319	3	5
Daily Transportation Forecasting	3.8397	0.273	-0.318	0.399	2	5
ITS Considering Energy Crisis and Sustainable Development	4.1542	-0.8	0.051	0.259	3	5

As seen in Table 8, the means, standard deviations, and the minimum and maximum values for the model components are shown separately. Given that each item is based on a five-point scale, the mean value for each item is considered to be 3. As can be observed, the means for all components are greater than 3, indicating a satisfactory level within the statistical population. Furthermore, since the skewness and kurtosis values for the variables fall within the range of (-2 to +2), it can be concluded that the data likely follows a normal distribution. Table 9 provides the convergent validity of the criteria based on Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE) indicators.

Table 9. Results of Cronbach’s Alpha, Composite Reliability, and Convergent Validity

Symbol	Components	Cronbach’s Alpha	AVE	CR
C1	Electronic Network Management	0.884	0.533	0.823
C2	Route Management	0.745	0.574	0.834
C3	Environmental Factors	0.758	0.601	0.774
C4	Transparency of Regulations	0.819	0.664	0.758
C5	Trust Management	0.849	0.645	0.784
C6	Technical Infrastructure	0.830	0.639	0.776
C7	Information Standardization	0.774	0.538	0.739
C8	Daily Transportation Forecasting	0.754	0.506	0.732
C9	ITS Considering Energy Crisis and Sustainable Development	0.823	0.733	0.813

Given that the appropriate values for Cronbach’s alpha are 0.7, for composite reliability (CR) 0.7, and for AVE 0.5, and according to the results in Table 10, all the criteria for the latent variables have acceptable values, confirming the reliability and convergent validity of the identified criteria.

To assess discriminant validity, Fornell-Larcker criteria were used, as shown in Table 10. Table 10 indicates the correlation of the latent constructs of the research model to assess the discriminant validity of the model.

Table 10. Correlation Coefficients of the Latent Constructs of the Research Model (for Confirming Discriminant Validity)

Variable	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	0.993								
C2	0.673	0.927							
C3	0.585	0.444	0.887						
C4	0.464	0.340	0.734	0.845					
C5	0.485	0.748	0.704	0.633	0.859				
C6	0.666	0.489	0.739	0.510	0.495	0.884			
C7	0.344	0.540	0.774	0.736	0.584	0.803	0.883		
C8	0.549	0.364	0.773	0.463	0.546	0.734	0.836	0.847	
C9	0.484	0.638	0.433	0.530	0.494	0.564	0.733	0.637	0.894

As seen in Table 10, the square root of AVE values is greater than the correlation of each construct with other constructs, meaning the correlation of the construct with its indicators is greater than its correlation with other constructs. Therefore, the discriminant validity of the latent constructs in the research model is confirmed.

Figure 2. Model Analysis in Terms of Significance Coefficients

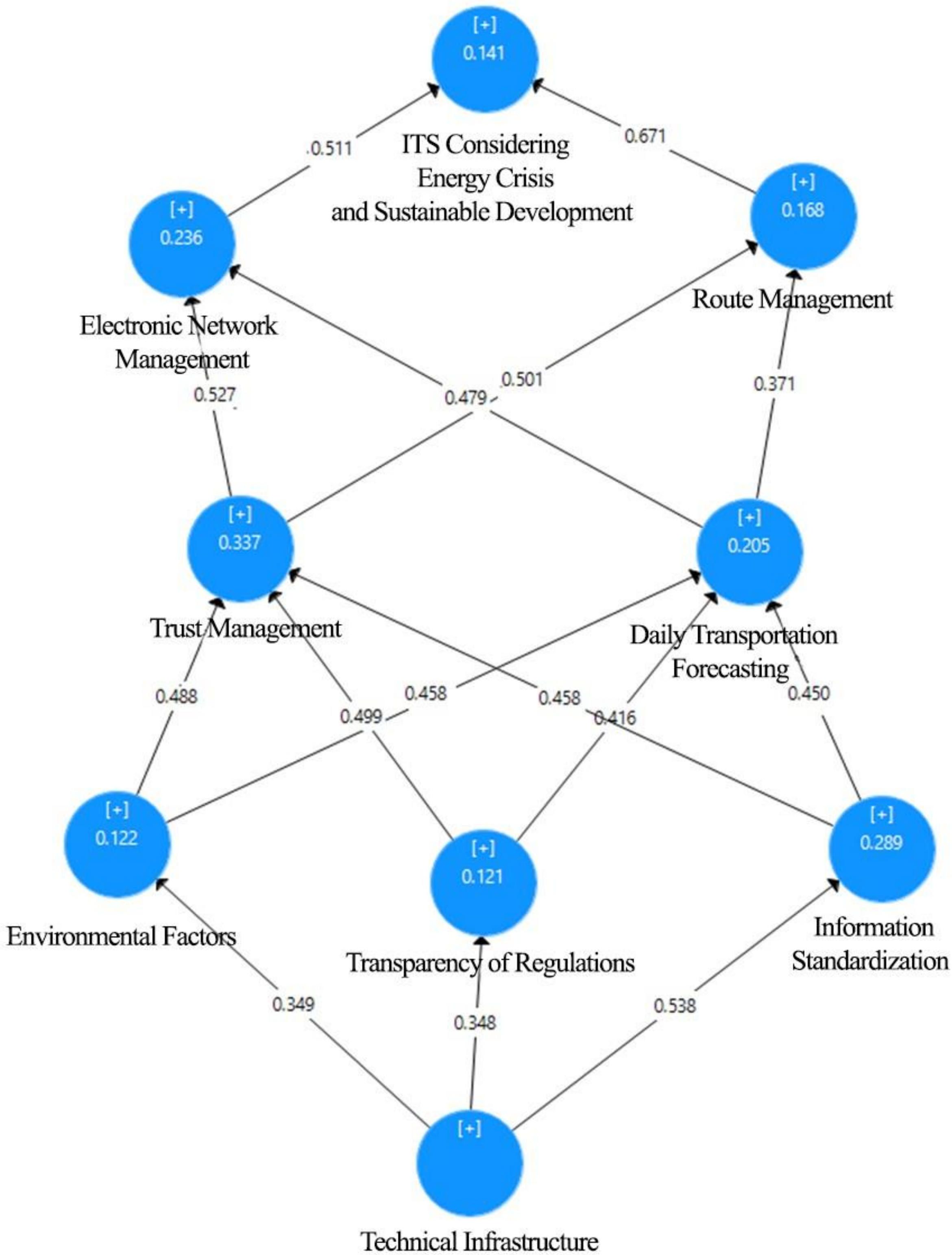


Figure 3. Model Analysis in Terms of t-statistic

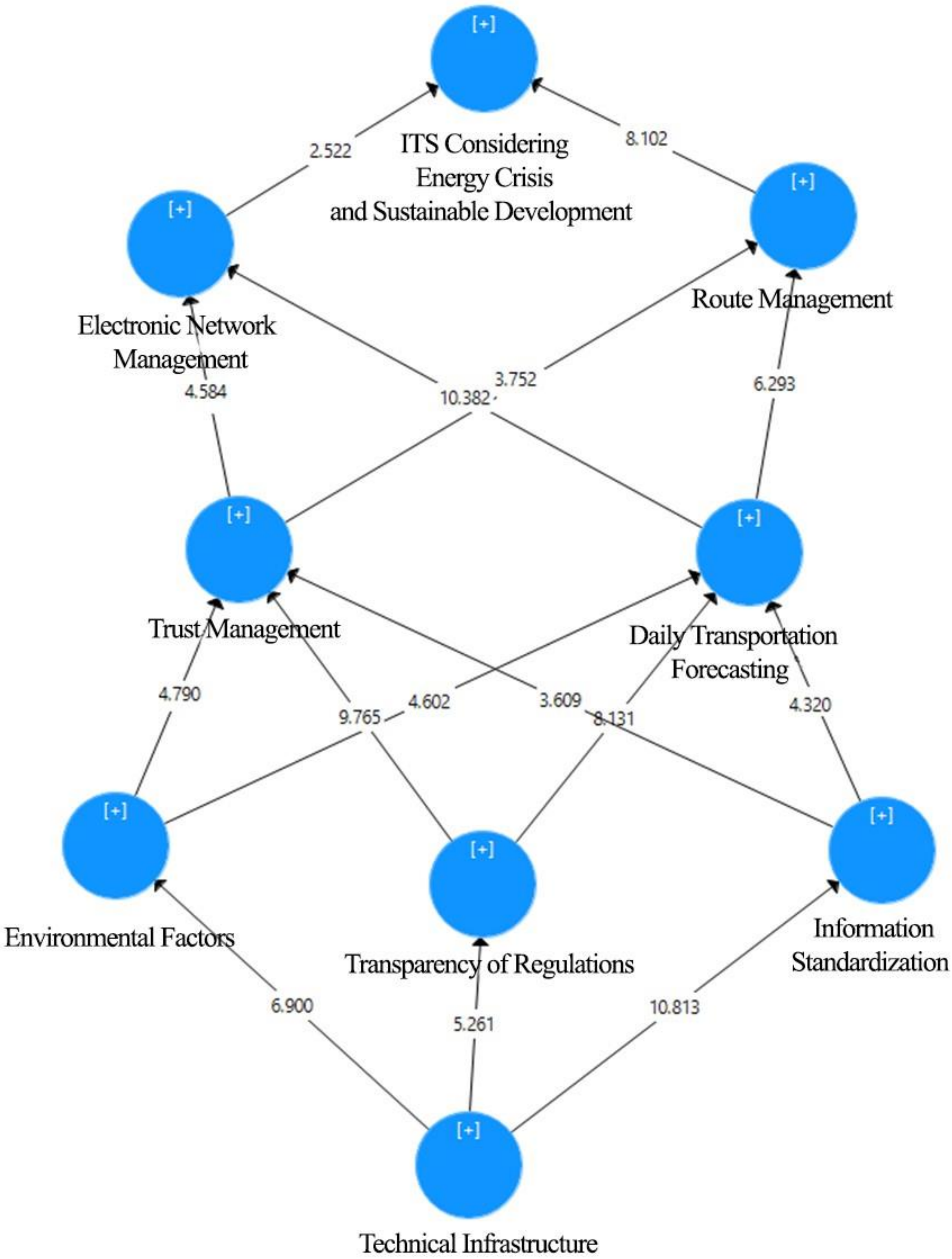


Table 11 shows the results of the factor loading coefficients for the dimensions and components of the variable.

Table 11. Results of Partial Least Squares Analysis of the Model Components

Path	Factor Loading	t-statistic	Status
Electronic Network Management → ITS Considering Energy Crisis and Sustainable Development	0.511	2.522	Confirmed
Route Management → ITS	0.671	8.102	Confirmed
Environmental Factors → Trust Management	0.488	4.790	Confirmed
Environmental Factors → Daily Transportation Forecasting	0.458	4.602	Confirmed
Transparency of Regulations → Trust Management	0.499	9.765	Confirmed
Transparency of Regulations → Daily Transportation Forecasting	0.416	8.131	Confirmed
Trust Management → Electronic Network Management	0.527	4.584	Confirmed
Trust Management → Route Management	0.501	3.752	Confirmed
Technical Infrastructure → Environmental Factors	0.349	6.900	Confirmed
Technical Infrastructure → Transparency of Regulations	0.348	5.261	Confirmed
Technical Infrastructure → Information Standardization	0.538	10.813	Confirmed
Information Standardization → Trust Management	0.458	4.320	Confirmed
Information Standardization → Daily Transportation Forecasting	0.450	3.609	Confirmed
Daily Transportation Forecasting → Electronic Network Management	0.479	10.382	Confirmed
Daily Transportation Forecasting → Route Management	0.371	6.293	Confirmed

According to the output of the PLS software and the significance levels for the confirmatory factor analysis of the indicators and components in Table 7, all factors had appropriate factor loadings, and their relationships with the latent variable were confirmed (the significance levels for all questions were below 0.05). Moreover, the fit of the structural model was evaluated using t-values, which must exceed 1.96 to confirm their significance at the 95% confidence level. As shown in Table 11, all t-values exceeded 1.96, confirming the significance of all questions and relationships between variables at the 95% confidence level.

4. Discussion and Conclusion

The aim of the present study was to propose a model of an intelligent transportation system (ITS) considering the energy crisis and sustainable development. Eight identified components (the identified categories are: electronic network management, route management, environmental factors, transparency of regulations, trust management, technical infrastructure, information standardization, and daily transportation forecasting) along with the main component of the study were analyzed by experts.

In an ITS, electronic network management refers to the application of information and communication technologies to improve the performance and efficiency of the transportation network. This includes using smart systems such as sensors, cameras, and communication systems to collect and exchange data. Through this, information regarding traffic conditions, routes, and energy consumption can be gathered and used to enhance network performance and optimize energy resource management.

Route management in an ITS involves optimizing transportation routes. This includes using algorithms and smart systems to predict and prevent traffic, optimize various routes, and reduce travel time and fuel consumption. With this approach, energy efficiency can be improved, while providing more flexibility in transportation routes.

In an ITS, environmental factors play a crucial role. This involves reducing air pollution, lowering fuel consumption, using renewable energy sources, and managing waste. By utilizing advanced technologies and appropriate management approaches, the negative impacts of the transportation system on the environment can be reduced, contributing to sustainable development.

In an ITS, transparency of regulations means providing access to complete and comprehensible information regarding transportation-related laws and regulations. This includes laws related to energy consumption, the use of natural resources, support for sustainable development, and similar topics. Ensuring transparency allows individuals and companies to make the best decisions regarding sustainable and efficient transportation methods based on accurate and reliable information.

In an ITS, trust management is the most important element for creating coordination and cooperation between individuals and organizations. By establishing trust among transportation companies, smarter, more efficient, and more effective journeys are possible. This trust can be ensured through securing information, respecting intellectual and physical property rights, fulfilling contractual obligations, and similar actions.

Technical infrastructure includes all the technologies, networks, and equipment necessary for the optimal performance of the ITS. This includes GPS systems, advanced communication networks, artificial intelligence systems for traffic prediction and route optimization, clean energy technologies, and similar elements. Enhancing and improving the technical infrastructure improves the performance and efficiency of the ITS, leading to reduced energy consumption and increased resource sustainability.

Information standardization in an ITS is fundamental for improving efficiency, increasing safety, and reducing energy consumption in the transportation sector. These standards include formats, protocols, and shared approaches for exchanging information between various transportation modes and smart systems. By using appropriate standards, information regarding traffic, possible routes, weather conditions, and other factors affecting transportation can be collected, processed, and transmitted in a coordinated manner. These standardized data can aid in improving the prediction of daily transportation conditions. Moreover, by analyzing standardized data, traffic patterns, energy needs, and pollution levels can be predicted, thus improving traffic management, energy use, and pollution control. These actions clearly contribute to sustainable development, increasing efficiency, and reducing the negative impacts of transportation on the environment.

An ITS, considering the energy crisis and sustainable development, offers numerous opportunities for optimizing resource management and reducing energy consumption. Among these opportunities is the use of information standards and daily transportation forecasting, which, through the collection, processing, and transmission of traffic, route, and weather data, enables more intelligent planning and efficient management in the transportation system.

By leveraging these standardized data, traffic patterns can be analyzed, and solutions such as increasing the use of public transportation, managing traffic, and using sustainable vehicles can be proposed. These actions improve citizens' quality of life, reduce traffic congestion, and lower energy consumption and air pollution. Additionally, these approaches and technologies contribute to sustainable development and clearly have a positive impact on reducing the negative effects of transportation on the environment.

Overall, an ITS that utilizes information standards and daily transportation forecasting provides a valuable solution for optimal resource management, increasing efficiency, and preserving the environment. This system creates a coordinated and intelligent mechanism for urban and intercity transportation, significantly contributing to improving the quality of life, enhancing safety, and reducing the negative impacts of transportation on the environment. An ITS, considering the energy crisis and sustainable development, can have a substantial impact. Below are several practical suggestions for improving this system in this regard:

- The ITS can leverage renewable energy sources such as wind, solar, and marine energy. This will reduce reliance on non-renewable energy sources and lower air pollution.
- Encouraging the use of zero-emission vehicles, such as electric cars or sustainable public transportation options like electric trains and hydrogen buses, can have a positive impact on reducing air pollution.
- Promoting car-sharing systems, including rental cars, ride-sharing, and on-demand services, can help reduce the number of vehicles in use, thereby lowering traffic and fuel consumption.
- Using smart transportation technologies to optimize routes and avoid unnecessary traffic and inefficient fuel consumption can improve energy efficiency and reduce air pollution.
- Investing in direct infrastructure for ITS, including electric vehicle charging stations and modern public transportation hubs, can increase the efficiency and accessibility of these systems.
- Offering incentives and discounts for using public transportation and promoting it as a sustainable and cost-effective option can reduce road traffic and help decrease fuel consumption and air pollution.
- Investing in research and development of innovative technologies to improve vehicle efficiency and reduce energy consumption, developing new technologies such as smart and automated vehicles, and enhancing ITS infrastructure can promote sustainable development.

Authors' Contributions

Authors equally contributed to this article.

Acknowledgments

Authors thank all participants who participate in this study.

Declaration of Interest

The authors report no conflict of interest.

Funding

According to the authors, this article has no financial support.

Ethical Considerations

All procedures performed in this study were under the ethical standards.

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