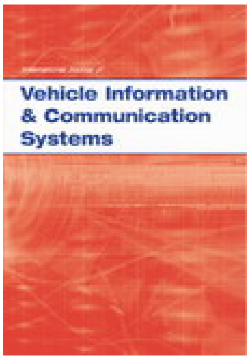

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Exploring the impact of e-transportation system on social, economic, and environmental development: moderation of information and communication technologies

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Exploring the impact of e-transportation system on social, economic, and environmental development: moderation of information and communication technologies

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Abstract: E-Transportation Systems (e-TS) offer crucial solutions for reducing carbon emissions, alleviating traffic congestion and enhancing energy efficiency. However, Information and Communication Technologies (ICTs) are vital for e-TS that eventually facilitate real-time data exchange among vehicles, infrastructure and users. This study particularly investigates the nexus among e-TS and sustainable development (i.e., social, economic and environmental development) along with moderation of evolving technologies in e-TS (e.g., vehicle-to-vehicle, vehicle-to-infrastructure, global positioning system, intelligent transportation systems, smart grid technologies and IoTs). Using a sample of seven hundred and sixty-six (N = 766) responses, this study found several insights into e-transportation systems. First, the study found the positive connections between e-TS and sustainable development in terms of three streams. Second, the study found a positive moderation of ICTs between e-TS and sustainable development. The study provides insights into e-TS and ICTs how integrations of these capabilities may improve social, economic and environmental development.

Keywords: e-transportation system; information and communication technologies; social development; economic development; environmental development; structure equation modelling.

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Biographical notes: Guang Shao studied in School of Management at Zhengzhou University (2002 to 2006) and received his Bachelor's degree in 2006. From 2006 to 2008, he studied at Fort Hays State University and received his Master's degree in 2008. Currently, he works in Henan Institute of Economics and Trade. He has published 18 papers. His research interests include economics and management.

1 Introduction

E-transportation system utilises electrically powered vehicles and infrastructure for sustainable mobility (Baronti et al., 2016; Chen and Weng, 2024). It involves electric vehicles, buses, bikes and scooters with charging stations and smart grid gadgets as their underpinnings. The target of this method is to trim off carbon emissions, fuel consumption and the environmental disturbances arising from the traditional transport system (Baronti et al., 2018). The e-transportation system as one of the most important factors influencing eco-friendliness and green mobility. For instance, through the use of EVs that are powered by renewable sources of energy, this significantly contributes to reducing greenhouse gas emissions, both climate change and air pollution that pose great challenges to our planet. In addition to this, it displaces traditional finite fossil fuels, contributing to energy security (Cejudo et al., 2024). The extensive EVs usage in mass transit leads to the innovation of technology, stimulates economic growth via jobs and improves public health with breakdown of dangerous pollutants, eventually creating a robust and intelligent transportation infrastructure (Weldon et al., 2016). E-transport system is a driver of social development since it puts a lot of emphasis on accessibility and equity in transportation. This ensures that people from low-income groups are able to afford and reach hospitals, working and learning places as well as other such facilities. Also, it decreases noise pollution, consequently it is quieter and more relaxed areas in cities which make great places for socialising and adapting to better living conditions (Carlsson and Johansson-Stenman, 2003).

The e-transportation system opens up new career opportunities for research and development of electric cars, including infrastructure development and renewable energy (Baronti et al., 2016). It diminishes the energy sector's import dependence, at the same time, enhancing energy security and releasing financial resources to develop other sectors, ultimately leading to overall economic growth and sustainability. It should be noted that electronic transportation system has a significant role in the development of environment when it is examined from the point of view of reducing of greenhouse gas emissions and air pollutants related with the traditional transportations. This shift to using electric cars that are powered by renewable energy sources contributes both to lowering global warming and reducing ecosystem degradation by cutting down the carbon emissions (Aijaz and Ahmad, 2022). Additionally, these standards for air quality aim to save natural resources and bring about the diversification of energy, thus producing higher quality air that the future generations can utilise it. Nevertheless, ICT which means Information and Communication Technologies cover the whole spectrum of technologies that are used for communication, data processing and information dissemination (Giannopoulos, 2004). It involves networks, information technologies, computers, software applications and digital platforms. Information and communication technologies are regarded as a critical tool of exchanging information as well as communication across various tools and networks. ICTs are key in this scenario of e-transportation optimisation (Heeks, 2010; Agrawal and Paulus, 2020). They allow for in real time collection of data and analysis that is required by efficient traffic management, route planning as well as electric vehicle charging infrastructure. ICTs act as an interlingual link between vehicles, infrastructure and users, thus improving safety and user experience through features like vehicle autonomy and vehicle-to-vehicle communication (Mnassri et al., 2024). Further, they also facilitate the smart grid integration, which allows for energy management and optimisation, therefore getting the maximum environmental and economic advantages of e-transportation systems (Qayyum et al., 2024; Bansal, 2005). Thus, where more research will be conducted on e-transportation systems, challenges including technological, infrastructural and policy-related ones will be addressed (Aijaz and Ahmad, 2022; Baronti et al., 2016). It not only facilitates better and greener (more efficient and sustainable) solutions but also takes care of the development of battery technology, infrastructure optimisation and policy frameworks. Undeniably, the further research is fundamental to potential gains, overcome barriers and eventually adoption of the technology.

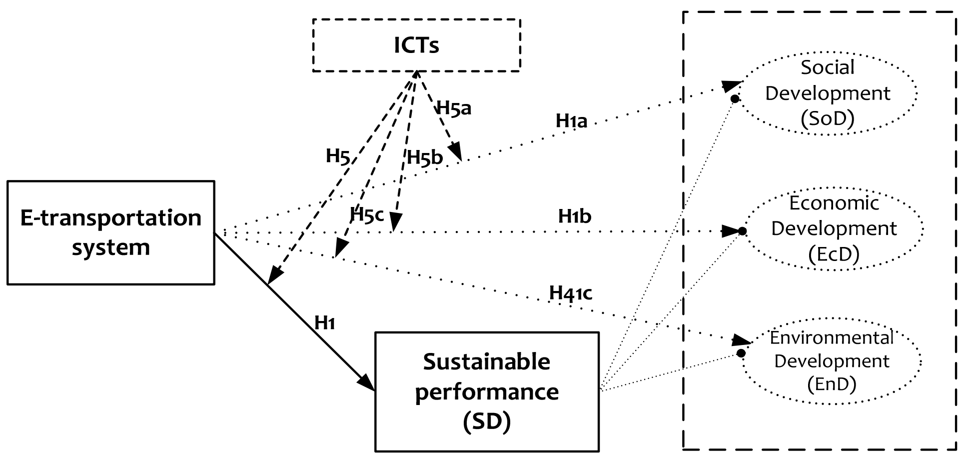
Additionally, there is a necessity for research to be done more on e-transports systems as the helps in the identification and implementation of unique solutions which help in the reduction of environmental consequences (Hamza-Lup et al., 2007). Research can result in the appearance of new types of batteries and charging stations, as well as the development of the technology for managing energy, what, eventually, will contribute to the progress and comprehensive use of e-transportation (Karneddi and Ronanki, 2022). Besides, it is a factor of analysing the short-run economic circumstances of changing to electric mobility, which in turn shapes the policies and strategies that promote the sustainable transportation, leaving the world a bit greener and stronger (Kolhe et al., 2024). Likewise, to carry out more research on ICTs in the context of e-transportation systems is crucial for optimising communication, data management and system integration (Mohanta et al., 2022). It can lead to advancements in vehicle-to-infrastructure communication, smart grid integration and cybersecurity measures, enhancing the efficiency, safety and sustainability of e-transportation networks. China now has the most population in the world. China's switch to e-transportation is a strategy to decrease pollution and dependence on fossil fuels and accordingly attain the goal of green development (Hamza-Lup et al., 2007; Du et al., 2017). Through investments in the electric's vehicle, this rapid charging infrastructure and the renewable energy the economy will go through technological innovation and development. Transitioning to e-transportation supports China's commitment to sustainability while addressing urban congestion and air quality concerns (Du et al., 2017). Based on such a massive significance about e-Transportation System (e-TS), sustainable development (i.e., social, economic and environmental development) and ICTs, this study currently attempts to meet certain objectives based on Chinese market as follows.

First, the study examines the linkage between the e-Transportation Supports (e-TS) to the sustainable development which means social, economic and sustainable development. Second, the study investigates the role of ICTs as a moderator between the relationships of e-TS and sustainable development, in that order. From the following section's schedules below, one can see the framework of this study: The following outlines underpinned the structure of this study. In the early part of the study, definitions with regard to theory and hypothesis are given. In the next segment of this paper, the tools employed were provided, through the sampling, as well as data obtaining and analysis procedures. There are significant findings regarding the effects and applications of the system provided in the study. The last sections of the blessed essay are limitations and future work on the topic at hand.

2 Literature review

The Theory of Technology Acceptance (TAM) is a psychological approach to explore and explain human behaviour response to technology innovation (Momani and Jamous, 2017). Such model points to the distinctive significance of usefulness and simplicity in an individual's intention to use the technology, correcting on whether such technology will be adopted or actually used within a certain context (Marangunić and Granić, 2015). TAM models constitute a pivotal factor in the field of information system research giving a systematic structure providing an opportunity for the evaluation of users' response to a new technical device. Recognition of influential factors of adoption that determine perceived usefulness and also should guide, development efforts and implementation strategies effectively is possible for researchers (Alomary and Woollard, 2015). The TAM model puts an emphasis on empirical studies because it gives hypotheses an underpinning for examining how people adopt new technologies (Marangunić and Granić, 2015; Taherdoost, 2018; Mishra and Singh, 2020). Researchers will verify the model and provide valuable information to improve it by comparing it with data. The model will show which factors could constitute adoption drivers for a particular region, as seen on Figure 1.

Figure 1 Research model



The concept has been adopted by different fields from information systems, marketing, healthcare, education and technology which all focus on the acceptance and adoption of technologies including mobile apps, e-commerce platforms and educational software (Marangunić and Granić, 2015). The results of these researches have validated the predictive power of TAM and also have majored in the factors influencing technology adoption, thus propelling the development of respective disciplines (Marangunić and Granić, 2015; Momani and Jamous, 2017). The TAM model stands as a pillar on which technologies are accepted, by highlighting the relevance of perceived usefulness and ease of adapting to the technology (Chuttur, 2009). It is of great help to researchers and practitioners in developing the assessment framework for attitudes and behaviours of users.

2.1 Hypotheses development

The development of the hypotheses section is also discussed that highlighting the nexus among e-transportation supports (e-TS) toward sustainable development (e.g., social, economic and environmental development) that is mediated via information and communication technology.

2.2 E-transportation system (e-TS) and sustainable development (SD)

The e-transportation system holds pivotal importance in fostering sustainable development by significantly reducing greenhouse gas emissions and dependence on fossil fuels (Aijaz and Ahmad, 2022; Baronti et al., 2016). Through advancements in Electric Vehicles (EVs) and associated infrastructure, such as charging stations powered by renewable energy sources, e-transportation mitigates air pollution, conserves natural resources and promotes energy efficiency (Aijaz and Ahmad, 2022; Chen and Weng, 2024; Harasis et al., 2024). Embracing this technology not only addresses environmental concerns but also contributes to economic growth, innovation and a healthier, more resilient society, aligning with the goals of sustainable development (Hamza-Lup et al., 2007). E-mobilisation systems like Electric Vehicles (EVs), release less emissions than conventional cars that run on internal combustion engine (Dasari, 2020; Ba et al., 2023). Such decrease in greenhouse gas emissions will assist the fight against climate change and improve air quality consequently contributing to environment protection (Johnson et al., 2007). The electrical vehicles are closer in conversion of the stored energy to the consumption and therefore are more energy-efficient than the traditional cars (Hamza-Lup et al., 2007). This increased efficiency leads to reduced energy consumption and reliance on fossil fuels, promoting energy sustainability. E-transportation systems often utilise renewable energy sources, such as solar or wind power, for charging electric vehicles (Baronti et al., 2016). By tapping into renewable energy, e-transportation helps conserve finite resources and reduces dependence on non-renewable energy sources, enhancing resource sustainability. The silence which electric vehicles add up to the already existing ambient noise, noise pollution in urban environments is reduced. Therefore, the reduction of noise levels inspiring better environment created under this social sustainability goals (Baronti et al., 2016; Jadhav and Kokate, 2022). However, engineering E-transportation system involves the implementation of charging infrastructure. Investing in charging stations and related infrastructure creates jobs, stimulates economic growth and supports local communities, contributing to economic sustainability (Tepe et al., 2023). E-transportation encourages sustainable urban planning and design practices by prioritising pedestrian-friendly infrastructure, bike lanes and public transportation alongside electric vehicle adoption (Aijaz and Ahmad, 2022; Baronti et al., 2016). This integrated approach to urban development promotes healthier, more liveable cities and supports sustainable communities (Yong et al., 2015). Hence, e-transportation systems play a crucial role in advancing sustainable development by reducing emissions, promoting energy efficiency, conserving resources, fostering innovation, enhancing equity and access and shaping more sustainable urban environments (Kolhe et al., 2024). These interconnected benefits highlight the integral relationship between e-transportation and sustainable development goals (Akib et al., 2022). Hence, with consideration of above précised discussion on e-TS and sustainable development (i.e., social, economic and environmental development), the author presently aim to execute the following hypotheses for empirical evidence within the market of China:

H1: e-transportation system is positively correlated with sustainable development.

H1a: e-transportation system is positively correlated with the social aspect of sustainable development.

H1b: e-transportation system is positively correlated with economic aspect of sustainable development.

H1c: e-transportation system is positively correlated with the environmental aspect of sustainable development.

2.3 Moderation of ICTs (information and communication technologies)

Information and Communication Technologies (ICTs) are vital for modern society, facilitating communication, access to information, and economic development (Heeks, 2010). They improve education, healthcare and general business productivity (Mase, 2012). ICTs are a means to minimise gaps, and give people power and also innovativeness (ElGhanam et al., 2021). This is a very important issue in shaping today's and tomorrow's interconnected world (ElGhanam et al., 2021; Heeks, 2010). Information and Communication Technologies (ICTs) exert a moderating influence on the relationship between e-transportation and sustainable development due to their capacity to collect, present and manage data effectively (Day et al., 2012; Srivastava and Panigrahi, 2019). ICTs suggest ways to do e-transportation efficiently and also reduce the amount of energy used and emissions that go into air which in turn helps to promote environmental sustainability (Srivastava and Panigrahi, 2019). Furthermore, ICTs provide accessibility and equity of e-transport for the population, which is a means to achieve durable social and economic prosperity (Baronti et al., 2016; Day et al., 2012). Information and communication technologies have been instrumental in optimising e-transportation efficiency by exploiting resources rationally with the aim of minimising traffic and environmental pollution (Higón et al., 2017). Real-time data collection, analysis and communication through ICT to include better traffic management, route planning and vehicle coordination, is therefore, the key to ensuring full utilisation of the e-transportation infrastructure (Ehrmann and Fratzscher, 2005). The digital technologies support the provision of e-mobility services, mainly through the establishment of cabs in the undeserved areas which indirectly enhances social equity and inclusivity (Heeks, 2010; Liu et al., 2005). The integration of ICTs into e-transportation systems provides for renewable energy sources, smart grids technology and energy-efficient practices (Aijaz and Ahmad, 2022). The ICTs contribute to reduction of carbon emissions and environmental pollution (Asongu et al., 2018; Higón et al., 2017).

ICT applications, for instance, smart charging infrastructure and vehicle-to-grid communication, as well as energy management systems, can contribute to the realisation of the main objectives (Vrkljan and Miller-Polgar, 2005). ICTs assist empirical policymaking and governance frameworks of e-transport systems, the policymakers use indicators of performance, policy analysis and stakeholders' engagement to get their policy decisions accepted (Ben-Yehuda and Wiseman, 2013). It is stated that by providing data analytics tools, simulation models and participatory platforms, ICTs enhance the transparency, accountability and responsiveness of governance structures, fostering collaborative efforts towards sustainable development goals in the transportation sector (Shanmugasundaram et al., 2019). ICTs serve as powerful tools for raising awareness about sustainable transportation practices and encouraging behavioural change among individuals and organisations (Asongu et al., 2018; Day et al., 2012). Through social media platforms, mobile applications and online communities, ICTs facilitate the dissemination of information about the environmental and social benefits of e-transportation, incentivising individuals to adopt sustainable commuting habits and choose eco-friendly transportation options (Asongu et al., 2018; Higón et al., 2017). ICTs enable the collection, processing and analysis of vast amounts of data generated by e-transportation systems (Baronti et al., 2016). Hence, with consideration of above précised discussion on ICTs, e-transportation and sustainable development, this study presently aims to execute the following hypotheses for empirical evidence within the market of China:

H2: ICTs positively moderate the relationships between e-transportation systems and sustainable development

H2a: ICTs positively moderate the relationships between e-transportation systems and social aspect of sustainable development

H2b: ICTs positively moderate the relationships between e-transportation systems and economic aspect of sustainable development

H2c: ICTs positively moderate the relationships between e-transportation systems and environmental aspect of sustainable development

3 Methodologies

On the present instant, the author utilised random distribution of the questionnaire among a total of 1200 participants within market of China. According to researchers, random sampling is one of the productive techniques for data collection in which participants have equal opportunities to receive the questionnaire. Thus, for the purpose of achieving primary data, having taken appointments online, the author personally visits the participants' locations along with dispersion of the questionnaires offered. Such tools as e-mail forwarding and forwarding of the links through WeChat application were also employed (Van Selm and Jankowski, 2006; Omer et al., 2016). It also needs to note that this application is predominantly used in the Chinese marketplace, and many specialists already employed similar applications in their data collection (Wang et al., 2021). In China specifically, this application is regarded as the most suitable and efficient method of collecting information (Wang et al., 2021). Further, this application enables the researcher to focus on respondents from various geographical locations and handle responsiveness (Wang et al., 2021). For this reason, in the context of this research both traditional and online methods of data collections including use of surveys with an aim of gaining quick responses were adopted.

In addition, a seven-point scale (Likert) was adopted to record the response and this scale was utilised owing to certain reasons such as fellows. This scale allows the researchers to obtain data from the target audience which has higher level of accuracy in data collection (Rehman et al., 2023; Zakir et al., 2022; Wei et al., 2019). It offers a balanced range of response options, allowing for more nuanced and precise data interpretation. This scale minimises response bias and provides statistical validity by offering greater insights into respondents' attitudes and opinions. From the selected sample size, the author got back ten hundred and eleven questionnaires. In addition, after removing improperly handled questionnaires, the author finally used a total of 766 surveys (*N*=766) as reported in below Table 1.

Table 1 Descriptive information

	Male		*Female*	
	Freq.	*%*	*Freq.*	*%*
Gender	418	54.57	348	45.43
Education of the participants				
Bachelor's degree	106	25.36	090	25.86
Master's degree	107	25.60	110	31.61
PhD degree	100	23.92	088	25.29
Other degrees or diploma	105	25.12	060	17.24
Age of the participants				
18–23	098	23.44	085	24.43
24–29	130	31.10	115	33.05
30–35	089	21.29	083	23.85
>36	101	24.16	065	18.68
Personal Income of the participants				
5–10 k RMB	095	22.73	098	28.16
11–16 k RMB	128	30.62	111	31.90
17–22 k RMB	090	21.53	080	22.99
>23 k RMB	105	25.12	059	16.95
N=766				

3.1 Measures

In this study, three variables were used such as independent, dependent and moderating variables to consider the nexus of e-Transportation Supports (e-TS) toward sustainable development (i.e., social, economic and environmental development) with moderation of ICTs such as global positioning system, vehicle-to-vehicle communication, vehicle-to-infrastructure communication, smart sensors, intelligent transportation systems, big data analytics, artificial intelligence, cybersecurity solutions and cloud computing. First, scales for e-TS were accessed using seven items as adopted from Baronti et al. (2016) and Kolhe et al. (2024). Second, scales for ICTs were accessed using eight items adopted from the previous studies (Asongu et al., 2018; Higón et al., 2017). Third, SD was accessed using three major constructs along with their distinct items as adopted from the previous studies of the researcher (Bansal, 2005).

3.2 Data analysis techniques

First, the author used the attribute statistics in order to identify the minimal information about parameters of the population (see Table 1). To put expand research further, a correlation testing technique was employed (see Table 3). In addition, there were the calculating and examining of discriminant validity by two methods such as Fornell–Larcker and HTMT (Ab Hamid et al., 2017; Fornell and Larcker, 1981). Once again, similar to the approach of convergent validity, the suggested measures on evaluation such as AVEs, loadings and reliability have been used accordingly by the researchers as it was suggested by Hair et al. (2011). SmartPLS for SEM was thereafter used to confirm the directional causality of the variables. However, the values of NFI and SRMR must be found for SEM authenticity (Hu and Bentler, 1999).

4 Results

4.1 Validity and reliability

The validity and reliability values are presented in the Table 2 along with the means and standard deviations description. It is recommended that the loadings and AVEs are higher than 0.5, and the reliability values which are more than 0.7 (Hair et al., 2011). Firstly, the reliability of each factor was examined by using the value of the composite reliability.

Table 2 Validation of the scales

	Items	*Mean*	*Standard deviation*	*Loadings*	*AVEs*	*Composite reliability*
e-transportation system (e-TS)					0.622	0.789
	e-TSF1	5.982	1.021	0.555		
	e-TSF2	5.122	1.540	0.634		
	e-TSF3	5.983	1.351	0.633		
	e-TSF4	5.134	1.021	0.555		
	e-TSF5	5.982	1.540	0.634		
	e-TSF6	5.130	1.540	0.634		
	e-TSF7	5.932	1.351	0.633		
Information and communications technologies (ICTs)					0.842	0.804
	ICTsF1	5.134	1.021	0.685		
	ICTsF2	5.982	1.540	0.638		
	ICTsF3	5.130	1.351	0.633		
	ICTsF4	5.932	1.021	0.639		
	ICTsF5	5.144	1.540	0.634		
	ICTsF6	5.134	1.351	0.611		

Table 2 Validation of the scales (continued)

	Items	*Mean*	*Standard deviation*	*Loadings*	*AVEs*	*Composite reliability*
Sustainable development (SD)					0.584	0.840
Social Development	SDF1	5.134	1.351	0.633		
	SDF2	5.982	1.021	0.633		
	SDF3	5.130	1.540	0.555		
	SDF4	5.932	1.540	0.634		
Economic Development	SDF5	5.144	1.351	0.633		
	SDF6	5.454	1.025	0.585		
	SDF7	5.130	1.540	0.634		
	SDF8	5.932	1.351	0.633		
Environmental Development	SDF9	5.144	1.021	0.555		
	SDF10	5.134	1.540	0.634		
	SDF11	5.651	1.458	0.544		
	SDF12	5.130	1.540	0.634		
	SDF13	5.932	1.351	0.634		

Note: * Items removed having <0.5 AVEs and loadings.

4.2 Correlation analysis

Table 3 shows the attained results of the covariance measures that will confirm the definitive variables of this research and interrelations. These outcomes are significant at values ranging from –1 to +1 (Hair et al., 2011; Hu and Bentler, 1999). This approach is considered as a credible method where global researchers employ to establish the interconnectivity of the factors.

Table 3 Pearson correlation

	e-TS	*ICTs*	*SD*	*SoD*	*EcD*	*EnD*
e-TS	1.000					
ICTs	0.251	1.000				
SD	0.336	0.320	1.000			
SoD	0.254	0.112	0.225	1.000		
EcD	0.244	0.350	0.234	0.228	1.000	
EnD	0.337	0.244	0.450	0.350	0.380	1.000

Note: values should be between –1 to +1 in Pearson testing; e-TS=e-transportation system; ICT=information and communication technologies; SD=sustainable development; SoD=social development; EcD=economic development; EnD=environmental development.

4.3 Model of discriminant validity

Table 4 below is the values for the discriminant analysis which is used for validation of the data set. The square roots of AVEs should be better than interrelationships while conducting the comparison (Fornell and Lacker, 1981). It is seen that the underlined bold values of the first row of each column are higher than the non-bold values of interrelationships.

Table 4 Discriminant validity

	e-TS	*ICTs*	*SD*	*SoD*	*EcD*	*EnD*
e-TS	0.822					
ICTs	0.124	0.752				
SD	0.225	0.350	0.855			
SoD	0.048	0.188	0.112	0.789		
EcD	0.238	0.235	0.364	0.240	0.884	
EnD	0.123	0.420	0.421	0.135	0.224	0.759

Note: Bold are AVE square roots and other are interrelationships; e-TS= e-transportation system; ICT=information and communication technologies; SD=sustainable development; SoD=social development; EcD=economic development; EnD=environmental development.

4.4 Heterotrait–monotrait (HTMT)

Apart from the work done by Fornell and Lacker (1981), there is another method HTMT that established the relationship and strengthened the results, as depicted in Table 5. Following recommendations made by authors on HTMT analysis, the values should be below 0.9 (Hair et al., 2011; Hu and Bentler, 1999). Therefore, to assess the HTMT for the current data set, the current outcomes justified the accuracy as a proof of the HTMT's applicability.

Table 5 HTMT

	e-TS	*ICTs*	*SD*	*SoD*	*EcD*	*EnD*
e-TS						
ICTs	0.251					
SD	0.211	0.140				
SoD	0.282	0.247	0.241			
EcD	0.147	0.307	0.369	0.307		
EnD	0.354	0.235	0.204	0.228	0.210	

Note: Values should be <0.9; e-TS=e-transportation system; ICT=information and communication technologies; SD=sustainable development; SoD=social development; EcD=economic development; EnD=environmental development.

4.5 Path relationships using SEM

The extracted values of the major flow paths which have been obtained from the beta values are represented in the below Table 6. Apparently, more suitable NFI and SRMR indices should be taken into account as to identify the SEM model's genuineness. For instance, it was postulated that the values of NFI should be more than 0.9 and SRMR should be less than 0.08 (Hu and Bentler, 1999). These current values are estimated and fitted as per the above recommendations where NFI was found as 0.988 and SRMR as 0. 0405.

Table 6 SEM model results

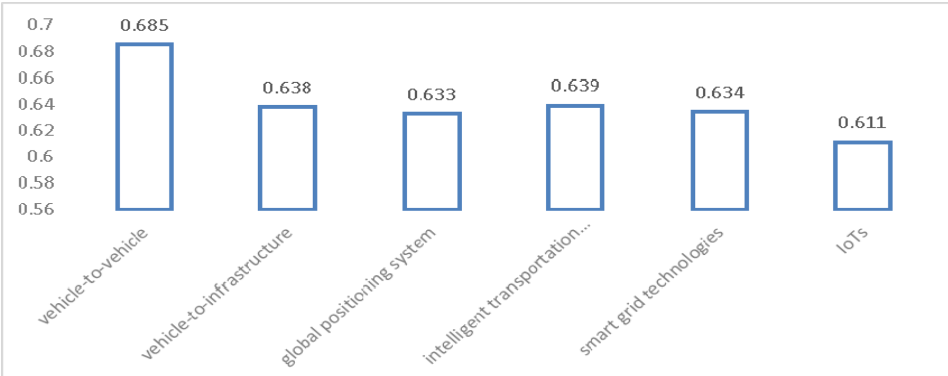
Paths	*Direction*	*Direct*	*Moderation*	*Sig.*	*Decision*
H1: e-TS→SD	±	0.025***	-	0.000	√
H1a: e-TS→SoD	±	0.125***	-	0.000	√
H1b: e-TS→EcD	±	0.258***	-	0.001	√
H1c: e-TS→EnD	±	0.089***	-	0.000	√
H2: e-TS*ICTs→SD	±	–	0.081***	0.000	√
H2a: e-TS*ICTs→SoD	±	–	0.194***	0.001	√
H2b: e-TS*ICTs→EcD	±	–	0.138***	0.002	√
H2c: e-TS*ICTs→EnD	±	–	0.207***	0.001	√

Note: ****p*<0.05; e-TS=e-transporatation system; ICT=information and communication technologies; SD=sustainable development; SoD=social development; EcD=economic development; EnD=environmental development.

5 Discussion

In total, eight hypotheses were formed to examine the relationship between the e-transportation supports (e-TS) for sustainable development SD (social, economic and ecological) with the moderation of ICTs that include GPS, V2V, V2I, smart sensors, intelligent transportation systems, big data analytics, AI, cybersecurity solutions, cloud computing and IoT. All the hypotheses are supporting which are showing a direct positive relationship of e-TS and SD with considering three streams of SD which are SoD, EcD and EnD. Furthermore, the outcomes are consistent with the prior research where scholars have claimed that there is a positive correlation of e-TS with respect to SD namely, SoD, EcD and EnD from the various domains of the world (Aijaz and Ahmad, 2022; Akib et al., 2022; Baronti et al., 2016; Dasari, 2020; Hamza-Lup et al., 2007) What could be observed was that there was moderation of ICTs results which showed a positive moderation of ICTs among the nexus of e-TS, SD, SoD, EcD and EnD, respectively as a comparison of ICTs is illustrated below Figure 2. These outcomes are supporting earlier sociality evidence in which specialists postulated for facilitation of ICTs as moderator in various area of the world (Asongu et al., 2018; Ben-Yehuda and Wiseman, 2013; Day et al., 2012; Ehrmann and Fratzscher, 2005; ElGhanam et al., 2021; Heeks, 2010).

Figure 2 Comparison analysis of ICTs (see online version for colours)



6 Implications

This work theoretically posits this study of e-Transportation Support (e-TS) as a plausible sustainable idea (social, economic and environmentally conscious development) from a perspective of integrating new technologies like the Global Positioning System, Smart Sensors, Intelligent Transportation System, Big Data Analytics, Artificial Intelligence, Information Security, Internet of Things transmitting and computing form the China's standpoint. This work adds up to literature with empirical evidence on the effects of e-TS on SD as well as every sub-factor including SoD, EcD and EnD. Similarly, ICTs survived the moderation effect on linking up of the e-TS, SD, SoD, EcD and EnD of the study.

From a managerial standpoint, managers should establish clear and measurable goals aligned with sustainable development objectives, such as reducing carbon emissions, promoting social equity and enhancing economic viability. These goals should serve as guiding principles for decision-making and performance evaluation throughout the planning, implementation and operation of e-transportation systems. Environmental and sustainable planning should be implemented in the strategy development process for e-transportation projects at the initial stage. Managers need to undertake comprehensive sustainability assessments to identify all the environmental, social and economic impacts belonging to the transport projects and include the measures of mitigation into a strategic plan with the purposes of decreasing negative effects of them and increasing positive ones. The managers of e-transportation system should take the lifecycle approach in its development and management, and they should consider environmental and social aspects at all phases of the lifecycle such as design, construction, operation and dismantling. The eco-footprint of transportation projects can be evaluated. For example, resource efficiency can be increased, and the wastes produced can be reduced. Simultaneously, the overall eco-footprint of the e-transport systems can be diminished. Managers should put emphasis on the allocation of funds to technological innovation and research and development for the purpose of a systematic improvement of the existing state-of-the-art in e-transportation technologies and methods. Through the utilisation of recent technologies like electric vehicles, autonomous vehicles, digital mobility solutions and smart infrastructure managers can finally increase the efficiency, reliability and sustainability of e-transportation systems that create a competitive and economic growth environment in transportation industry. Furthermore, the importance of developing an environment for collaboration and partnerships among the diverse stakeholders – government offices, private sector players, civil society organisations and community leaders – to co-create sustainable transportation solutions cannot be underestimated. Stakeholders' early involvement through dialogue and collaboration ensures that collective expertise, resource shares and perspectives enrich planning and decision-making processes and as a result more overarching, holistic and context-sensitive e-transportation projects are developed that meet different needs and priorities. The managers should create a rigorous performance monitoring and evaluating system to check the extent that the systems are in line with sustainability objectives and targets. It is commonly achieved by gathering data on the main performance indicators such as energy efficiency, greenhouse gas emissions, mode share and user experience on a regular basis. Having a close look at the effectiveness of the interventions can guide managers to make better decisions on how to improve the system further.

However, managers should focus on core investments in the ICT masterplan which would include the design of broadband networks, sensor networks and a communication system to set the communication of e-transport systems. Managers need to consider infrastructure reliable and high-speed ICT so that proper connectivity, real-time exchange of data and efficient flow of information is ensured. This will be necessary to implement short transportation solutions and services of green mobility. The use of data analytics as well as data-driven decision-making techniques should be handled by management for larger management to be able to discover the valuable insights found in all the huge data in e-transportation systems. Managers can derive multiple benefits from evaluating transport data on a real-time basis such as identification being carried out of traffic patterns, optimisation of route planning, prediction of fluctuations in demand and ultimately increased running efficiency which will translate to less congestion, less energy consumption and an overall better traveling experience in e-transportation systems. An e-transportation plan which comprises of ITSs powered by ICTs is a recommended strategy as ITSs can contribute to the safety, efficiency and sustainability of the whole transport network. The managers need to champion the implementation of smart mobility techniques which come about due to the innovations in the field of ICTs, like car search platforms, on demand services and integrated multimodal trip apps. In this way, the managers may apply the IoT technologies to contribute to connectivity and interoperability among the heterogeneous constituents of e-transportation systems, infrastructure and smart devices. ICT should help managers in both transitioning to e-transportation and incorporating renewable energy sources with ICT-driven energy management systems. Similarly, endorsement and practice of these managerial recommendations, managers will be able to discover the ways ICT can help to transition e-transportation networks toward a low-carbon, efficient and accessible system. Hence, the managers will have an opportunity to contribute to the achievement of the Sustainable Development Goals and foster people-centred, inclusive and environmentally friendly transportation system.

7 Conclusion

This study confirms that innovative e-electric transportation systems represent a key element of sustainability, as they lead to a lowered content of carbon in the environment, the addition of road capacity, and the improvement of the living standards of urban populations. ICTs integration plays a key role, and it provides people with the opportunity to use efficient, accessible, and environmentally friendly transportation services for the community. Through e-transportation undertakings, the diverse stakeholders could set a standard for green way of life, both at home and worldwide. ICTs are inseparable elements of the high-quality e-transportation systems and long-lasting development goals. ICTs are the umbrella term for a range of technologies such as embedded sensors in devices that provide real-time data analysis, integration of different modes of transport and user engagement, which are all useful in improving transport networks in terms of efficiency, accessibility and environmental performance. Stakeholders can do that through the utilisation of ICTs and thus, they will achieve sustainable mobility solutions that include pollution reduction and social equity improvement; therefore, the air quality is improved. Therefore, embracing ICTs in e-transportation systems is essential for building resilient, inclusive and environmentally sustainable transportation infrastructure for future generations. As currently affirmed a positive connection of e-TS toward SD along with other factors like SoD, EcD and EnD. This study also concluded a moderation of ICTs (e.g., vehicle-to-vehicle, vehicle-to-infrastructure, global positioning system, intelligent transportation systems, smart grid technologies and IoTs) among the nexus of e-TS, SD, SoD, EcD and EnD.

7.1 Drawbacks and future research

The following are some limitations of this research for future studies: This study contributes to the understanding of the domains of China's perceived e-TS, ICT, SD, SoD, EcD and EnD. First, the sample size was small which restricts the sample in generalisation. Secondly, 'the study did not clearly define its key variables'; this practically means that the study had 'a conceptual framework blurry' to say the least. Second, among the mentioned categories of countries, only the developing one was described more thoroughly; namely, China. Thus, when involving the longitudinal studies, many more respondents may be trapped in other contexts and the samples obtained may be of better size. I also think that the futures studies should be also expanded with the supply of additional mediating and/or moderating variables with regard to which one can have the same conclusion concerning the type of the relations between e-TS, SD, SoD, EcD and EnD. Hence, in this chapter, the broadest use of harnessing ICT tools Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Global Positioning System (GPS), Intelligent Transportation System (ITS), smart grid technology, IoTs were discussed while each of these types solely can be individually conducted in the future to have a clear picture of today's use. Lastly, the author can also intend to perform more deeper analysis in the future by carrying out the comparison of the public with the private systems within China and across the global in order to lend further credence to the discovery made.

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References

Ab Hamid, M.R., Sami, W. and Sidek, M.M. (2017) 'Discriminant validity assessment: use of Fornell & Larcker criterion versus HTMT criterion', Paper presented at *the Journal of Physics: Conference Series*. Doi: 10.1088/1742-6596/890/1/012163.

Agrawal, A. and Paulus, R. (2020) 'Intelligent traffic light design and control in smart cities: a survey on techniques and methodologies', *International Journal of Vehicle Information and Communication Systems*, Vol. 5, No. 4, pp.436–481.

Aijaz, I. and Ahmad, A. (2022) 'Electric vehicles for environmental sustainability', *Smart Technologies for Energy and Environmental Sustainability*, pp.131–145.

Akib, F.A., Shawn, N., Mostafa, S., Rasheduzzaman, M. and Hossain, M.M. (2022) 'Impacts of Electric vehicle for sustainable transportation in Dhaka City', Paper presented at *the International Conference on Advancement in Electrical and Electronic Engineering (ICAEEE)*, IEEE, Bangladesh.

Alomary, A. and Woollard, J. (2015) 'How is technology accepted by users? A review of technology acceptance models and theories', *Proceedings of the IRES 17th International Conference*, London, UK, pp.1–4.

Asongu, S.A., Le Roux, S. and Biekpe, N. (2018) 'Enhancing ICT for environmental sustainability in sub-Saharan Africa', *Technological Forecasting and Social Change*, Vol. 127, pp.209–216.

Ba, T., Li, S., Gao, Y. and Tan, D. (2023) 'Research on the interactive design of electric vehicle interior based on voice sensing and visual imagery', *International Journal of Vehicle Information and Communication Systems*, Vol. 8, Nos. 1/2, pp.152–169.

Bansal, P. (2005) 'Evolving sustainably: a longitudinal study of corporate sustainable development', *Strategic Management Journal*, Vol. 26, No. 3, pp.197–218.

Baronti, F., Chow, M.-Y., Ma, C., Rahimi-Eichi, H. and Saletti, R. (2016) 'E-transportation: the role of embedded systems in electric energy transfer from grid to vehicle', *EURASIP Journal on Embedded Systems*, pp.1–12.

Baronti, F., Vazquez, S. and Chow, M-Y. (2018) 'Modeling, control, and integration of energy storage systems in e-transportation and smart grid', *IEEE Transactions on Industrial Electronics*, Vol. 65, No. 8, pp.6548–6551.

Ben-Yehuda, R. and Wiseman, Y. (2013) 'The offline scheduler for embedded vehicular systems', *International Journal of vehicle Information and Communication Systems*, Vol. 3, No. 1, pp.44–57.

Carlsson, F. and Johansson-Stenman, O. (2003) 'Costs and benefits of electric vehicles', *Journal of Transport Economics and Policy (JTEP)*, Vol. 37, No. 1, pp.1–28.

Cejudo, I., Arandia, I., Urbieta, I., Irigoyen, E., Arregui, H. and Loyo, E. (2024) 'Electric vehicle battery consumption estimation model based on simulated environments', *International Journal of Vehicle Information and Communication Systems*, Vol. 9, No. 3, pp.309–333.

Chen, X. and Weng, C. (2024) 'An examination of policy disclosure for adoption of electric vehicles and its impact on economic development with moderation of financial risk', *International Journal of Vehicle Information and Communication Systems*, Vol. 9, No. 3, pp.292–308.

Chuttur, M. (2009) *Overview of the Technology Acceptance Model: Origins, Developments and Future Directions*, Working Papers on Information Systems.

Dasari, Y. (2020) *Design, Analysis, and Control of Switched Supercapacitor Banks for e-Transportation Electric Energy Storage Systems*, University of Ontario Institute of Technology, Government of Canada.

Day, A., Paquet, S., Scott, N. and Hambley, L. (2012) 'Perceived information and communication technology (ICT) demands on employee outcomes: the moderating effect of organizational ICT support', *Journal of Occupational Health Psychology*, Vol. 17, No. 4, pp.473–491.

Du, J., Ouyang, M. and Chen, J. (2017) 'Prospects for Chinese electric vehicle technologies in 2016–2020: ambition and rationality', *Energy*, Vol. 120, pp.584–596.

Ehrmann, M. and Fratzscher, M. (2005) 'Exchange rates and fundamentals: new evidence from real-time data', *Journal of International Money and Finance*, Vol. 24, No. 2, pp.317–341.

ElGhanam, E., Hassan, M., Osman, A. and Ahmed, I. (2021) 'Review of communication technologies for electric vehicle charging management and coordination', *World Electric Vehicle Journal*, Vol. 12, No. 3. Doi: 10.3390/wevj12030092.

Fornell, C. and Larcker, D. F. (1981) 'Evaluating structural equation models with unobservable variables and measurement error', *Journal of Marketing Research*, Vol. 18, No. 1, pp.39–50.

Giannopoulos, G.A. (2004) 'The application of information and communication technologies in transport', *European Journal of Operational Research*, Vol. 152, No. 2, pp.302–320.

Hair, J.F., Ringle, C.M. and Sarstedt, M. (2011) 'The use of partial least squares (PLS) to address marketing management topics', *Journal of Marketing Theory and Practice*, Vol. 19, No. 2, pp.135–138.

Hamza-Lup, G.L., Hua, K.A. and Peng, R. (2007) 'Leveraging e-transportation in real-time traffic evacuation management', *Electronic Commerce Research and Applications*, Vol. 6, No. 4, pp.413–424.

Harasis, S., Khan, I. and Massoud, A. (2024) 'Enabling large-scale integration of electric bus fleets in harsh environments: possibilities, potentials, and challenges', *Energy*, Vol. 300. Doi: 10.1016/j.energy.2024.131564.

Heeks, R. (2010) 'Do information and communication technologies (ICTs) contribute to development?', *Journal of International Development*, Vol. 22, No. 5, pp.625–640.

Higón, D.A., Gholami, R. and Shirazi, F. (2017) 'ICT and environmental sustainability: a global perspective', *Telematics and Informatics*, Vol. 34, No. 4, pp.85–95.

Hu, L.T. and Bentler, P.M. (1999) 'Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives', *Structural Equation Modeling: A Multidisciplinary Journal*, Vol. 6, No. 1, pp.1–55.

Jadhav, D.B. and Kokate, R.D. (2022) 'Development of environment friendly nanoelectronic sensing elements for hybrid electric vehicles', *International Journal of Vehicle Information and Communication Systems*, Vol. 7, No. 2, pp.146–160.

Johnson, J.M-F., Franzluebbers, A.J., Weyers, S.L. and Reicosky, D.C. (2007) 'Agricultural opportunities to mitigate greenhouse gas emissions', *Environmental Pollution*, Vol. 150, No. 1, pp.107–124.

Karneddi, H. and Ronanki, D. (2022) 'Universal bridgeless onboard battery charger with wide output voltage range for e-transportation', Paper presented at the *IEEE Industry Applications Society Annual Meeting (IAS)*, IEEE, USA.

Kolhe, N.P., Deori, G. and Rajoria, V. (2024) 'Youth and public transportation: economics, sustainability, and shifting trends towards e-transportation', *Energy Efficient Vehicles*, CRC Press, pp.33–57.

Liu, S-H., Liao, H-L. and Peng, C-J. (2005) 'Applying the technology acceptance model and flow theory to online e-learning users' acceptance behavior', *Issues in Information Systems*, Vol. 6, No. 2, pp.175–181.

Marangunić, N. and Granić, A. (2015) 'Technology acceptance model: a literature review from 1986 to 2013', *Universal Access in the Information Society*, Vol. 14, pp.81–95.

Mase, K. (2012) 'Information and communication technology and electric vehicles – paving the way towards a smart community', *IEICE Transactions on Communications*, Vol. 95, No. 6, pp.1902–1910.

Mishra, S. and Singh, M. (2020) 'A conceptual framework and architecture for m-governance', *International Journal of Vehicle Information and Communication Systems*, Vol. 5, No. 1, pp.90–108.

Momani, A. M. and Jamous, M. (2017) 'The evolution of technology acceptance theories', *International Journal of Contemporary Computer Research (IJCCR)*, Vol. 1, No. 1, pp.51–58.

Mohanta, B.K., Jena, D., Satapathy, U. and Ramasubbareddy, S. (2022) 'Collaborative decision making system in intelligent transportation system using distributed blockchain technology', *International Journal of Vehicle Information and Communication Systems*, Vol. 7, No. 1, pp.64–81.

Mnassri, A., Nasri, S., Boussif, M. and Cherif, A. (2024) 'Real-time voice-controlled human machine interface system for wheelchairs implementation using Raspberry Pi', *International Journal of Vehicle Information and Communication Systems*, Vol. 9, No. 1, pp.81–102.

Rehman, S.U., Usman, M., Fernando, Y., Kamarudin, D. and Waheed, A. (2023) 'Improving manufacturing supply chain performance: nexus of industrial internet of things, blockchain technology and innovativeness', *Journal of Science and Technology Policy Management*.

Omer, N., Ahmed, A., Rabbi, F., Farrukh, M. and Waheed, A. (2016) 'Role of empowerment and leadership in turnover intentions among the Generation Y academicians in Saudi Arabian Higher Educational Institutes', *Journal for Studies in Management and Planning*, Vol. 1, No. 11, pp.719–733.

Qayyum, M., Zhang, Y., Ali, M. and Kirikkaleli, D. (2024) 'Towards environmental sustainability: The role of information and communication technology and institutional quality on ecological footprint in MERCOSUR nations', *Environmental Technology and Innovation*, Vol. 34. Doi: 10.1016/j.eti.2023.103523.

Shanmugasundaram, N., Sushita, K., Kumar, S.P. and Ganesh, E. (2019) 'Genetic algorithm-based road network design for optimising the vehicle travel distance', *International Journal of Vehicle Information and Communication Systems*, Vol. 4, No. 4, pp.344–354.

Srivastava, S.K. and Panigrahi, P.K. (2019) 'Social participation among the elderly: moderated mediation model of information and communication technology (ICT)', *Communications of the Association for Information Systems*, Vol. 44, No. 1. Doi: 10.17705/1CAIS.04433.

Taherdoost, H. (2018) 'A review of technology acceptance and adoption models and theories', *Procedia Manufacturing*, Vol. 22, pp.960–967.

Tepe, B., Jablonski, S., Hesse, H. and Jossen, A. (2023) 'Lithium-ion battery utilization in various modes of e-transportation', *eTransportation*, Vol. 18. Doi: 10.1016/j.etran.2023.100274.

Van Selm, M. and Jankowski, N.W. (2006) 'Conducting online surveys', *Quality and Quantity*, Vol. 40, pp.435–456.

Vrkljan, B.H. and Miller-Polgar, J. (2005) 'Advancements in vehicular technology: potential implications for the older driver', *International Journal of Vehicle Information and Communication Systems*, Vol. 1, Nos. 1/2, pp.88–105.

Wang, X., Tao, J., Zhu, Q., Wu, X., Li, T., Zhao, C. and Guan, N. (2021) 'Depression and anxiety symptoms to COVID-19 outbreak among the public, medical staff and patients during the initial phase of the pandemic: an online questionnaire survey by a WeChat Mini Program', *BMJ Open*, Vol. 11, No. 6. Doi: 10.1136/bmjopen-2020-046350.

Wei, Q.S., Imran, M. and Waheed, A. (2019) 'The impact of higher education quality on student's satisfaction: empirical evidence from PR China', *Pacific International Journal*, Vol. 2, No. 1, pp.19–26.

Weldon, P., Morrissey, P., Brady, J. and O'Mahony, M. (2016) 'An investigation into usage patterns of electric vehicles in Ireland', *Transportation Research Part D: Transport and Environment*, Vol. 43, pp.207–225.

Yong, J.Y., Ramachandaramurthy, V.K., Tan, K.M. and Mithulananthan, N. (2015) 'A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects', *Renewable and Sustainable Energy Reviews*, Vol. 49, pp.365–385.

Zakir, F., Wang, D., Waheed, A. and Rehman, A. (2022) 'Exploring the nexus between supply chain agility and firms' performance within emerging nations', J*ournal of Engineering, Project and Production Management*, Vol. 12, No. 3, pp.202–208.