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How Sustainable Transportation Can Utilize Climate Change Technologies to Mitigate Climate Change

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Abstract: The build-up of greenhouse gases (GHGs) is causing warmness in the Earth's atmosphere, resulting in climate change. The transport sector is one of the active causes of GHG emissions and it is imperative to use sustainable transport sources to control climate change. There is a measure that aims to encourage citizens to stop using their own vehicles as their choice of transport and instead opt for joint sustainable mobility during traveling. In this study, a quantitative research method was used and data were collected from a sample of 410 respondents through a questionnaire. Furthermore, this study also took a simulation-based (n = 10,000) sample size of electric rail vehicle data. The data were analyzed using structural equation modelling. The results revealed that sustainable transportation, climate change technologies, and electric rail vehicles reduce climate change in the ecoregions of China. We conclude that sustainable transportation policies could be formulated and implemented to reduce climate change. In response to the research results, it is recommended that, since climate change is a multi-level governance issue, the outdated pyramidal transport industry models must be shifted to a sustainable transportation system model.

Keywords: sustainability; transportation; climate change; reduced carbon emissions

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1. Introduction

The transportation industry is crucial as it is an integral part of the economy and the environment. Investment, growth, and carbon dioxide (CO_2) emissions are all areas in which it has a significant impact on the economy and environment. More specifically, the transport sector creates acceptable and undesired outputs at a specific level of transportation inputs, such as traffic flow, traffic automobiles, and energy consumption. Moreover, greenhouse gases (GHGs), especially CO_2 emissions, have negative effects on countries, making climate change and ecological degradation urgent problems. Two fourths of all greenhouse gas emissions come from the transportation industry [1].

Thus, the focus of this study is on transportation and its effect on climate change. This topic constitutes a new domain with unstudied potential in sustainable transportation to reduce carbon emissions and address climate change globally. Both personal mobility and the transportation of heavy objects have dramatically increased over the last century. This progress has been significantly influenced by the advancement of the internal combustion engine. Engine efficiency has increased, and emissions have decreased significantly. Additional upgrades are needed to comply with local zero-emission regulations and global climate goals. Rapid renewable energy sources are essential for producing clean power and the wide-scale use of sustainable fuels. As every nation has a responsibility, developing countries must learn to reduce their reliance on fossil fuels as their economies expand. They should indeed pursue a sustainable path and swiftly convey crucial insights to gain expertise. Technology evaluations should consider the influence of each life cycle stage rather than just the tailpipe emissions. It would be smart to adopt a fact-driven approach, keep various options open, and build on prior accomplishments, as we consider a wide range of diverse uses across the transportation sector. A variety of low-carbon technologies should be pursued rather than placing all the stakes on one [2].

Research that considers sustainable transportation to reduce carbon emissions have a rich background to address the issue of climate change. For example, Ref. [1] observed that to create low-carbon transportation and land-use policies to address climate change, it is essential to understand the factors affecting climate change with the help of CO_2 emissions. They aimed to determine how the built environment (BE) involves CO_2 emissions connected to commuting and how it affects climate change. Most studies were conducted in developed countries and evaluated the link between BE and CO_2 emissions using conventional modeling, considering the direct effects associated with BE. Predicting the overall impact of BE on commuter CO_2 emissions while accounting for the mediating role of GHG technologies is a research gap. This study, therefore, looks at both the direct and indirect effects of BE on CO_2 emissions, connected to commuting, that change the climate.

Several authors found that sustainable development promotion with the help of forests reduced the adverse effects of global warming and possibly addressed climate change, GHG emission reduction, and improvement in environmental quality, which is sometimes decreased due to transport-related pollution [3–5]. The research addressed regional and local sources of CO_2 and other GHG emissions. Globally speaking, 23% of the GHG emissions connected to energy in 2004 were from mobile sources of CO_2. In China, mobile sources accounted for 28% of all human caused GHG emissions in 2004 and a whopping 39% of all CO_2 emissions. Methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFCs) are driving the Earth's atmosphere's warming condition. As part of the evaluation, the CO_2 emissions for several megacities, the carbon footprint represented in CO_2, and the CO_2 per capita used as a sustainability scale are all examined to control climate change [6].

There has been increasing research effort and specialization in climate change and transportation factors. An important part of the economy and environment is the transportation industry. However, because of its fast growth, it significantly provides both beneficial and harmful outputs to the economy and the sustainable environment. Thus, it is necessary to assess transportation efficiency in relation to the economy and the sustainable environment. This research contributes to the debate by examining the combined influence of economic and environmental issues, in contrast to other studies that looked at environmental and economic consequences individually. Additionally, the impact of transportation-related climate change mitigation technologies is also examined using three outputs and five inputs for thirty-five nations from 2000 to 2020 [7]. In a nutshell, this paper contributes by examining the predictive impact of transportation and transportation infrastructure on climate change and climate resilience for the Earth's atmosphere and the mediating role of CO_2 and GHG of new technologies and electric rail vehicles. According to the results, the efficiency levels are significantly influenced by technologies for reducing climate change in the transportation sector. Additionally, the combined influence of climate change mitigation technology and environmental research and development has a negative impact on transportation efficiency. Air transportation efficiency is more impacted by climate change mitigation technologies than rail and road transportation. According to these findings, governments should concentrate on the policy ramifications for transportation inputs and the desired and unwanted outcomes [7–9]. From the above systematic literature and critical scientific discussion, it has been proven that CO_2, a GHG, is released into the atmosphere when fossil fuels such as gasoline and diesel are burned. The increase in GHGs such as CO_2, CH_4, N_2O, and HFCs is warming the Earth's atmosphere, which is changing the climate to become more hazardous. This is caused by transportation and automobiles.

Using sustainable transportation methods is essential to reduce climate change since the transportation industry is one of the most significant contributors to GHG emissions, which is a big problem for the sustainable environment and climate change. The fight against climate change depends on new and developing technologies, such as electric rail vehicles and buses, zero-carbon energy sources, and the implementation of policies for automobile vehicles. In other words, more severe weather events are being brought on by increased emissions and warming temperatures, which in turn are seriously disrupting transportation and infrastructure. In a similar vein, climate change could be mitigated if transportation infrastructure is updated and transport vehicles are made to be more climate resilient, which demands large expenditures on transportation infrastructure. Therefore, this research aims to examine the effect of rail vehicle transport infrastructure on climate change and offers legislation policy suggestions to persuade people to use more environmentally friendly forms of transportation over their automobiles in China. The remaining portion of this study is organized as follows: Section 2 offers a literature review along with hypotheses, section three gives insights on data and methodology, Section 4 is about results and discussion, while Section 5 concludes the research.

2. Literature Review

Over the past century, human mobility and the movement of large goods have expanded with the help of transportation. The development of the internal combustion engine has tremendously increased emissions, leading to pollution [1]. For instance, Ref. [10] briefed that local zero-emission standards and global climate objectives need further renovations to meet these requirements and reduce carbon emissions. Ref. [11] described that producing clean energy and the wide-scale usage of sustainable fuels is impossible without the rapid development of renewable energy sources. Their findings revealed that a wide variety of diversified transportation purposes and the relationship between low-carbon technology and climate change mitigation are significant.

Ref. [2] examined how CO_2 emissions affect climate change and how to implement low-carbon transportation for a sustainable environment. Climate change mitigation and sustainable transport have a connection that further improves the polluted environment for human beings. Climate change mitigation and a reduction in GHG emissions is often difficult due to automobile pollution [1,3–5]. Ref. [6] focused on CO_2 and other GHG emissions from regional transportation and local resources. The findings showed that automobile CO_2 sources accounted for 23% of global energy related GHG emissions. Regarding human caused GHGs, automobile sources accounted for 28% of all US emissions in 2004 and a staggering 39% of all CH_4, N_2O, and HFC emissions. They have controlled climate change by examining CO_2 emissions from several megacities, and carbon footprints in CO_2 and the amount of CO_2 per person were used as a sustainability measure.

Furthermore, lowering GHG emissions in the transportation industry could disturb the environment and cause climate change. Transport inefficiency is aggravated by the combined effect of climate change mitigation technologies. Climate change mitigation technologies have a more significant influence on air transportation efficiency as compared with rail and road transportation [7–9]. Studies on climate change and transportation have received more attention and expertise recently, but again GHGs such as CO_2 and HFCs are the factors that affect the Earth's atmosphere [12–15]. On the other hand, Ref. [7] suggested that the transportation business significantly influences both the economy and the environment. As a result of its rapid expansion, it has sustained the economy but has harmed the sustainable environment, which is a detrimental factor. A suggestion was put forward to the policymakers to evaluate hazardous transportation factors in the context of GHG.

The effectiveness of the transportation industry has been studied and several viable technological solutions have been found to sustain it. For example, Refs. [16,17] pointed out that the estimation of cities' GHG emissions has improved. Cities need more data on GHG emissions to assess where the present issues come from. The common practice of projecting 2020 emissions to the beginning of 2022 is no longer adequate. For instance, cities' climate change objectives might include an aim to cut emissions from 2007 by 80% until 2030. Many other factors, such as transport traffic gas emissions in the form of CO_2, CH_4, and N_2O, are other hazards to a sustainable environment. However, climate change and transportation have a relationship and more expertise is needed in mitigating global warming. The study found that GHGs such as CO_2, CH_4, N_2O, and HFCs have an inverse association with climate change [13]. For example, Ref. [14] measured the reflection of the transportation industry and climate change and the intervening effect of GHGs. Likewise, zero GHG emissions are impossible due to transportation needing fuel and petrol, which causes environmental disturbance and climate change. The study found that climate change mitigation technologies and road transport automation are not associated. Air and railway transportation could be associated with climate change mitigation technologies [8].

Ref. [18] investigated the change in air pollution patterns during COVID-19 in China. They revealed that the change in air pollution from pre-COVID to active COVID was greater than in previous years due to the government's lockdown policies. In the period of post-COVID, air pollutant concentration is increasing. Air pollutants showed a positive correlation with COVID-19 cases. The COVID-19 pandemic had numerous negative effects on human health and the global economy. Ref. [19] also presented a spatial–spectral algorithm method to examine sustainable transportation and found a significant relationship between climate change and spatial transportation efficiency. Ref. [20] studied the effect that strict controlling measures of the COVID-19 epidemic had on the air quality in Wuhan (a city in China) from 2019 to 2021 and found that air-quality pollutants dwindled during active-COVID-19. In addition, they evaluated the evolution of air contaminants from 2017 to 2021 and discovered that they all declined until 2020. The high correlation between the air quality index (AQI) and PM10 and PM2.5 is further supported by regression analysis.

Ref. [21] analyzed the influence of the strict controlling measures of COVID-19 on the air quality of Anhui. Both regression and path analyses were taken into account to identify these relationships. During the time of peak activity of COVID-19, they discovered a reduction in air pollution: 21% for PM10 and 19% for PM2.5. An AQI drop of 3% after COVID-19 indicates that air quality may deteriorate in the future, but an even more dramatic drop of 16% was reported while COVID-19 was at its peak. Similarly, Ref. [22] predicted air pollution in China using data collected from 72 air quality monitoring stations and found a significant affiliation between transportation and air quality. In a similar vein, Refs. [23,24] used the algorithm method and found vehicle infrastructure as a significant predictor of climate change. In the context of the above studies, it is proved that sustainable transportation and reduced carbon emissions could address climate change in China's most developed cities, which has not been analyzed before; thus, a gap exists. Table 1 depicts a literature review and model analysis techniques, which are scientifically applied in the climate change domain.

Hypotheses

H1. Climate change technologies and electric rail vehicles collectively intervene in the relationship between sustainable transportation and reduced climate change.

H2. Sustainable transportation has a significant direct impact on climate change technologies.

H3. Climate change technologies and electric rail vehicles mediate the relationship between sustainable transportation and reduced climate change.

Table 1. Literature Review.

Author	Year	Variables	Analytical Technique	Findings
[2]	2022	Climate change, transportation, sustainable environment	Computer-based simulation	Significant relation between climate change, transportation, sustainable environment
[1]	2022	Climate change mitigation, GHG emission, transportation pollution	Computer-based simulation	Transportation enhances GHG emission and causes climate change
[4]	2022	GHG emission and abatement, transportation strategies	Geospatial application and satellite imageries	Abatement transportation strategies lowers GHG emission
[6]	2022	GHG emissions, transportation	Regressions analysis	Transport raises GHG emissions
[7]	2021	Transportation, CO_2, economic development	Autoregressive distributed lag model	Rapid expansion of transportation business sustained the economy but harmed the sustainable environment
[8]	2022	Climate change mitigation technologies, GHG emissions, air, rail, and road transportation	Descriptive and inferential analysis	Climate change mitigation technologies have significant influence on air, rail, and road transportation efficiency
[13]	2022	GHG emission, climate change	Fully modified ordinary least square	GHGs (CO_2, CH_4, N_2O, and HFCs) have inverse association with climate change
[14]	2000	Climate change mitigation technologies, transportation	Autoregressive distributed lag model	Climate change mitigation technologies and road transport automation are insignificantly associated.
[15]	2006	GHG emission, transportation	Descriptive and inferential analysis	Transportation increases GHG emission
[17]	2022	Climate change, transportation, GHG emission	Statistical simulation	Transportation increases GHG emission and causes climate change
[18]	2022	Air pollution, COVID-19	Inferential analysis	Significant relation between air pollution and COVID-19
[19]	2021	Sustainable transportation, climate change	spatial–spectral algorithm method	Significant relation between transportation and climate change

3. Data and Methodology

This study used positivistic research methods associated with the quantitative research process. Each study design is rooted in ontology and epistemology, which is the root of the examination stance. For example, quantitative research measures the objectivity of reality and these objective things are universal and rigid in nature [25–28]. Similarly, every research has a population that has a specific parameter. This study's population was "State-Owned Enterprises (SOEs)".

The nature of this research was mixed method on a basis of data analysis. We have collected data with the help of a survey and from previously adapted constructs. Diversified data analysis techniques were applied in the form of structural equational modelling (SEM) using AMOS and Python software to draw simulation results, which is one ubiquitous statistical technique. AMOS and computer-based software can predict good future directions [29,30]. Confirmatory factor analysis and structural models are used with the help of AMOS [31]. In this regard, the prediction was measured through transportation and transportation infrastructure, CO_2 and GHGs, their predictive relationships with technologies such as electric cars, and climate change and climate resilience. Ref. [32] defined that quantitative techniques and statistical tools could compare previous results with the present scenario. These integrated technological tools can bring predictions for future issues with the help of balance software, designs, and analytical applications. Furthermore, engineering sciences and chemical engineering sciences measure the humane perspectives' objective interpretation and computer-based coding for such types of complicated phenomena and analysis techniques [28]. This research used computer-based coding for the prediction of transportation and transportation infrastructure, CO_2 and GHGs, their predictive relationships with technologies such as electric rail vehicles, and climate change and climate resilience. Likewise, the rationale behind choosing SOEs is to better understand the climate change agenda. This ministry is working on the control of climate change and their policies for SOEs on grassroots levels. In a nutshell, this study applied a unique computer-based application and statistical modelling to measure and test the proposed hypotheses to draw conclusions for predictive objective interpretation.

Different health issues have been announced in the last few years and researchers have followed COVID-19 standard operating procedures. It is to be noted that this study used SOEs' data with the help of Python to better understand the transportation industry's influence on climate change. Moreover, the collected data were analyzed with the help of inferential statistics, and the items were arranged from the existing previous scientific literature. This study tested hypotheses and compared Python results with the past scientific literature and predicted a good sustainable transportation model for the future mitigation of climate change with chemical engineering. With the help of local language researchers, as well as researchers who performed Python coding, we administered a questionnaire and collected data.

In total, 92 participants' questionnaires were used for pilot testing, and we confirmed the questionnaire's reliability and validity. The study measured 4 variables to generate the sample size for the prediction of climate change. "G*Power software, version 3.1.9.7" was used, which is further linked with the "power analysis", for the sample size selection, and Equation (1) is the statistical derivation of the sample size. A total of 410 respondents' samples were generated based on several variables. Similarly, 410 members of the ministry of ecology gave us responses and the units of analysis were employees and SEOs.

$$\begin{gathered} Y = X\beta + \varepsilon \\ X = (1X_1,\ X_{2\ldots\ldots}X_m)\ and\ N \times (m+1,\ matrix = X_i\ ) \\ \beta \text{ of length } = (m+1) \\ \varepsilon \text{ of length } N = (\varepsilon i\ \sim\ N(0,\ \sigma)) \end{gathered} \tag{1}$$

Suppose that . . .

$$\text{H0}:\ R^2 Y.B = 0$$

$$\text{H1}:\ R^2 Y.B > 0.$$

The effect size and its equation for the sample size are given below:

$$f^2 = \frac{R^2\ Y.B}{1 - R^2\ Y.B}$$

$$R^2\ Y.B = \frac{f^2}{2 + f^2}$$

Lastly, this paper examines the predictive impact of transportation and transportation infrastructure on climate change and climate resilience for the Earth's atmosphere and the mediating role of CO_2 and GHG technologies and electric rail vehicles. The analysis of SEM was used to measure the initial model. Similarly, the Python simulation and statistical model fit with the help of the coefficient of determination conducted per change or variance in the Earth's atmosphere and climate change.

This paper constructed linearity with the help of a linear model to study the transportation industry and its relationship and dependency on climate change and resilience, on CO_2 and GHG climate change technologies, and electric rail vehicles. Like previously tested dimensions, factors, indicators, and items were used from the previously existing literature. For instance, the "Sustainable Transportation Scale (4-items), Climate Change Technologies scale (3-items), Electric rail vehicles Scale (3-items), and Reduce Climate Change Scale (7-items)" [33] (see Appendix A). On the other hand, the study used Python to measure climate change effects due to the transportation industry with the data of SOEs.

Researchers employed the formula for the F test linear multiple regression: fixed model and R2 deviation of predictors. AMOS and Python were used to assess the initial model and model fit. To get a better idea of how employees used climate technologies to reduce climate change, which is produced due to the transportation industry, this research revealed two different models for future prediction. For example, the initial model with four indicators, and its RMSEA and SRMR values, are more than the cut-off points, 0.642 and 0.201; however, the GFI, CFI, and NNFI values are lower than the cut-off point which indicates that there is no optimal fitness present. The χ^2df and χ^2/df values, on the other hand, are 2.288 and 2.210, and both are over the cut-off limit. SEM and error terms, with the combination of six indicators, were measured for their causal and effect theoretical relationships and to know the predictive inferential measure of the personnel perception regarding sustainable transportation to reduce climate change.

As a result, the model needed to be modified. For asymmetrical outcomes, data preprocessing actions were required in the modelling phase, to counter erroneous, insignificant results, and repeated information was eliminated from the data. With various predictors and several regress processes, the "sum of squared differences" between the line and the actual data point is minimized with the help of Equation (2).

$$\begin{gathered} Otcome\ i = (\text{model}) + \text{ error } i \\ Y = (b_0 + b_1\ X_{i1}\ + b_0 + b_2\ X_{i2}\ + \ldots\ b_0 + b_n\ X_n\ ) + \varepsilon_i \end{gathered} \tag{2}$$

The SEM examines the extent of dependence in the linear equation model and contributes to structural modelling in applied statistics. The SEM's fundamental formula is depicted in Equation (3).

$$\begin{gathered} (\alpha.\alpha) = [N-r]\left[\sum_{g-1}^{G} \frac{(N)^{g\ f(\mu^g,\ \Sigma g,\ x^{(g)},\ \ s^{(g)})}}{N}\right] = [N-r]\ F(\alpha.\alpha) \\ \text{fkl}\ (\mu^g \sum(g) x^{(g)} S^{(g)} = \log[\sum g] + tr(S^{(g)\ \Sigma\,(g-1) + (x^{(g)} - \mu^g)\ \Sigma\,(g-1)\ (x^{(g)} - \mu^g).}\ ) \\ c = \left(N^1 - 1\right) F^{(1)} = (N-1)F. \\ \mathrm{C} = \sum_{g=1}^{(G)} N^{(g)}\ F^{(g)} = FN. \end{gathered} \tag{3}$$

Regression equations are predicated on the idea that the data have been normalized and that any outliers have been eliminated. An evaluation of the model fit (second model) was carried out using bootstrapping to get accurate results and efficient predictions of people's perceptions of climate change and the transportation business.

4. Results

Before testing the hypotheses, the data reliability and multicollinearity were thoroughly assessed to ensure the robustness and accuracy of our findings. Firstly, we conducted checks of the data reliability and validity using established measures. The results indicated that our data exhibited a high reliability and validity, suggesting that the measurement instruments employed in our study effectively captured the intended constructs. Furthermore, we assessed the issue of multicollinearity using Variance Inflation Factor (VIF) analysis. The VIF scores, which provide an indication of the correlation between the predictor variables, were within the acceptable threshold. This indicates that multicollinearity was not a significant concern in our dataset. The absence of multicollinearity enhances the accuracy of our analyses and ensures the independence of the predictor variables. The results of our data's reliability and multicollinearity assessments provide confidence in the quality and integrity of our dataset. These findings support the validity and reliability of our study and strengthen the credibility of the conclusions drawn from our analyses.

According to this study, all the indicators are examined, and a formula is developed for each (statement). The construct validity and dependability are good (see Figure 1), and the model may be used to assess structural equations in the future, as demonstrated in Figure 2. For the reliable forecasting of reduced climate change, the fitness of the first and second models are compared. To achieve the expected forecast for the statistical findings, this research included two control variables (high and low transportation costs) in the suggested model, along with covariate routes and error terms (e3 and e4). The model's statistical significance is evaluated considering these extra variables (see Figures 2 and 3).

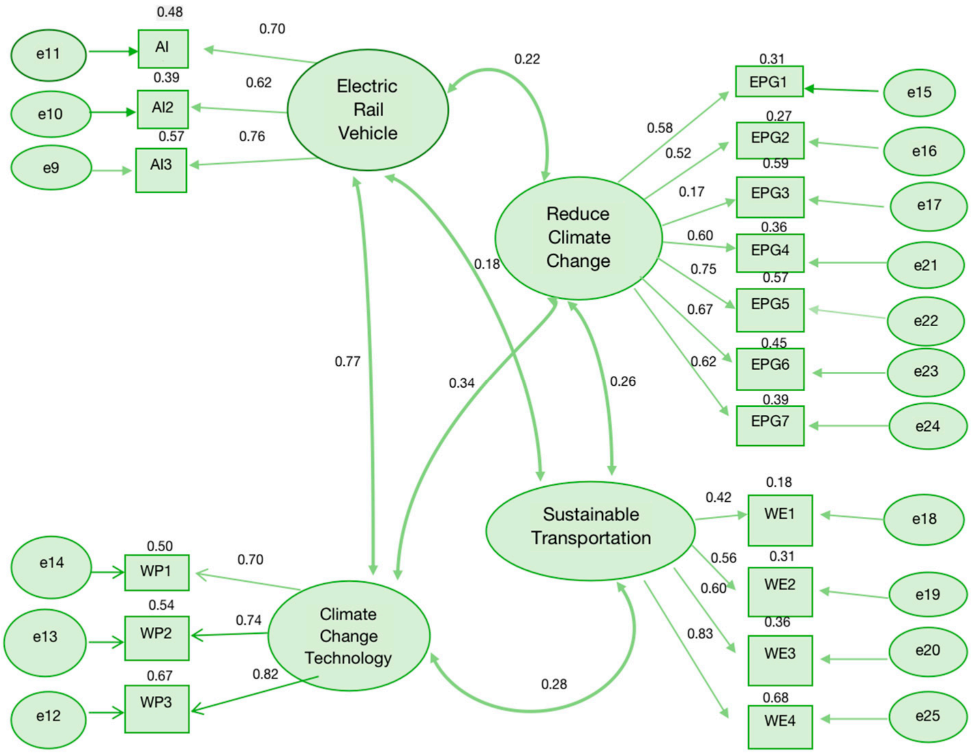

Figure 1. Combined Measurement Model of Reduced Climate Change (n = 410).

The primary objective of statistical path analysis is to identify any relationships between the variables under study. Using SEM, it is determined whether a group of variables is linked in some causal way. The R2 correlation between the initial fit and the subsequent fit models was discovered. An arrow-and-variable flowchart is used to show the causal flow or the absolute path of cause and effect for future predictions in linear analysis. Path analysis is an excellent method for measuring the relationship between direct and indirect causal effects and it shows the theoretical explanation of how various causes and effects interact to produce numerical outcomes in the form of a diagram (ratio and percentages).

When doing path analysis, it is critical to demonstrate the causal relationships between research outcomes and the variables used to predict them [1]. Indirect repercussions contribute to the advancement of scientific knowledge. Endogenous indicators are influenced by other variables or indicators when a variable has an indirect effect on it. The SEM was developed to examine these associations. The numerical display and model fit are shown in Table 2.

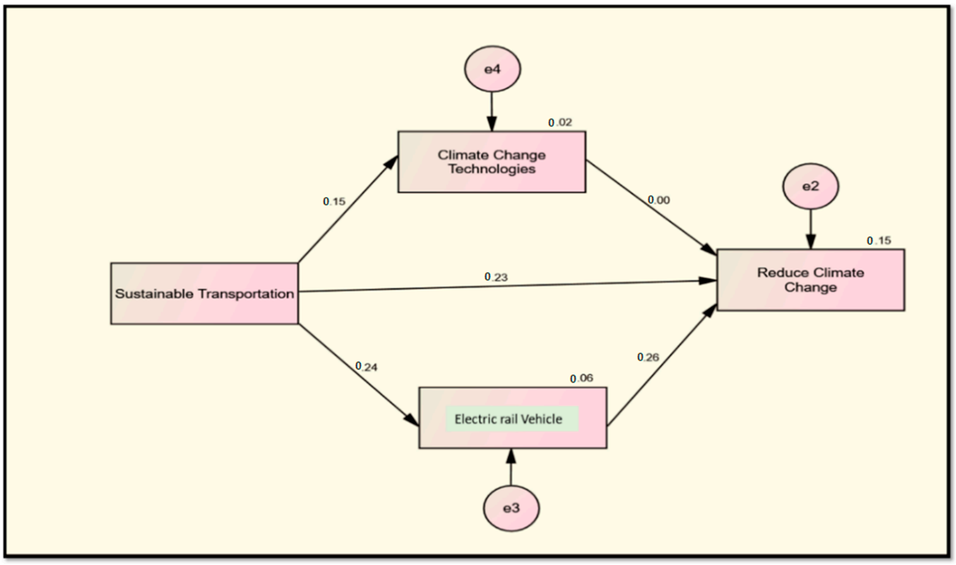

Figure 2. Empirical Results from Complex Multivariate Initial Model Representation and Standardized Regression Coefficient (A complex multivariate model of three endogenous constructs and one exogenous indicator, completely standardized maximum likelihood parade).

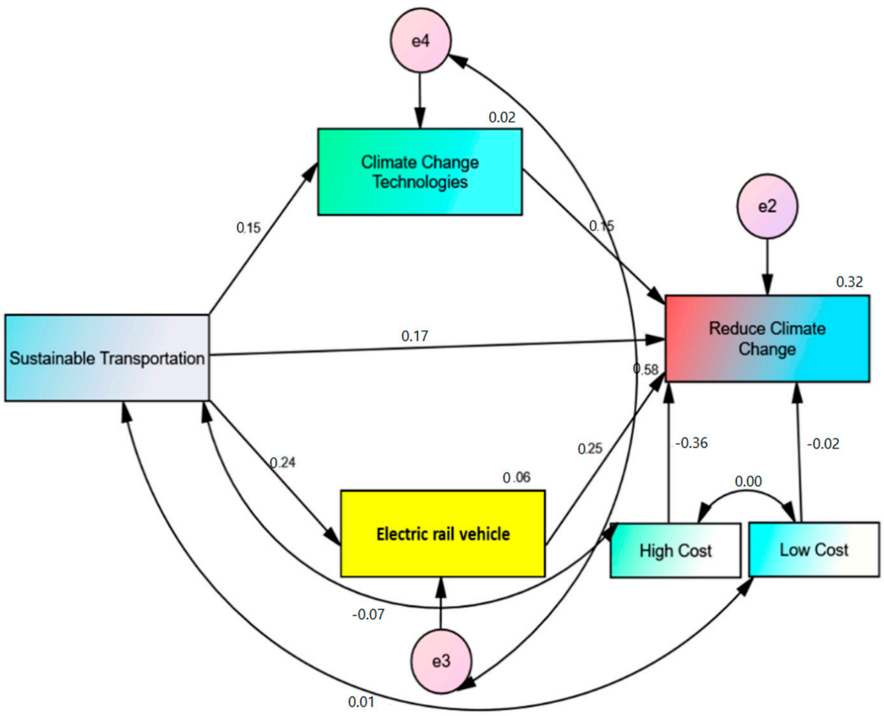

Figure 3. Empirical Results from a Complex Multivariate Model Representation Standardized Regression Coefficient for Sustainable Transportation and Reduced Climate Change.

Table 2. Fit Indices for Sustainable Transportation and Reduced Climate Change (n = 410).

Model	$\chi^2 df$	χ^2/df	*GFI*	*CFI*	*NNFI*	*RMSEA*	*SRMR*
Initial Model	2.288	2.210	0.854	0.583	0.855	0.642	0.201
Model Fit	8.329	6.582	0.949	0.862	0.919	0.081	0.060
$\Delta\chi^2$	6.014						

Note: n = 424, all the changes in Chi-square values are computed relative to model, χ^2 > 0.05, GFI = Goodness of fit index, CFI = comparative fit index, NNFI (TLI) = non-normed fit index, RMSEA = root mean square error of approximation, SRMR = standardized root mean square, $\Delta\chi^2$ = Chi-square change.

The statistical equation for the SEM was proposed to measure sustainable transportation in relation to a reduction in climate change. Equation (4) shows a covariance-based model for future climate change reduction.

$$\begin{gathered}
C\ (\alpha.\alpha) = [N-r]\left[\sum_{g-1}^{G} \frac{(N)^{g\ f(\mu^{g},\ \Sigma\ g,\ x^{(g)},\ S^{(g)})}}{N}\right] = [N-r]\ F(\alpha.\alpha) \\
\text{fkl}\ (\mu^{g} \textstyle\sum(g) x^{(g)} S^{(g)} = \log[\sum g] + tr(S^{(g)}\ {}^{\Sigma\,(g-1)+(x^{(g)}-\mu^{g})\ \Sigma\,(g-1)\ (x^{(g)}-\mu^{g})}). \\
c = \left(N^{1}-1\right)F^{(1)} = (N-1)F. \\
\mathrm{C} = \sum_{g=1}^{(G)} N^{(g)} F^{(g)} = FN. \\
(D1) CMIN\ Initial\ Model = \chi^{2} df = 2.288 \\
CMIN\ Model\ Fit = \chi^{2} df = 8.329 \\
\Delta\chi^{2} = 8.329 - 2.288 = 6.014 \\
D2\ fml\ (\mu^{g} \textstyle\sum(g) x^{(g)} S^{(g)}) = fkl\ (\mu^{g} \sum(g) x^{(g)} S^{(g)}) - fkl\ (\mu^{g} \sum(g) x^{(g)} S^{(g)}) \\
= \log[\textstyle\sum g] + tr\left(s^{g} \sum(g-1) + \left(x^{(g)} - \mu^{(g)}\right) \sum(g-1)(x^{(g)} - \mu^{(g)})\right). \\
Initial\ Model = \chi^{2}/df = 2.210 \\
Model\ fit = \chi^{2}/df = 6.582
\end{gathered} \tag{4}$$

The fit indices indicate that sustainable transportation, electric rail vehicles, climate change technologies, and a reduction in climate change have good model fit indices, as shown in Table 2. Similarly, this study found the absolute fit and the model were also significant with $p < 0.00$ and χ^2 (6404) = 8.329. The fit indices measurement explained that the theory correlates and the tested model fits. The model fit representation is compulsory and its fit indices (GFI, CFI, NNFI, RMSEA, and SRMR) were compared in step 1 and step 2 for the final inferences. Because the Chi-square test of absolute model fit is sensitive to sample size and parameter number, investigators usually employ descriptive fit statistics to evaluate the model's total fit in data. Equation (5) calculates the absolute and relative fit indices.

$$GFI = 1 - \frac{\dot{\mathrm{F}}}{\dot{\mathrm{F}}_{b}}$$

$$f\left(\sum((g), s^{(g)}) = \frac{1}{2}\ tr\ [K^{(g-1)}]\left(x^{(g)} - \sum(g-1)\right)\right)2.$$

$$Model\ fit\ value\ of\ GFI = 0.948$$

$$CFI = 1 - \frac{\max\left(\hat{\mathrm{C}} - d, 0\right)}{\max\left(\hat{\mathrm{C}}_{b} - d_{b}, 0\right)} = 1\frac{NCP}{\mathrm{NC}(P_{b})}$$

$$RNI = 1 - \frac{\hat{\mathrm{C}} - d}{\hat{\mathrm{C}}_{b} - d_{b}}$$

$$Model\ fit\ value\ of\ CFI = 0.862$$

$$TLI = 1 - \frac{\frac{\hat{\mathrm{C}}_{b}}{d_{b}} - \frac{\hat{\mathrm{C}}}{d}}{\frac{\hat{\mathrm{C}}_{b}}{d_{b}} - 1}$$

$$Model\ fit\ value\ of\ TLI = 0.919$$

$$SRMR = \sqrt{\sum_{g-1}^{G}, \left\{ \sum_{i-1}^{pR}, \sum_{j-1}^{j \leq i}, ^{(gij-;\ \sigma^{(gij)})} \right\} / \sum_{g-1}^{G} p * (g).}$$

$$Model\ fit\ value\ of\ SRMR = 0.060$$

$$Population\ RMSEA = \sqrt{\frac{\frac{F}{0}}{d}}$$

$$Estimated\ RMSEA = \sqrt{\frac{\frac{F}{0}}{d}}$$

$$LO\ 90 = \sqrt{\frac{\delta L/n}{d}}$$

$$HI\ 90 = \sqrt{\frac{\delta U/n}{d}}$$

$$RMSEA = 0.081$$

As a result, Table 2 and the graphical representation were evaluated on the set criteria [34] that the value of χ^2/df should be between 1 and 3. Likewise, the value of RMSEA and SRMR could be less than 0.08, while the CFI, TLI, NNFI, and GFI values should typically be greater than 0.90 and are regarded as a good value when it becomes $0.9 \leq 0.8$; it is then permitted in certain instances. The study model, which is also our saturation model, was fitted since the p values were smaller than ($p < 0.05 = 0.05$) (Table 2). In a similar way, the modification of the model is a very complex process if the result is fulfilling the prescribed criteria and changes are made to the model fit in the variables' inter-correlation and the relationship between the control variables. For example, sustainable transportation, electric rail vehicles, climate change technologies, and reduced climate change were inter-correlated with endogenous constructs and am exogenous path, and the final model was fit during the statistical modification indices. Because some of the elements were the same in the content and the context, further modification indices suggested that variance and covariance should be drawn between the error terms of variables. Furthermore, the study of Ref. [34] found error term and covariance to be important, and Ref. [35] defined that a quasi-experimental survey-based study is an important method to draw variance between legitimate factors. For instance, covariance errors should be at least 4.0. The value of covariance, and the "chi-square change", were higher than 4.0 and therefore were acceptable. The "chi-square change" value was 6.014. It was a modification process of the models and the early warning model suggested that the value was 6.0140. Consequently, the modification process removed all the non-significant paths in step two and added some covariance paths and control variables. As a result, the value of the RMSEA and SRMR of the model fit was again calculated and covariance insignificant paths in the second phase were removed. The results revealed that the (RMSEA = 0.081) and (SRMR = 0.060) had given the absolute model estimation. The importance of GFI = 0.949, CFI = 0.862, and NNFI = 0.919 were measured for the model fit. Similarly, the value of the goodness of fit ($\chi^2/\mathrm{df} = 6.582$) was increased, which is a sign of excellent prediction. Therefore, the study found that unique differences between the proposed and saturated models partially existed. This saturated model was the perfect model for the projection between sustainable transportation and a reduction in climate change when the mediation model of climate change technologies and electric rail vehicles was added. In conclusion, this study inferenced that the saturated model fit, and the theoretical model did not need any modification for the model fitness (Figure 3).

The saturated model was depicted in Figure 3 and the path coefficient was significant. The p values were measured, which were less than 0.05. These paths showed that each path coefficient had a significant relationship with each other. Similarly, the arrow indications of the paths is explained with beta values. The role of the beta value is important for the degree and direction with direct and indirect relationships. The independent variable is sustainable transportation, and the dependent variable is reduced climate change, which is further linked with the mediation model of climate change technologies and electric rail vehicles. The model paths, such as sustainable transportation, climate change technologies, and electric rail vehicles, have a predictive association with a reduction in climate change and the beta values (sustainable transportation <--- reduced climate change: β = 0.17 ***, sustainable transportation <--- climate change technologies: β = 0.15 ***, sustainable transportation <--- electric rail vehicles: β = 0.24 ***, climate change technologies <--- reduced climate change: β = 0.15 ***, electric rail vehicles <--- reduced climate change: β = 0.25 ***). These results conclude that both indirect and direct relationships exist between sustainable transportation, climate change technologies, and electric rail vehicles and a reduction in climate change. The inferential data concludes that a reduced climate change factor was a strong coefficient for sustainable transportation when climate change technologies and electric rail vehicles were applied. Similarly, the R2 variance was 100 × 0.110 = 11%. This means 11% variance would occur due to sustainable transportation in reduced climate change. Likewise, R2 was measured for sustainable transportation, climate change technologies, and electric rail vehicles with a variance of 100 × 0.164 = 16%. R2 predicted a 16% total change in the reduction of climate change in China per year if sustainable transportation considers climate change technologies and electric rail vehicles. Our hypothesis-1 was statistically justified that climate change technologies and electric rail vehicles collectively intervening the relationship between sustainable transportation and reduced climate change (Figure 3).

This study used the bootstrapping technique to assess the direct and indirect effects on the study variables of the statistical sample enlargement in the model fit modification and estimations process. Sustainable transportation directly and indirectly affects an output of reduced climate change through climate change technologies and electric rail vehicles. In a similar context, it was indicated that a 5000-bootstrapped sample is reliable and valid for SEM-based linear multiple regression relationship factors.

In this paper, it was hypothesized that sustainable transportation has a significant direct impact on climate change technologies; hypothesis-2 is accepted. Likewise, the results of the direct effects (shown in Table 3) revealed that sustainable transportation is a highly significant and positive predictor for electric rail vehicles. Sustainable transportation caused by climate change technologies and electric rail vehicles directly reduces climate change. The statistical direct theory concluded that wind-powered sustainable transportation such as electric rail vehicles and climate change technologies could reduce climate change (Table 3).

Table 3. Direct Effects for the Paths of Reduced Climate Change (n = 410).

Variables	Climate Change Technologies		Electric Rail Vehicles		Reduced Climate Change	
Sustainable transportation	B	S.E	β	S.E	β	S.E
	0.162	0.051	0.282 ***	0.055	0.162 ***	0.039
R^2	0.110					

Note: *** $p < 0.001$.

On the other hand, this study hypothesized that climate change technologies and electric rail vehicles mediate the relationship between sustainable transportation and reduced climate change (Table 4); here, hypothesis-3 is acknowledged. The results reported in Table 4 depict the indirect effects of climate change technologies and electric rail vehicles in the context of reduced climate change. Similarly, climate change technologies were found as a positive intervening predictor for reduced climate change. Similarly, the statistical model of electric power was significant and was also a positive mediator for reduced climate change in China's ecology. The results reveal that, overall, the mediation model can bring a 16% change in China's atmospheric conditions.

Table 4. Indirect Effects of the Paths for Sustainable Transportation and Reduced Climate Change (n = 410).

Variables	Reduced Climate Change		
	β	S.E	C.R.
Sustainable transportation	-	-	-
Climate change technologies	0.131 ***	0.045	3.168
Electric rail vehicles	0.204 ***	0.042	4.874
R^2	0.164		

Note: *** $p < 0.001$.

The projection of model fit, and hypotheses testing showed that one of the control variable hypotheses was not accepted, and all the theoretical and practical proposed hypotheses were accepted in the model. For example, sustainable transportation could predict climate change technologies, electric rail vehicles, and reduce climate change in the ecoregions of China. Finally, the results of the paths concluded that six paths were significant and one path was insignificant and the statistical projection is shown in Table 5.

Table 5. Hypothetical Paths' and Hypotheses; Significance Levels for Reduced Climate Change (n = 410).

Hypotheses	Paths	Variables	Estimate	S.E.	C.R.	P	Label
Electric Rail Vehicles	<---	Sustainable Transportation	0.282	0.055	5.168	***	Sig
Climate change Technologies	<---	Sustainable Transportation	0.162	0.051	3.168	***	Sig
Reduced Climate Change	<---	Climate Change Technologies	0.131	0.045	2.939	***	Sig
Reduced Climate Change	<---	Sustainable Transportation	0.162	0.039	4.122	***	Sig
Reduced Climate Change	<---	Electric Rail Vehicles	0.204	0.042	4.874	***	Sig
Reduced Climate Change	<---	High-Cost Transportation	−0.303	0.034	−8.897	***	Sig
Reduced Climate Change	<---	Low-Cost Transportation	−0.009	0.021	−0.423	0.672	Insig

Note: *** $p < 0.001$.

Simulation and Forecasting Results

The simulation results are also beneficial for the theoretical modelling and simulation-based (n = 10,000) sample size when electric rail vehicles are considered. The geographical ecoregions of China include eleven subdivision ecoregions. This study also applied Python to different datasets for a graphical representation and depicted the results of sustainable transportation on reducing climate change (Earth's atmosphere warmness). This quasi-experiment was conducted to learn the ecology ministry personnel's opinions regarding a reduction in climate change (Earth's atmosphere warmness) in the ecoregions of China. The data on sustainable transportation have shown some drastic results, and it was revealed that the combination of climate change technologies and electric rail vehicles could reduce climate change at the national level of China. The data pertaining to sustainable transportation have yielded significant findings, revealing the potential for mitigating climate change through the combination of climate change technologies and electric rail vehicles, particularly at the national level in China. Figure 4a–d) provides a visual representation of the reduced model highlighting the impact of sustainable transportation on climate change across various ecoregions in China. This figure serves as a valuable tool for enhancing the discussion on the findings related to the reduction in climate change through sustainable transportation. By examining the specific details and trends presented in Figure 4, further insights can be gained into the effectiveness and implications of sustainable transportation practices in addressing climate change in different ecoregions of China.

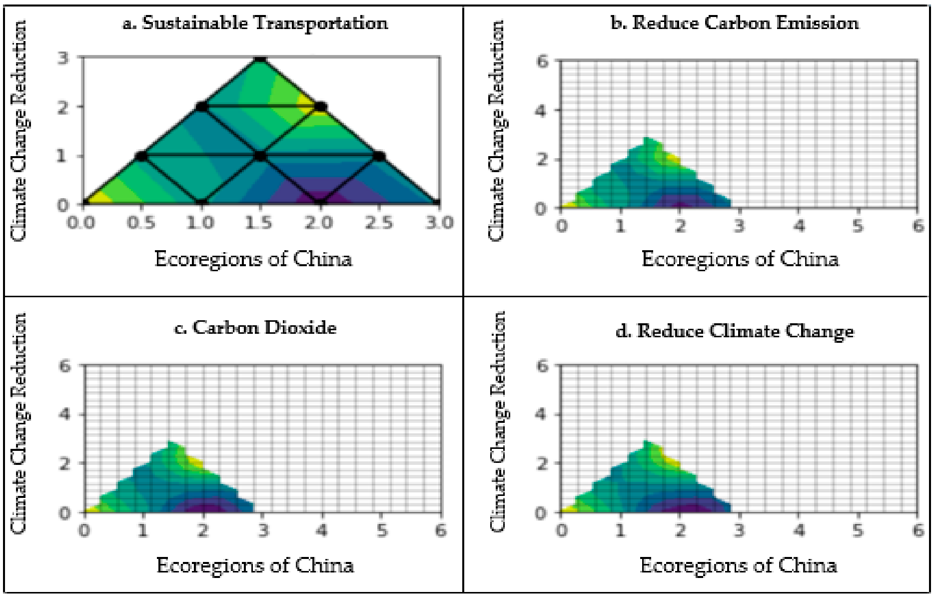

Figure 4. Reduced Model of Climate Change Due to Sustainable Transportation in the Ecoregions of China: (**a**) Sustainable Transportation; (**b**) Reduction in Carbon Emissions; (**c**) Carbon dioxide; (**d**) Reduction in Climate Change.

The real-time data trends were measured on the specific sampling base. Similarly, the ecoregions of China have some particular variations in the predictive training model, which is good as the ways sustainable transportation can reduce climate change in the future is revealed through the forecasting measurement of the Python dataset. Figure 5a illustrates a crucial aspect related to sustainable transportation by highlighting the potential consequences of not implementing sustainable transportation measures. The depiction suggests that, in the absence of sustainable transportation, the climate in the ecoregions of China is likely to experience abrupt changes. This portrayal emphasizes the urgency and significance of adopting sustainable transportation practices to mitigate adverse climate impacts. The findings presented in Figure 5a underscore the importance of sustainable transportation in preserving environmental stability and averting potential disruptions to the ecoregions of China. The visual representation serves as a powerful reminder of the alarming situation that could unfold without effective sustainable transportation strategies. By considering the details and implications conveyed by Figure 5a, policymakers, stakeholders, and researchers can gain a deeper understanding of the critical role that sustainable transportation plays in combating climate change and ensuring the long-term ecological well-being of China's ecoregions. Furthermore, the lines of the histography established that predictive changes could have occurred with the help of sustainable transportation, which would reduce climate change (Figure 5b). Figure 5b sheds light on the potential positive outcomes that can be achieved through the implementation of sustainable transportation practices in addressing climate change. The lines depicted in the histogram signify the predictive changes that could occur with the aid of sustainable transportation, leading to a reduction in climate change impacts. This representation highlights the promising and proactive role of sustainable transportation in mitigating climate change effects within the context of the ecoregions of China. By demonstrating the potential changes that can be realized through sustainable transportation interventions, Figure 5b provides valuable insights into the transformative impact of adopting eco-friendly transportation modes and technologies.

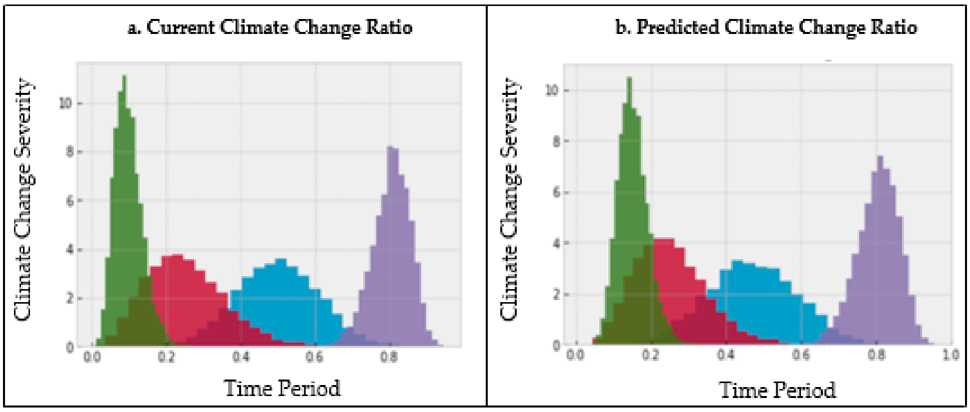

Figure 5. (**a**) Current Climate Change Ratio, (**b**) Predictive Climate Change Ratio.

The findings conveyed in Figure 5b emphasize the importance of proactive measures and investments in sustainable transportation infrastructure and policies. By embracing sustainable transportation practices, such as the use of low-carbon vehicles, improved public transportation systems, and the integration of renewable energy sources, it becomes possible to foster a significant reduction in GHG emissions and promote a more sustainable and resilient future. Thus, Figure 5b serves as a powerful visual tool that strengthens the discourse surrounding the positive correlation between sustainable transportation and climate change mitigation. It reinforces the need for continued efforts and policy interventions to promote and support sustainable transportation solutions to effectively address climate change challenges in the ecoregions of China.

However, the effects of GHGs (CH_4, N_2O, and HFCs) were also compared. It has been proven that these three chemical elements individually and collectively affect (see Figure 6) the Earth's atmospheric conditions hazardously. Figure 6 provides a comprehensive assessment of the impact of GHGs, specifically CH_4, N_2O, and HFCs, on the atmospheric conditions of the Earth. Figure 6 demonstrates that these three chemical elements, both individually and collectively, exert a hazardous influence on the Earth's atmosphere. By visualizing the data and trends presented in Figure 6, a deeper understanding of the significant role played by these GHGs in shaping atmospheric conditions can be gained. The representation emphasizes the need for comprehensive and targeted measures to address the emissions and concentrations of these gases to mitigate their adverse effects on the environment and human health.

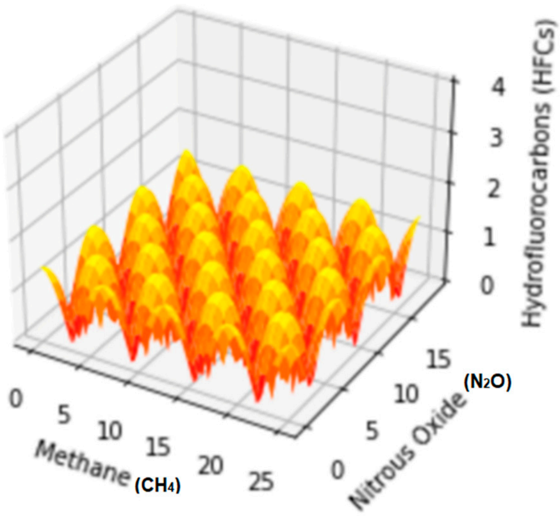

Figure 6. Combined Effect of Chemical Elements on the Earth's Atmospheric.

The findings depicted in Figure 6 reaffirm the urgency and importance of global efforts to reduce GHG emissions and combat climate change. It underscores the role of these GHGs in contributing to the greenhouse effect and global warming, leading to various environmental and climatic consequences. Furthermore, Figure 6 serves as a valuable tool for policymakers, researchers, and stakeholders to recognize the specific contributions of CH_4, N_2O, and HFCs to atmospheric changes. This knowledge can inform the development and implementation of effective strategies, policies, and technologies to mitigate the emissions of these gases and mitigate their impact on climate change. Hence, Figure 6 highlights the critical significance of understanding and addressing the harmful effects of CH_4, N_2O, and HFCs to safeguard the Earth's atmospheric conditions and mitigate the risks associated with climate change. It reinforces the need for concerted global actions to reduce GHG emissions and transition towards more sustainable and environmentally friendly practices.

Figure **??** showed the Earth's atmosphere's warmness on different Earth-level surfaces. The findings revealed that unsustainable transportation and non-electric rail vehicles could increase 0.5% climate change in the ecoregions of China. Similarly, it is significantly measured that sustainable transportation could decrease or address climate change by up to 20% in the ecoregions of China. The figure emphasizes the importance of sustainable transportation in mitigating climate change and underscores the substantial impact it can have on reducing greenhouse gas emissions and the overall warming of the Earth's atmosphere. It provides a visual representation of the significant difference in climate change outcomes based on the choice of transportation options, serving as a compelling argument for the adoption of sustainable transportation practices in the ecoregions of China.

Lastly, this study found unique combined results regarding sustainable transportation systems and reduced climate change at different alpha levels. In conclusion, a sustainable transportation system could reduce climate change at each alpha level if climate change technologies and electric rail vehicles are implemented on the Earth level. These possibilities would reduce climate change and address atmospheric conditions in the natural environment. The model was trained at different alpha levels and measured change in the reduced climate change factorability.

Table 6 (Figure 7) presents the calculated modal split for an electric rail vehicle, along with sensitivity analysis ranges, considering a 20% variation in all mode attributes. The modal split represents the distribution of people using different modes of transportation. The table shows the modal split for various modes of transportation, including cars, carpooling, transit, cycling, walking, and electric rail. At present, cars have the highest modal split with 31%, indicating that 31% of people use cars as their primary mode of transportation. The sensitivity analysis estimates a range of 19–23% for the car modal split, accounting for the variation in mode attributes. Looking ahead, the projected future modal split for cars is expected to be in the range of 27–29%. Carpooling currently has a modal split of 16%, suggesting that 16% of people choose carpooling as their mode of transportation. The sensitivity analysis shows a range of 8.4–11% for the carpool modal split. In the future, the projected modal split for carpooling is anticipated to be around 8.4–8.6%. The current modal split for transit is 5.1%, indicating that 5.1% of people use transit options for their transportation needs. Through the sensitivity analysis, the modal split for transit is estimated to range from 3.8 to 4.1%. Looking ahead, the projected future modal split for transit is expected to be in the range of 3.7–3.9%. Cycling currently accounts for a modal split of 29.8%, indicating that a significant portion of people, approximately 29.8%, prefer cycling as their mode of transportation. The sensitivity analysis suggests a range of 20–22% for the modal split of cycling. In the future, the projected modal split for cycling is anticipated to be around 24–26%. Walking has a current modal split of 17.6%, indicating that 17.6% of people prefer walking as their mode of transportation. The sensitivity analysis estimates a range of 15–16% for the modal split of walking. Looking ahead, the projected future modal split for walking is expected to be in the range of 14–15%. The sensitivity analysis suggests a range of 22–29% for the modal split of electric rail. In the future, the projected modal split for electric rail is expected to be around 14% and 19%. Thus, Table 6 (Figure 7) provides an overview of the current and projected modal splits for different modes of transportation, with a specific focus on the modal split for an electric rail vehicle. The sensitivity analysis ranges account for variations in the mode attributes and offer insights into the potential changes in modal splits for each mode in the future.

Table 6. Modal Split Calculation for Electric Rail Vehicle with Sensitivity Analysis on a 20% Changes of other selected Mode Traits.

Mode	Modal Split (Current)	Multinomial Logit (MNL) (%)	Model Split (Future), NL
Car	31%	23 (19–23)	29 (27–29)
Carpool	16%	11 (8.4–11)	8.6 (8.4–8.6)
Transit	5.1%	4.1 (3.8–4.1)	3.9 (3.7–3.9)
Cycle	29.8%	22 (20–22)	26 (24–26)
Walk	17.6%	16 (15–16)	15 (14–15)
Electric Rail	-	22 (22–29)	14 (14–19)

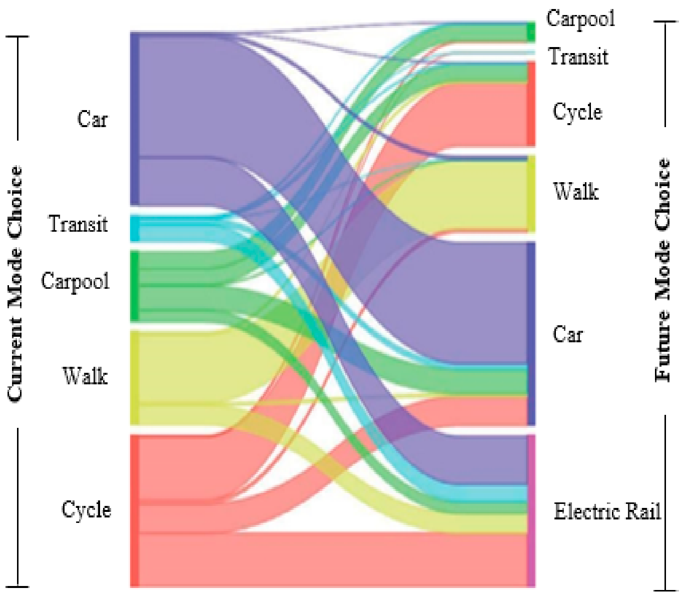

Figure 7. Sankey diagram of current and future mode choice for the nested logit model.

5. Discussion

China is one of the most advanced technological countries, and therefore could reduce GHG emissions via a sustainable transportation industry. This study discovers China's dynamic links between public transportation, cutting-edge technology, and CO_2 emissions. This study found through the novel dynamic autoregressive distributed lag simulation that sustainable transport and new technologies reduce pollution. The environmental cost of using public transportation and spending more money per person is higher. As a result, authorities should not encourage transport infrastructure and should take advantage of innovative technology's significant environmental benefits for a clean environment. Similarly, the current study found that a sustainable transportation system could reduce climate change in different ecoregions of China if the climate change technologies and electric rail vehicles are implemented in the transportation industry. On the other hand, Mexican vehicle fuel consumption and its challenging links with environmental changes increase the Earth's atmospheric warmness. Additionally, this leads to a significant increase in g CO_2/km and fuel consumption and the use of 69.25 more gasoline a year, resulting in an additional 129.024 kg of CO_2 (12.18 g CO_2/km), costing USD 1414.08. More than 45 million vehicles are now in use in Mexico, with an average age of 15.3 years, and 5.806 million metric tons of CO_2 are emitted, making up 3.6% of total emissions. As a result, governments may devise procedures and strategies for conforming to low pollution standards by examining electric rail vehicles and their negative implications for climate change. Furthermore, the present study chose the theoretical interpretation of electric rail vehicles as sustainable transportation and it was found that electric rail vehicles can reduce climate change up to 11%. Thus, our findings are in line with prior studies [6–8,13–19,36–39].

Ref. [10] measured the internal combustion engine and its tremendous impact on pollution. Similarly, it was found that local zero-emission standards and the global climate need further renovations to reduce carbon emissions. Our study results revealed that electric rail vehicles and sustainable transportation could reduce climate change through climate change technologies. Furthermore, the study developed a conceptual understanding of climate change and the Chinese Government's implementations for non-governmental organizations (NGOs) as well as their role in the discussions with other ecoregions. Additionally, Ref. [40] drew a conceptual framework for the third parties, such as "Superior Communist Party and Central Government, National People Congress, Chinese People's Political Consultative Conference, Supervisory Committee and Public, "Media and Courts", should follow the environmental law and implement these laws and regulations in their third parties' organizations. In this context, the present study would add law and regulation to these environmental ethics and advise that third parties' ownership should follow the law and regulations for the transport industries. Likewise, it was found that explosive population expansion and suffocating pollution have damaged green sustainability due to current transportation systems, which have less energy and burn more fuel. This study will help reduce emissions such as N_2O, CO_2, and particulates in the green environment. It is best to avoid driving an outdated car in a highly populated location since the transportation system contributes significantly to global warming. Transportation systems and highly populated urban areas are significant sources of air pollution, releasing CH_4, N_2O, CO_2, and other emissions into the atmosphere. This might harm the global climate [41–43]. A clean environment is essential to the survival of ecosystems since pollution impedes their growth. The policymakers should rebuild an eco-friendly atmosphere and cities' transportation systems to reduce climate change in the country. In a similar vein, the current study revealed that GHGs (CH_4, N_2O, and HFCs) collectively influenced the Earth's atmospheric conditions [44,45].

Public transit systems, including buses, trams, and electric rail, exhibit lower energy consumption per passenger per kilometer compared with private vehicles. This is attributed to factors such as larger passenger capacity, optimized routes, and the use of efficient technologies. Public transit benefits from economies of scale, enabling the transportation of more passengers with less energy input. Additionally, the introduction of electric and hybrid buses and trains further reduces energy consumption and dependence on fossil fuels.

Regarding GHG emissions, public transit has the potential to significantly contribute to emission reduction compared with private vehicles. Private vehicles, typically powered by combustion engines, emit GHGs, primarily CO_2, during operation. Conversely, public transit systems can shift towards electric or low-emission alternatives, such as electric buses or trains powered by renewable energy sources. This transition can substantially decrease overall GHG emissions, as electric rail systems produce zero tailpipe emissions when powered by renewable sources. By promoting the adoption of electric public transportation and integrating renewable energy, cities can make significant strides in addressing climate change and improving air quality.

Tonnage kilometer statistics offer insights into the efficiency and utilization of transportation modes, particularly in freight transport. Public transit systems, benefiting from their larger capacity and optimized routes, can transport larger quantities of goods per unit of energy consumed compared with private vehicles. This efficient movement of goods through public transit helps reduce energy waste and promotes a more sustainable transportation system. Effective urban planning and the integration of public transit networks further enhance tonnage kilometer efficiency by optimizing routes and minimizing empty trips.

Passenger kilometer statistics provide an assessment of the utilization and efficiency of public transit and private vehicles in terms of passenger capacity and distance traveled. Public transit systems strive to maximize passenger kilometer efficiency by carrying a larger number of passengers over long distances. Achieving this involves factors such as offering frequent and reliable services, optimizing routes, and utilizing vehicles efficiently. On the other hand, private vehicles often exhibit lower passenger kilometer efficiency due to lower occupancy rates and less optimized travel patterns. Encouraging a shift from private vehicles to public transit, especially electric rail, can increase overall passenger kilometer efficiency while alleviating congestion on roadways.

The modal split analysis reveals that cars currently hold the highest modal split, indicating their dominance as the primary mode of transportation with 31% usage. However, the projected future modal split for cars shows a slight decline to 27–29%, potentially indicating a shift towards other modes. Interestingly, cycling demonstrates a significant modal split of 29.8%, highlighting its popularity as an alternative mode of transportation. The projected future modal split for cycling also shows growth to 24–26%, emphasizing its potential for further adoption. Carpooling, transit, and walking show stable modal splits, while electric rail presents a wide range of sensitivity analysis, indicating the need for further investigation. These findings emphasize the importance of considering alternative modes of transportation, such as cycling, in efforts to promote sustainable and efficient urban mobility.

6. Conclusions

In this analysis, it is proposed that governments and civil society follow the law and regulate climate change, such as limiting gasoline and diesel's release of CO_2 and GHGs into the atmosphere. Such chemical reactions build up CO_2 and other GHGs, such as CH_4, N_2O, and HFCs, which cause climate change and alternately, global warming. This study concludes that sustainable transportation policies could be formulated and implemented to reduce climate change. Similarly, a research study argued that it is highly desirable for the Chinese legal system and political decision-making processes to address climate change by implementing sustainable transportation with the help of climate change technologies and electric rail vehicles, which reduce GHGs such as CH_4, N_2O, and HFCs. The lawmakers, such as those theorizing legal principles and third parties' general principles, and legal authorities should apply this conceptual model to transportation industries to mitigate climate change. Chinese third-party transport industry owners should be aware of climate change and be mindful to act accordingly in their industries. It is challenging to combat climate change via a "managerial model" directly involved in the transport industries. Therefore, from this vantage point, adopting a bottom-up or hybrid strategy would create a kind of interactive platform to sustain the transport industry with the combination of climate technology and electric rail vehicles.

6.1. Recommendations and Suggestions

It is recommended that since climate change is a multi-level governance issue, the old pyramidal model of the transport industries must be shifted to a sustainable transportation system. The recommendation to put forward to the policymakers is to implement a bottom-up strategy or hybrid dynamic approach to the transport industries for combating climate change issues in China. The government should make decisions regarding electric rail vehicles and recycle old non-electrical vehicles, enhancing climate change response behaviors. In terms of climate change, this study will better encourage the application of electric rail vehicles and accomplish more acceptable hybrid dynamic model vehicles for the Chinese transport industries.

6.2. Limitations and Future Directions

Like other studies, this one has certain caveats; therefore, we will discuss some potential future research avenues. Public and road transportation are the two main branches of the transportation industry. Future research can compare the two to show which one is more environmentally and financially responsible. This report avoids a country-by-country breakdown in favor of a regional concentration on China. With this limitation in mind, it would be helpful to have a time-series estimate at both the individual and national levels to grasp the connection between transportation and climate change technology. It is also important to recognize the existence of intra-urban variation as a phenomenon deserving further study, as this variety has the potential to lead to more fruitful and nuanced policy outcomes if it is studied. The significance of this link increases when additional modes of transportation, such as airplanes and trains, are taken into account. If these correlations hold true for countries with varying rates of economic development, we may learn something new. Finally, considering the tight interconnectedness between our variables and investigating the consequences of these variables on things such as economic growth, health spending, financial development, and automobile use may help us achieve better empirical results.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. Questionnaire

Sustainable Transportation
Using electric transportation reduces environmental pollution.
Encouraging walking and cycling can reduce carbon emissions.
Implementing carpooling initiatives can help reduce traffic congestion and carbon footprint.
Investing in electric vehicles promotes sustainable transportation practices.
Climate Change Technologies
Renewable energy sources play a crucial role in mitigating climate change.
Carbon capture and storage technologies can help reduce greenhouse gas emissions.
Implementation of energy-efficient technologies is essential for combating climate change.
Electric Rail Vehicles
Electric rail vehicles are a sustainable and eco-friendly mode of transportation.
Electric rail vehicles have the potential to reduce carbon emissions significantly.
Investment in electric rail vehicles contribute to a cleaner and greener environment.
Reduce Climate Change
Conserving energy by turning off lights and appliances when not in use.
Supporting renewable energy initiatives in your community.
Reducing personal carbon footprint by using electric transportation.
Planting trees and promoting afforestation to absorb carbon dioxide.
Advocating for government policies and regulations to address climate change.
Supporting companies and organizations that prioritize environmental sustainability.
Educating others about the importance of climate change mitigation and sustainability.

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