Environmental Responsibility of Passenger Car Users: Eco-Driving for a Greener Tomorrow

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Abstract

A recent study by the Japan Automobile Manufacturers Association (JAMA) specified that vehicle users generated 70% of pollution through tailpipe emissions, reducing air quality. These tailpipe emissions create serious environmental problems that can be suppressed by driving an environmentally friendly vehicle. This study aims to recognise the role of ecological knowledge, attitude, and intention in the eco-friendly driving behaviour of Passenger Car Users (PCU). The literature suggests that environmental attitudes and intentions are formulated into environmentally friendly behaviour. The eco-friendly driving practice can reduce up to 35 percent of petrol and gas consumption and 96% of accident rates, stress levels, mishap percentages, and roadblocks during rush hours. Gathered primary data from specific areas in Chennai to assess eco-friendly driving behaviour among 400 car users, using a Likert scale and applying statistical analyses including multiple regression and Structural Equation Model. Thus, following and practising eco-friendly driving behaviour is essential to control emissions and fuel consumption to improve environmental protection and human health.

Keywords: Eco-friendly Behaviour, Environment, Structural Equation Modelling, Tailpipe Emission, Automobile.

JEL Classifications: Q01, R41, M31, R41

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1. Introduction

Introduction Global automobiles are responsible for 25% of carbon discharge (OICA, 2020). Automobile users generate 70% of carbon; the remaining 30% is contributed by automobile producers (JAMA). Globally, at present, there are more than 2 billion vehicles. Among them, 50% are cars, which is expected to increase by 8% yearly. Normally, the older car releases more than 203g/km of carbon, the normal car model releases up to 170g/km, and the 2020 new car model releases 140g/km per emission standard (Nasr Azadani, 2024; Fontaras & Samaras, 2010). According to a study of Mahamuni-2014, the passenger car emits 4.6 million metric tonnes of carbon into the atmosphere in a year (Mahamuni & Tambe, 2014). Normally, the engine combusts the fuel and converts it into various emission forms, resulting in environmental pollution. These tailpipe emissions have already played a major role in the global perspective via global warming, greenhouse gases, ozone depletion, climatic change, acid rain, etc. (Orecchini & Sabatini, 2003). It creates serious environmental problems that have become unresolved among many countries.

Maria Neira, the health director of the World Health Organization (WHO), said, "We are in a risky situation which already has a greater impact on global health due to air pollution. There is a demand for concert solutions to clean up the air we all breathe" (Rehfuess & Neira, 2006). The WHO reported that the air quality in Indian metropolitan cities is worse than that of other cities. According to the Centre for Science and Environment (CSE), the top twenty polluted cities in the world are among the thirteen major cities in India (Pratheepkumar et al., 2017). As per the report Survey of Teri Environmental 2014, automobile tailpipe emissions are mainly responsible for air contamination in the cities of Mumbai, Bangalore, Delhi, Chennai, Kolkata, Guwahati, Hyderabad, Coimbatore, Jamshedpur, Kanpur, Indore, etc with more than 35%. The study conducted by the Green Rating Project (GRP) testified that tailpipe emission exhaust carries 70% of carbon, nitrogen (45%), hydrocarbon (34%), and other elements.

Smog is measured and considered a life-threatening factor for all living creatures and has become the 4th dangerous factor for death. It kills around 1.2 million Indians annually (Ramachandra & Sreejith, 2015), and every minute, two Indians die. Vehicle-related pollution causes several health problems for humans and is considered the root cause of various diseases (Prothero & Fitchett, 2000; Timmermans and Lataire, 2006). Some of the health issues are nasal suffocation, watery eyes, skin rash, pulmonary disorders like – lungs, chest, asthma, diseases, etc. (Jamson & AH Jamson, 2015; Pilkington, 1997; Arokiaraj, 2015) and also damage to the principal organs of the liver, kidneys, heart, and brain (Romero et al., 2024). The study conducted by Sundeep, the director of the 'Chest Research Foundation,' concluded that nearly half of the patients' visits to the doctor reported respiratory problems due to air pollution (Salvi & Barnes, 2009). Apart from pollution, another important problem is horn sound. It is measured that over the past ten years, it has gradually increased. A high level of noise pollution causes high blood pressure, faster heartbeat rate, dilatation of the pupils, headache, sleeping disturbance, nervous tension, and stress (David & Banumathi, 2014; Timmermans & Lataire, 2006).

The issue of tailpipe emissions can be suppressed by driving a vehicle in an environmentally friendly manner (Arokiaraj, 2015). The concept of eco-friendly driving behaviour has begun in developed nations like Austria as environmentally friendly driving means "climate: active mobile and energy-saving mode whereas, in Germany, it is called "new driving – clever, safe, further" and "the new driving" in the Netherlands (D'Souza & Peretiatko, 2007; Safai & Devara, 2012). Promoting environmental driving behaviour programs is mandatory in other nations like Australia, Canada, the UK & the USA. In response to eco-friendly driving behaviour, practices have reduced up to 35% of fuel consumption and 96% of accident rates.

Another study shows that practicing eco-friendly driving has eliminated up to 2 million tons of carbon emissions (Safai & Devara, 2012). Small changes in driving behaviour could reduce tailpipe emissions and fuel consumption (Arokiaraj, 2015). Research conducted by the Japanese Ando Ryosuke and Nishihori Yasuhide observed that economic-driving behaviour could reduce 25% of fuel consumption (Ando & Ochi, 2010; Lin Wang, 2022). Simultaneously, it also brings down the stress level, accident rate, and traffic congestion. Proper awareness about the public's environmental problems would change attitudes and intentions towards environmentally committed people. Thus, it is essential to understand eco-friendly driving to improve the environment, human health, and the economy.

This study is prepared as follows: the introduction outlines the environmental challenges posed by automobile emissions and the importance of eco-friendly driving. The literature review explores the theories and prior studies on ecological knowledge, attitudes, and behaviour, which established the foundation for the research framework. The research method describes the data collection and analysis techniques, that were focused on passenger car users in Chennai. The subsequent sections present the findings and discussion of interpreting the statistical results, followed by the conclusion, which summarises insights and implications for promoting sustainable driving practices.

2. Literature Review

A literature review was gathered to understand the vehicle users' eco-friendly driving behaviour habits through ecological knowledge, attitude level, and intention towards the environment. The knowledge and attitude of the people regarding environmental behaviour have been conceptualised, which is unintentionally reflected in their attitude and behaviour (Straughan & JA Roberts, 1999). Many studies were conducted about behaviour, intention, and attitude to protect the environment, formed on people's knowledge and will be revealed and changed into environmentally committed people. In his research, monks, 2009 stated that environmental behaviour is the key technique to reducing pollution globally (Monks & Blake, 2009). Environmental knowledge is also needed to frame environmentally concerned behaviour (Boztepe, 2012; Krause, 1993).

The controlled driving attitude indicated a high level of knowledge about environmental impacts (Straughan & Roberts 1999). Nowadays, consumers are more aware of environmental issues and saving the environment (Arokiaraj & Banumathi, 2015). The ecological attitude and knowledge are both significant.

The Theory of Responsible Action states that environmentally responsible behaviour is influenced by attitude and intention (Hines & Tomera, 1987). Meanwhile, according to Ajzen and Fishbein, in "The Theory of Reasoned Action (TRA)," " behaviour is the outcome of intention, and attitude is the root cause of intention" (Ajzen & Fishbein, 1980). So basically, behaviour is moulded with the help of knowledge that can be composed of people's attitudes and intentions (Pratheepkumar & Arokiaraj, 2017). The consistency theory explains the relationship between attitude and behaviour (Newhouse, 1990).

Ecological attitude explains why consumers engage in environmentally conscious behaviour. People's feelings towards environmental aspects define the ecological attitude (Hines & Tomera, 1987). The degree of ecological awareness positively determines their attitude towards environmental behaviour. Environmentally responsible behaviour is an act by a person or group motivated by the continual use of natural resources (Cottrell & Graefe, 1997). Kollmuss & Agyeman defined it as "behaviour is conscious to seek to minimise the negative impact of one's actions on the natural and built sustainable future" (Kollmuss & Agyeman, 2002; Srivel & David, 2018; Chada et al., 2023).

It is well-known that not all attitudes are interpreted as behaviour; there is an attitude-behaviour gap. This gap is also present in environmental behaviour (Bartiaux, 2008). The Theory of Planned Behaviour (TPB) and TRA are extensively applied in Western cultures. Nevertheless, it is unclear what their assumptions are underpinned in the Indian context, especially in the environmental driving behaviour of passenger car users. However, limited research has discussed the direct relationships between ecological knowledge, intention, attitude, and driving behaviour towards the environment. The theoretical framework of eco-friendly driving behaviour was formed below,

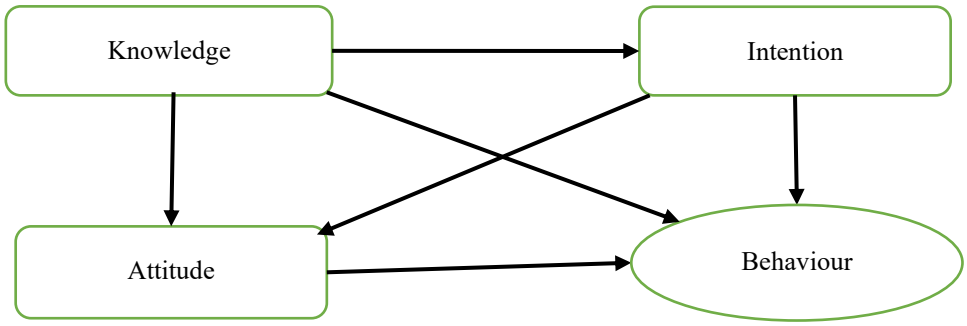

Figure 1. The Theoretical Framework of Eco-friendly Driving Behaviour
Source: Ajzen & Fishbein.

3. Research Method

Primary data was gathered from the PCUs in the Chennai region. It was collected from the particular areas of Chennai (India) are Anna Nagar, Guindy, Nungambakkam, T.Nagar, Vadapalani, Koyambedu, Meenambakkam, and Ambattur Industrial Estate are selected and considered as major areas for the study area. Four hundred data were gathered with the help of the Stratified Random Sampling technique in the Chennai region. The questionnaire was developed based on literature reviews concerned about the eco-friendly driving behaviour of passenger car users. A 5-point Likert

scale (Strongly Disagree-to-Strongly Agreed) was applied in the questionnaire circulated among the PCUs to understand their environmental knowledge level, attitude, intention, and eco-friendly driving practice. Descriptive statistics were used to measure the percentage of respondents. The normality test was conducted to identify the data's distribution, and the data's reliability was also checked. Multiple regression was performed to understand the significance of variables, and based on the result, the Structural Equation Model (SEM) was extended to identify the significant impact among exogenous and endogenous variables.

Table 1. The Demographic Profile of PCU

Driving Profile	Category	%	Driving Profile	Category	%
Gender	Male	76	Brand Name	Maruti	16
	Female	24		Tata	14
Car Size	Small	38		Toyota	13
	Medium	36		Chevrolet	8
	Large	14		Mitsubishi	03
	Luxury	12		Renault	02
Years Used	1 - 5 Yrs	35		BMW	01
	7 months - 1 Yr	30		Volkswagen	01
	> 6 months	14		Audi	01
	6 - 10 Yrs	12		Fiat	01
	< 25 Yrs	03		Others	40
	11 - 15 Yrs	02	Fuel Used	< 25 Litres	25
	16 - 20 Yrs	02		16 - 20 Litres	20
	21 - 25 Yrs	02		21 -25 Litres	20
Experience	1 - 5 Yrs	32		6 - 10 Litres	13
	7 months - 1 Yr	24		11 - 15 Litres	13
	6 - 10 Yrs	18		> 5 Litres	09
	> 6 months	13	City Speed	41 - 60 km/s	43
	11 - 15 Yrs	04		21 - 40km/s	25
	16 - 20 Yrs	03		61 - 80 km/s	14
	21 - 25 Yrs	03		81 - 100 km/s	08
	< 25 Yrs	03		> 20 km/s	05
Driving Style	Careful	35		101 - 120 km/s	03
	Relaxed	34		< 121km/s	02
	Aggressive	13	Highways Speed	91 - 120 km/s	36
	Sporty	09		61 - 90km/s	24
	Assertive	09		121 - 150 km/s	18
				151 - 180 km/s	11
				31 - 60 km/s	05
				> 30 km/s	04
				< 181 km/s	02

Source: Primary Data.

The above passenger car user profiles show that 76% of respondents are male. They mostly prefer small (38%) and medium-sized cars (36%). It was found that 35% of PCUs have been using their car for the last five years, and 32% of PCUs had a minimum of 5 years of experience. The driving style of PCUs is driving their vehicle carefully (35%), relaxed (34%), aggressively (13%), sporty (9%) and assertively (9%). The data were collected from 15 different brands among passenger cars such as Audi, Mercedes Benz, Toyota, Chevrolét, Fiät, Ford, Tata, Hyundai, Maruti Suzuki,

Mitsubishi, Mahindra, Honda, Renault Nissan, Volkswagen, and Skoda. Based on the above car brands, it is recognised that 16% of car models belong to Maruti, followed by Toyota (13%), Tata (14%), and others. As mentioned above, there are around 76 car models from those 15 brands. Among the car models are Maruti Suzuki (Swift Dizier), Tata (Indica), Toyota (Fortuner), Ford (Figo), and Hyundai (i10), Honda (City), are the leading models in the study area. On average, the respondents consume 25 litres of fuel per month. Around 43% of them drove within the city limits (41 - 60 km/s) and on highways, whilst 36% drove with a speed of about 91 - 120 km/s. It is evident that the driving style and car speed depend upon the driver's behaviour (vehicle user), the crowd on the road, urgency, and travelling purpose.

The normality distribution was checked based on the Kurtosis and Skewness values. The thumb rule required that the calculated values should be between ± 1.96, which accepts the normal distribution of the data. The result of Kurtosis and Skewness values shows that the computed values are between ± 1.96, ensuring the normal distribution of the data. The reliability of the data was verified with Cronbach's alpha value (α). The calculated values show that all the factors are more than 0.7, which insists they have construct validity and internal consistency (Kline). The multicollinearity of all independent variables (Intention, Attitude, and Knowledge) was checked. The tolerance and Variance Inflation Factor values (VIF) were also within the cutoff range. The multiple regression was analysed to understand the impact of the independent variables on eco-friendly driving behaviour. The independent variables are ecological knowledge, environmental attitude, and environmental intention. The results show that the adjusted R2 value is 0.401which, which means that three independent variables influence eco-friendly driving behaviour by 40%. The regression-ANOVA test value explains that the dependent variable has been forecasted based on the independent variables F (3, 396) = 89.874, P< 0.0005, showing the model fit.

Table 2. The Result of Multiple Regression for Ecofriendly Driving Behaviour

Coefficients [a]	Standardised Coefficients	Unstandardised Coefficients		**T - Value**	**P - Value**	Collinearity Statistics	
	β	**β**	Std. Error			Tolerance	V I F
(Constant)		0.81	0.20	4.011	0.000		
Knowledge	0.274	0.31	0.06	5.330	0.000	0.570	1.75
Attitude	0.161	0.18	0.05	1.604	0.010	0.666	1.50
Intention	0.389	0.40	0.05	8.015	0.000	0.637	1.57

a. Dependent Variable: Eco-friendly Driving Behaviour

Source: Primary Data.

The regression outcome shows that ecological knowledge, attitude, and intention have positively influenced the eco-friendly driving behaviour of the PCU. It supported the TRA by Ajzen and Fishbein that usually attitudes had very weakly predicted behaviours (Fishbein & Ajzen, 1975). The interrelationship between the variables, SEM and CFA, was determined using AMOS.

The CFA and SEM were formulated using TPB and TRA to form the eco-friendly behaviour theoretical model. First, 11 observed variables were taken into three different factors (knowledge, attitude, and intention) into the constructed model, and the CFA model fitness was tested. Based on the model result as mentioned in Table 5, the value Normed Chi-Square (χ2d.f.), Tucker-Lewis Index (TLI), Comparative Fit Index (CFI), Goodness of Fit Index (GFI), Root Mean Square Error (RMSEA) and Root Mean Square Residual (RMR) falls under the model fitness. The measured variables were also verified. The T-value shows that all the items exceeded 2.0, representing that they are statistically significant at 0.01% (Anderson & Gerbing, 1988). The observed variables are highly related to the theoretically constructed model.

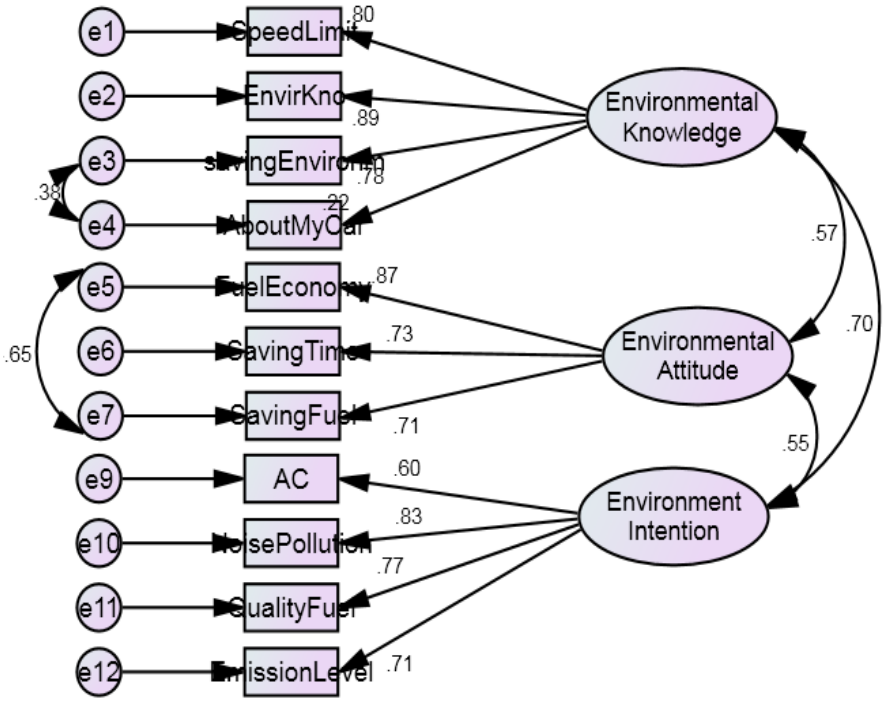

Figure 2. Confirmatory Factor Analysis (CFA) for the Passenger Car User (PCU)
Source: Primary Data.

Table 3. Model Summary of Measurement Result of Validity and Reliability

Factors	No. of Items	Mean	Standard Deviation	Item to Total Correlation	AVE	Composite Reliability	Reliability
Knowledge	4	4.135	0.038	0.683	0.518	0.82	0.781
Intention	3	3.88	0.043	0.663	0.536	0.788	0.761
Attitude	4	3.864	0.045	0.558	0.600	0.817	0.813
Eco-friendly Behaviour	5	3.924	0.044	0.614	0.507	0.834	0.845

Source: Primary Data.

The composite reliability of all the construct values falls between the range of .788 to .834, which is more than 0.60, the suggested level (Gefen & Boudreau, 2000). The assessment of

convergent validity of the scale ensures the value of Average Variance Extracted (AVE) should be more than 0.50 (Bagozzi et al., 2000). The above AVE values are more than 0.50, per the thumb rule. The AVE has also compared the squared correlation between unobserved constructs of knowledge, intention, attitude, and driving behaviour. According to Fornell and Larcker, the constructs squared correlation between each pair should be against the average of the AVE estimates (Fornell & Larcker, 1981). The unobserved variables are also statistically significant at a 0.01% level, ensuring the discriminant validity, as shown in Table 4.

Table 4. Convergent and Discriminant Validity for the Eco-friendly Driving Behaviour

	Knowledge	Intention	Attitude	Ecofriendly Driving Behaviour
Knowledge	0.720			
Intention	0.706	0.732		
Attitude	0.576	0.555	0.774	
Eco-friendly Behaviour	0.651	0.696	0.443	0.712

Source: Primary Data.

Based on the measurement model, the SEM was performed. The main purpose of SEM is to investigate the interrelationship between ecological knowledge, intention, and attitude towards the eco-friendly driving behaviour of PCUs. Here, the exogenous variable is knowledge, whereas the endogenous variables are attitude, intention, and eco-friendly behaviour.

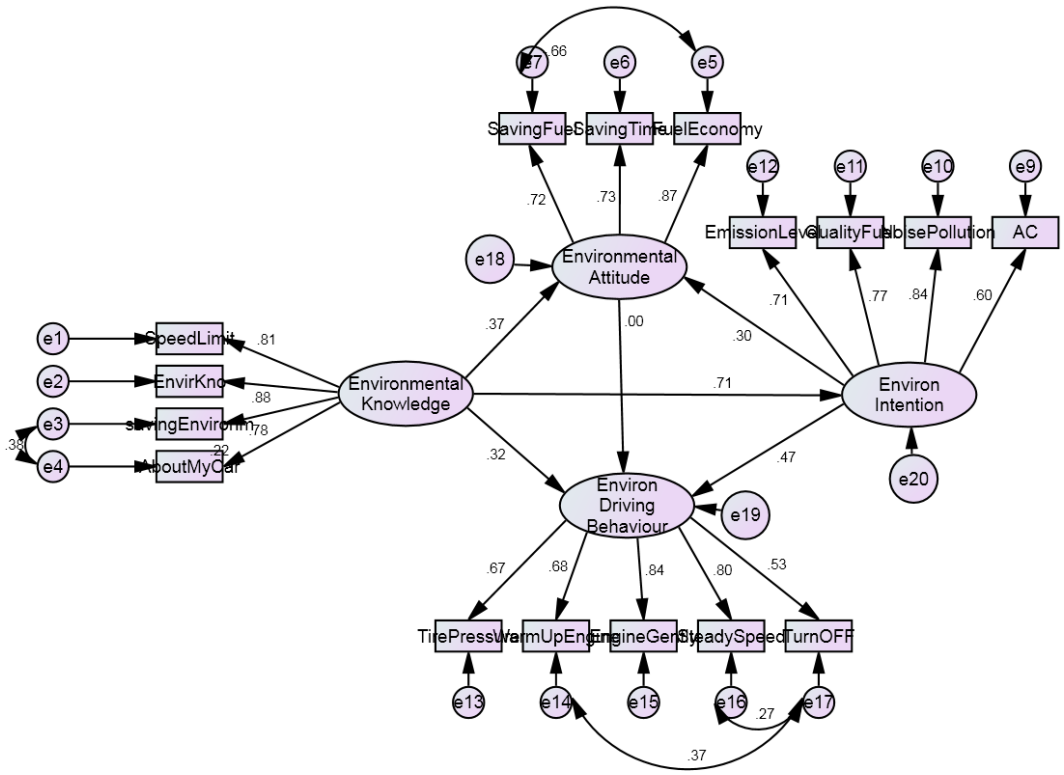

Figure 3. SEM for Ecofriendly Driving Behaviour of PCU

Source: Primary Data.

The SEM model was performed for the PCUs, as displayed in Fig 3 above. The test result shows the model's overall fit; the $\chi 2$ value is 279.627 with 94 degrees of freedom (d.f.), and the model P-value is < 0.001. The normed chi-square is 2.9, which was calculated from ($\chi 2$/ d.f.), which also falls under the thumb rule < 4.0 (Chau & Hu, 2001; Koufteros, 1999). All the fit indices are within the acceptable range. The CFI, GFI, and TLI are recommended to be more than 0.70 for a good model (Hu & Bentler, 1999). The calculated values of (CFI = 0.939), (GFI = 0.920), and (TLI = 0.923) are all greater than 0.90, which represents the perfect goodness fit indices.

The RMSEA and RMR explain the error that occurs in the model. The recommended value should be less than 0.10. the calculated value is 0.08, representing a good model (Kline, 1998). In the structural model, RMR and RMSEA are calculated; both values are within the acceptable range. The RMR is 0.059, and the RMSEA is 0.070. The badness of fit indices also falls under 0.08, ensuring the model fits. These appropriate indices of measurement and SEM model are presented in Table 5.

Table 5. Model Fit Indices for Ecofriendly Driving Behaviour

Statistics	Model	
	CFA	**SEM**
χ^2	138.964	279.627
d.f.	39	94
χ^2d.f.	3.5	2.9
CFI	.948	.939
TLI	.927	.923
GFI	.941	.920
RMR	.053	.059
RMSEA	.080	.070

Source: Primary Data.

This model clearly shows the driver's mentality in the Chennai region, which represents Indian PCUs. They possess enough ecological knowledge, which has strongly influenced their environmental intention (71%), and ecological expertise also affects their environmental attitude (37%). Finally, the ecological attitude has failed to control its role in the eco-friendly driving behaviours of PCUs. On the other hand, environmental intention directly influenced eco-friendly driving behaviour by 47% (Maloney & Ward, 1973), 1973; Hines et al., 1987, and ecological knowledge directly influenced the eco-friendly driving behaviour of PCU by 32% (Arokiaraj, 2015; Schahn & Holzer, 1990).

Table 6. Result of Structural Equation Model

SEM Result	Estimate	P-Value
Knowledge–to–Attitude	.37***	0.000
Knowledge–to–Ecofriendly Driving Behaviour	.32***	0.000
Knowledge–to–Intention	.71***	0.000
Attitude–to–Ecofriendly Driving Behaviour	0.003	0.961
Intention–to–Attitude	.30***	0.000
Intention–to–Ecofriendly Driving Behaviour	.47***	0.000

Source: Primary Data.

4. Practical Implications

The Structural Equation Model (SEM) analysis, displaying robust fit indices and significant pathways, offers valuable insights into promoting eco-friendly driving behaviour among passenger car users (PCUs) in Chennai. The pathways underscore the significance of enhancing ecological knowledge, intention, and attitude, guiding targeted interventions and campaigns. Policymakers can leverage this understanding to tailor sustainable transportation policies, aligning with the unique driving profiles identified in the region. Continuous monitoring and adaptation of interventions based on real-time data are crucial for ensuring the ongoing effectiveness of initiatives that foster eco-conscious driving practices among PCUs in Chennai.

5. Conclusions

The analysis concludes that their environmental knowledge and intentions significantly influence the eco-friendly driving behaviour of passenger car users (PCUs). While a clear correlation exists between good knowledge and intention, the structural model falls short in identifying a substantial role of ecological attitude in shaping drivers' behaviour. Notably, the study highlights that despite having a positive environmental attitude, PCUs do not necessarily translate this attitude into their driving practices, particularly in mitigating tailpipe emissions.

Furthermore, the findings emphasise the critical need to address drivers' attitudes to promote eco-friendly driving effectively, which is essential for reducing pollution levels and fuel consumption. The study underscores the potential impact of attitudinal shifts on controlling traffic congestion, as PCU attitudes significantly contribute to increased vehicle emissions and fuel consumption. In essence, the conclusion emphasises the pivotal role of attitude modification in fostering sustainable driving habits and minimising environmental impact among PCUs.

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