



## Research article

# Investigating the role of green behavior and perceived benefits in shaping green car buying behavior with environmental awareness as a moderator

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## ARTICLE INFO

## Keywords:

Environmental awareness  
Green behavior  
Perceived green benefits  
Green buying behavior

## ABSTRACT

As the planet faces the challenge of global warming, every individual and organization must adopt green practices to protect nature. The automobile industry is one of the primary industries which can contribute significantly towards sustainability. This study aims to examine the impact of green behavior and green perceived benefits on the green buying behaviors of automobiles. The research also explores the moderating influence of environmental awareness on the mechanism. The research is based on a quantitative method for which primary data was gathered from 406 respondents across Pakistan, China and Saudi Arabia via Quota-based purposive sampling. The gathered data was analyzed via SmartPLS. The results show that green behavior and perceived benefits positively and significantly influence green buying behavior. The findings also show the moderating role of environmental awareness on green behavior towards green buying and show no impact on the perceived benefits towards buying behavior. The study has practical and theoretical implications for managers, researchers, policymakers and institutions in the context of green automobile development and businesses. The study also contributes to the attainment of sustainable development goals.

## 1. Introduction

The transportation sector faces numerous sustainability issues spanning the realms of society, economy, and the environment [1]. Its large role in carbon dioxide emissions is a particularly serious issue. The sector depends primarily on oil and gas for land, water, and

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<https://doi.org/10.1016/j.heliyon.2024.e30098>

Received 10 January 2024; Received in revised form 14 April 2024; Accepted 19 April 2024

Available online 30 April 2024

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air transportation, making it a major driver of climate change. In addition to endangering the natural world, it also has disastrous effects like raising the level of the oceans, increasing the frequency of catastrophic weather occurrences, and altering ecosystems. The industry needs to mitigate or reduce such emissions to combat global challenges. Along with these issues, tackling sustainability concerns is further complicated by noise pollution, security concerns, unequal access, and technological advances in driverless and electric cars in the transport industry. The auto industry is leading a major shift for sustainability in a time engraved by increasing environmental worries [2]. The need for environmentally friendly automobiles has increased due to the demand for sustainable transportation choices in developed and developing economies such as Pakistan [3], which is facing rapid population growth, urbanization, and several environmental issues [4]. Among the urgent problems which have pushed policymakers and people to look for environmentally friendly alternatives, especially within the auto sector, are toxic emissions, depletion of resources, and fuel inefficiency [5]. Many countries across the globe have taken the initiative in the production and use of green cars. China is leading the world in the adoption of green cars. About 22 % of cars sold as passenger vehicles will be electric (EVs) in 2022, higher than those sold worldwide. This was made possible by the policies and initiatives of the Chinese government. It is still actively promoting the sale of EVs through various incentive programs [6]. Despite government initiatives and support for encouraging and promoting EVs, the adoption of EVs is facing challenges. The adoption of green cars in Pakistan is very slow, and it is necessary to determine the consumer factors that influence the decision [7]. Similarly, Saudi Arabia has taken initiatives to reduce its dependency on oil and shift towards greener products. The adoption of EVs in Saudi Arabia is very low, and the government is very ambitious to promote and encourage EVs among the people [8]. Although the people of Pakistan are moving towards buying green cars, the process is very slow, and it is still necessary to speed up the adoption process and reduce the environmental impact as soon as possible. In addition, it is also necessary for Saudi Arabia to successfully implement its Vision 2030 to find out the factors necessary for the adoption of EVs.

As the world struggles to deal with the repercussions of the changing climate and growing environmental awareness, it is important to determine the essential factors contributing to green buying decisions [9]. Many researchers have explored the individual factors [10], technological factors [11], and environmental impact [12] for the buying of green automobiles. They have focused on factors like carbon footprints, lower running costs [13], energy use, environmentally friendly behavior, etc. Although researchers have explored the factors necessary for environmentally friendly buying behavior [14], a significant gap exists in addressing the issues in the adoption of EVs in Pakistan and Saudi Arabia. This research aims to integrate behavioral, technological and awareness into a single framework and their impact on buying behavior of green cars in China, Pakistan and Saudi Arabia. In considering this, it becomes essential and important to find out the factors which influence customers to make greener purchases [15].

Concerns about sustainability along with the damaging impact of transport on the environment is increasing globally [16]. These issues have led to the importance and interest in green buying behavior [17]. Consumers of cars are recognizing the benefits in choosing eco-friendly vehicles and are becoming more conscious of the significance of their buying decisions through environmental awareness [18]. Many researches have studied the relationship between green behavior and green purchases, which indicate that green behavior leads to green purchases [19]. Similarly, there have been researches on the relationship of perceived benefits and green purchases [20]. In addition, the role of environmental awareness has also attracted a lot of researchers and has a significant role in green purchases [14]. With each passing day, pro-environmental behaviour [21] is becoming more important due to the necessity of addressing ecological issues and promoting sustainability [22], especially regarding consumer decisions like buying green cars. Despite the increased environmental issues, little is known about how people's pro-environmental behaviour and perceived benefits of making ecologically friendly decisions influence their decisions to buy green cars. This research integrates green behavior, perceived benefits, environmental awareness and green-buying behavior into a single framework for the attainment of its objectives.

Although there are studies, that have discussed these factors individually, this study integrates them in one framework. This research aims to clarify the complex dynamics of buyer's decision-making about green vehicles to promote sustainable mobility options and ensure the preservation of the environment. The research has the following objectives:

1. To determine the relationship between green behavior perceived benefits and green car buying behavior.
2. To investigate the moderating role of environmental awareness on the relationship between green behavior and perceived benefits towards green car buying behavior.
3. To provide insights to researchers and policymakers for the adoption of green cars.

The study also aims to address the following questions.

1. How do green behavior and perceived benefits relate to green car buying behavior?
2. Is there any moderating role of environmental awareness on the relationship between green behavior and perceived benefits towards green car buying behavior?

This research is remarkably significant as it explores important concerns regarding buyer behavior and environmental sustainability. As the study integrates prior theories, it will provide theoretical, managerial and empirical implications. The study offers useful insights with vast implications by examining the roles of green behavior and perceived benefits while considering the moderating influence of environmental knowledge. These insights will help businesses modify their plans, assist legislators in developing suitable legislation, and add to the international debate on green consumption.

With the aim to attain the above-mentioned objectives and answer the mentioned questions, this study establishes its foundation on theory of planned behavior, perceived benefits theory and theory of environmental concerns. These theories provide understandings and directions for the relationship among the green behavior, perceived benefits, environmental awareness and green buying behavior

which are the variable of the study. The research is divided into introduction, development of hypothesis and theoretical framework (literature review), methodology, results and discussion; and conclusion. The introduction presents the research background, identifies the gap, research problem, objectives, significance and structure of the study. The development of hypothesis and theoretical framework consists of the theories and literature survey for green behavior, perceived benefits, environmental awareness and green buying behavior and the relationship among them in the light of theories. Methodology section explains the research philosophy, population and sample, measurement tools and research tools used in the study. Results and discussion section explain the results and its interpretation. The conclusion section concludes the main findings of the study along with their theoretical, practical and managerial implications, contribution to sustainable development goals and limitations.

## 2. Development of hypotheses and theoretical framework

### 2.1. Theories

Numerous theories across different fields of psychology, consumer behaviour, and environmental sciences can be used to study the impact of green behavior, perceived benefits, and environmental awareness on the green-buying behavior of cars. Some of the most relevant and common theories are:

**Theory of Planned Behavior:** It is a commonly used concept in research on consumer behavior [23]. It implies that subjective norms, attitudes, and perceived behavioral control impact the intentions of individuals to engage in a behaviour, like purchasing a green automobile. In the context of this research, social standards, attitudes towards environmentally friendly vehicles, and perceived influence over the buying decision can all be investigated using this theory.

**Perceived Benefits Theory:** According to this idea, customers are inclined to get involved in a behaviour if they believe it will result in significant benefits [24]. It is essential to examine how green car use is perceived. In the context of this study, this theory can be applied to find out the impact of perceived benefits on the consumption or buying of cars.

**The theory of Environmental Concern:** It revolves around expanding ecological knowledge and concern [25]. It can be useful to comprehend how people's levels of environmental knowledge affect their choices for environmentally friendly behaviour and products. This theory can be used to study the relationship between EA and the consumption of cars.

### 2.2. Green behaviour and green buying behavior

"Green behavior" refers to a broad range of daily environmentally responsible decisions and actions people make [26]. It is a comprehensive approach to environmentally conscious living. It encompasses a wide range of behaviours, such as choosing sustainable modes of transportation, reducing waste, conserving water, making eco-friendly purchases, and contributing to environmental initiatives [27].

A close connection exists between green behavior and green-buying behavior, affecting and supporting the other. An individual's green-buying behavior, which comprises making responsible choices while buying goods and services, is significantly influenced by their green behavior, which includes eco-aware behaviour and green practices [28]. It increases awareness and concern for the environment. People who embrace habits like recycling, trash reduction, energy conservation, or support environmentally friendly modes of transportation become more conscious of ecological problems and the far-reaching impacts of their decisions [29]. When it comes to purchasing purchases, this higher awareness leads to the purchase of sustainable products. Green behavior expresses one's sustainable commitments and values [30]. The significance of environmental protection increases when a person repeatedly adheres to environmentally conscious behaviour. As a result, people support and seek ecologically friendly products when they align with their values [31].

Green behavior also has a societal impact and serves as a positive role model. Those who embrace GB generally inspire and encourage their friends, family, and other members of their social networks to do the same, advancing the goal of environmental sustainability [32]. It further increases environmental consciousness and leads to the selection of green products when purchasing. Additionally, the green behavior influences market trends and industry. The demand for green items and solutions grows when individuals adopt environmentally conscious attitudes. This also positively impacts businesses, enabling them to enhance their products in a more ecologically friendly manner [33]. The link between green behavior and green-buying behavior assists in developing an eco-friendly culture of consumption. It fosters sustainability and drives evolution in customer preferences and manufacturing by allowing people to consider environmental concerns when purchasing.

### 2.3. Perceived benefits and green buying behavior

The term "perceived benefits" involves the perceived advantages or beneficial outcomes people or organizations think they will experience due to a specific decision, action, product, service, etc. [34]. These advantages depend on individual perceptions, values, and subjective evaluations instead of necessarily quantifiable. They have an important effect on how people act and make decisions [35]. PB have a significant impact on green-buying behavior. Firms, legislators, and researchers must understand how PB and green-buying behavior interact because they provide insight into the causes and reasons for environmentally responsible consumption. Economic benefits are one of the PBs that significantly affect green-buying behavior. Consumers consider the possible financial savings from ecologically conscious decisions. For example, people spend money on hybrid cars intending to reduce fuel costs [36]. The perception of financial benefit can strongly incentivise people to choose environmentally friendly options. Perceived benefits also

plays a significant role in green customers' purchasing choices, supporting their dedication towards ecological preservation and serving as a motivating factor for environmentally friendly purchases. Furthermore, there are psychosocial benefits as well, the accomplishment of which gives a sense of achievement, societal recognition, self-esteem, etc., all of which are connected to environmentally responsible decisions and drive people to purchase green or environmentally friendly products [37].

Most consumers believe buying environmentally friendly products aligns with their ethical and moral values [38]. They choose ecologically friendly options whenever presented with options which might be more harmful to the environment because they feel responsible for the earth and the well-being of the next generations [39]. While making greener purchases, buyers consider benefits like decreased exposure to hazardous materials, a lesser ecological imprint, and better living conditions. These benefits can outweigh the expenses and provide a strong rationale for green-buying behavior [40]. A significant factor influencing consumers' green purchasing decisions is perceived benefits. Consumers evaluate the benefits they expect from making environmentally conscious decisions, including financial savings, a reduced ecological footprint, psychological well-being, etc. [41]. Industries and governments can develop a more environmentally friendly and conscious society by recognizing and considering these perceived advantages.

#### 2.4. Environmental awareness

Environmental awareness is the degree of cognition and knowledge that people possess towards the environment and its various ecological problems and difficulties. It is essential in determining how individuals and groups will respond to ecological problems and progress sustainability practices [42]. It plays an important moderating role in the complex interaction between green behavior, perceived benefits, and green-buying behavior and has essential implications for knowing how people make eco-friendly decisions [43].

First, EA increases the impact of perceived benefits on green-buying behavior. People will perceive more benefits when they know more about environmental challenges and their impacts. Financial savings, a lower carbon footprint, etc., become more attractive to consumers [44]. They are, therefore, inclined to consider these advantages when making eco-friendly purchases. Environmentally aware people participate in environmentally friendly endeavours like energy efficiency, recycling, and reducing waste, further strengthening the green behavior and green-buying behavior relationship [45].

Environmental awareness can also lessen the perceived barriers linked with green-buying behavior. Some customers could perceive green products as costlier or less useful than conventional alternatives. High environmental awareness equips people to see these obstacles as solvable rather than inescapable. They are more inclined to make environmentally friendly purchases when they realize the financial and practical advantages exceed those of cost and convenience. Environmentally aware Individuals also promote sustainability in their social networks [46]. Their dedication to green behavior and thorough understanding of the perceived benefits of such decisions make them effective agents for persuading others to do likewise [47]. This social impact also affects green-buying behavior since environmentally conscious people promote and encourage eco-friendly goods and services to others in their network, further fostering a culture of eco-aware consumption.

EA is a potent moderating factor that strengthens the relationship between green behavior and green-buying behavior, reduces perceived challenges, encourages responsible choices, and fosters advocacy across societies. Individuals who are more aware of the environment also help to advance the trend towards green consumption.

#### 2.5. Green buying behavior

Green-buying behavior is a conscious choice for goods and services with a smaller negative ecological impact. It is a commitment towards reducing the negative effects of consumerism on the environment and society [48]. Individuals who engage in green-buying behavior will look for goods and services that adhere to their ecological principles and beliefs [49]. This means making a conscious decision to choose products that are produced, packaged, and shipped sustainably. When making buying decisions, such clients prioritise sustainability factors like carbon footprint, waste, etc. Green consumers are frequently inclined to spend even more for ecologically friendly goods. Even if the costs are high, they believe it is worthwhile to support businesses and brands that adhere to green practices [50]. They believe that eliminating ecological damage and encouraging eco-aware consumerism gives lasting benefits. These benefits include energy efficiency, waste reduction, reduced carbon emissions, and cost savings, extending to each corner of the individual's life and society [51].

In the context of automobile purchases, green-buying behavior shows a deliberate change in consumer attitudes towards cleaner, less polluting forms of mobility. Consumers are opting for cars sensibly as awareness of environmental problems is growing [52]. When buying cars, such individuals consider power consumption efficiency, environmental footprint ratings, and other options [53]. They select the one having the least possible carbon emissions, better fuel efficiency and advanced technology. Given the prospect of zero emissions, electric and hybrid automobiles are preferred options. When choosing a green vehicle, customers also consider other factors like the usability, range, and availability of infrastructure for charging [54]. It can be encouraged by the governments through tax and registration fees incentives and other rebates to make eco-friendly behavior and choice more common and attractive for people [55], and many countries are considering this to promote green behavior and reduce carbon footprints from transportation.

Green-buying behavior refers to consumers' deliberate and purposeful efforts to choose options consistent with their ecological values and beliefs. Satisfying the needs of an environmentally aware consumer drives people to adopt greener practices, use green goods, and participate in social responsibility efforts. GBB, in the context of cars, shows a widespread dedication to decreasing the negative environmental effects of personal mobility, influenced by eco-awareness, financial concerns, and the availability of greener options. As people become more aware of environmental concerns and technology advances continuously, this behavior will evolve

towards a greener future.

### 2.6. Theoretical mechanisms

The theoretical framework of this study, as shown in Fig. 1, is based on the integration of theory of planned behavior, perceived benefits theory and theory of environmental concern, which jointly provide an in-depth exploration of the complex factors that affect people’s purchase decisions. They demonstrate the forces, intentions, and hidden processes that influence consumers’ decisions regarding eco-friendly automobiles, which are essential for advancing green modes of transportation and ecological conservation activities.

Theory of planned behavior provides an invaluable basis for comprehending the fundamental processes of green car purchasing behavior [56]. Initially, people’s attitudes are crucial; positive perceptions towards features like ecological friendliness, efficiency of fuel, and general advantages of green automobiles have the potential to grow towards an increased intention to buy these cars. In addition, subjective norms also emerge as humans are frequently impacted by the beliefs and actions of their relatives, friends, and society. Positive subjective norms related to green cars will increase the desire to purchase green vehicles. The last factor, perceived behavioral control, shows how consumers can meet challenges, including pricing, infrastructure, and accessibility. The desire to choose green cars can increase if one believes in greater control regarding these aspects.

The perceived benefits theory stresses the essential role of perceived benefits in affecting consumer behaviour. Consumers are inclined to purchase environmentally friendly vehicles when they see the advantages, such as energy savings, lower environmental effects, and other incentives [57]. These advantages serve as stimuli for consumers to make green purchasing decisions. Recognizing the perceived benefits effect on consumers’ choices will help improve the purchase of environmentally friendly cars in countries facing environmental and economic issues.

The theory of environmental concern offers crucial insights regarding how people’s environmental values, norms and beliefs influence their purchase behavior [58]. Initially, consumer decisions are significantly influenced by environmental beliefs and values. People who prioritise green automobiles and have environmental concerns are more likely to be motivated by their beliefs. This ecological concern becomes a potent motivator, pushing people to select green cars. Furthermore, EA creates personal rules that encourage environmentally responsible behavior. Given this situation, customers who are more concerned about the environment are more morally inclined to choose green vehicles because they are consistent with their beliefs and values. The intention of buying environmentally friendly automobiles is further strengthened by the stimulation of one’s norms, which makes it an essential factor in deciding what to buy.

#### 2.6.1. Hypotheses

- H1. Green Behavior has a positive relationship with green buying behavior
- H2. Perceived benefit has a positive relationship with green buying behavior
- H3. Environmental awareness moderates the relationship between green behavior and green buying behavior
- H4. Environmental awareness moderates the relationship between perceived benefit and green buying behavior

#### 2.6.2. Theoretical framework

The theoretical model in Fig. 1 shows that green behavior and perceived benefit are the two essential factors leading to environmentally friendly buying behavior. It is important to note that green behaviors encompass the norms, attitudes, values, etc., towards the environment, while green buying behavior is the choice for green products or green buying. Similarly, environmental awareness plays a moderating role in the relationship between green behavior and green buying behavior. In other words, if people are well aware of the importance and environmental issues, their green behavior will more likely lead to green buying decisions, and vice versa. Similarly, environmental awareness will also influence the relationship between perceived benefits and green buying behavior. The theoretical mechanism section discussed above gives more details of the framework.

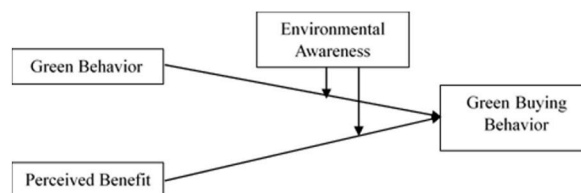


Fig. 1. Theoretical framework.

### 3. Methodology

#### 3.1. Research philosophy

Philosophy is the basic stance of the research, which directs the researchers for the research implementation. Two major research philosophies the social sciences research experts followed when diagnosing a social phenomenon are positivism and interpretivism. This research followed the assumptions of the positivism philosophy. Positivism is a pure scientific philosophy that relies on quantifying the social phenomenon and believes in the objective and singular reality. This study is also based on the singular reality reflected by the previously established theories the researcher is testing to its context. The researcher used a quantitative technique to convert reality into quantifiable numbers to better analyze based on the absolute scientific phenomenon. While the researcher used the deductive approach to answer the problem in question by the research.

#### 3.2. Population and sample

The population of this study includes university students and graduates in Pakistan, China and Saudi Arabia. However, it is impossible to cover their population in social sciences research, so drawing a sample for the data analysis is recommended. Regarding sampling, two common techniques are used in the social sciences: probability and non-probability sampling. Every social scientist wishes to adopt a probability-based sampling for their study, but in most cases, it is not possible to do a probability sampling because it does not meet the basic assumptions of probability sampling. For the adoption of probability sampling, there are two basic assumptions: first, the exact number of the population must be known; second, every individual member of the population must be approachable by the researcher. As both assumptions are not met, so a non-probability sampling is better to adopt. Among the several types of non-probability sampling, the quota-based purposive sampling technique is adopted to select the proper respondents better. First, the population is divided into three quotas: Saudi Arabia, Pakistan, and China; then, based on the researcher's judgment, the sample size was 406 respondents. The data was gathered during the time period from 1<sup>st</sup> August 2022 to 3<sup>rd</sup> September 2022. For the sample size of the research, the scholars unanimously suggested different sample sizes for primary data sample size. However, most suggest a minimum sample size of more than 380 for the Smart PLS to properly forecast the entire population where the exact population is unknown. For the data analysis, CB-SEM and PLS-SEM are two options for the researcher to run a structural equation model. Both approaches have their assumptions. CB-SEM is used for the theory development, while PLS-SEM is used for the theory testing. The PLS-SEM is the most suitable option because this study is based on the prior theories the researcher will test in its context. The other thing which encouraged the researcher to adopt the PLS-SEM is that it does not have any assumption of normality due to the non-parametric approach. It is also impossible for the primary data in the real-world survey to achieve the basic assumptions of normality.

In many researches, social desirability bias is one of the main problems in data collection and sampling. And the respondents respond the way they do not do [59]. The survey was designed to reduce the social desirability bias of respondents [60]. For example,

**Table 1**  
Measurement tool.

Construct	Items
Environmental Awareness [62]	I read about environmental issues in the mass media I am concerned about environmental problems at my place. I always discuss environmental problems with my friends. I do not use plastic bags to wrap things. I conserve the use of electric energy at home. I conserve the use of water supply. I deliver information on the environment to my family members. I am involved in environmental awareness activities in my social life. I am aware of my responsibility towards the environment.
Green Buying Behavior [63]	I do not use anything harmful to the environment in all possible ways. I usually prefer to purchase green automobile products. If I have to buy car batteries, I always purchase batteries with no mercury or rechargeable ones. I try to purchase cars with little and no environmental harm, even though they are more expensive. I always purchase bio-degradable products when they are disposed of. I always refrain from purchasing disposable products for my automobile.
Green Behavior [64]	Supporting environmental protection makes me feel that I'm an environmentally responsible person. I feel proud of being a green person. I always prefer green and sustainable products. I feel happy using green products rather than considering the product's price. Supporting environmental protection makes me feel meaningful.
Perceived benefit [65]	In the green industry, green innovation can generate new automobiles. In the green industry, green innovation can change the basis of competition. In the green industry, green innovation can be used to improve the quality of automobiles. In the green industry, green innovation can change the balance of the economy. In the green industry, green innovation can change the balance of power in business relationships.

Note: Table indicates the construct with its respective items.

the study included respondents with a graduate degree or currently studying at universities from different walks of life. They were assured that their response would be kept secret and not shared with any person or organization individually. Diversity provided by different age groups further reduces the social desirability bias. In addition, the questionnaire used in this research was adopted from previous studies and is structured indirectly, reducing the issue [61].

3.3. Measurement tools

The study adopted the instruments/measurement scales already developed and used by prior researchers, as shown in Table 1. The researcher collected data from the industry respondents via a closed-ended questionnaire. The first part of the questionnaire was composed of some explanation about the research and the consent to be asked from the respondents to fulfil the ethical consideration of the research. The ethical approval consent form is attached to the supplementary materials. The second part was based on the demographic questions about the research respondents. The third and last part was composed of five-point Likert scale questions representing all the measures of the study adopted from prior studies. The details of the questions with the respective measure and the source of the adoption are mentioned in Table 1.

3.4. Statistical tools

For the data analysis based on the complex model, having a mediation or moderation relationship is suggested to adopt structural equation modelling. For structural equation modelling, there are two common methods to be adopted in social sciences. The first is covariance-based structural equation modelling, and the second is variance-based. However, there are assumptions for the adoption of both techniques. As we know, co-variance-based structural equation modelling is used for theory development, while variance modelling is used for theory testing. As this study is based on theory testing, it is better to use a variance-based technique. The SmartPLS is the most common software the social scientist uses for the variance-based approach.

4. Results and discussion

4.1. Demographic profile of the respondents

Table 2: respondent’s demography shows the demographic distribution of the research respondents. This shows 406 respondents, of whom 308 were males and 98 were females. The second section of the table shows the respondents’ age-wise distribution, which shows six age groups. Most of them belong to the age group of 31–40 years, with a percentage of 32 %, while the age group under 20 years has the fewest respondents, with a percentage of 2 %. The third section of the demographic table indicates the country of respondents. Table 2 shows that most respondents have experience of 1–2 years, with a percentage of 32 %, while the least have experience of more than six years, with a percentage of 9 %.

4.2. Descriptive statistics

Table 3: descriptive statistics show each construct item’s mean and deviation values, how they were rated on the Likert scale and how much the responses deviated from the mean. It was observed from the table that most of the mean of the items are greater than the middle value of 2.5, which shows that the raters are mostly inclined towards agreement.

**Table 2**  
Respondents demography.

Gender	Frequency	Percentage
Male	308	76 %
Female	98	24 %
Total	406	100 %
Age Group	Frequency	Percentage
Less than 20 Years	8	2 %
20–30 Years	108	27 %
31–40 Years	128	32 %
41–50 Years	106	26 %
51–60 Years	42	10 %
61 and Above Years	14	3 %
Total	406	100 %
Country	Frequency	Percentage
Saudi Arabia	105	26 %
Pakistan	131	32 %
China	170	42 %
Total	406	100 %

Note: Table indicates the frequency and the percentage of the research respondents.

**Table 3**  
Descriptive statistics, reliability and convergent validity.

Construct	Items	Mean	S D	Outer loadings	Cronbach's Alpha	Composite Reliability	AVE
Environmental Awareness	EA1	3.303	1.598	0.788	0.936	0.947	0.664
	EA2	3.305	1.533	0.776			
	EA3	3.527	1.395	0.834			
	EA4	3.495	1.296	0.834			
	EA5	3.241	1.332	0.848			
	EA6	3.347	1.39	0.837			
	EA7	3.685	1.045	0.837			
	EA8	3.635	1.074	0.823			
	EA9	3.68	1.081	0.751			
Green Buying Behavior	GBB1	3.618	1.07	0.799	0.798	0.86	0.552
	GBB2	3.611	1.135	0.755			
	GBB3	3.404	1.384	0.751			
	GBB4	3.653	1.237	0.651			
	GBB5	3.534	1.237	0.751			
	GBB6	3.483	1.286	0.861			
Green Behavior	GB1	3.897	1.408	0.894			
	GB2	3.571	1.006	0.86			
	GB3	4.485	1.453	0.819			
	GB4	4.325	0.375	0.865			
	GB5	4.204	0.612	0.801			
Perceived benefit	PB1	4.268	0.806	0.625	0.902	0.929	0.728
	PB2	4.261	0.749	0.889			
	PB3	4.158	0.665	0.929			
	PB4	3.914	0.862	0.883			
	PB5	4.071	1.115	0.904			

Note: Table Indicates items reliability, construct reliability, convergent validity, mean and standard deviation of the respondents ratings on likert scale.

### 4.3. Reliability of the scales

Reliability refers to the degree to which the measurement results are accurate. Using a SmartPLS, there are two types of reliability: item reliability and construct reliability.

#### 4.3.1. Item's reliability

Item reliability is the measure that defines how much the results of the measurement of the items of a construct are accurate and reliable. The measure used for the item reliability is outer loading. The threshold value for the item's reliability is 0.7, but a value of 0.6 is also acceptable if the initial requirement of the convergent validity is established. Table 3 shows the item's reliability, showing that all the items have an outer loading value greater than the threshold value, indicating that all the model items are reliable.

#### 4.3.2. Construct reliability

Construct reliability explains how reliable the overall construct is for further study. The measures used for the construct reliability are composite reliability and Cronbach alpha. The threshold value for both measures is 0.7 and above. Table 3 also shows that all the constructs have Cronbach alpha and composite reliability values greater than the threshold value, indicating that all the constructs are reliable.

### 4.4. Validity of the scales

Validity refers to the degree to which the tool measures what it claims to measure. When using structural equation modelling, there are two types of validity: convergent and discriminant.

#### 4.4.1. Convergent validity of the scales

Convergent validity explains how much the items of a construct are valid and reflect the overall construct. The measure used for the convergent validity is AVE. The threshold value for the AVE is 0.5 or above. Table 3 indicates that all the constructs have an AVE value greater than the threshold value, indicating that all the constructs are convergently valid.

#### 4.4.2. Discriminant validity of the scales

Discriminant validity refers to how much one construct of the model is theoretically different from the other. Three common measures for discriminant validity are HTMT, Fornell Larcker criteria, and cross-loadings. Most researchers suggest that HTMT is the most robust measure for discriminant validity when using an approach based on the SmartPLS. In cross-loading, the outer loading of the items is compared with the self-construct and other constructs. If the self-loading of the items with its construct is higher than the cross-loading with other constructs, it seems the discriminant validity is established. If we compare them, it is confirmed that all the self-loadings are greater than the cross-loadings. The second measure is the Fornell Larcker Criteria, assuming that the AVE's square



must be greater than the values of its respective columns and rows. This validity assumption is also validated. The next measure of validity is the HTMT ratio. The threshold value for the HTMT is 0.85 or below. Table 4 shows that all the HTMT values are smaller than the threshold value, indicating that all the constructs are discriminately valid. Fig. 2 of the HTMT graph represents the graphical view of these values incorporated in the HTMT values.

4.5. Common method bias

Common method bias is a major issue the primary data survey research faces. Common method bias is faced in the primary data survey when the respondents rate the overall survey uniformly. The different measures are used for the common method bias analysis, but the researcher suggests using the VIF value for the common method bias. A model is said to be free from common method bias if the VIF values if the VIF values are not exceeded from the 3.3. Variance inflated factor denotes that all the items have a VIF value smaller than the threshold value, indicating that the model has achieved its fitness.

4.6. Model fitness

Once the reliability, validity, and common method bias issues of the model are addressed, it is necessary to diagnose the model based on multivariate analysis to find its fitness. Different measures like SRMR, NFI, and Chi-Square are used for the model fitness. The SRMR is the difference between the observed and model implied correlations. NFI stands for Norm Fit Index which computes the Chi<sup>2</sup> value of the proposed model and compares it against a meaningful benchmark. While d\_ULS and d\_G are the exact fit criteria for the model fitness. The Chi-square goodness of fit test checks whether your sample data is likely to be from a specific theoretical distribution. Statisticians and researchers suggest the SRMR value is the most robust technique for model fitness when using SmartPLS. The threshold value for the SRMR is 0.08 and below. Table 5 shows the model fitness’s SRMR value of 0.08, which is not greater than the threshold value, indicating that the model has achieved its fitness.

4.7. Structural model

Fig. 3 shows the structural model of the study.

4.8. Regression analysis and hypothesis testing

Regression analysis is a common technique that statisticians use to predict the association among the variables or phenomena of the social context. The two common measures used for the significance of a cause-and-effect relationship are t-value and p-value. The threshold value for the significance of the t-value is 1.96 and above, while the p-value is 0.05 or below. Table 6 shows four relationships, among which two are direct while the rest are based on moderating relationships. Table 8 shows that both of the direct relationship-based hypotheses are supported by the findings of the study, which have the p and t values within the threshold value range. While the moderate relationship between green behavior’s effect on the green buying behavior and the moderation of environmental awareness is significant, the moderation relationships of environmental awareness on the effect of perceived benefit and green buying behavior are insignificant. The beta value for each relationship shows the strength of the relationship.

4.9. Coefficient of determination

The coefficient of determination explains the percentage of variation on the dependent variable by the collective effect of the model’s independent variables. The measure used for the coefficient of determination is R square. Table 7 shows a value of 0.615, which denotes that 61.5 % of the variation in the dependent variable green buying behavior is due to green behavior, perceived benefit, and environmental awareness.

4.10. Predictive relevance of the model

The model’s Predictive relevance explains the model’s prediction power when the same model is tested in a context other than the present research. The measure used for the predictive power is Q square. A value of Q square greater than zero for the case of primary data is considered a good prediction value. Table 7 denotes a value of 0.434, indicating that the model has a prediction power of 43.4 %.

**Table 4**  
HTMT values.

	Environmental Awareness	Green Behavior	Green Buying Behavior
Green Behavior	0.610		
Green Buying Behavior	0.803	0.620	
Perceived Benefit	0.465	0.701	0.552

Note: Table indicates the HTMT ratios of the constructs.

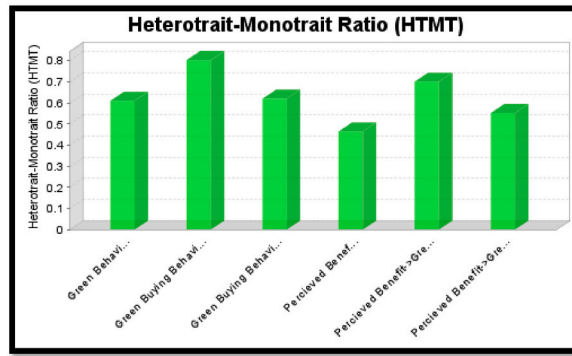


Fig. 2. HTMT graph.

Table 5  
Model fitness.

	Saturated Model	Estimated Model
SRMR	0.08	0.08
d_uls	2.065	2.065
d_g	1.247	1.247
Chi-Square	2592.571	2592.571
NFI	0.721	0.721

Note: Table indicates the values of the measures which explains the model fitness.

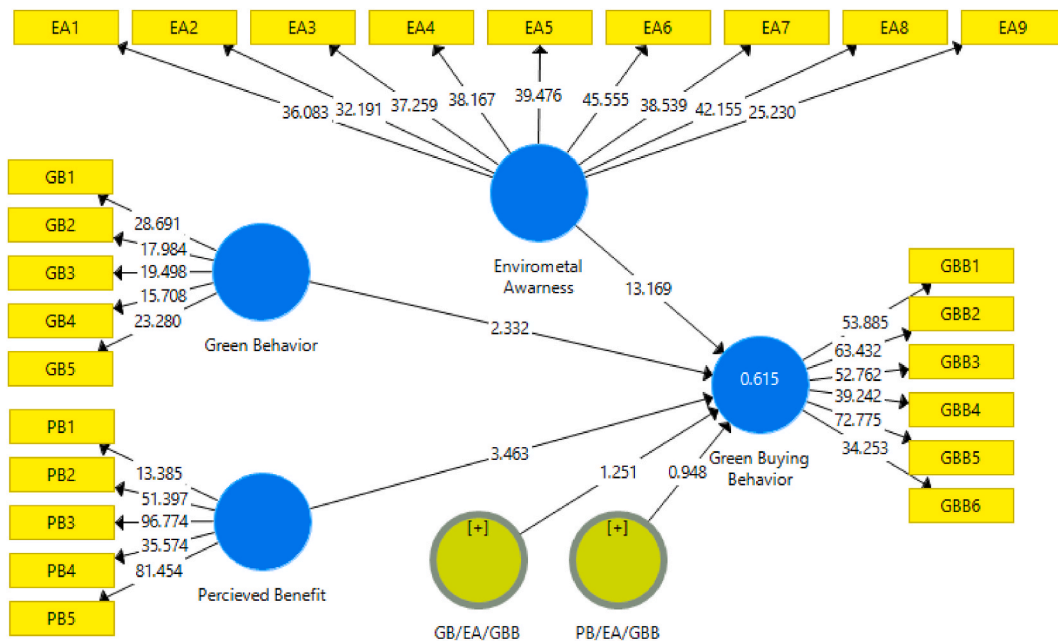


Fig. 3. Structural model.

4.11. IPMA analysis

IPMA stands for importance and performance analysis, which explains the importance and performance of the individual variables of the model for the dependent variable. Table 8 shows that environmental awareness has a value of 72.8 % and green behavior has a value of 17.2 %, with the highest and smallest values, respectively. The perceived benefits, with a value of 78.3 %, and environmental awareness, with a value of 68.22 %, have the highest and smallest values, respectively.

**Table 6**  
Hypothesis testing.

Hypothesis	Beta	T-Value	P-Values	Results
H1: Green Behavior - > Green Buying Behavior	0.135	2.332	0.020	Supported
H2: Perceived Benefit - > Green Buying Behavior	0.160	3.463	0.001	Supported
H3: GB/EA/GBB - > Green Buying Behavior	0.618	13.169	0.000	Supported
H4: PB/EA/GBB - > Green Buying Behavior	-0.035	0.948	0.343	Not Supported

Note: Table Indicates the hypothesized relationship and their significance level.

**Table 7**  
R and Q square.

Dependent Variable	R Square	T Statistics	P Values
Green Buying Behavior	0.615	18.202	0
	<b>SSO</b>	<b>SSE</b>	<b>Q<sup>2</sup> (= 1-SSE/SSO)</b>
Environmental Awareness	3654	3654	
Green Behavior	2030	2030	
Green Buying Behavior	2436	1379.279	0.434
Perceived Benefit	2030	2030	

Note: Table indicates the Q square value which is a measure of model prediction.

**Table 8**  
IPMA analysis.

Construct	Importance	Performances
Environmental Awareness	0.728	68.22
Green Behavior	0.172	76.285
Perceived Benefit	0.269	78.333

Note: Table indicates the Importance and performance of the constructs.

4.12. MGA analysis

4.12.1. MGA based on gender

MGA stands for the multi-group analysis. This is an advanced technique used in the SmartPLS to compare the effect of the population groups and how their presence and absence will affect the relationships of the study. Table 9 shows the gender-wise comparison of the population and how the study relationships are affected by gender. This table indicates no significant relationship difference due to the population's gender.

4.12.2. MGA based on country

Table 9 shows the country-wise effect of the population on the relationships of the study. The threshold value for the difference between country to country is the p-value smaller than 0.05. The table shows that all the relationships have a p-value higher than the threshold value. This indicates that there is not any significant difference between the population of the study across the countries.

**Table 9**  
MGA based on gender and country wise.

Relationships	Beta-diff (Male-Female)	P-Value
Green Behavior - > Green Buying Behavior	-0.048	0.759
Perceived Benefit - > Green Buying Behavior	0.095	0.367
<b>Relationships</b>	<b>Beta-diff (Saudi-Pakistan)</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.014	0.622
Perceived Benefit - > Green Buying Behavior	0.062	0.453
<b>Relationships</b>	<b>Beta-diff (Saudi-China)</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.021	0.331
Perceived Benefit - > Green Buying Behavior	0.033	0.322
<b>Relationships</b>	<b>Beta-diff (China-Pakistan)</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.012	0.116
Perceived Benefit - > Green Buying Behavior	0.032	0.722

Note: Table indicates the gender and country wise difference of the respondents.

However past literature based on the implications of electric vehicles in different countries suggests that their usage is not the same as per the growth and economic condition of the country. Different studies show this effect in different ways in different countries. Most studies suggest that in developed countries, this effect is at the maximum level, while in the less developed countries are very low for electric vehicles. According to the literature, this effect is due to their economic and awareness condition. In those countries that are more developed, their public purchasing power is higher, so they can be more attracted to green vehicles. Green vehicles are more expensive than ordinary vehicles. So that is why the adoption of green vehicles in the se countries is greater than in other less developed countries.

Another factor for adopting green vehicles is people’s education and awareness level. Those more developed countries are probably more knowledgeable and aware of sustainability. If people are more aware of sustainable practices, it is more likely to adopt more sustainable practices. That’s why people from developed countries move more towards green vehicle as compared to less developed countries to safeguard the environment better. The findings of this study show no such difference between China, Pakistan, and Saudi Arabia. This is because there is not much difference between these countries’ economies.

4.12.3. MGA based on age group

Table 10 shows the population’s age-wise effect on the study’s relationships. The threshold value for the difference between the different age groups is the p-value smaller than 0.05. The table shows that all the relationships have a p-value higher than the threshold value. This indicates that there is not any significant difference between the population of the study across all the age groups.

5. Discussion

This study examines the relationships of green behavior and perceived benefits with the buying of green vehicles in Pakistan, China, and Saudi Arabia. This study further aims to explore the mediating role of environmental awareness on the relationship of green behavior and benefits with green-buying behavior. From the results of this study, it was concluded that the green behaviour and the

**Table 10**  
MGA based on age.

Relationships	Beta-diff (>20 - 20 to 30) Years	P-Value
Green Behavior - > Green Buying Behavior	0.112	0.622
Perceived Benefit - > Green Buying Behavior	0.193	0.326
<b>Relationships</b>	<b>Beta-diff ( &gt; 20–31 to 40) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.002	0.521
Perceived Benefit - > Green Buying Behavior	0.005	0.344
<b>Relationships</b>	<b>Beta-diff ( &gt; 20–41 to 50) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.143	0.312
Perceived Benefit - > Green Buying Behavior	0.112	0.422
<b>Relationships</b>	<b>Beta-diff ( &gt; 20–51 to 60) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.052	0.522
Perceived Benefit - > Green Buying Behavior	0.007	0.412
<b>Relationships</b>	<b>Beta-diff ( &gt; 20–60 &lt; ) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.118	0.933
Perceived Benefit - > Green Buying Behavior	0.022	0.722
<b>Relationships</b>	<b>Beta-diff (20 to 30–41 to 50) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.091	0.224
Perceived Benefit - > Green Buying Behavior	0.084	0.442
<b>Relationships</b>	<b>Beta-diff (20 to 30–51 to 60) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.077	0.231
Perceived Benefit - > Green Buying Behavior	0.064	0.444
<b>Relationships</b>	<b>Beta-diff (20 to 30–60 &lt; ) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.083	0.116
Perceived Benefit - > Green Buying Behavior	0.063	0.722
<b>Relationships</b>	<b>Beta-diff (31 to 40–51 to 60) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.055	0.331
Perceived Benefit - > Green Buying Behavior	0.063	0.322
<b>Relationships</b>	<b>Beta-diff (31 to 40–60 &lt; ) Years</b>	<b>P-Value</b>
Green Behavior - > Green Buying Behavior	0.088	0.223
Perceived Benefit - > Green Buying Behavior	0.063	0.417

Note: Table indicates the Multigroup analysis based on respondents age groups.

perceived benefits will enhance the green-buying behavior of the people using green vehicles in Pakistan, China, and Saudi Arabia. The research examines four hypotheses, among which two are based on direct relationships while the rest are based on moderating relationships. The study's first hypothesis claims that green behavior will lead them toward the green-buying behavior of green vehicles in the context of Pakistan, China, and Saudi Arabia. However, the results based on the study's findings also have the findings that highly support the argument that green behavior is responsible for the green-buying behavior with  $p$ ,  $t$ , and beta values of 0.020, 2.332, and 0.135, respectively. The past literature based on the relationship that green behavior impacts green-buying behavior also has the same nature as the findings, with a significant positive relationship [66]. However, these studies have been conducted in different areas and have the same nature of the findings.

The second hypothesis of the model of the study argues that perceived benefits will lead to green-buying behavior. According to this hypothesis, people always buy green vehicles based on their perceived benefits. The results of this study also support the same argument with  $p$ ,  $t$ , and beta values of 0.001, 3.463, and 0.160, respectively. However, past literature where researchers have conducted different studies based on these relationships that people always look at the benefits of the products to buy the products also have significant findings [67]. Although these studies have been conducted in different geographical contexts, they have the same nature of the results. The third and fourth hypotheses are based on the moderating relationship. This hypothesis claimed that increasing the environmental awareness of the green vehicle user will increase the effect of the green behavior and ultimately boost the green-buying behavior towards green vehicles. Although this study has the same nature as the significant findings, it was claimed to have  $p$ ,  $t$ , and beta values of 0.000, 13.169, and 0.618, respectively. Past studies based on environmental awareness also have the same results, that awareness of anything will better lead the person to practice that thing [56]. The fourth and last hypothesis of the model claimed that environmental awareness would boost the effect of the perceived benefits won the green-buying behavior. The result of this study shows that this relationship is not supported by the data collected, which have  $p$ ,  $t$ , and beta values of 0.343, 0.948, and 0.035, respectively. If we look at the past researchers' findings, they also have the opposite findings [68].

The study examines the connections between green behavior, the benefits of green automobiles as consumers perceive, and green car purchasing behavior. It has immense importance for society and the environment. These connections offer important insights into how consumers' behavior [69]. Promoting green transport solutions is crucial since the world suffers continually from sustainability concerns like global warming and air pollution [70]. The investigation helps legislators, manufacturers, and advertisers design policies to encourage environmentally friendly choices by exploring how green behavior and perceived benefits affect green automobile purchasing decisions [71]. Further, it provides useful insights for formulating efficient incentive programs as governments worldwide develop laws to cut carbon footprints to promote the adoption of ecologically friendly vehicles [72]. The research develops a deeper understanding by including the moderating impact of environmental awareness. Environmental awareness is a factor that covers the comprehension of environmental concerns, and it is essential to examine how it affects the linkages between green behavior, perceived benefits, and green buying behaviour. The relationship between these aspects seems to be enhanced by environmental awareness; this may highlight the significance of awareness-raising and education initiatives in supporting green consumer decisions [73]. On the other hand, reducing some connections might mean that additional practical challenges or monetary factors influence the adoption of green cars even more. The study justifies the need to enhance environmental legislation, promotional strategies, and educational initiatives to promote sustainable and environmentally friendly consumer behavior in green automobiles and beyond.

## 6. Conclusion

This study examines the relationships of green behavior and perceived benefits with green vehicle users' green-buying behavior in the Pakistani, Chinese and Saudi Arabian contexts. This study also explores the moderating role of environmental awareness on the relationships of green behavior and perceived benefits with green buying behavior. From the results of this study, it was concluded that green behavior and the perceived benefits have positive relationships with the green buying behavior of people using green vehicles. The results also show that environmental awareness has a moderating role on the relationship of green behavior with green buying behavior and has not moderating role of the relationship of perceived benefit with green buying behavior. This shows that with the increase in the environmental awareness, there will be an increase in people's behavior toward green cars buying. The results regarding the moderating role of environmental awareness on the relationship of perceived benefits and green car buying behaviors is quite surprising and needs further explorations.

### 6.1. Contribution to sustainable development goals

The study investigated the interplay among green behavior, perceived benefits, and green-buying behavior with an environmental awareness as a moderator. It substantially contributed to attaining SGDs, aiming to address the urgent socioeconomic and environmental concerns. It boosts initiatives to advance green transportation, decrease carbon footprints, promote responsible consumption, and promote innovation, thereby advancing the United Nations agenda for SGDs. Some of the contributions are listed below:

1. SDG-7: The study aligns with SDG-7 (Affordable and Clean Energy), which seeks to ensure everyone can access affordable, sustainable energy by examining automobile green-buying behavior. Green vehicles, like hybrids and electric cars, foster sustainable and environmentally friendly mobility by lowering carbon footprints and dependence on energy from fossil fuels.
2. SDG-9 stresses that innovation is important for manufacturing sustainable automobiles and encouraging environmentally friendly consumer behavior. The study aligns with SDG-9 (Industry, Innovation, and Infrastructure), emphasizing how green behavior and

perceived benefits impact car purchasing decisions. It seeks the development of robust infrastructure, advancement of sustainable industrialization, and innovation.

3. SDG-11: The study's findings about consumer behavior to advise regulations and efforts that promote green transportation and establish an environmentally responsible society. This is aligned with SDG-11 (Sustainable Cities and Communities).
4. SDG-12: The study promotes SDG-12 (Responsible Consumption and Production) by analyzing responsible consumption variables, especially car purchases. Knowing the influence of GB, perceived benefits, and EA on the buyer's decisions will provide insights to policymakers and businesses to design sustainable production and consumption strategies.
5. SDG-13: The research also stresses immediate action regarding climate change and its consequences and aligns with SDG-13 (Climate Action).
6. SDG-14 and SDG-15: Besides its main objective, the investigation supports SDGs-14 (Life Below Water) and SDG-15 (Life on Land) by minimizing ecological impacts caused by automobile emissions.
7. SDG 17: The research results provide a foundation for collaboration among stakeholders, particularly governments, corporations, and society at large, to encourage environmentally friendly purchases for achieving SDGs (SDG-17 Partnerships for the Goals).

## 6.2. Implications

The study has empirical, practical, theoretical, and managerial implications.

### 6.2.1. Empirical implications

The findings of the study provide some valuable empirical implications.

1. The lack of green behavior is one of the main factors in adopting green cars in Pakistan and Saudi Arabia, as evidenced by the findings showing that green behavior has a relationship with purchasing green cars.
2. The findings show that a lack of understanding about perceived benefits contributes to the low adoption of green cars.
3. Lack of environmental awareness is another essential factor, as the finding shows it influences the relationship between green behavior and buying behavior.
4. MGA analysis shows that there is no difference between the countries. Due to green behavior, perceived benefits, and environmental awareness, China is leading the world in adopting green cars.

### 6.2.2. Practical implications

The study has the following practical implications.

1. Customer Awareness: There is a need for advertising campaigns and educational initiatives that promote the advantages of green vehicles for the environment and raise customer awareness of their purchasing decisions.
2. Tailored Marketing: Automakers and dealers can utilize the study insights to develop marketing plans that consider consumers' level of environmental consciousness in these strategies.
3. Product Development: Automobile makers can invest in producing environmentally friendly automobiles that adhere to green behavior standards and provide obvious and alluring perceived benefits.

### 6.2.3. Theoretical implications

The study has the following theoretical implications.

1. The study integrates multiple theories into a single framework and tests for the first time, providing valuable insight into the knowledge regarding green buying behavior.
2. The research suggests that a thorough and holistic understanding of green-buying behavior needs an interdisciplinary approach, and integrating multiple theories are required.
3. By stressing the importance of moderating factors like environmental awareness, this research improves current theories related to environmental behavior like theory of planned behavior and perceived benefits theory. The complexities regarding the interactions of awareness with norms, attitudes, and perceived behavioral control in influencing green purchasing behavior need further exploration.

### 6.2.4. Managerial implications

The study has the following managerial implications.

1. Product Positioning: The research can be used to attract more customers as automobile sector managers can promote green vehicles as green choices that provide significant benefits like improved fuel economy and lower maintenance expenses.
2. Eco-Friendly Incentives: Policymakers and Businesses and policymakers can offer incentives where there is less EA to boost green-buying behavior.
3. Market Segmentation: Managers may target their advertising campaigns appropriately and optimize their marketing strategies by identifying specific consumer segments with different levels of environmental awareness.

4. Environmental Compliance: Managers and regulatory institutions can work together to create transparent and reliable eco-labeling rules and regulations.

### 6.3. Limitations and future research directions

Limitations are the door and opportunity for the new researcher to work in the same context to enhance the body of the subject knowledge further. The study has several limitations, but some of them are as mentioned.

1. A quantitative approach was used to analyze the model of this study; further, the researcher can use the same model with a qualitative approach to find new social variables responsible for the green buying behavior of green vehicles.

### Ethical approval

Ethical approval was obtained from the research ethics committee University of Gwadar on 02-01-2023 having ethical approval no. 2023/UG/ORIC/P-11. The research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The procedures used in this study adhere to the tents of the declaration of Helsinki.

### Funding

This research is funded by King Saud University, Riyadh, Saudi Arabia, through Researchers Supporting Program Number (RSP2024R206), King Saud University, Riyadh, Saudi Arabia.

### Informed consent statement

Informed consent was obtained from all participants before the data was collected. Participants were informed about their rights, the purpose of the study and to safeguard their personal information.

### Data availability statement

Data will be available by requesting the corresponding author.

### Declaration of AI tools

Grammarly and Quill Bot were used for grammar and language improvement.

### CRediT authorship contribution statement

**Jie Wu:** Data curation, Conceptualization. **Sayed Fayaz Ahmad:** Writing – original draft, Investigation, Data curation, Conceptualization. **Jaweria:** Ms, Methodology, Investigation, Data curation. **Yasser A. Ali:** Resources, Investigation. **Muna Al-Razgan:** Validation, Formal analysis. **Emad Mahrous Awwad:** Resources, Funding acquisition, Data curation. **Ahmad Y.A. Bani Ahmad Ayassrah:** Writing – original draft, Methodology, Formal analysis.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Acknowledgments

The authors acknowledge and are thankful to those who participated directly or indirectly in the study. In Particular, they present their appreciation to King Saud University for funding this research through Researchers Supporting Program number (RSP2024R206), King Saud University, Riyadh, Saudi Arabia.

### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e30098>.

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