

UNCOVERING THE BARRIERS TO SUSTAINABLE TRANSPORTATION: A RESEARCH STUDY OF ENERGY-EFFICIENT AUTOMOBILES IN KARACHI, PAKISTAN

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Abstract

The paper analyses the qualities, social determinants as well as behavioral perceptions of consumers on hybrid cars using the Diffusion of Innovation Model by Rogers. The systematic survey of 104 people is effective in relation to the socioeconomic, environmental, and technological factors affecting the consumer adoption. The article discusses the qualities, social determinants, and behavioral perceptions of the consumers towards the hybrid cars based on the Diffusion of Innovation Model by Rogers. The systematic survey of 104 people is helpful as far as the socioeconomic, environmental, and technological aspects affecting the consumer acceptance. It is hoped that the findings will provide the policy-makers and the marketers with the information on the strategies that should be implemented to overcome these barriers, raise the population awareness, and encourage the adoption of energy-efficient cars on a large scale in Pakistan, therefore, leading to the realization of sustainable urban mobility and climate sustainability.

INTRODUCTION

Transportation systems around the world are getting more attention because they are major providers of greenhouse gas emissions (GHG), environmental pollution, as well as too much use of fossil fuels. As cities grow, especially in developing countries, using internal combustion engine (ICE) vehicles makes environmental

damage, health problems, and economic problems related to energy imports worse (Aguirre-Urreta MI et.al., 2019). Pakistan is one of the country's most at risk from climate change because it has limited ability to adapt, economic problems, and problems with its infrastructure (Pakistan Bureau of Statistics; Engineering Development Board,

Government of Pakistan). Karachi is Pakistan's largest city and a major problem area. High traffic, air pollution, and fuel consumption all come together there, making energy-efficient vehicles a possible solution (Javid MA et.al., 2021).

There are many reasons why hybrid technology is not becoming popular in Pakistan quickly. These include high prices, not enough people knowing about them, and not enough policies that support them. There is also the lack of purchasing due to the high importation tax, limited availability of finance and low incentives. The lack of good after-sales service, spare parts and trained technicians also leaves the customers less certain (Anwar S et.al., 2022).

The theory of diffusions of innovations is a beneficial tool to study the process of spreading new technologies among a community of individuals (Adithya Remitasari et.al.) This theory explains how, why, and how quickly innovation is adopted, which includes the stages of awareness,

persuasion, decision-making, implementation and confirmation. The theory assists us in becoming aware of how individuals interested in hybrid cars pass through their awareness about them into purchasing one (Qureshi et.al., 2019). Individuals get to know about hybrid cars and its advantages in the knowledge stage. The persuasion stage involves people switching their minds depending on what they perceive as the advantages and disadvantages. Decision stage is where individuals determine whether they should utilize the new idea or not. The implementation phase is the one when individuals begin the usage of the product. Finally, during the confirmation phase, users seek confirmation of their decision and they might continue using the technology or quit using it. Being aware of these steps, the researchers could identify the things that simplify or complicate each of the stages in the adoption process (Mahmoud M et.al., 2021).

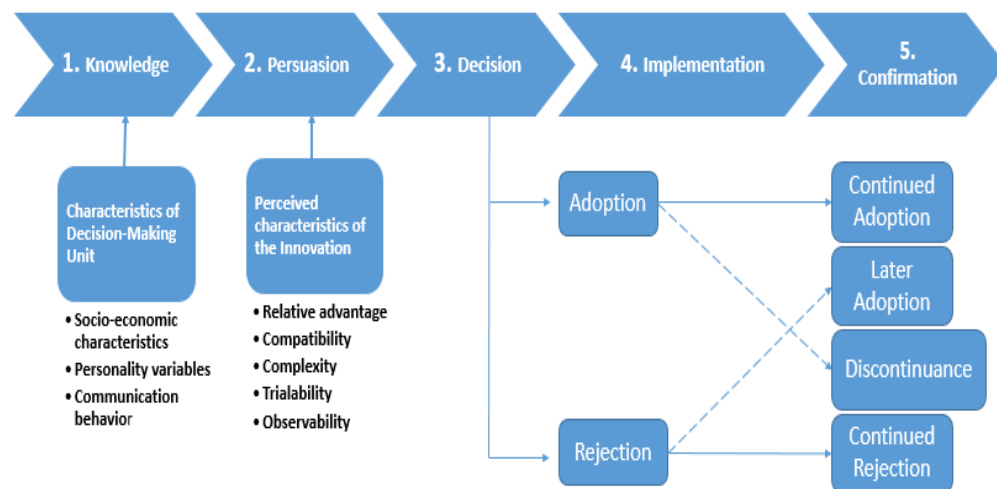


Figure 1: Shows the five stage model of innovation-decision process

The aim of this research is to classify and examine all the primary barriers and incitement that prevent individuals in Karachi, Pakistan, from purchasing energy-efficient vehicles. Using Rogers' Diffusion of Innovations model, the research seeks to clarify the influence of the

knowledge, persuasion, decision, implementation, and confirmation stages on consumer behavior concerning the adoption of hybrid vehicles (Ashfaq M et.al., 2021). The study has three goals: first, to look at how people think about and make decisions about hybrid cars; second, to find the economic, psychological, social, and policy-related factors that either help or hurt adoption; and

third, to give policymakers, manufacturers, and marketers practical advice on how to speed up the spread of energy-efficient technologies in Pakistan (Roger E.M, 2003).

LITERATURE REVIEW

Global Environmental Concerns

The rapid urbanization and industrialization of the world has necessitated increased energy aspects, and this has led to a massive contribution to greenhouse emissions and environmental destruction. Transportation has become one of the largest sources of carbon dioxide emission over the past several decades, which is primarily attributed to massive consumption of fossil fuels, such as diesel and petrol (Fransen et al., 2019). Transportation sector in the world contributes to an average of one-third of the total CO₂ emission. This is one of the main points of concern of climate action policies (Fontaras et.al., 2017).

It is quite evident that the gradual increase of the surface temperatures within the last century demonstrates the necessity of seeking the means of transportation in the long term perspective. The fact that the period between 1983 and 2012 was the warmest in the last thirty years since the beginning of the millennium demonstrates that the issue is huge. By the end of the same century, it is predicted that carbon dioxide concentration in the atmosphere will be extremely harmful in case the current trends on emission remain unchanged (Lohse-Busch et.al., 2020). These tendencies reveal the significance of the transport sector to develop new technologies and transform the way people behave. Good alternatives, such as hybrid and electric cars that are more energy-efficient than regular cars, have been produced (Mulholland et.al., 2023).

Pakistan Environmental Concerns

Climate change threatens Pakistan more than any other country despite the fact that the country emits less than 1 percent of the global greenhouse gases. The natural disasters are floods, droughts and heat waves, but these occurrences are repeated in the country. These catastrophes have claimed the lives of thousands of individuals and done a lot of harm to the economy. Agriculture, water

supply and food security continue to be troublesome due to climate change (Adithya Remitasari et.al.).

This is not the first flood that has hit Pakistan since the past decade, particularly the horrible ones witnessed in 2010 and 2011 which displaced millions of people and inflicted great destruction on infrastructure and the lives of people in Pakistan. The frequency of such incidences has made Pakistan one of the top ten countries in the list of countries most vulnerable to risks associated with climate. To address these issues the Government of Pakistan initiated a complete environmental policy in 2005. This was aimed at ensuring sustainable economic development and reduction in greenhouse gas emission. It is also a member of the global climate agreements such as the Kyoto Protocol and participates in the worldwide activities to curb carbon emissions (Abid et.al., 2015).

Nonetheless, these policies are not as effective as they could be, since there are not enough mechanisms to implement them, and funds. The transportation industry is still highly dependent on fossil fuels, hence explaining why the air in large cities such as Karachi, Lahore, and Islamabad is so polluted. Pakistan would be able to achieve its environmental objectives by adopting energy-saving technologies such as hybrid cars. This may significantly impact reduction of emissions and quality of air (Mulholland et.al., 2023).

Economic Pakistan Concerns

Various economic reasons play a significant role in the purchase of energy-saving vehicles by people. The economy of Pakistan is very dependent on oil and gas that it imports in other nations to support its increasing energy demands. The nation is not self sufficient in oil production thus it imports a lot of its fuel annually. This is not only straining the foreign reserves, but also renders the economy susceptible to fluctuations in the cost of oil in the global markets. In this case, hybrid cars can reduce the consumption of oil by a significant margin and the cost of importing fuel will no longer be a heavy weight on the economy (Abas et.al., 2017).

Karachi is the largest economic hub in Pakistan and therefore millions of people commute in

Karachi on a daily basis. High price of gas, price of auto repair and poor conditions of the infrastructure of the city are of great concern to residents. Under such circumstances, the hybrid cars can be used to save money and save the country energy which should be achieved through the long term advantages of hybrid cars such as reduced costs of fuel and good energy efficiency.

Diffusion of Innovation Theory of Rogers

The theory of Diffusion of Innovations by Everett Rogers is one of the ways of thinking about how people begin to use. hybrid cars. This theory can be used to learn how new ideas and technologies

circulate within a society. The model outlines five major factors that may make or break an innovation, including relative advantage, compatibility, complexity, trialability, and traceability (Mapoma et al., 2018). Relative benefit is the degree of superiority of an innovation in comparison to other alternatives that are already existing. It implies that hybrid cars are more environmentally friendly and cheaper, in addition to having improved gas mileage. The shapes of culture, infrastructure, and the perceived value of owning a hybrid car will all have the ability to influence the compatibility of a vehicle to Pakistani consumers (Ashfaq M et.al., 2021).

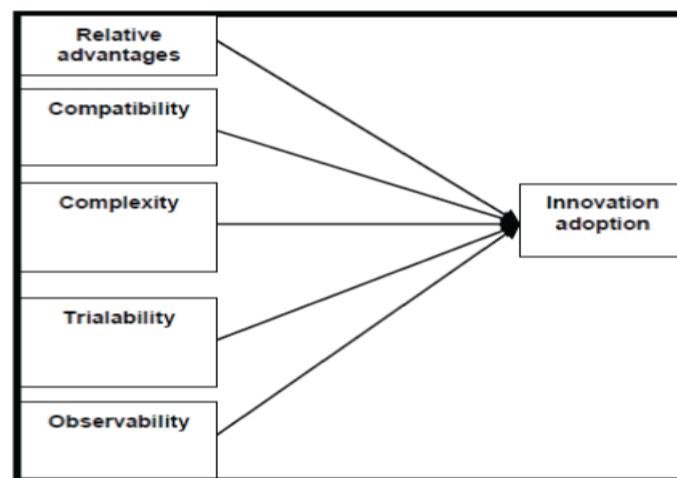


Figure 2: Shows the perceived characteristics of innovation

Automobile Market in Pakistan

The car market is highly significant to Pakistan economy as it generates high revenues and generates numerous employment opportunities. The vehicle market in the country has expanded significantly due to increasing demands on purchases of vehicles and also the government has relaxed its regulations to allow foreign investors in the country. The policy, the Automotive Development Policy (2016–2021), made it easy to conduct business in Pakistan by the international car companies by providing them with tax holidays and assisting them in the production of cars (Roger E.M, 2003). This has

since attracted the attention of major automobile manufacturers such as Hyundai, Kia and Volkswagen which show interest in manufacturing cars in the region.

This would aid in the development of the market. Despite these developments, hybrid and electric cars are not being purchased by many individuals. Most of the market comprises conventional fuel vehicles and that hybrid parts are not even produced locally further renders them less affordable. By installing the appropriate regulations, providing the population with money, and educating people about the advantages of using greener transportation, Pakistan may persuade people to switch towards greener transportation (Lohse-Busch et.al., 2020). The

largest city in the country is Karachi, where these types of programmes can be tried and the level of their efficiency checked.

RESEARCH METHODOLOGY

Participants

One hundred and forty-four responses had been collected using an online questionnaire survey that was distributed using Google forms. The sample included car drivers in the various regions of Karachi, which was done to ensure that individuals with diverse socio-economic backgrounds were taken into consideration. The survey was conducted in areas such as Clifton, Gulshan-e-Iqbal, Gulistan-e-Jauhar, Defence, Saddar, P.E.C.H.S., Korangi Town, Shah Faisal Town, North Nazimabad and Orangi Town. One of the questions that were used during the screening ensured that the responses were relevant

as the individuals responding were driving cars at the time the question was asked. Other questions identified individuals who were conversant with the hybrid vehicle technology. The duration in which the data was collected was approximately six weeks.

To make the people understand, the questionnaire began with a brief description and an illustrative figure explaining the functioning of hybrid cars. A pilot test of the survey was conducted to 12 individuals before the survey was sent to all the respondents to ensure face and content validity of the survey. This survey involved both drivers and non-drivers of the hybrid cars, a move that aided us to have better insights to the factors that influence the adoption of the hybrid cars in Karachi.

Table 1: Overview of the types of respondents

Number of Interview Respondents	
Hybrid car drivers	80
Hybrid car non-drivers	24
Total	104



Study Site

The research was conducted in Karachi, Pakistan, which is a city selected due to its economic relevance and the availability of many transportation modes. Karachi is the largest and most populated city of Pakistan and it has over 11 million residents. It is also the principal industrial and financial centre of Pakistan and its GDP is approximately USD 164 billion.

Not only does Karachi have the economic strength, but it is a major transportation center. It boasts of two largest seaports in Pakistan, Port of Karachi and Port Qasim and the busiest airport in the country, the Jinnah International Airport. The car dealerships in the city are also well established and therefore make it a very good place to visit in order to see how people are purchasing energy-saving cars.

Table 2: Classification of the adoption qualities and other significant determinants of Roger

Adoption Qualities	Significant Determinants
Primary Advantage	Better fuel efficiency
	Lower emissions
	Annual cost savings
Compatibility	Compatible with modern lifestyle
	Compatible with Environmental policies
Complexity	Purchase Price is high

	Less knowledge of technology
	Less technicians available
	Operation and Maintenance is complex
	Less variety is available
	Personality mindset
Trialability	Import Duty on Hybrid cars should be reduced
	More incentives should be given by the government
Observability	Satisfaction with new technology
	Willing to suggest Hybrid cars to peers
	Future willingness to invest in Hybrid technology

Study Design

The research design will be grounded on the Innovation Diffusion Theory by Rogers which analyzes the five most critical elements of persuasion:

1. Advantage over others
2. Affinity
3. Complicatedness
4. Tryability
5. Seeing

The literature review was completed in search of the primary factors that influence the diffusion of the technology of hybrid vehicles on both a local and global level. It is through this review that the questionnaire was assembled differently and that the data would be collected differently. In this

quantitative study, the method of conducting the survey was chosen as the most suitable tool, a five-point Likert scale was used to measure items (1 = strongly disagree to 5 = strongly agree). The demographic questions were based on such aspects as gender, age, level of income, and level of education.

Descriptive Statistics

There were 104 people in the sample, and they comes under the limitation of 18 to 45 years old. People who answered were men (84.6%), and only 15.4% were women. Most of the people who took part had a college degree, which means that the people who answered the questions were fairly well-informed.

Table 3: Summary of the descriptive statistics

Variable	Category	n	Percentage (%)
Gender	Male	88.1	85
Age (By Jun 30 2021) - (Years)	Female	16.1	15
	18-24	24	24
	25-34	38	37
	35-44	30	29
	45+	12	12
Monthly Household Income (Rs.)	< 50,000	25	24
	50,000-150,000	29	28
	150,002-250,000	27	26

Qualification	250,003-350,000	12	12
	350,001+	11	11
	Matriculation	1	1
	Intermediate	5	5
	Bachelors	39	38
	Masters and PhD	55	53
	Other	4	4

RESULTS AND DISCUSSION

This part of the research showcases the main results and analysis of those factors that will affect the adoption of energy-efficient cars (hybrid cars) in Karachi, Pakistan, using Rogers' Innovation Diffusion Model. The model's attributes do the sorting of the results, and the statistical analyses do the backing of the results in uncovering both the factors that make it more attractive and those that make it less attractive to people to adopt the model.

Significant Determinants

1. Basic Virtue

The outcomes reveal that fuel efficiency is the hybrid car's benefit that is beyond doubt recognized. Over 94% of the respondents who responded to the question believed that hybrid cars perform better than normal cars as far as fuel efficiency is concerned. Approximately 47% had a strong agreement that hybrid cars reduced emissions by a significant amount.

Nearly 74% of respondents by whose answers the information was obtained indicated that hybrid cars save them on fuel and this is a significant factor that may make individuals purchase them.

2. Compatibility

The other significant consideration was the compatibility of the individual to his/her own values and lifestyle. Over 47 per cent strongly agreed that hybrid cars would fit well in a modern and environmentally friendly lifestyle.

The findings are in favor of the Congruency Theory, and interpreted that about 84 percent of the respondents who responded indicated that hybrid vehicles are in congruence with both

environmental policies and values that are sustainable.

3. Complexity

The most significant factor preventing people to buy it is still the high price of the first purchase. Majority of those who responded indicated that the major issue was the increased price of vehicles in Pakistan that is attributed to devaluation of the currency and the fact that Pakistan is not producing its own imports. Moreover, 34 percent of respondents who responded indicated that they found it more difficult to maintain hybrid cars in proper condition, and 45 percent were concerned about short supply of professional mechanics.

Such findings comply with the existing studies that proved that psychological risk, temporal risk, and social influence can deter consumers to adopt new automotive technologies.

4. Observability

Observability and trialability were found to have a good impact on adoption. Over 64 percent of survey respondents agreed that incentives by governments would accelerate diffusion process and 52 percent concurred that reducing the duties on imports of hybrid vehicles would make them readily available.

More than 80 percent were satisfied with the hybrid cars and would recommend them to others after using them before. This indicates that there is a possibility that the market may expand significantly in the future in case more people heard about them and could be able to access them.

Tabulate Significance**1. Accretive Significance of Drivers**

When looking at determinants across attributes, relative advantage and compatibility were the most important factors in getting people to adopt. Fuel savings, environmental awareness, and compatibility with modern lifestyles were all factors that helped consumers accept the product.

2. Accumulative Significance of Barriers

The biggest problems were not having enough money, not having enough models, and not having enough people who knew how to fix things. These things make it much harder for people in Pakistan's growing car market to buy hybrid cars.

DATA ANALYSIS

We used SPSS software to do statistical analyses to see how the five attributes were related to each other. The tests listed below were used:

1. Test of Pearson Chi-Square
2. Test of Phi/Cramer

3. Tables of Contingency
4. Principal Component Analysis (PCA)
5. Exploratory Data Analysis (EDA)

The Kaiser-Meyer-Olkin (KMO) examination interpreted that it was sufficiently good for factor analysis. The values of Eigen greater than 1 founded by PCA with four important components, these components showed most of the differences between the variables.

Following Exploratory Factor Analysis (EFA) confirmed these four components, showing that relative advantage and compatibility are the most important positive factors and that complexity is the main barrier.

These results show that the main reasons people in Karachi buy hybrid cars are that they think they will save money and help the environment. However, they are limited by money, technology, and infrastructure issues.

Table 4: KMO and Bartlett's Examination

Suitability of data for structure detection:

Kaiser-Meyer-Olkin Sampling for Measurement		0.595
Bartlett's Examination of Sphericity	Approx. Chi-Square	337.9
	df	120.0
	Sig.	0

Kaiser-Meyer-Olkin Measure of sampling Adequacy (KMO): The ratio of the degree of variability of your variables which could be due to underlying components. [{Factor analysis is not likely to be of much use} ($0.50 < \text{KMO} \leq 0.60$) $\Rightarrow$ 1) {factor analysis may be useful}].

Bartlett's test of Sphericity (significance value):

- 1 - variables are independent (not suitable in structure detection)
- $0.05 < 0.05$ factor analyses can come in handy.

Table 5: Explanatory Total Variance.

Checking Kaiser Criteria (1st column - Total)

S.No.	Eigen Initial values			Sum Extraction of Squared Loadings			Sum Rotation of Squared Loadings
	Total	Variance Percentage (%)	Cumulative Percentage (%)	Total	Variance Percentage (%)	Cumulative Percentage (%)	Total
1	4	24.138	24.138	3.862	24.138	24.138	3.288
2	3	17.841	41.979	2.855	17.841	41.979	2.775
3	2	10.707	52.686	1.713	10.707	52.686	1.962
4	1	9.018	61.704	1.443	9.018	61.704	2.161
5	1	6.697	68.401	1.071	6.697	68.401	1.790
6	1	6.159	74.559				
7	1	5.293	79.853				
8	1	3.970	83.823				
9	1	3.347	87.169				
10	1	3.219	90.388				
11	1	2.527	92.915				
12	.340	2.128	95.042				
13	1	1.850	96.893				
14	.235	1.468	98.361				
15	.2	1.222	99.583				
16	.12	.417	100.000				
Principal Module Analysis.							

The primary four components explain much more variance than the remaining components, so after this plot using best judgement the recommended number of components for extraction are 4,

because after component 4 very little variance is observed.

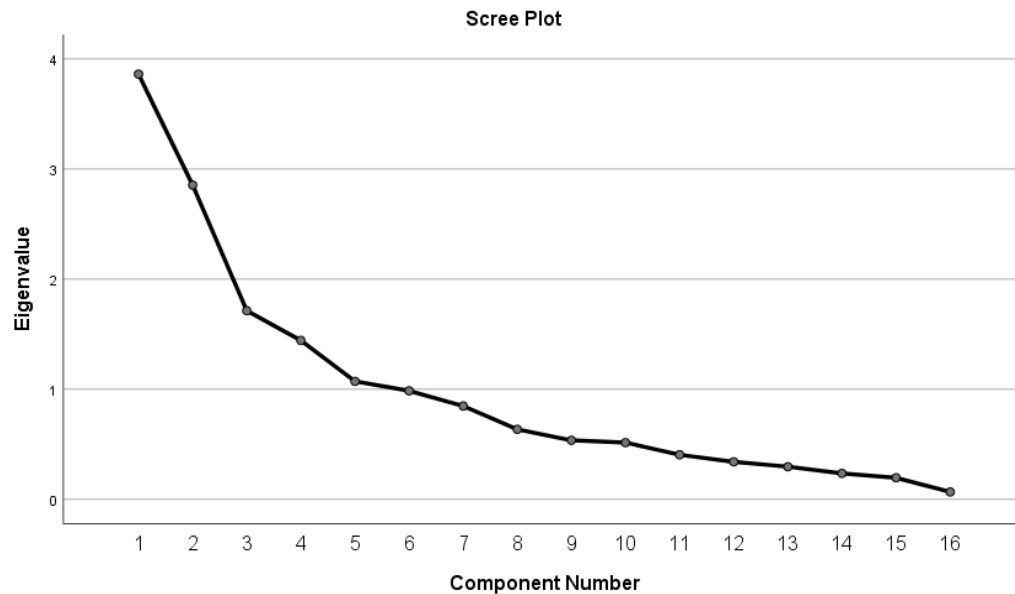


Figure 3: Scree plot showing component variation

Version Monte Carlo PCA Parallel Analysis.

Replications number: 100

Variables number: 16

Subject numbers: 71



Table 6: Check list Eigen values in total variance determine extraction using Parallel Analysis.

Number of Eigen Values	Eigen value Randomly	Standard Deviation
1	2	0.1
2	2	0.2
3	1.5	1
4	1	1
5	1.3	1.1
6	1.1	1.1
7	1.8	1.04
8	1	1.04
9	1	1.04
10	1	1.04
11	1	1.1
12	1	1.1
13	0.5	1.1
14	0.42	1.1
15	0.4	1.05

Table 7: Depicts component Matrix.

	Module				
	01	02	03	04	05
V1_Observability	.803	-.284	.173	.094	-.072
V3_Observability	.759	-.326	.068	-.353	-.044
V3_RA	.712	-.154	-.260	-.168	.015
V2_Observability	.710	-.415	.207	-.288	-.298
V1_Compatibility	.585	.022	-.068	.572	-.081
V3_Complexity	.570	.440	-.254	-.357	-.317
V4_Complexity	.224	.776	-.059	-.235	.050
V6_Complexity	.277	.721	-.164	.250	-.075
V5_Complexity	.305	.697	.024	.129	-.090
V2_Complexity	.102	.437	-.645	-.012	.065
V1_Trialability	.181	.368	.637	-.198	.223
V1_Complexity	.208	.160	.500	.488	-.089
V2_Trialability	.246	.431	.477	-.117	.407
V2_Compatibility	.527	-.214	-.114	.562	.023
V2_RA	.290	-.287	-.393	.026	.624

V1_RA	.485	-.050	-.028	-.020	.485
Principal Module Analysis.					
Five Components Extracted					

There are four strongest components of interrelationships as demonstrated in the table. After having determined the right number of components to keep, since the solution is a five factors solution, to only retain 4 components the tests are re-run with four components:

- Fixed number of factors (factors to extract) - Convergence MAXimumiterations = 25
- Method: Orthogonal Rotation (Direct Oblimin)
- Pairwise exclusions.
- Higher percentage of variance explaining suitability of four component solution is explained by rotation of four component solution

Table 8: Principal Component Analysis is the Extraction Method.

Module	Eigen Initial values			Sum Extraction of Squared Loadings			Sum Rotation of Squared Loadings
	Total	Variance Percentage (%)	Cumulative Percentage (%)	Total	Variance Percentage (%)	Cumulative Percentage (%)	Total
1	3.862	24.138	24.138	3.862	24.138	24.138	3.288
2	2.855	17.841	41.979	2.855	17.841	41.979	2.775
3	1.713	10.707	52.686	1.713	10.707	52.686	1.962
4	1.443	9.018	61.704	1.443	9.018	61.704	2.161
5	1.071	6.697	68.401	1.071	6.697	68.401	1.790
6	.985	6.159	74.559				
7	.847	5.293	79.85				

			3				
8	.635	3.970	83.82 3				
9	.535	3.347	87.16 9				
10	.515	3.219	90.38 8				
11	.404	2.527	92.91 5				
12	.340	2.128	95.04 2				
13	.296	1.850	96.89 3				
14	.235	1.468	98.36 1				
15	.195	1.222	99.58 3				
16	.067	.417	100.0 00				
Principal Module Analysis.							

Obtain a total variance cannot be added into the sums of squared loadings

Having identified the right amount of components to be included (4) to substantiate suitability of data to structure detection:

The results of these 4 components are an Exploratory Factor Analysis (Principal Axis Factoring):

- Depending on predetermined factors (factors to extract)

- Convergence Maximum Iterations = 25

The orthogonal Rotation (Direct Oblimin) is used.

- Excluding cases pairwise

Suppress little coefficients (Absolute value <): 0.30

Table 9: Pattern Matrix

	Facet			
	01	02	03	04

V3_Observability	0.908			
V2_Observability	0.888			
V1_Observability	0.640			.416
V3_RA	0.599			
V1_RA	0.309			
V4_Complexity		0.697	.312	
V3_Complexity	0.470	0.671		
V6_Complexity		0.662		
V2_Complexity		0.601	-.309	
V5_Complexity		0.548	0.301	
V1_Trialability			0.707	
V2_Trialability			0.508	
V2_RA				
V1_Compatibility				.701
V2_Compatibility				.596
V1_Complexity			.338	.340
Principal Module Analysis.				

The converged rotation took 11 repetitions.

Extractions Technique: Principal Axis Faceting.

- Rotation Technique: Oblimin and Kaiser Normalization.
- The converged rotation took 11 iterations.

The loadings in the pattern matrix table are representing the correlation between a measured variable and a factor, and the fact that the factors may co-relate with one another is controlled.

CONCLUSION AND RECOMMENDATION

Conclusion

This research found the most important things that affect the decision to buy energy-efficient cars in Karachi. The results showed that consumers are motivated by fuel efficiency, cost savings, and environmental benefits. On the other hand, high prices, limited availability, and a lack of skilled technicians are barriers. Relative advantage and compatibility are two of Rogers' innovation traits that strongly encourage adoption. Complexity, on the other hand, is still the biggest barrier. In general, people in Karachi are interested in sustainable transportation, but economic and structural problems are making the change take longer.

Recommendations

1. Give hybrid cars tax breaks and lower import duties as incentives from the government.
2. Start campaigns to raise public awareness about the financial and environmental benefits.
3. Offer technical training programs to help people become skilled technicians for hybrid vehicles.
4. Add service centers and charging stations for hybrid and electric cars to the infrastructure.
5. Encourage local manufacturing and assembly to lower costs and make things more available.
6. Encourage ongoing research to keep an eye on changes in consumer behavior and the effectiveness of policies.

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REFERENCES

- Abas et.al. (2017). Review of GHG emissions in Pakistan compared to SAARC countries. *Science Direct* , 990-1016.
- Abid et.al. (2015). Farmers' perceptions of and adaptation strategies to climate change and their determinants: The case of Punjab province, Pakistan. *Earth System Dynamics* , 225-243.
- Adithya Remitasari et.al. (n.d.). Slide Share. Retrieved from Diffusion of Innovation: <https://www.slideshare.net/slideshow/diffusion-of-innovation-70766923/70766923>
- Aguirre-Urreta MI et.al. (2019). Detecting common method bias: performance of the Harman's single-factor test. *ACM SIGMIS Database: the DATABASE for Advances in Information Systems*. ACM , 50:45–70.
- Anwar S et.al. (2022). Consumers' switching intentions from conventional to green vehicles in the context of smog risk in Pakistan. *Case Stud Transp Policy*. , 10:1695–705.
- Ashfaq M et.al. (2021). You plant a virtual tree, we'll plant a real tree: understanding users' adoption of the ant forest mobile gaming application from a behavioral reasoning theory perspective. *J Clean Prod* , 310: 127394.
- Fontaras et.al. (2017). Fuel consumption and CO2 emissions from passenger cars in Europe—Laboratory versus real-world emissions. *Google Scholar* , 60, 97–131.
- Fransen et.al. (2019). A. *Enhancing NDCs: Opportunities in Transport*. Retrieved from www.wri.org/
- Javid MA et.al. (2021). Understanding traffic congestion from stakeholders' perceptions in the central area of Lahore, Pakistan. *J Appl Eng Sci*. , 19:125–36.
- Lohse-Busch et.al. (2020). Automotive fuel cell stack and system efficiency and fuel consumption based on vehicle testing on a

chassis dynamometer. *Google Scholar* , 45, 861-872.

Mahmoud M et.al. (2021). actors impacting consumers' intention toward adoption of electric vehicles in Malaysia. *J Clean Prod* , 282: 124474.

Mapoma et.al. (2018). Spatial analysis of groundwater suitability for drinking and irrigation in Lahore, Pakistan. *Science Direct* , 1-16.

Mulholland et.al. (2023). *Emissions from Trucks in the European Union: An Analysis of the 2020*

Reporting Period. Retrieved from <https://theicct.org/wp-content/uploads/2023/07/hdv-co2-emissions-eu-2020-reporting-2-jul23.pdf>

Qureshi et.al. (2019). Electric Vehicles in Pakistan: Policy Recommendations. LUMS Energy Institute U.S.-Pakistan Cent. *Adv. Stud. Energy* 1 .

Roger E.M. (2003). Elements of diffusion. *Diffusion of innovations*.

The screenshot displays the QuillBot AI Detector interface. On the left, a sidebar lists various tools: Paraphraser, Grammar Checker, AI Detector (selected), AI Humanizer, AI Chat, AI Image Generator, Summarizer, Translator, Citation Generator, QuillBot Flow, and QuillBot for Chrome. The main area shows a text input field with the following content:

Uncovering the Barriers to Sustainable Transportation: A research study of Energy-Efficient Automobiles in Karachi, Pakistan

ABSTRACT

The paper analyses the qualities, social determinants as well as behavioral perceptions of consumers on hybrid cars using the Diffusion of Innovation Model by Rogers. The systematic survey of 104 people is effective in relation to the socioeconomic, environmental, and technological factors affecting the consumer adoption. The article discusses the qualities, social determinants, and behavioral perceptions of the consumers towards the hybrid cars based on the Diffusion of Innovation Model by Rogers. The systematic survey of 104 people is helpful as far as the socioeconomic, environmental, and technological aspects affecting the consumer acceptance. It is hoped that the findings will provide the policy-makers and the marketers with the information on the strategies that should be implemented to overcome these barriers, raise the population awareness, and encourage the adoption of energy-efficient cars on a large scale in Pakistan, therefore, leading to the realization of sustainable urban mobility and climate sustainability.

Keywords: Hybrid cars, Drivers and barriers, Diffusion of innovation, Hybrid cars Pakistan, Rogers Model

INTRODUCTION

Transportation systems around the world are getting more attention because they are major providers of greenhouse gas emissions (GHG), environmental pollution, as well as too much use of fossil fuels. As cities grow, especially in developing countries, using internal combustion engine (ICE) vehicles makes environmental damage, health problems, and economic problems related to energy imports worse (Aguirre-Urreta MI et al., 2019). Pakistan is one of the country's most at risk from climate change because it has limited ability to adapt, economic problems, and problems with its infrastructure (Pakistan Bureau of Statistics, Engineering Development Board, Government of Pakistan). Karachi is Pakistan's largest city and a major problem area. High traffic, air pollution, and fuel consumption all come together there, making energy-efficient vehicles a possible solution (David MA et al., 2021).

4,561 Words

Analysis complete

Want your text to sound more authentic? [Refine with Paraphraser](#)

On the right, the AI Detector results are shown. A bar chart indicates that 0% of the text is likely AI-generated. Below the chart, a table shows the breakdown of the text:

Category	Percentage
AI generated	0%
AI generated & AI refined	0%
Human-written & AI-refined	1%
Human-written	99%

Below the table, there is a section titled "Understanding your results" with a dropdown arrow.