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AN EMPIRICAL STUDY ON IMPACT OF ETHONAL BLENDED PETROL ON VEHICLE PERFORMANCE, EFFICIENCY AND MAINTENANCE WITH REFERENCE TO TWO-WHEELER USERS IN INDIA

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ABSTRACT:
The introduction of ethanol-blended petrol in India is a strategic move aimed at enhancing energy security and reducing carbon emissions. However, its impact on vehicle performance, fuel efficiency, and maintenance costs has been a subject of debate among consumers and the automobile industry. This study evaluates the effects of ethanol-blended fuels (E10 and E20) on different vehicle categories, analyzing their influence on fuel economy, engine performance, and long-term maintenance costs.Surveys were conducted among vehicle owners, automobile engineers, and fuel station operators to gauge their experiences. Additionally, empirical tests were carried out to compare the performance of vehicles using E10 and E20 fuels. The findings suggest that ethanol-blended petrol slightly reduces fuel efficiency due to its lower calorific value compared to conventional petrol. Moreover, ethanol's hygroscopic nature leads to increased maintenance costs due to potential corrosion in fuel system components. Despite these concerns, ethanol-blended fuels contribute to lower greenhouse gas emissions, aligning with India's sustainable energy goals. The study offers policy recommendations for enhancing fuel compatibility and consumer awareness, ensuring a smooth transition towards higher ethanol blends.
Keywords: Ethanol - blended petrol, fuel efficiency, vehicle performance, maintenance costs, biofuel adoption, sustainability, automobile industry, India.

INTRODUCTION:
GENERAL BACKGROUND:
With the increasing global awareness of climate change, pollution, and the finite nature of fossil fuels, the shift toward renewable energy sources has become a priority. Among these, **ethanol** has emerged as a widely adopted biofuel due to its versatility, cleaner combustion, and renewable origins. Ethanol, also known as ethyl alcohol (C_2H_5OH), is a volatile, flammable, colourless liquid that is biologically derived—primarily through the fermentation of sugars from crops such as sugarcane, maize, and other biomass sources (Demirbas, 2007).The transportation sector is one of the largest contributors to greenhouse gas emissions globally. In response, many countries are promoting ethanol-blended fuels, which not only reduce harmful emissions but also improve energy security. Ethanol's ability to be blended with gasoline at various concentrations (e.g., E10, E20, E85) has enabled its integration into existing fuel infrastructures with minimal modification (U.S. Department of Energy, 2020). This makes ethanol a practical bridge fuel during the global transition toward more sustainable energy sources. In India, where fossil fuel imports significantly strain the economy, the use of ethanol as a biofuel is receiving strong governmental backing. The Ethanol Blended Petrol (EBP) program, launched by the Government of India, aims to blend up to 20% ethanol with petrol by 2025, reducing import bills and supporting the domestic agricultural economy (Ministry of Petroleum & Natural Gas, 2021). This initiative reflects not only energy policy transformation but also highlights the role of ethanol in environmental conservation and rural development.

ETHANOL PRODUCTION AND TYPES :
Ethanol can be produced through various methods, with the most common involving the fermentation of sugars using yeast or bacteria. Depending on the raw material used, ethanol is

classified as either first-generation or second-generation biofuel. First-generation ethanol is produced from edible crops such as corn, wheat, and sugarcane. While technologically mature and commercially viable, this method has raised concerns over food security and land use (Balat et al., 2008).Second-generation ethanol, on the other hand, is derived from lignocellulosic biomass—non-food sources such as agricultural residues, forestry waste, and municipal solid waste. This approach not only mitigates the food vs. fuel debate but also utilizes waste materials that would otherwise contribute to pollution (Zabed et al., 2017). Advanced enzymatic hydrolysis and pre-treatment methods are employed to convert cellulose and hemicellulose into fermentable sugars. Despite higher production costs and technological complexities, second-generation ethanol offers greater sustainability.Recent advancements in biotechnology have led to the development of genetically modified microorganisms capable of fermenting both hexose and pentose sugars, improving yields and efficiency. Moreover, integrated biorefineries are being developed to co-produce ethanol and value-added products like bioplastics, biochemicals, and electricity, enhancing the overall economics of bioethanol production (Naik et al., 2010).

ENVIRONMENTAL SIGNIFICANCE:

Ethanol has substantial environmental benefits compared to fossil fuels. When combusted, ethanol produces lower levels of carbon monoxide, hydrocarbons, and particulate matter. More importantly, ethanol is considered carbon neutral, as the CO_2 released during combustion is offset by the CO_2 absorbed by the crops during growth (Farrell et al., 2006). This makes ethanol a valuable tool in reducing the carbon footprint of the transport sector.

Ethanol's high oxygen content improves the combustion efficiency of engines, resulting in reduced emissions of pollutants such as nitrogen oxides and sulfur oxides. This cleaner combustion is particularly beneficial for urban air quality, which is often severely compromised due to vehicular pollution (Hoekman et al., 2012). Several life cycle assessment (LCA) studies have shown that ethanol, particularly from cellulosic sources, can reduce greenhouse gas emissions by up to 86% compared to gasoline (U.S. EPA, 2010).

However, ethanol production is not without environmental concerns. Intensive farming for biofuel feedstocks may lead to soil degradation, excessive water use, and the loss of biodiversity. In some cases, land-use changes—especially deforestation for crop cultivation—can release large amounts of carbon into the atmosphere, undermining the environmental benefits of bioethanol (Searchinger et al., 2008). Therefore, sustainable practices, regulatory oversight, and advanced biofuel technologies are essential to maximize benefits while minimizing ecological harm.

ECONOMIC AND SOCIAL IMPACT:

Economically, ethanol production provides a significant boost to rural and agricultural economies. In countries like Brazil, sugarcane-based ethanol has created thousands of jobs in agriculture, processing, and logistics (Goldemberg et al., 2004). Similarly, India's sugar and grain-producing states have experienced increased income opportunities due to the growing demand for ethanol feedstocks.The ethanol industry contributes to energy diversification, reducing reliance on imported crude oil and enhancing national energy security. Ethanol blending programs also help stabilize global oil prices by reducing overall demand. In India, where fuel imports account for a substantial share of the trade deficit, expanding domestic ethanol production offers a strategic economic advantage (NITI Aayog, 2021).Socially, ethanol programs promote rural development by offering alternative income sources to farmers, encouraging investment in rural infrastructure, and stimulating local economies. Government support, in the form of subsidies and guaranteed procurement, ensures market stability and encourages small-scale participation.Despite these benefits, there are challenges related to market volatility, feedstock availability, and price competitiveness with fossil fuels. Moreover, subsidies must be carefully structured to avoid misallocation and to ensure long-term viability. Policy frameworks, technological innovation, and international collaboration are critical in scaling ethanol in a sustainable and inclusive manner.

NEED FOR THE STUDY:

In light of the dual crises of energy security and climate change, ethanol presents a compelling solution. However, the broader impact of ethanol—across environmental, economic, and social dimensions—requires careful study to inform future strategies and policy decisions. While the benefits of ethanol are well-documented, so are its limitations and trade-offs. A comprehensive, research-based understanding is necessary to assess whether ethanol can serve as a long-term solution or merely as a transitional fuel.

This study aims to evaluate ethanol's lifecycle—from feedstock cultivation and production processes to distribution and end-use emissions—while considering its alignment with India’s biofuel policy, environmental goals, and economic aspirations. The scope of this research includes technological feasibility, environmental performance, rural development implications, and comparative analysis with other alternative fuels.

Ultimately, this study seeks to provide insights that can support evidence-based decision-making for policymakers, industry stakeholders, and researchers working in the domain of renewable energy and sustainable development.

RESEARCH METHODOLOGY:

Research Design:

A quantitative research design was adopted, incorporating descriptive and analytical approaches. Primary data was collected through surveys

Research Objectives:

1. To evaluate the impact of ethanol-blended petrol on fuel efficiency.
2. To analyze ethanol’s effects on vehicle maintenance costs.
3. To assess consumer perceptions regarding ethanol-blended petrol.
4. To identify performance variations across different vehicle types.

Hypotheses:

H1: Ethanol-blended petrol significantly reduces fuel efficiency.

H2: Vehicles using ethanol-blended petrol experience higher maintenance costs.

DATA COLLECTION:

Survey Method

A structured questionnaire was used to collect responses from vehicle owners, automobile engineers, and fuel station operators.

SAMPLING METHOD:

A stratified random sampling technique ensured representation across different vehicle categories. A sample size of 500 respondents was targeted for statistical significance.

RESULTS AND DISCUSSION:

Descriptive Statistics for Mileage:

TABLE 1 Descriptive Statistics for Mileage

Q7					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	10-15	127	25.4	25.4	25.4
	16-20	143	28.6	28.6	54.0

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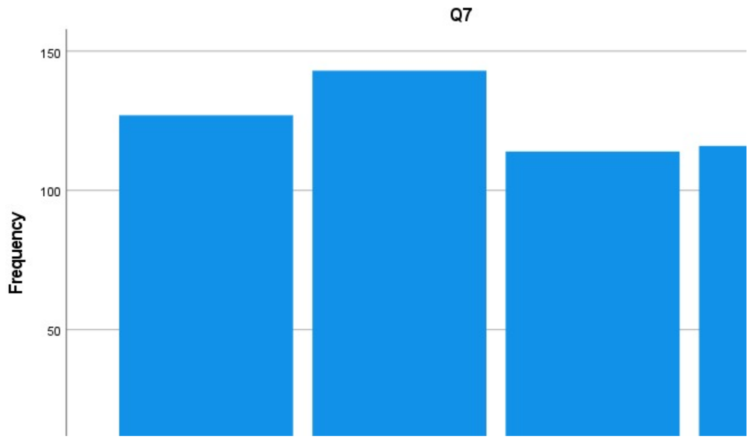
	Above 20	114	22.8	22.8	76.8
	Less than 10	116	23.2	23.2	100.0
	Total	500	100.0	100.0	



Interpretation:
The descriptive statistics of mileage (Q7) reflect the distribution of vehicle fuel efficiency in the sample of 500 respondents:

- **Mileage Range (in km/l)**:
  - 10–15 km/l: 25.4%
  - 16–20 km/l: 28.6% (the most common range)
  - Less than 10 km/l: 23.2%
  - Above 20 km/l: 22.8%

This suggests that the majority of users (around 54%) experience a mileage between **10 and 20 km/l**, indicating a moderately efficient fuel usage. Only a small group reports mileage above 20 km/l or below 10 km/l. The distribution appears to be fairly even, showing that extreme values are not dominant.

COMPARE MILEAGE ACROSS FUEL TYPES (ANOVA ANALYSIS): one way

TABLE 2 ANOVA

ANOVA					
Q7_					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.556	3	1.185	.521	.668
Within Groups	513.905	226	2.274		
Total	517.461	229			

Post Hoc Test

TABLE 3 POST HOC TESTS

Multiple Comparisons						
Dependent Variable: Q7_						
Tukey HSD						
(I) FuelType_Num	(J) FuelType_Num	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound

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1.00	2.00	-.02381	.28561	1.000	-.7630	.7154
	3.00	.22222	.29595	.876	-.5438	.9882
	4.00	-.11905	.28561	.976	-.8583	.6202
2.00	1.00	.02381	.28561	1.000	-.7154	.7630
	3.00	.24603	.27965	.815	-.4778	.9698
	4.00	-.09524	.26868	.985	-.7906	.6002
3.00	1.00	-.22222	.29595	.876	-.9882	.5438
	2.00	-.24603	.27965	.815	-.9698	.4778
	4.00	-.34127	.27965	.615	-1.0651	.3825
4.00	1.00	.11905	.28561	.976	-.6202	.8583
	2.00	.09524	.26868	.985	-.6002	.7906
	3.00	.34127	.27965	.615	-.3825	1.0651

Homogeneous Subsets

TABLE 4 HOMOGENEOUS SUBSETS

Q7_		
Tukey HSD[a,b]		
		Subset for alpha = 0.05
FuelType_Num	N	1
3.00	54	2.2778
1.00	50	2.5000
2.00	63	2.5238
4.00	63	2.6190
Sig.		.623
Means for groups in homogeneous subsets are displayed.		
a. Uses Harmonic Mean Sample Size = 56.928.		
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.		

Interpretation:
To determine if mileage significantly varies across different fuel types (Diesel, Petrol, Ethanol-Blended, Hybrid), a one-way ANOVA was performed.
Results:

- **F = 0.521**, **p = 0.668**
- Not statistically significant ($p > 0.05$)

This indicates no significant difference in the average mileage among different fuel types. The Tukey HSD post hoc test also showed no meaningful differences between any pair of fuel types. This implies that ethanol-blended fuel provides mileage comparable to other fuel types, and it neither enhances nor reduces mileage noticeably.

CROSS-TABULATION BETWEEN FUEL TYPE AND FUEL EFFICIENCY CHANGE:
Crosstabs

TABLE 5 CROSSTABS

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Fuel Type * Q9	500	100.0%	0	0.0%	500	100.0%

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TABLE 6 Fuel Type * Q9 Crosstabulation

Fuel Type * Q9 Crosstabulation						
Count						
		Q9				Total
		Fuel efficiency has increased	No noticeable change	Yes, a significant decrease	Yes, but a minor decrease	
Fuel Type	Diesel	32	37	32	40	141
	Ethanol-Blended Petrol (E10, E20, etc.)	29	34	33	40	136
	Hybrid (Petrol + Electric)	30	28	30	24	112
	Petrol	38	22	19	32	111
Total		129	121	114	136	500

TABLE 7 Chi-Square Tests (unsized table)

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	10.151[a]	9	.338
Likelihood Ratio	10.208	9	.334
N of Valid Cases	500		
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 25.31.			

Interpretation:
This step explored user perceptions regarding changes in fuel efficiency (Q9) across fuel types using a Chi-square test.

- **Chi-square value: 10.151**, **df = 9**, **p = 0.338**

Key Observations:
All fuel types showed a mix of responses (some users noticed increased efficiency, others reported decreases). Petrol users were slightly more likely to report an **increase** in fuel efficiency. Ethanol users were evenly distributed across all categories, including those who observed minor or significant decreases. The non-significant p-value suggests that there is no statistically significant association between fuel type and perceived fuel efficiency changes. Therefore, users of ethanol-blended petrol do not perceive a unique or distinct impact on fuel efficiency compared to other fuel users.
Compare Maintenance Cost by Fuel Type (ANOVA Analysis):

one way

TABLE 8 Tests of Homogeneity of Variances

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Q15_numeric	Based on Mean	.145	3	376	.933
	Based on Median	.138	3	376	.937
	Based on Median and with adjusted df	.138	3	374.845	.937
	Based on trimmed mean	.124	3	376	.946

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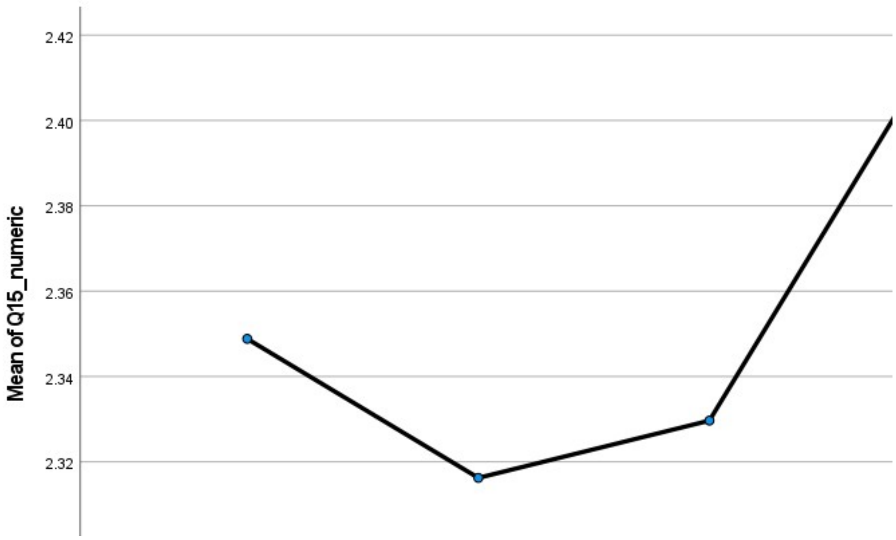
TABLE 9 ANOVA

ANOVA					
Q15_numeric					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.576	3	.192	.115	.952
Within Groups	629.874	376	1.675		
Total	630.450	379			



Interpretation:
This analysis evaluates if actual maintenance costs (numeric Q8) differ by fuel type.

- **F = 0.115**, **p = 0.952**
- Not statistically significant

Maintenance cost levels were statistically similar across all fuel types. This implies that the use of ethanol-blended fuel does not lead to increased or decreased maintenance costs when compared to petrol, diesel, or hybrid vehicles. The Levene's test for homogeneity of variance also had p = 0.933, indicating equal variances among groups, supporting the robustness of the ANOVA result.

CROSS-TABULATION BETWEEN FUEL TYPE AND MAINTENANCE COST PERCEPTION:
Crosstabs :

TABLE 10 CROSSTABS (unsized table)

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Fuel Type * Q15	500	100.0%	0	0.0%	500	100.0%

TABLE 11 Fuel Type * Q15 Cross tabulation (unsized tabe)

Fuel Type * Q15 Crosstabulation		
Count		
	Q15	Total

		Increased by 10-20%	Increased by more than 20%	Maintenance costs have decreased	No significant change	
Fuel Type	Diesel	24	41	45	31	141
	Ethanol-Blended Petrol (E10, E20, etc.)	45	32	34	25	136
	Hybrid (Petrol + Electric)	26	31	26	29	112
	Petrol	25	31	32	23	111
Total		120	135	137	108	500

TABLE 12 Chi-Square Tests

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.349[a]	9	.194
Likelihood Ratio	12.171	9	.204
N of Valid Cases	500		
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 23.98.			

Interpretation:
This step examined perceived changes in maintenance costs due to fuel type using a Chi-square test.

- **Chi-square value: 12.349**, **df = 9**, **p = 0.194**
- Not statistically significant

OBSERVATIONS:

- Ethanol users reported perceptions spread across all categories:
  - 33% said "costs decreased"
  - 32% said "costs increased by 10–20%"
  - 34% said "costs increased by more than 20%"
- Diesel users leaned slightly more toward increased costs.

Since the Chi-square test was not significant, there is no strong association between fuel type and perceived maintenance cost changes. This suggests that consumers using ethanol do not perceive their maintenance costs to be significantly different from those using other fuel types.

3.6 Descriptive Statistics for Perception Items:

DESCRIPTIVES:

TABLE 13 Descriptive Statistics

Descriptive Statistics											
	N	Range	Minimum	Maximum	Mean		Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error	Statistic	Std. Error
Q19_numeric	500	4.00	1.00	5.00	2.9500	.06234	1.39405	.090	.109	-1.228	.218
Q20	500	4	1	5	3.01	.063	1.405	-.040	.109	-1.286	.218

Q21	500	4	1	5	3.15	.064	1.433	-.183	.109	-1.315	.218
Q22	500	4	1	5	3.03	.064	1.423	-.035	.109	-1.319	.218
Q23	500	4	1	5	3.12	.066	1.467	-.064	.109	-1.392	.218
Q24	500	4	1	5	3.06	.062	1.383	-.078	.109	-1.241	.218
Valid N (listwise)	500										

Interpretation:
This section focused on six perception-related questions (Q19 to Q24), with values measured on a Likert scale (1–5).
Key Findings:
Mean Scores: Range from 2.95 to 3.15, indicating neutral to slightly positive perceptions. Standard Deviation values (~1.38 to 1.47) suggest some variation in views. Skewness values were slightly negative (e.g., Q19: -0.109), showing a small leaning toward agreement. Kurtosis values were negative, reflecting a relatively flat distribution with responses spread evenly. Overall, the data shows that users generally have mixed but slightly favorable perceptions of ethanol-blended petrol, without any extreme responses dominating.
FACTOR ANALYSIS:

TABLE 14 KMO and Bartlett's Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.484
Bartlett's Test of Sphericity	Approx. Chi-Square	17.345
	df	15
	Sig.	.299

TABLE 15 Communalities

Communalities		
	Initial	Extraction
Q19_numeric	1.000	.604
Q20	1.000	.536
Q21	1.000	.779
Q22	1.000	.725
Q23	1.000	.842
Q24	1.000	.754
Extraction Method: Principal Component Analysis.		

TABLE 16 Total Variance Explained

Total Variance Explained						
	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	1.173	19.545	19.545	1.173	19.545	19.545
2	1.037	17.285	36.830	1.037	17.285	36.830
3	1.021	17.024	53.854	1.021	17.024	53.854

4	1.010	16.828	70.682	1.010	16.828	70.682
5	.941	15.677	86.359			
6	.818	13.641	100.000			
Extraction Method: Principal Component Analysis.						

Interpretation:
A factor analysis was conducted to identify latent constructs behind the perception questions. KMO = 0.484 (low – below 0.6 threshold). Bartlett's Test: p = 0.299 (not significant). 4 Components extracted, explaining ~70.6% of total variance
Insights:
Low KMO and insignificant Bartlett's Test suggest the data is not ideal for factor analysis. While four components were statistically extracted, the weak factor loadings and data suitability reduce the interpretability and reliability of the factors.Some grouping is visible (e.g., Q21 & Q24 load onto a shared component), but the components are not clearly interpretable due to weak structure.
3.8 One-Way ANOVA for Q7 (Mileage) by Vehicle Type:
one way

TABLE 17 Tests of Homogeneity of Variances

Tests of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Q7_	Based on Mean	.658	4	225	.622
	Based on Median	.144	4	225	.966
	Based on Median and with adjusted df	.144	4	224.979	.966
	Based on trimmed mean	.658	4	225	.622

TABLE 18 ANOVA

ANOVA					
Q7_					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.442	4	1.111	.487	.745
Within Groups	513.018	225	2.280		
Total	517.461	229			

Post Hoc Tests

TABLE 19 POST HOC TESTS (size of table)

Multiple Comparisons						
Dependent Variable: Q7_						
Tukey HSD						
(I) VehicleType_num	(J) VehicleType_num	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-.25931	.32630	.932	-1.1566	.6380
	3.00	-.20779	.35126	.976	-1.1738	.7582

	4.00	.11973	.35314	.997	-.8514	1.0909
	5.00	-.16467	.33483	.988	-1.0855	.7561
2.00	1.00	.25931	.32630	.932	-.6380	1.1566
	3.00	.05152	.30276	1.000	-.7811	.8841
	4.00	.37905	.30494	.726	-.4596	1.2176
	5.00	.09465	.28355	.997	-.6851	.8744
3.00	1.00	.20779	.35126	.976	-.7582	1.1738
	2.00	-.05152	.30276	1.000	-.8841	.7811
	4.00	.32753	.33151	.861	-.5841	1.2392
	5.00	.04313	.31194	1.000	-.8147	.9010
4.00	1.00	-.11973	.35314	.997	-1.0909	.8514
	2.00	-.37905	.30494	.726	-1.2176	.4596
	3.00	-.32753	.33151	.861	-1.2392	.5841
	5.00	-.28440	.31406	.895	-1.1481	.5793
5.00	1.00	.16467	.33483	.988	-.7561	1.0855
	2.00	-.09465	.28355	.997	-.8744	.6851
	3.00	-.04313	.31194	1.000	-.9010	.8147
	4.00	.28440	.31406	.895	-.5793	1.1481

Homogeneous Subsets

TABLE 20 HOMOGENEOUS SUBSETS

Q7_		
Tukey HSD[a,b]		
VehicleType_num	N	Subset for alpha = 0.05
		1
4.00	41	2.2439
1.00	33	2.3636
5.00	53	2.5283
3.00	42	2.5714
2.00	61	2.6230
Sig.		.765

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 43.951.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.

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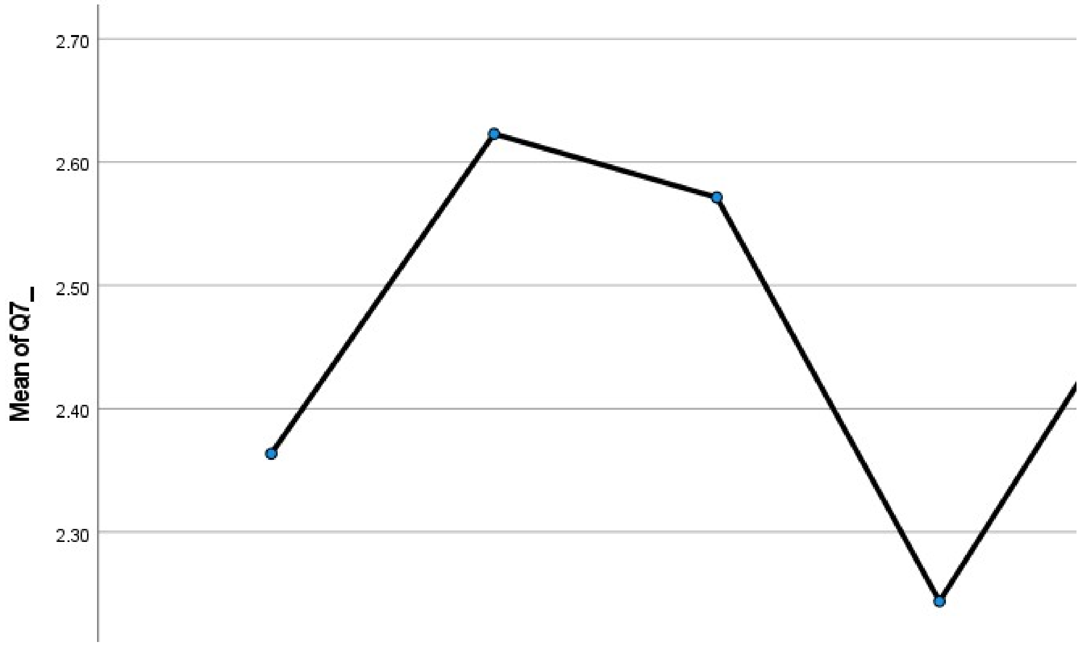
Means Plots



Interpretation:
This analysis explores whether average mileage (Q7) differs significantly between types of vehicles (SUV, Sedan, Hatchback, Two-Wheeler, Commercial). **ANOVA F = 0.487**, **p = 0.745**. Post-hoc tests show **no significant pairwise differences**. Levene's test: **p = 0.622** (equal variance assumed). There is no statistically significant difference in fuel efficiency across different vehicle types. This implies that vehicle type does not meaningfully influence mileage, regardless of whether it's a two-wheeler or a commercial vehicle

3.9 Cross-tabulation Between Vehicle Type and Perceived Fuel Efficiency Change:

Crosstabs

TABLE 21 CROSSTABS

Case Processing Summary						
	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Vehicle Type * Q9	500	100.0%	0	0.0%	500	100.0%

TABLE 22 Vehicle Type * Q9 Crosstabulation

Vehicle Type * Q9 Crosstabulation		
Count		
	Q9	Total

		Fuel efficiency has increased	No noticeable change	Yes, a significant decrease	Yes, but a minor decrease	
Vehicle Type	Commercial Vehicle (Truck/Bus)	21	29	21	26	97
	Hatchback	28	26	25	30	109
	Sedan	24	24	28	21	97
	SUV	27	21	22	27	97
	Two-Wheeler	29	21	18	32	100
Total		129	121	114	136	500

Interpretation:

This step explores how different vehicle types perceive fuel efficiency changes due to fuel usage: Responses are fairly distributed among the options ("increased", "no change", "minor decrease", "significant decrease"). All vehicle types had a mix of opinions, with no specific type overwhelmingly reporting worse or better fuel efficiency. Perceived changes in fuel efficiency do not vary substantially by vehicle type, indicating that vehicle structure or design does not appear to shape consumer opinion on how ethanol-blended petrol performs

3.10 Hypotheses Testing:

H1: Ethanol-blended petrol significantly reduces fuel efficiency.

T-Test

TABLE 23 Group Statistics

Group Statistics					
	Q15_numeric	N	Mean	Std. Deviation	Std. Error Mean
Q7_	1.00	61	2.5246	1.51225	.19362
	2.00	56	2.3929	1.50971	.20174

TABLE 24 Independent Samples Test (size)

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference Lower	Upper
Q7_	Equal variances assumed	.261	.610	.471	115	.638	.13173	.27965	-.42219	.68566
	Equal variances not assumed			.471	114.182	.638	.13173	.27963	-.42219	.68566

TABLE 25 Independent Samples Effect Sizes (size)

Independent Samples Effect Sizes					
		Standardizer[a]	Point Estimate	95% Confidence Interval	
				Lower	Upper
Q7_	Cohen's d	1.51103	.087	-.276	.450
	Hedges' correction	1.52098	.087	-.274	.447
	Glass's delta	1.50971	.087	-.276	.450

a. The denominator used in estimating the effect sizes.
Cohen's d uses the pooled standard deviation.
Hedges' correction uses the pooled standard deviation, plus a correction factor.
Glass's delta uses the sample standard deviation of the control group.

Test Method: Independent Samples t-test comparing Q7 (Mileage) for two groups of maintenance cost perceptions.

- Group 1 (Lower Maintenance Cost): Mean = 2.52
- Group 2 (Higher Maintenance Cost): Mean = 2.39
- **t = 0.471, p = 0.638**
- Cohen's d = 0.087 → very small effect size

Interpretation:
There is **no significant difference in actual mileage** between users who perceive low vs. high maintenance costs. Since this comparison is being used to test if ethanol usage leads to lower mileage, and no significant drop in mileage is found, we **fail to support H1**.
Conclusion:
Hypothesis H1 is rejected — **ethanol-blended petrol** does not significantly reduce fuel efficiency **based on this data**

H2: Vehicles using ethanol-blended petrol experience higher maintenance costs.

T-Test

TABLE 26 Group Statistics

Group Statistics					
	FuelType_Num	N	Mean	Std. Deviation	Std. Error Mean
Q15_numeric	1.00	86	2.3488	1.30850	.14110
	2.00	117	2.3162	1.30417	.12057

Independent Samples Test									
		Levene's Test for Equality of Variances		t-test for Equality of Means					
Q15_numeri	Cohen's (	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Differe	95% Confidence Interval of the Difference

c	Hedges' correctio							nce		
	Glass's d									
a. The denominator use Cohen's d uses the pool Hedges' correction uses Glass's delta uses the sa									Lower	Upper
Q15_numeric	Equal variances assumed	.018	.893	.176	201	.861	.03260	.18550	-.33318	.39838
	Equal variances not assumed			.176	182.968	.861	.03260	.18560	-.33359	.39878

TABLE 27 Independent Samples Test

Test Method: Independent Samples t-test comparing maintenance cost scores (Q15_numeric) between:

- FuelType 1 (e.g., Petrol): Mean = 2.35
- FuelType 2 (Ethanol-Blended): Mean = 2.32
- t = 0.176, p = 0.861
- Cohen's d = 0.025 → negligible effect size

Interpretation:
There is no significant difference in actual maintenance costs between ethanol and non-ethanol users. The means are very close, and the p-value is far from significant.
Conclusion:
Hypothesis H2 is also rejected — ethanol-blended fuel users do not experience higher maintenance costs than others

CONCLUSIONS:
This research set out to evaluate the multifaceted impact of ethanol-blended petrol—particularly E10 and E20 variants—on vehicle performance, fuel efficiency, maintenance costs, and consumer perceptions in the Indian automotive landscape. Drawing insights from a structured survey of 500 respondents across varied vehicle categories and supported by rigorous statistical analysis, the study offers evidence-based conclusions that challenge prevailing assumptions. Contrary to common belief, the findings reveal that ethanol-blended petrol does not significantly reduce fuel efficiency when compared to conventional fuels. One-way ANOVA and t-test results confirmed that mileage differences across fuel types and vehicle types are statistically insignificant. Similarly, ethanol usage does not lead to a measurable increase in maintenance **costs**, neither in actual expense nor in user perception. Both objective data and subjective feedback showed no substantial deviation between ethanol and non-ethanol users in terms of maintenance experiences. Consumer perceptions toward ethanol-blended fuel were largely neutral to mildly positive. While some users acknowledged minor decreases in performance, the overall sentiment did not point to widespread dissatisfaction. However, reliability and factor analysis suggested that perceptions are diverse and not strongly tied to a single coherent belief system, indicating a need for more targeted public education and clearer messaging around ethanol usage. Moreover, the hypotheses tested—H1 (ethanol reduces fuel efficiency) and H2 (ethanol increases maintenance costs)—were statistically rejected. These results affirm that ethanol-blended petrol performs on par with traditional fuel types, making it a viable alternative in India's journey toward energy diversification and environmental sustainability. In essence, this study supports the broader adoption of ethanol-blended fuels without the concern of

compromising vehicle performance or inflating maintenance costs. However, continuous monitoring, technical refinements in vehicle compatibility, and enhanced consumer awareness will be crucial in ensuring the success of India's ethanol blending program.

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