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Machine Learning Integration with Random Parameter Tobit Model for Sustainable Road Safety Improvement

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Abstract. *Pakistan is a developing country. Its transportation infrastructure mainly consists of road network. About 95% passengers and fright is transported using the road network. This high demand on road network is because of the unreliable railway system between the cities. Due to such high demand on road network the accident involvement risk of an individual is much high as compared to developed countries. This study uses a new modeling approach to estimate road safety risk for WTP. A correlated random parameters Tobit model (heterogeneity-in-mean) is integrated with machine learning (Decision tree). The decision tree categorizes higher-order interactions, while the model captures unobserved correlations and heterogeneity. The framework examines WTP determinants using a representative sample of 3178 road users from Pakistan. The model estimates WTP for different (fatal and severe injury) risk reductions to monetize road traffic crash costs. Results show maximum respondents are willing to support safety improvement policies. The model reveals significant WTP heterogeneity linked to perceptions of road safety and accident risk. Systematic preference heterogeneity emerges through higher-order interactions, offering insights into WTP relationships. Marginal effects highlight varying sensitivities to explanatory variables, quantifying their impact on WTP probability and magnitude. The framework provides two key contributions. It identifies public WTP determinants, emphasizing heterogeneous effects. It also helps in prioritization safety policies by understanding public sensitivity to WTP. The insights further emphasizing on the importance of road safety interventions to the specific socio-economic profiles of road users. This study offers a significant contribution to road safety improvement by providing valuable recommendations for policy makers. By integrating detailed socio-economic factors, it also addresses the urgent need for targeted traffic safety interventions in Pakistan. These findings are expected to aid policymakers and stakeholders in developing effective strategies to enhance road safety and reduce the accident involvement risk effectively.*

Keywords: *Transportation infrastructure, Tobit model, Machine Learning, Fatalities, Injuries, Road Safety, Willingness-to-pay*

1. INTRODUCTION

Road accidents are a major issue globally. They cost about 1-3% of any country GDP result in an estimated 1.36 million fatalities annually (WHO 2019). This issue is more severe in developing countries that face much higher fatalities rate due to immature road network systems. This rate is mostly under estimated due to lake of reliable data. In developed countries road safety has improved since early 1970s (Rizzi and Ortúzar 2006). An important factor is valuing the risk reduction of fatal accidents in project evaluations. This approach of evaluation still lacks in many developing countries (Jaździk-Osmólska 2021). Pakistan in comparison with its neighbor countries has the highest number of road accident fatalities. The common causes of road accidents in the country includes over speeding, drunk driving and fatigued driving. There is also a lack of proper data recording system and research on road traffic accidents which makes it difficult to develop effective policies for safety improvements and crash

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prevention (Hussain, Shi et al. 2021). An essential tool for road safety improvement is to comprehend the behavioral factors influencing road users and their willingness to contribute financially for their risk reduction in the involvement of a fatal or sever injury accident (Naeem and Selvam 2024). The primary road users considered in the study are pedestrians, bike riders and passenger car drivers.

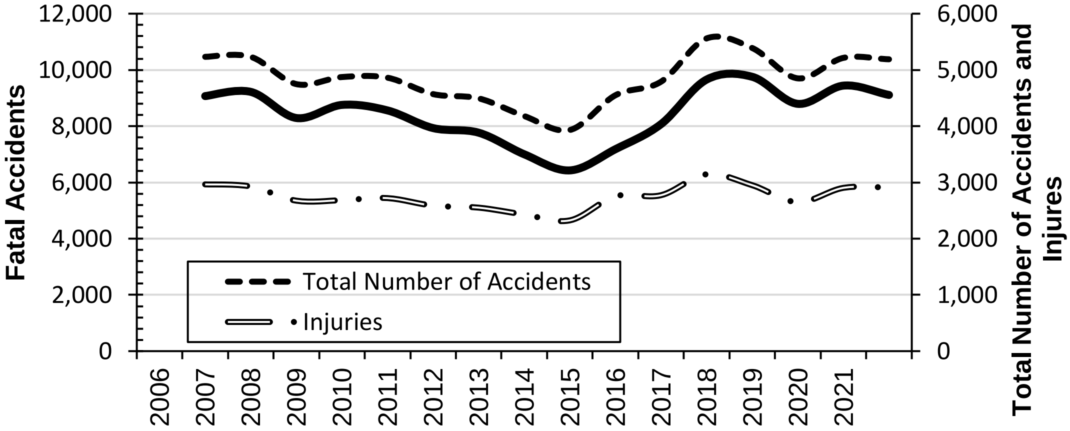

Figure 1 Number of accidents, injuries and fatalities in Pakistan

Preventing road crashes needs effective interventions and public resources. This creates a significant burden on society particularly in low/middle income countries with competing needs for sustainable development (Akbari, Heydari et al. 2024). Cost/benefit analyses are carried out to ensure efficient resource use and enhance policy transparency. Comparing the benefits of road safety policies with their costs requires monetary valuation (Weisbrod, Lynch et al. 2008). Monetizing expected benefits from safety measures improves the efficiency and equity of transport projects. The value of enhanced traffic safety perceived by individuals is measured through their willingness (Weisbrod, Lynch et al. 2009).

Theory of microeconomic states that individual choices shape economic welfare (Kaliszyk and Parsert 2018). Road crashes pose significant societal losses(Naeem, Subhan et al. 2020). These losses should reflect the willingness-to-pay of affected individuals. WTP is the additional amount road users agree to pay for improved safety measures and involvement risk reduction in fatal and injury crashes. It values risk reduction that shows the benefits of enhanced traffic safety (Tooth 2010). This approach also identifies potential factors driving financial contributions to safety programs. Understanding these factors helps policymakers in shaping campaigns to secure public contributions and ease the economic burden of road crashes (Naeem and Selvam 2024).

2. LITERATURE REVIEW

Several studies in developed and high-income countries have used the technique of WTP for road safety improvement. This technique is widely accepted to derive monetary values using individual preferences (Beli and Nalmpantis 2020). In developing countries mostly cost/benefit analyses for road safety programs remain unreliable. This is because of poor data quality (Daniels, Martensen et al. 2019). Adaptation of standard road safety methods in low-income countries is essential for data quality improvement (Heydari, Hickford et al. 2019). Road safety benefits in these regions are not formally integrated with other benefits. Instead, fatalities and injuries are valued using the human capital approach which is based on accounting principles. This often underestimates the benefits of improved traffic safety which make such investments cost-ineffective (Rezagholi 2023).

Understanding of individuals' Willingness-to-pay for improved road safety is missing in literature for developing countries. Research done in developed countries cannot be applied as well. WTP is closely related to individual characteristics, perceptions and other situational factors. These factors vary spatially. A national-level understanding of individuals' preferences can prioritize safety interventions and reduce reluctance to road financing policies. Personalizing road safety measures improves acceptance among target groups(Subhan, Ali et al. 2023). Valuations comparison of risk reduction across countries having different transport systems is impractical. This study addresses these gaps by examining WTP determinants and evaluating road crash risk reductions at national level.

Many factors are involved in WTP examination for road safety interactions. Identification of these interactions are dependent on analysis type, knowledge domain and are subjective to the model (Nordhoff, Kyriakidis et al. 2019). WTP models lack a systematic approach to compromise findings replicability. Most studies use conventional statistical models to link WTP with contributing factors and ignore variables complex interactions. Analysts often avoid specifying second- and higher-order interactions that adds to complexity. These interactions increase significantly as factors grow(Subhan, Ali et al. 2023).

The study contributes in threefold. At first, it demonstrates the machine learning technique to understand WTP and uncover complex relationships of variables which is simply not possible with traditional models. Machine learning also overcome the data inaccuracies which is common in developing countries. By using these models, the study explores community perceptions to reduce policy resistance. It clusters the population based on financial willingness into smaller groups which helps policymakers to alter road safety policies.

Second, it investigates the probability of significant factors and expected WTP values for improvement of road safety. By utilization of proposed framework, this study estimates monetary values for fatal and severe injury risk reductions in developing country.

Finally, the study advises a new modeling framework that integrates machine learning for higher-order interactions and a correlated random parameters Tobit model. This integration captures the unobserved heterogeneity. This framework identifies heterogeneous effects from multiple WTP determinants. These findings will help policymakers consider group-specific heterogeneity and formulate policies suited to diverse public perceptions of road safety improvements.

3. METHODS

Questionnaire design

The primary focus of questionnaire is to provoke the participants for road safety programs. The respondents choose the maximum amount that they can contribute to reduce their risk of involvement in a road crash. Different studies have estimated road crash risk reduction values using stated preference contingent valuation and stated choice surveys. The contingent valuation (CV) method effectively assesses crash risk reduction. Studies done also shows that payment cards simplify this process and provide confident WTP values. A WTP-CV with a payment card approach is more suitable for Pakistani respondents who are less educated and unfamiliar with such improvement valuations. The questionnaire has four sections: (1) introduction of new road safety policy for crashes and risks reduction (2) socio-economic details with traveling patterns (3) crash history, road infrastructure perception, risk awareness and (4) a WTP question for reducing traffic crash risks.

Survey details

Data was collected at five major cites of Pakistan i: e Karachi, Lahore, Quetta, Islamabad and Peshawar. As per the record of Provincial Police Departments (Crime Branch) A.I.G (Operation), Islamabad Police about 10379 accident having 44% share of fatal accidents were recorded in the year 2021-22. 5608 individuals lost their lives while 13059 were injured (Statistics 2021). Respondents were shown figures to highlight traffic crash risks and the necessity for road safety improvements. Traffic crashes are common tragedies with severe effects on individuals' life and society. Many individuals believed that the government should finance road safety measures. However, respondents needed a brief explanation about the benefits of such policies. Trained undergraduate students conducted face-to-face interviews to ensure participants understood the questionnaire and selected exact desired WTP amount. The beneficial contributions were explained to participants. The road safety program was prescribed as a new policy to reduce fatalities and severe injuries resulting from road crashes. Only participants aged 18 or older, living in the study area for over a year, were included. They could easily understand crash risks and the provided information. The safety program aimed to minimize fatalities and severe injuries by 50% as the aim of National Road Safety Strategy 2018–2030. Respondents received a payment card and were asked, "How much would you annually contribute for a program reducing fatalities and severe injuries by 50%?" They indicated their maximum contribution using the payment card. Table 1 present the statistics of respondents.

Table:1 Descriptive characteristics of Sample

Variable	Description	Mean	Standard Deviation	Count	Percentage
Dependent Variable					
Willingness to Pay (1000 PKR)		1.47	1.49	-	-
Independent Variables					
Age	Respondent Age (Years)	37.53	7.62	-	-
Young	Age ≤ 30 Years	24.83	3.64	788	24.80
Middle Aged	30 < Age ≥ 40 Years	36.83	2.52	1470	46.26
Old	Age > 40 Years	48.22	3.99	920	28.95
Gender					
Male		-	-	2626	82.63
Female		-	-	552	17.37
Family Status					
Unmarried		-	-	1036	32.60
Married with no Children’s		-	-	101	3.18
Married with Children’s		-	-	2041	64.22
Education	Education Level of Respondent				
Uneducated		-	-	287	9.03
SSC (Grade 10)		-	-	538	16.93
HSSC (Grade 12)		-	-	960	30.21
Bachelor's		-	-	1009	31.75
Above Bachelor		-	-	384	12.08
Occupation					
Student		-	-	705	22.18
Unemployed		-	-	161	5.07
Private Employee		-	-	958	30.14
Own Business		-	-	421	13.25
Government Employee		-	-	933	29.36
Personal Monthly Income (1000 PKR)		74.28	49.77	-	-
0 - 25000		-	-	428	13.47
>25000 - 50000		-	-	784	24.67
>50000 - 750000		-	-	708	22.28
>75000 - 100000		-	-	855	26.90
> 100000		-	-	403	12.68
House Hold Income (1000 PKR)					
0 - 30000		-	-	371	11.67
>25000 - 50000		-	-	396	12.46
>50000 - 750000		-	-	708	22.28
>75000 - 100000		-	-	815	25.65
> 100000		-	-	888	27.94
Sole Earner					
Yes		-	-	694	21.84
No		-	-	2484	78.16
Car Ownership					
No Personal Car/Bike		-	-	1094	34.42
Have Personal Bike		-	-	1392	43.80

Have Personal Car		-	-	692	21.77
Monthly Travel Cost (1000 PKR)		15.21	4.96		
Work/Study Trip		-	-	2496	78.54
Recreational Trip		-	-	682	21.46
Road Crash History/Direct and Indirect (Last 10 Years)					
Yes		-	-	1361	42.83
No		-	-	1817	57.17
Risk Perception					
Higher	=1 if the respondent value a higher own risk than average	-	-	2138	67.28
Lower	=0 1 if the respondent value a lower own risk than average	-	-	1040	32.72
Road Infrastructure Safety Perception (RISP)					
SPRI	=1 if the respondent value safe travel and road infrastructure	-	-	1229	38.67
USPRI	=0 if the respondent value unsafe travel and road infrastructure	-	-	1949	61.33
Risk Type					
Fatal	=1 if the respondent value FRR	-	-	1637	51.51
Severe Injury	=0 if the respondent value SIRR	-	-	1541	48.49

Note: SPRI: Safe perception of road infrastructure; USPRI: Unsafe perception of road infrastructure. Sample size = 3178

4. RESULTS

Willingness-to-pay Rate

Among 3178 respondents interviewed, 1159 choose a zero willingness-to-pay (WTP) amount making the refusal rate 36.47%. About 17.04% and 57.11% respondents refused to pay for fatal and severe injury risk reduction programs respectively. The high refusal rate of WTP also aligns with previous road pricing studies. A thorough analysis of refusal motivations confirmed this reasoning. Respondents gave four main reasons for refusing WTP: "Not concerned for safety program," "No financial means to contribute," "Safety program is not practical," "Inefficient use of financial means for safety program," and ". These reasons varied by program. Most respondents cited "No financial means" due to the country's financial conditions. The proportion of WTP refusal for fatal risk reduction due to financial means was higher than for severe injury risk reduction. Conversely, more respondents deemed severe injury risk reduction programs useless compared to fatal risk reduction programs.

The comparison of WTP distributions for both risk reductions is further illustrated in Kernel density plots as shown in figure 2. Several observations emerge. The Kolmogorov-Smirnov test demonstrate significant differences in WTP distributions (p-value < 0.001), indicating heterogeneity. Levene's test confirms equal spread, suggesting equal homogeneity in variances for both programs. Refusal percentage is lower for fatal risk reduction as compared to severe injury. Mostly values of WTP for both programs fall below PKR 4500. Higher WTP values (above PKR 4500) are almost similar for both programs, with a longer right tail. For positive WTP contributions, Kolmogorov-Smirnov and Levene’s tests show identical distributions and equal variance (p-value > 0.05), indicating homogeneity in positive WTP contributions for road safety programs.

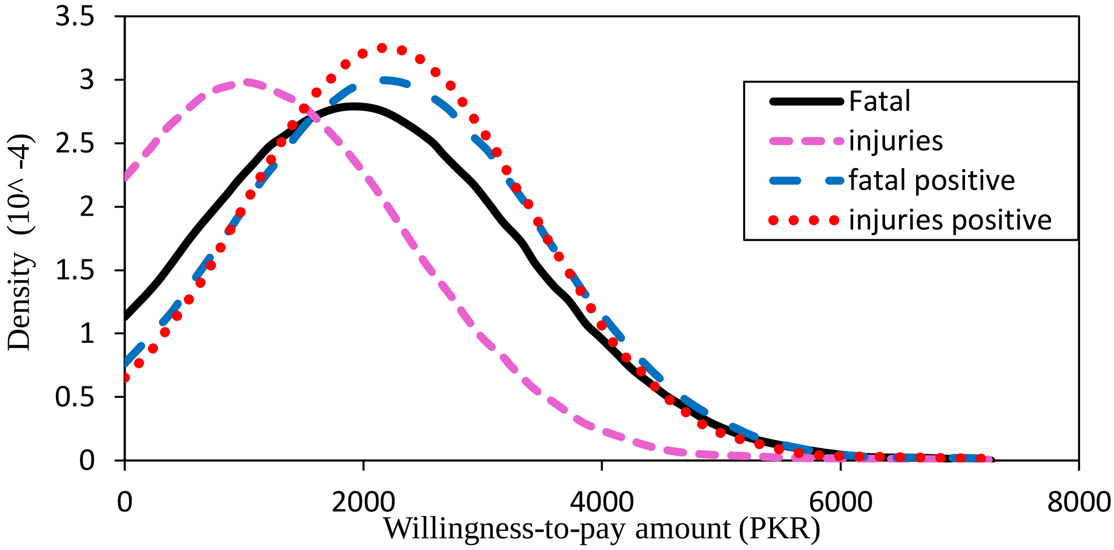

Figure 2 WTP Distribution

Quantitative willingness-to-pay and risk reduction values

Table 2 shows mean WTP estimated values for both programs. A two-sample independent test indicates a significant difference between the mean WTP values for these risk reduction programs (z-value = 8.384, p-value < 0.001). Individuals are willing to pay about double amount for fatal risk reduction. No statistical difference is found between the mean positive WTP (above zero) for both programs (z-value = 0.076, p-value > 0.05). WTP reflects preferences for reducing fatality or severe injury risks from road crashes. These values can estimate the value of a fatal risk reduction or severe injury risk reduction by dividing WTP by the corresponding 50% risk reduction. Estimated values based on mean WTP are shown in Table 2. On average each participant is willing-to-pay PKR 1934 & 1084 for 50% reduction in fatal and sever injuries respectively. The overall value of risk reduction is 24.184 (million) and 3.997(million) respectively for fatal and severe injuries. Value of fatal risk reduction is about 6 times higher than sever injury.

Table 2 Mean values of risk reduction and WTP

Risk Reduction	Mean	95% Confidence Interval Lower	Upper
Fatal Crash	1934	1743	2075
Severe Injury Crash	1084	907	1225
Risk Reduction value (fatal)	24.184	20.818	25.051
Risk Reduction value (Injury)	3.997	3.491	5.174

The estimated values of risk reduction (fatal and injury) can be used to estimate the economic losses of road accidents. This estimation also highlights the severity of road safety at national level. These values can serve as benchmark for initiation of cost-effective road safety interventions. These values also enable the calculation of benefits from reducing fatalities and severe injuries caused by road crashes. The estimated values will increase the transparency of cost-effectiveness along with efficacy and equity of safety uplifting interventions.

Analysis of decision tree

The initial part of the developed framework identifies higher-order interaction effects. Machine learning technique was applied to detect these interactions. A decision tree was developed using the Chi-Squared Automatic Interaction Detection algorithm. It tested various combinations based on set thresholds values. The variables included were situational, demographic, and risk perception with an average monthly travel cost of PKR 15693. The decision tree classified 75% of data cases with 55 terminal nodes which are illustrated in Table 3.

Table 3 Decision Tree Interaction effects

Terminal Nodes	Description of Decision Tree	WTP Frequency	
		Yes	No
1	FRR, HRP, TC > 15693	796	0
2	FRR, HRP, TC = 15693, HI	194	0
3	FRR, HRP, TC = 15693, LI, F	10	10
4	FRR, HRP, TC = 15693, LI, M, AB	10	0
5	FRR, HRP, TC = 15693, LI, M, BA	41	0
6	FRR, HRP, TC = 15693, LI, M, INT, NCH	10	5
7	FRR, HRP, TC = 15693, LI, M, INT, CH	31	0
8	FRR, HRP, TC = 15693, LI, M, Matric	5	0
9	FRR, HRP, TC = 15693, MI, NCH	25	36
10	FRR, HRP, TC = 15693, MI, CH	26	0
11	FRR, LRP, MA, Married, TC > 15693, AB or INT	51	0
12	FRR, LRP, MA, Married, TC > 15693, BA	31	5
13	FRR, LRP, MA Married, TC = 15693	117	0
14	FRR, LRP, MA, Unmarried, AB or INT	10	0
15	FRR, LRP, MA, Unmarried, BA	5	5
16	FRR, LRP, Older or Young, HI	41	0
17	FRR, LRP, Older or Young, LI, NCH	41	56
18	FRR, LRP, Older or Young, LI, CH	15	0
19	FRR, LRP, Older or Young, MI, Employed	15	25
20	FRR, LRP, Older or Young, MI, Unemployed	0	46
21	SIRR, MA, AB, NCH	51	0
22	SIRR, Young, AB, NCH	5	5
23	SIRR, HRP HI, BA, NCH	51	0
24	SIRR, HRP, MA, LI, BA, NCH	10	0
25	SIRR, HRP, Young, LI, BA, NCH	15	10
26	SIRR, HRP, MA, MI, BA, NCH	0	15
27	SIRR, HRP, Older or Young, MI, BA, NCH	10	20
28	SIRR, LRP, MA, BA, NCH	0	26
29	SIRR, LRP, older, BA, NCH	10	5
30	SIRR, LRP, Young, BA, NCH	0	25
31	SIRR, HRP, MA, TC > 15693, INT, NCH	10	0
32	SIRR, HRP, Older or Young, TC > 15693, INT, NCH	15	31
33	SIRR, HRP, Middle or Young aged, TC = 15693, INT, NCH	5	62
34	SIRR, HRP, Older, TC = 15693, INT, Employed, NCH	15	11
35	SIRR, HRP, Older, TC = 15693, INT, Unemployed, NCH	5	15
36	SIRR, LRP, HI, INT, NCH	5	5
37	SIRR, LRP, Middle-aged, MI/LI, INT, NCH	0	15
38	SIRR, LRP, Older, MI/LI, INT, NCH	0	67
39	SIRR, LRP, young, MI/LI, INT, NCH	5	87
40	SIRR, HRP higher, TC > 15693, Matric, NCH	20	25
41	SIRR, LRP, TC > 15693, Matric, NCH	5	41
42	SIRR, TC = 15693, HI/MI, Matric, NCH	0	214
43	SIRR, HRP higher, TC = 15693, LI, Matric, NCH	5	5

44	SIRR, LRP, TC = 15693, LI, Matric, NCH	0	26
45	SIRR, HRP higher, HI, AB, CH	10	83
46	SIRR, HRP, HI, BA/INT/Matric, CH	173	0
47	SIRR, HRP higher, TC > 15693, MI/LI, F, CH	46	0
48	SIRR, HRP higher, TC > 15693, MI/LI, Male, CH	82	15
49	SIRR, HRP, Middle-aged, TC = 15693, MI/LI, CH	20	0
50	SIRR, HRP, Older or Young, TC = 15693, MI/LI, CH	27	32
51	SIRR, LRP, Middle-aged, TC > 15693, HI/MI, AB or BA, CH	10	10
52	SIRR, LRP, Older or Young, TC > 15693, HI or MI, AB or BA, CH	0	15
53	SIRR, LRP lower, TC > 15693, HI or MI, INT or Matric, CH	10	0
54	SIRR, LRP, TC = 15693, HI or MI, CH	0	21
55	SIRR, LRP, LI, CH	10	0

Note: FRR (Fatal Risk Reduction), SIRR (Severe Injury Risk Reduction), HRP (High Risk Perception), LRP (Low Risk Perception), TC (Travel Cost), HI (High Income), LI (Low Income), F (Female), M (Male), AB (Above Bachelor), BA (Bachelor), INT (Intermediate), NCH (No Crash History), CH (With Crash History), MI (Middle Income), MA (Middle Aged).

Models Development

Correlated random parameters Tobit model (CRPTM) with interaction effects have been developed. The estimated results of the model are presented in Table 4.

Variables	Estimate Parameters	s.e	z-value	p-value	95% CI of estimated parameter	
					lower	upper
Non-random parameters						
constant	-0.685	0.243	-2.81	0.005	-	-
Young aged	-0.151	0.034	-4.67	<0.001	-0.211	-0.085
Old Aged	-0.375	0.113	-3.42	<0.001	-0.594	-0.161
Sole earner (Yes=1)	-0.39	0.011	-3.21	<0.001	-0.065	-0.019
Trip purpose (Work/study=1)	1.031	0.115	8.73	<0.001	0.801	1.24
Travel Cost (1000 PKR)	0.69	0.087	7.29	<0.001	0.053	0.085
Risk Type (Fatal=1)	0.459	0.168	4.32	<0.001	0.249	0.669
LRP	-0.281	0.084	-3.26	<0.001	-0.447	0.113
Interaction Term 9	-1.462	0.181	-8.16	<0.001	-1.817	-1.114
Interaction Term 29	2.315	0.183	10.91	<0.001	1.951	2.671
Interaction Term 45	-0.848	0.128	-6.54	<0.001	-1.101	-0.601
Random Parameters						
SPRI (mean)	1.483	0.295	-5.05	<0.001	-2.061	-0.908
SPRI (SD)	1.115	0.349	3.15	<0.001		
HRP (mean)	0.539	0.174	3.11	<0.001	0.202	0.887
HRP (SD)	0.851	0.101	8.51	<0.001		
SPRI (Heterogeneity in mean)						
Gender (Female)	0.75	0.289	2.63	<0.008	0.201	1.327

5. DISCUSSION

Majority of developing low-income countries are facing severe social and economic effects due to road crashes. Road crash not only causing financial damage but also affect the quality of life. To minimize these effects policy makers must focus on resource allocation for safety improvement. Due to limited financial resource and other compelling needs the community support is essential for road safety improvement. The safety interventions primary relies on cost-benefit analysis approach which is often ignored due to poor data quality and scared financial resource. This study considers end-user perceptions to estimate public willingness-to-pay (WTP) for road safety improvements which also reduce policy resistance. The combination of machine learning with correlated random parameters Tobit model reveals significant higher-order interactions through decision tree approach.

The model results demonstrates that majority of the respondents with high-risk perception about their crash involvement are more willing to pay. A small proportion of respondents with same perception are less willing. The results also reveal that respondents with high road infrastructure safety perception to are less willing to pay. The model also indicated that the variable of gender presents heterogeneity in WTP since the female population are more willing to pay while the male population in majority are reluctant.

WTP values for fatal and severe injury risk reductions are estimated for Pakistan. The value of fatal risk reduction is higher as compared to severe injury risk reduction. These findings support policymaking by valuing road crash risk reduction. The study segmented road users into smaller homogeneous groups to reveal their sensitivities toward WTP. The proposed framework is flexible and not area specific. It can be applied to different regions with similar demographic and economic nature. With necessary adjustments for regional conditions its findings can be transfer to other developing countries. These countries should have similar economic levels, social characteristics, road user attitudes, roadway features, and driving conditions. However, new data is needed to re-estimate the model and guide discussions. This study offers an alternative for developing countries to create road safety policies and estimate public WTP for road safety improvement.

6. CONCLUSIONS

Sustainability in Road Safety Improvement and Linkage to UN SDGs

The study provides a robust foundation for achieving multiple UN SDGs through innovative road safety policies. By integrating innovative modeling techniques and focusing on public engagement, policymakers can create sustainable solutions to address road safety challenges in developing countries like Pakistan. These efforts will save valuable lives, enhance road infrastructure that will contribute to a safer and more sustainable future.

Good Health and Well-being - SDG 3

The study identifies key determinants of willingness-to-pay (WTP) for road safety improvements in Pakistan. It provides actionable insights into reducing fatalities and injuries by integrating innovative models of machine learning with Tobit model which provide a flexible framework for targeted safety interventions. By quantification of risk reduction value and the economic burden of road crashes the study highlights the importance of prioritizing road safety policies to support long-term strategies for health and safety improvements which is directly aligned with SDG 3.6. Policymakers can use these insights to reduce preventable road crashes (fatalities and injuries) and allocate resources to programs that maximize safety outcomes for vulnerable populations (pedestrians, cyclists, motorcyclists)

Decent Work and Economic Growth - SDG 8

The study evaluates the economic impact of road crashes and advocates for cost-effective interventions to reduce financial losses and protect economic stability. Road crashes impose a significant economic burden which is reflected in GDP losses. By emphasizing risk reduction, it aligns with SDG 8.8 to enhance economic productivity.

Industry, Innovation and Infrastructure - SDG 9

By integrating machine learning to uncover higher-order interactions, the study provides a novel method to understand public preferences for infrastructure investments. It enables better design and implementation of road safety measures tailored to specific socio-economic groups. Sustainable road infrastructure contributes to economic development and human well-being. The study's findings advocate prioritizing financial contributions to policies that improve road conditions and mitigate crash risks. It promotes investments in crash-resistant road designs for safety interventions.

Sustainable Cities and Communities - SDG 11

The study proposes interventions to reduce traffic fatalities and injuries through public participation for a safer transport system. It favors the raises of community engagement for financial contribution and accountability to ensure sustainable urban mobility while focusing on individual WTP for road safety. It also encourages to implement programs that educate communities about traffic risks and benefits of road safety policies and establish benchmarks for evaluating the effectiveness of road safety initiatives based on WTP indicators.

Partnerships for the Goals - SDG 17

The research highlights the need for collaborative efforts between policymakers, researchers, and communities to prioritize and implement effective road safety interventions. Leveraging partnerships ensures resources are allocated efficiently and interventions are scaled across regions with similar socio-economic and infrastructure challenges. It encourages to facilitate knowledge exchange between countries facing similar road safety challenges and collaborate with international organizations such as WHO and UNDP to align national safety policies with global standards.

Summary

The study contributes to the UN SDGs by addressing critical issues in road safety through innovative methods and public engagement. Its insights provide a roadmap for achieving multiple SDGs, from health and infrastructure to economic growth and sustainable cities. These findings can guide policymakers in prioritizing sustainable road safety policies that improve well-being, enhance infrastructure, and support economic stability.

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