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Willingness to Pay for Second Generation Bioethanol: A Contingent Valuation Approach

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Abstract

Increasing the use of biofuels to reduce pollution is an effort in many countries. An alternative that is starting to be marketed internationally, which reduces greenhouse gas emissions and applies circular economy for its production is second-generation bioethanol (E2G); however, in Peru there are no policies for its commercialization in the current gasohol blend. This study will determine consumer's willingness to pay (WTP) for E2G by applying surveys using the double-bounded dichotomous choice contingent valuation method (CVM). A total of 472 consumers of premium and regular gasohol in Metropolitan Lima were asked about their WTP for E2G, demographic characteristics, vehicle usage and level of perception related to the environment. It was found that users of premium and regular gasohol would be willing to pay a premium of 10.40% and 7.03% respectively. Likewise, it was obtained that people who have a higher perceived consumer effectiveness (PCE) are more likely to pay a premium for E2G.

Keywords
Contingent valuation, double-bounded, willingness to pay, second-generation, bioethanol.

1. Introduction
Nowadays, pollution and socioeconomic problems caused by fossil fuel production are constantly increasing, which is driving more greenhouse gas (GHG) emissions into the atmosphere and promotes the global warming crisis (Hwang et al., 2023). In 2021, 52.8 gigatons of CO2 equivalent were emitted globally, representing an increase of 4% over the prior year. Likewise, the energy, industrial and transport sectors contribute 37%, 26% and 14% respectively to this

problem, being road transport a subsector with high growth in emissions (United Nations Environment Programme, 2022). In the Peruvian context, transportation sector contributes 40% to the total GHG emissions and it is projected that, if effective mitigation measures are not established, the amount of emissions in the country will increase in 200% by 2050 (Heising, 2020). It is projected that the global energy demand will increase by 28% between 2015 and 2040, making it necessary to develop renewable energy alternatives, which are expected to have a rapid consumption growth, with an average of 2.3% annually (Energy Information Administration, 2017). Biofuels are one of the renewable alternatives currently employed, among which is first-generation ethanol (E1G), which is produced from organic crops. However, although crop-based biofuels are key to a transition to a cleaner energy, the long-term viability has been questioned, as a large-scale expansion could negatively affect agricultural land due to land use change (LUC) and, consequently, food supply could be compromised, making this an important factor to consider when developing legal frameworks to promote biofuels (Weng et al., 2019). In this regard, studies suggest that the alternative to promote are second-generation biofuels, which result from processing organic waste matter and do not compete with staple food crops (Plassmann, 2018).

In Peru, the ethanol generated domestically is E1G, the main producer is Caña Brava, with a maximum capacity of 370 thousand liters/day (Caña Brava, 2023). In addition, premium and regular gasohol are the only two gasohol types currently marketed nationwide, which are composed of a blend of 92.2% gasoline and 7.8% ethanol (Peruvian State Procurement Authority, 2023). On the other hand, a study has assessed the energy potential of second-generation ethanol (E2G) production using agricultural and agro-industrial waste generated on a national scale. This study revealed a production potential of 3.51 tons of E2G per year, which could satisfy approximately 9.11% of the annual energy demand while concurrently reducing CO2 emissions by around 78.3% when compared to emissions from oil combustion (Linares Luján et al., 2020).

Prior studies have agreed that the increasing research in E2G production raises the necessity to find whether a market willing to pay for this alternative exists. Several investigations have applied the contingent valuation method (CVM) to determine the willingness to pay (WTP) for E2G. For example, a study conducted in South Korea found that, on average, drivers would be willing to pay a premium of 4.3% for gasoline with E2G (Mamadzhanov et al., 2019). Similarly, a study conducted in the United States concludes that citizens would pay a premium of 11% (Li and McCluskey, 2017). Finally, in the Latin American region, a study in Brazil found that people would pay a premium of 8.5% for gasoline with E2G (Garcia et al. 2022).

To determine whether there is a market for E2G in Peru, the objective of this study is to determine the WTP for this alternative by consumers of premium and regular gasohol in Metropolitan Lima and to determine the factors of influence. Based on the results, decisions could be made to support the research and promotion of E2G.

2. Methodology

The CVM was employed, which is used to evaluate WTP of consumers in order to establish alternatives that improve environmental quality, affected by variables such as age, education, gender and occupation, among others (Hao et al., 2023). In this methodology, dichotomous choice questions are used, for which there are approaches such as single-bounded and double-bounded (Kim et al., 2019). In the first case, the model is called a referendum and consists of the respondent answering yes or no to a single question. In contrast, in the second case two questions are answered, in which the second question depends on the initial answer. The problem with the first approach is that it is not statistically efficient compared to the second method, given its lack of ability to reliably estimate willingness to pay, which is corrected by adding the second question (Tudela-Mamani, 2017).

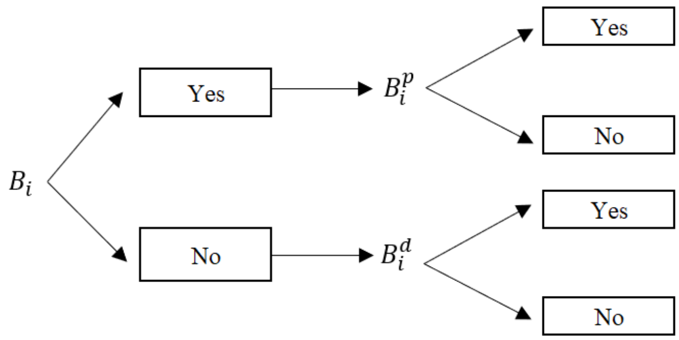

Figure 1. Double-dichotomous choice in contingent valuation method

To conduct the study, the methodology of fuel price premiums and discounts formulated by García et. al. (2022) was considered (Figure 1). For the first round, the respondent will answer yes or no to a random price, which takes as a reference the average market price of regular and premium gasohol, obtained from the list of prices of petrol stations in Metropolitan Lima during July and August of 2023, which are available on the website of the Peruvian Supervisory Agency for Investment in Energy and Mining (2023). The resulting average values were PEN 16.21 and PEN 17.87 for regular and premium gasohol, respectively. The nine alternatives presented in the first round have premiums or discounts ranging from 5% to 20%, with increases or decreases of 5%.

Based on the contingent valuation methodology proposed by López-Feldman (2012), the answers generate four possible outcomes, where the initial bid is t1, the second bid is t2 and WTP is the willingness to pay for E2G:

$$t_1 \leq WTP \leq t_2 \text{ (Yes, No)} \quad (1)$$
$$t_2 \leq WTP \leq \infty \text{ (Yes, Yes)} \quad (2)$$
$$t_2 \leq WTP \leq t_1 \text{ (No, Yes)} \quad (3)$$
$$0 \leq WTP \leq t_2 \text{ (No, No)} \quad (4)$$

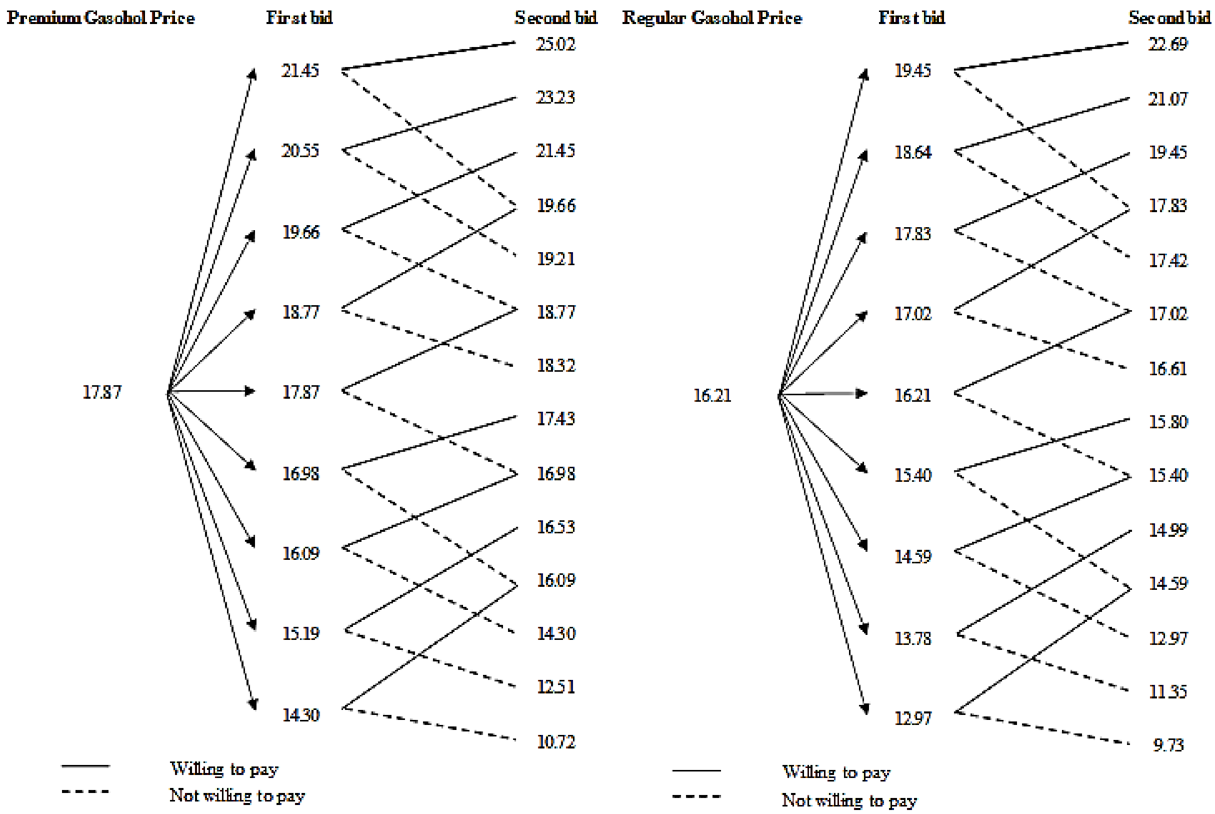

Figure 2. Rounds of bidding choices for E2G based on Premium and Regular gasohol market prices with price premium and discount

Figure 2 illustrates the two rounds of prices offered to participants in relation to the price that they would be willing to pay for premium or regular gasohol blended with E2G. In this case, the economic value of resources is assessed by maximizing consumer utility, obtained from consumer surveys (Hao et al. 2023), under the following assumption:

$$WTP_i(z_i, u_i) = z_i'\beta + u_i \text{ and } u_i \sim N(0, \sigma^2) \qquad (5)$$

Where z_i is a vector of explanatory variables, β is a vector of parameters and u_i is an error term, the probability of each four possible outcomes can be determined as follows:

$$Pr(yes, no) = \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right) - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) \qquad (6)$$

$$Pr(yes, yes) = \left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) \qquad (7)$$

$$Pr(no, yes) = \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right) \qquad (8)$$

$$Pr(no, no) = 1 - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) \qquad (9)$$

Where ϕ is the cumulative normal distribution. Then, to find the unknown parameters β and σ, the following equation is maximized:

$$\sum_{i=1}^{N}\left[d_i^{yn} ln\left(\phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right) - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right) + d_i^{yy} ln\left(\phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right) + d_i^{ny} ln\left(\phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right) - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^1}{\sigma}\right)\right) + d_i^{nn} ln\left(1 - \phi\left(z_i'\frac{\beta}{\sigma} - \frac{t^2}{\sigma}\right)\right)\right] \qquad (10)$$

Where d_i^{yn}, d_i^{yy}, d_i^{ny}, d_i^{nn} are indicator variables, which take a specific value according to each response. This indicates that a specific respondent contributes to the maximum likelihood logarithm in only one of its four blocks. Considering that Peruvian population may not be fully informed about second-generation biofuels and that there is no complete national assessment of the energy potential of agricultural and agro-industrial residues in the country's regions (Flores et al. 2022), information about E2G was provided to the sample analyzed, both for premium and regular gasohol consumers. A total of 472 surveys were conducted in public and crowded places in the districts of Metropolitan Lima. Participants who responded to the survey received a reward for their contribution. The distribution of the 472 surveys was stratified between consumers of regular gasohol and premium gasohol, according to the current demand for these types of gasohol in Metropolitan Lima, which has a distribution of 37% and 63% respectively (Supervisory Agency for Investment in Energy and Mining, 2023). In this regard, it was determined to conduct 174 surveys for consumers of regular gasohol and 298 for those who use premium gasohol. In addition, the questionnaire underwent a validation process by experts in the fields of economics, statistics, business and environment. Each survey took approximately 10 to 15 minutes.

The questionnaire consists of four sections. The first section contained information about the current situation of the country concerning fuels and E2G, as well as two dichotomous questions about WTP with the randomly assigned price, according to the type of gasohol used. The second section consisted of queries about demographic characteristics, such as age, sex, level of education, among others. The third part contained questions about preferences as a driver and knowledge about biofuels. The last section contained questions about perceived consumer effectiveness (PCE), a concept defined as the consumers' perception of the degree of impact of their actions on the mitigation of environmental problems, which means whether the consumer perceives that his or her intentions and behaviors have a positive influence on the prevention of environmental problems (Kamalanon et al., 2022). Researchers also suggest that PCE is key to determining whether the individual will engage in socially responsible consumption (Liang et al., 2020). It has been found that people tend to show a higher level of interest in environmental protection as they perceive that they have a higher level of influence over the environment (Higueras-Castillo et al. 2019). Following the methodology applied by Garcia et. al. (2022), four questions on PCE were asked, in this case, a scale from 1 to 5 was used for each one so that the total value of PCE varies in a range from 4 to 20. As the respondent's answers are closer to 20, it means that the individual perceives that his or her actions have a greater impact on the environment.

3. Results and Discussion

For the comparison of the results, it was considered that the representativeness of the surveys is an important factor in empirical research (Muschalik et al. 2021). Therefore, the census population statistics of Metropolitan Lima, extracted from the repository of the National Institute of Statistics and Informatics (2017), were used as a reference.

Regarding the demographic variables, results obtained can be visualized in Table 1, which indicates that the sex distribution is 31% women and 69% men, which differs from the distribution reported in census, which is 51.4% women and 48.6% men.

Regarding the age, 31.3% of the population belongs to the 26 to 39 age range, which is a value close to the 34% obtained. On the other hand, the eastern and northern zones have the highest population, with 28% each. Results of the census reflect that the proportion of the population living in the Eastern, Northern, Central and Southern regions is 29%, 28.7%, 22.3% and 20% respectively.

Regarding the educational level of Lima's citizens, the analysis revealed that people with primary education constituted 8% of the population, those with secondary education comprised 31%, citizens with technical education made up 21% and finally citizens with higher education made up the remaining 40%. The census results indicate that 10.6% of citizens have completed primary education, 43.8% has completed secondary education, 18.1% has completed technical education, and 26.1% of citizens have attained higher education. In this regard, survey results reflect similar values. However, regarding higher education, the average was higher when compared to the census data. Likewise, about per-capita income, results indicate that the majority of respondents earn between PEN 3,001 to PEN 6,000, which is higher than the average per-capita income in Metropolitan Lima, which is PEN 1,947.5 (National Institute of Statistics and Informatics, 2019).

One bias encountered was limited access to databases containing complete and official information on the number of drivers and their demographic characteristics, since it was not available. This can be reflected in differences in the results concerning sex, education level and per-capita income level of the sample versus the population data.

Table 1. Summary statistics for demographic variables

Variable	Respondents		Full sample	
	Premium	Regular		
Age				
18 - 25	56	25	81	17%
26 - 39	99	61	160	34%
40 - 50	54	45	99	21%
51 - 60	42	24	66	14%
+60	47	19	66	14%
Sex				
Male	198	126	324	69%
Female	100	48	148	31%
Education				
Elementary school	29	9	38	8%
Secondary school	86	59	145	31%
Technical school	54	46	100	21%
University	96	52	148	31%
Higher degree	33	8	41	9%
Residence				
Central Lima	66	42	108	23%
Eastern Lima	89	45	134	28%
Northern Lima	82	48	130	28%
Southern Lima	61	39	100	21%
Income				
Less than PEN 1,025	11	10	21	4%
PEN 1,026 - 3,000	92	63	155	33%
PEN 3,001 - 6,000	109	59	168	36%
PEN 6,001 - 10,000	63	35	98	21%
More than PEN 10,001	23	7	30	6%

The results related to vehicle use are shown in Table 2. As can be observed, the majority of people own only one vehicle and drive between 5,001 to 10,000 kilometers annually, which is lower than the annual mileage traveled, which is approximately 22,000 km per year (Ministry of Environment, 2015). Finally, a low percentage of respondents knew about biofuels and the law that promotes their use in Peru.

Table 2. Summary statistics for vehicle use variables

Variable	Respondents		Full sample	
	Premium	Regular		
Number of vehicles				
One	177	131	308	65%
Two	85	35	120	25%
Three or more	36	8	44	10%
Km. driven per year				
Less than 5,000 km	53	19	72	15%
5,001 - 10,000 km	97	49	146	31%
10,001 km - 20,000 km	78	39	117	25%
20,001 km - 30,000 km	42	37	79	17%
More than 30,000 km	28	30	58	12%
Knowledge about biofuels				
Yes	102	63	165	35%
No	196	111	307	65%
Knowledge about the law on biofuels				
Yes	76	42	118	25%
No	222	132	354	75%

The results regarding the respondents' perception variables are listed in Table 3. A Likert scale was used, where 1 means completely disagree and 5 completely agree. In the four questions, the majority of people chose the highest values of the scale.

Table 3. Summary statistics for vehicle use variables

Variable	**Respondents**		**Full sample**	
	Premium	**Regular**		
Importance of price				
1	3	4	7	1%
2	10	11	21	4%
3	16	15	31	7%
4	116	80	196	42%
5	153	64	217	46%
Importance of efficiency				
1	5	3	8	2%
2	5	11	16	3%
3	26	16	42	9%
4	109	81	190	40%
5	153	63	216	46%
Importance of eco-friendly fuel				
1	9	1	10	2%
2	19	3	22	5%
3	47	31	78	17%
4	108	84	192	41%
5	115	55	170	36%
Importance of brand				
1	5	4	9	2%
2	11	13	24	5%
3	58	34	92	19%
4	130	71	201	43%
5	94	52	146	31%

Table 4 shows the number of positive and negative responses from premium gasohol users to the second bid. As can be observed, 43.3% of the total number of people who were offered a premium in the second round would be willing to pay. In the case of discounts, 66.4% of this segment would be willing to pay. Looking at the results for premiums and discounts, the affirmative responses do not follow a trend as the premium increases, so it is not significant. In the case of affirmative responses to discounts, a decreasing trend is observed from the 10% discount onwards. This could be explained by people's perception of the fuel quality, for most consumers, higher prices imply better quality, lower prices suggest the opposite (Beauvais et al. 2020).

Table 4. Distribution of bid responses - Premium gasohol

%	**2.5**	**5.0**	**7.5**	**10**	**20**	**30**	**40**	**Total**
Premium (bid2 > PEN 17.87)								
Yes	3	19	5	19	9	6	10	71
No	7	21	16	21	13	7	8	93
Total	10	40	21	40	22	13	18	164
Discount (bid2 < PEN 17.87)								
Yes	22	20	24	20	2	1	0	89
No	9	11	4	12	3	3	3	45
Total	31	31	28	32	5	4	3	134

Regarding regular gasohol consumers, Table 5 shows that only 34.0% of citizens would pay a premium for gasohol with E2G, while 60.0% would pay for the alternative in the case of discounts. Observing the responses for each premium and discount value, in this case, there is a decreasing trend as the premium increases, which means that, as the premium becomes higher, fewer people would pay. This same behavior occurs when the discount increases, in the same way, it could be explained by the perception of the product quality concerning engine integrity, since people could see it as an alternative that generates a greater deterioration of the engine. Consumers expect to pay reasonable and fair prices to the extent that price variation demonstrates differences in factors such as fuel quality, taxes apportioned and variations in the cost of transportation (Holmes et al., 2022).

Table 5. Distribution of bid responses - Regular gasohol

%	**2.5**	**5.0**	**7.5**	**10**	**20**	**30**	**40**	**Total**
Premium (bid2 > PEN 16.21)								
Yes	2	14	1	10	4	1	0	32
No	3	9	8	16	8	9	9	62
Total	5	23	9	26	12	10	9	94
Discount (bid2 < PEN 16.21)								
Yes	9	13	10	15	1	0	0	48
No	5	7	8	9	2	1	0	32
Total	14	20	18	24	3	1	0	80

Information obtained from the PCE questions is shown in Table 6. PCE refers to people's perception of how their actions can make a difference in solving environmental problems. For example, concerning green purchasing, consumers feel committed to having a positive impact and therefore they perform actions that promote the mitigation of environmental pollution (Hussain and Huang, 2022). As can be observed, the greatest number of responses to the four questions asked are concentrated in the highest values of the scale. Additionally, an average value of 15.9 was obtained, so it is inferred that the respondents have a high PCE. To review the internal consistency of the PCE questions, Cronbach's Alpha was used, resulting in 0.87, which is even higher than the acceptable value of 0.7 (Acosta-Banda et al. 2021). In addition, the item-total correlation values were greater than 0.3 in the case of the four questions. In this sense, a correct internal consistency between all the items is evidenced and each item individually contributes adequately to the total construct (D'Avila et al., 2021).

Table 6. Distribution of bid responses - Regular gasohol

PCE	**Answer**	**Prem.**	**Reg.**	**Total**		**Item corr.**
Q1	1	7	2	9	2%	0.84
	2	18	14	32	7%	
	3	42	24	66	14%	
	4	137	78	215	46%	
	5	94	56	150	32%	
Q2	1	12	4	16	3%	0.86
	2	38	14	52	11%	
	3	50	23	73	15%	
	4	118	83	201	43%	
	5	80	50	130	28%	
Q3	1	6	5	11	2%	0.90
	2	23	13	36	8%	
	3	49	21	70	15%	
	4	142	89	231	49%	
	5	78	46	124	26%	
Q4	1	5	8	13	3%	0.81
	2	11	5	16	3%	
	3	24	19	43	9%	
	4	109	69	178	38%	

	5	149	73	222	47%	
		Mean of total scaled scores	Standard deviation		Cronbach Alpha	
Total Score		15.90	0.99		0.87	

The variables employed in the CVM model are detailed in Table 7. The variables sex, education level, area where the surveyed people live and knowledge about biofuels are binary variables. On the other hand, the age, income, kilometers driven, importance of price, efficiency, eco-friendly fuel, brand and PCE are continuous variables.

Table 7. Description of explanatory variables

Variable	Description	Type
Sex	1 = Female, 0 otherwise	Binary
Age	Reported age	Continuous
Education	1 = bachelor's degree or above, 0 otherwise	Binary
Income	Scale of 1 to 5	Continuous
North	1 = Northern Lima, 0 otherwise	Binary
South	1 = Southern Lima, 0 otherwise	Binary
East	1 = Eastern Lima, 0 otherwise	Binary
Central	1 = Central Lima, 0 otherwise	Binary
Vehicles	1 = More than 1 vehicle, 0 otherwise	Binary
Kilometers	Scale of 1 to 5	Continuous
Biofuels	1 = Knowledgeable about biofuels, 0 otherwise	Binary
Regulation	1 = Knowledgeable about biofuels regulation, 0 otherwise	Binary
Price	Scale from 1 to 5	Continuous
Efficiency	Scale from 1 to 5	Continuous
Ecofriendly	Scale from 1 to 5	Continuous
Brand	Scale from 1 to 5	Continuous
PCE	Scale from 5 to 20	Continuous

Table 8 shows the model results, which were obtained using the double command in STATA, from the data of premium gasohol users. About the demographic variables, age and education have a statistically significant impact on WTP ($p < 0.05$ and $p < 0.01$ respectively). Likewise, the sign of the coefficient indicates that as a person becomes older, WTP decreases, the opposite case for education, where it is observed that as the level of education increases, so does WTP. On the other hand, only those who live in the eastern zone had significant results ($p < 0.05$), thus denoting that when a person lives in that zone, his or her WTP decreases. The results suggest that sex, income and the northern, southern and central zones are not significant in explaining WTP.

In the case of the vehicle use variables, it is observed that the number of vehicles and total kilometers traveled present statistically significant coefficients ($p < 0.01$ for both cases), which indicates that when an individual has more than one vehicle or drives more kilometers, WTP decreases, this could be explained because in both scenarios it implies a greater expense for individuals. Additionally, the results suggest that knowing about biofuels and the law that regulates them does not have a major influence on WTP. Regarding the importance perception questions, only the importance of using an eco-friendly fuel is significant ($p < 0.01$).

Finally, PCE was significant in the study ($p < 0.10$) with a positive coefficient, indicating that premium gasohol users perceive that their behaviors could help reduce the impact on the environment, which is reflected in a higher WTP. This result is contrary to the result obtained in the study conducted by García et al. (2022), which found a negative coefficient for PCE. This could be explained by the different way in which the survey was conducted, since in this research the procedure was performed face to face.

Studies have investigated the biases of executing surveys in one way or another, in which it is recognized that there is bias due to misinterpretation of the questions, confusion due to a large number of options for a single question, avoidance of cognitive load and pressure to provide socially desirable or correct responses (Spencer et al., 2022). It is recognized that not presenting certain limitations in surveys related to economic and financial issues is relatively complicated, given the biases presented (Villa et al., 2023).

Table 8. Coefficient estimates of the explanatory variables on mean WTP - Premium Gasohol

Variables	Coef.	Std err.	Z	P-value[1]	[95% conf. interval]	
Constant	18.591	2.319	8.020	0.000***	14.047	23.135
Sex	0.542	0.542	1.000	0.317	-0.520	1.603
Age	-0.038	0.017	-2.240	0.025**	-0.071	-0.005
Education	2.615	0.648	4.040	0.000***	1.345	3.885
Income	0.147	0.315	0.470	0.639	-0.469	0.764
North	-0.060	0.721	-0.080	0.933	-1.473	1.352
South	0.322	0.793	0.410	0.685	-1.233	1.876
East	-1.388	0.701	-1.980	0.048**	-2.762	-0.014
Vehicles	-1.439	0.529	-2.720	0.007***	-2.476	-0.402
Kilometers	-0.618	0.223	-2.780	0.005***	-1.055	-0.182
Biofuels	0.465	0.586	0.790	0.427	-0.683	1.612
Regulation	0.019	0.688	0.030	0.978	-1.329	1.367
Price	-1.194	0.341	-3.500	0.000***	-1.863	-0.525
Efficiency	0.518	0.327	1.590	0.113	-0.122	1.158
Ecofriendly	0.800	0.265	3.020	0.003***	0.281	1.320
Brand	0.075	0.301	0.250	0.803	-0.515	0.665
PCE	0.176	0.091	1.940	0.052*	-0.002	0.353
Log-likelihood	-324.36					

[1] ***,**,* for 1%, 5% and 10% significance level, respectively.

The model results from the data of regular gasohol users are presented in Table 9. The demographic variables such as sex ($p < 0.05$), education and income ($p < 0.01$ for both cases) have statistically significant coefficients. Likewise, the positive coefficient denotes that as the level of education and income increases, so does WTP. The same happens with the sex variable, since it has a positive coefficient, showing that women have a higher WTP. The variables of age and area are not statistically significant. On the other hand, concerning vehicle use, the variable of number of vehicles is statistically significant ($p < 0.10$). Similarly, the eco-friendly fuel variable proves to be statistically significant ($p < 0.05$). However, since the coefficient value is negative, it is inferred that people who care about sustainable fuels have lower WTP. The result obtained is contrary to what was found in premium gasohol, which is counterintuitive and could be explained by the bias previously discussed. In consumer behavior, there has always been a difference between intention and actual behavior, although studies have considered these two concepts to be highly correlated. This phenomenon is referred to as "literal inconsistency", which refers to a way of acting that is different from the declared one (Nguyen et al., 2019). Finally, PCE is a statistically significant variable ($p < 0.01$), as the value of PCE increases, WTP will also increase.

Table 9. Coefficient estimates of the explanatory variables on mean WTP - Regular Gasohol

Variables	Coef.	Std err.	Z	P-value[1]	[95% conf. interval]	
Constant	12.035	1.561	7.710	0.000***	8.975	15.094
Sex	0.952	0.399	2.390	0.017**	0.170	1.733
Age	0.002	0.013	0.150	0.885	-0.023	0.027
Education	1.437	0.437	3.290	0.001***	0.580	2.293
Income	0.717	0.215	3.330	0.001***	0.295	1.138
North	0.063	0.492	0.130	0.898	-0.902	1.028
South	0.358	0.517	0.690	0.489	-0.655	1.372
East	-0.584	0.488	-1.200	0.231	-1.540	0.372
Vehicles	-0.721	0.420	-1.720	0.086*	-1.544	0.103
Kilometers	0.026	0.139	0.190	0.850	-0.246	0.298
Biofuels	0.163	0.440	0.370	0.711	-0.699	1.026

Regulation	0.342	0.458	0.750	0.456	-0.556	1.240
Price	-0.102	0.207	-0.490	0.621	-0.508	0.303
Efficiency	0.067	0.218	0.310	0.759	-0.361	0.495
Ecofriendly	-0.617	0.266	-2.320	0.02**	-1.139	-0.096
Brand	-0.057	0.190	-0.300	0.763	-0.429	0.315
PCE	0.327	0.068	4.800	0.001***	0.194	0.461
Log-likelihood	-174.63					

[1] ***,**,* for 1%, 5% and 10% significance level, respectively.

Following the approach of López-Feldman (2012), the following formula is used to calculate the WTP of each segment of gasohol consumers in Metropolitan Lima:

$$\mathrm{WTP} = \bar{z}_i' * \beta \qquad (11)$$

Table 10 reveals that premium gasohol users are willing to pay an average premium of 10.40% for E2G, while those who use regular gasohol would only pay an average premium of 7.03%, despite premium gasohol has a higher market price than regular gasohol due to the difference in octane ratings. Premium gasohol has 96 octanes, while regular gasohol has only 91 octanes (Peruvian Petroleum Company, 2022). The difference in premiums can be explained by the vehicle age and income. Older vehicles tend to use regular gasohol, while newer cars use premium gasohol (Nahui-Ortiz et al., 2020). Likewise, people with higher incomes are more likely to purchase more modern cars, and it has been shown that households with lower incomes tend to buy older cars. In many cases, car dependency in the lower strata is relatively high, since its use implies not only private transportation but an asset to generate profit, this makes the decision to buy a car more complex incomes (Pierce and Connolly, 2023).

Table 10. Results for Willingness to Pay

Sample	**Mean WTP**	**95% Confidence Interval**
Regular	7.03%	4.26% - 9.75%
Premium	10.40%	7.39% - 13.43%

4. Conclusion

The increasing GHG emissions that are causing global warming has led nations to reach agreements to try to reduce this problem, as the case of Peru, which since 2016 has been part of the Paris Agreement, in which the country commits to reduce its GHG emissions in 30% by 2030, which represents a reduction of 89.4 MtCO2 (Ministry of Environment, 2016).Bioethanol production in Peru uses first-generation technologies since the sugarcane plantations serve as raw material. However, the national demand for this biofuel has not have an increase, experiencing changes only due to increases in the domestic gasoline demand, as the blend of 7.8% remains constant. On the other hand, there has been an increase in the number of vehicles using liquefied petroleum gas (LPG) and natural gas for vehicles (LNG), which also creates a limitation to boost the ethanol industry in the country (Nolte, 2022), despite it is recognized that Peru has a significant agricultural potential to produce second-generation ethanol. In this sense, the public energy policy should be aimed at strengthening the national biofuels industry and further research of second-generation technologies.

In this study, the CVM was applied to 472 respondents in Metropolitan Lima, which showed that consumers of premium gasohol would be willing to pay a premium of 10.40% for the second-generation alternative, while consumers of regular gasohol would pay a premium of 7.03%. The result concerning premium gasohol is higher in comparison with premiums obtained in other studies. Such is the case of the study conducted by Garcia et al. (2022), in which the surveyed population would be willing to pay a premium of 8.5%. Likewise, Mamadzhanov et al. (2019), in their study conducted in South Korea obtained that consumers would be willing to pay a premium of 4.3%. Then, concerning the findings of this study, it could be determined that as PCE increases so does WTP. This result indicates that a large part of the market found for E2G in Metropolitan Lima would be consumers who perceive that their actions could reduce the environmental impact. This is contrary to the finding of Garcia et al. (2022) in Brazil, which indicates that as the value of PCE increases, there would be lower WTP. However, there are similarities in the results obtained by consumers of regular gasohol because in this segment the knowledge about biofuels is a variable that directly influences WTP. This may indicate that to promote E2G in Peru, more information should be provided.

This study could serve as a preliminary phase in the assess of the market for E2G in Peru, to establish the suitable fiscal incentives by the government in the scenario of a future promotion of second-generation fuels as a mean to reduce the GHG emissions.

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