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Invierte.Pe and the Economic Benefits of Drinking Water Projects Using the Parametric Model

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Abstract

The objective of the research is to obtain the economic benefits of drinking water projects using the parametric logit model, from an Invierte.pe perspective. The methodology applied was the parametric contingent valuation model using the Logit model to estimate the willingness to pay (WTP), information was collected through the application of surveys to project users on their willingness or unwillingness to pay an amount of money for improvement of the drinking water supply service. The result was a WTP of 4.27 soles and economic benefits of the project for the first year of 314,511.00 soles and for the twentieth year of 370,080.00 soles. In conclusion, it is possible to incorporate in Invierte.pe the parametric logit model in the estimation of economic benefits of drinking water projects.

Keywords: Drinking water, Invierte.pe, economic evaluation.

Introduction

A new administrative system in Peru is Invierte.pe which symbolizes the "National System of Multiannual Programming and Investment Management", appeared on December 1, 2016 with legislative decree 1252 (MEF, 2016), and is applied as of February 24, 2017. It was amended with legislative decree 1432 on September 16, 2018 (MEF, 2018a). In addition, on December 9, 2018, the Invierte.pe regulations were approved by Supreme Decree 284 (MEF, 2018b), and on January 23, 2019, Invierte.pe General Directive 001 was published (MEF, 2019). The Invierte.pe aims to use public resources effectively to provide infrastructure service that helps Peru's development.

The fundamentals are efficiency to close gaps through priority investments in the first phase "multiannual investment programming" (PMI), and to achieve the prioritized infrastructure by optimizing state resources based on the analysis of benefits and costs in the second phase

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"*formulation and evaluation*" (FyE) (MEF, 2021). In addition, Invierte.pe provides simpler and faster priority social investment mechanisms to local and regional governments and state ministries.

According to (MEF, 2024a), the Invierte.pe has 6 guiding principles which are: principle 1 mentions that closing gaps is the main purpose of the PMI, principle 2 indicates that the PMI links the objectives of the Strategic Planning System with the national budget system, principle 3 points out that state resources are oriented to provide public infrastructure and the provision of public services, principle 4 seeks that public state funds generate a high level of impact on citizens, principle 5 is oriented to ensure the funds allocated for the execution and operation of the project, and principle 6 promotes quality and transparency in the management of the country's investment. The investment cycle is a mechanism that has four phases, where investment projects are born, designed, evaluated, executed and finally produce social benefits (MEF, 2024b). In addition, according to the Peruvian Ministry of Economy and Finance, Invierte.pe has standard technical sheets to formulate and evaluate drinking water investment projects in urban and rural areas (MEF, 2024c).

The Ministry of Housing, Construction and Sanitation (MVCS), within Invierte.pe, disseminates the electronic spreadsheet of the standard technical data sheet for sanitation projects in the urban area and rural (MVCS, 2022a), which were approved with Technical Report No. 498-2022 (MVCS, 2022c).

The problem identified in the article evidences the absence of the application of parametric Logit models in obtaining economic benefits from the implementation of drinking water projects, since the Invierte.pe system was created, only the estimation of direct benefits through the release of resources and the increase in drinking water consumption has been applied.

In addition, in the general guide of public investment projects by the Invierte.pe (MEF, 2022), it explains that after the execution of the investment project, the inhabitants receive direct social benefits due to the influence of saving money when paying for water cylinders, monetary savings in medicines due to the reduction of gastrointestinal diseases, and the feeling of optimism when integrating into society by having access to public water service inside the homes.

Also, according to the instructions, spreadsheets and specific methodologies of the sectoral standard technical sheet for housing and sanitation, the social benefit is given by the satisfaction of having drinking water service in the home and is quantified by the savings of resources and the willingness of people to pay when water consumption increases (MVCS, 2022d, 2022e).

It is necessary to indicate that the feasibility or non-feasibility of a project by the formulating unit depends on the economic and technical analysis of the standard technical file or profile, to determine the justification for the implementation of a project (MEF, 2019).

According to the recommendations of the Invierte.pe feasibility report, greater rigor, speed, and methodological and technical transparency should be established for projects in the second phase of the M&E investment cycle, and improvements should be identified in the evaluation and sensitivity analysis, improving the determination of the factors that affect social profitability, as well as social benefits (MEF, 2021).

Within the framework of the solutions reported in the background is the article by (Thakur et al., 2022), which studies the willingness to pay of households in Bihar in India for drinking water that does not contain arsenic, and conducted primary surveys in the districts that have arsenic.

(Barton, 2002), studies the contingent valuation for water improvements in the cities of Jaco and Puntaneras in Costa Rica, tests WTP transfers and benefits in communities. (Bui et al., 2022), analyzes the willingness to pay for access to a better domestic system that is safe and reliable in Vietnam Hanoi, taking into account that there is an increase in population numbers and also there is an increase in surface and groundwater pollution, due to the insufficient provision of investment in urban water supply systems. (Antonio et al., 2022), investigates the justification for replacing drinking water pipes on the assumption of the presence of asbestos through contingent valuation and the preferences of the inhabitants of Gorizia in northern Italy, indicates that the WTP is a mechanism that supports and helps to substantiate recommendations for state intervention.

Alcalá et al. (2022), states that the water problem in the world is related to over demand, scarcity and pollution of this resource, investigates the WTP of consumers for better quality drinking water in Guanajuato Mexico, using contingent valuation, random utility technique and logistic regression. (Ahmad et al., 2005), conducts surveys in the rural area of families in Bangladesh India, applying contingent valuation and the Logit model calculates the WTP for arsenic-free tap water. (Orgill et al., 2013), studies the WTP for quality drinking water in Cambodia, analyzes the valuation contingent valuation and Logit regression on the perception of households to increase water quality. (Morais et al., 2014), indicates the insufficient management of tree cover which produces drinking water scarcity in Palmas Brazil, estimates the benefits and WTP of the city by tree cover with the Logit technique and contingent valuation.

Muhammad et al. (2020), studies the willingness to pay of households in Peshawar Pakistan for increasing the quality of urban planning and development of drinking water supply services. Considering the urban development and accelerated urbanization worldwide the main problem in the countries is the quality of drinking water. He conducted surveys in municipalities using the Logit technique and contingent valuation to find the WTP. In addition, he suggests using this technique to have more sustained information to design sustainable planning policies and to be able to know the opinion of the users.

This article has identified a gap in the estimation of economic benefits using the parametric logit model in the methodologies for the development of potable water investment projects through the standard technical data sheets (FTE) and pre-investment studies of the *Invierte.pe*; since a review of the general guide for the formulation of investment projects (MEF, 2022), the FTE spreadsheet for rural sanitation projects (MVCS, 2022a), the FTE instructions for rural sanitation projects (MVCS, 2022d), the FTE spreadsheet for urban sanitation projects (MVCS, 2022b), and the FTE instructions for urban sanitation projects (MVCS, 2022e), was carried out; In the FTE, it was found that only the direct benefits of drinking water are estimated through the release of resources and the increased consumption of drinking water. In the FTE and in the *Invierte.pe* drinking water project profiles, the parametric logit model is not applied, which is a sophisticated technique, perfected in the calculation of economic benefits, taking into account that this variable represents a solid foundation to determine the profitability and approval of a project.

Consequently, the purpose of the article is to obtain the economic benefits in drinking water projects through the parametric logit model, within the approach and perspective of *Invierte.pe*.

Materials and Methods

The following steps were considered in the methodology used: First, a drinking water project was identified in the investment management system *Invierte.pe* which has the following project

code 2145715. Second, following the parametric contingent valuation methodology, 102 surveys were conducted among the beneficiary population of the project through the creation of a hypothetical market, the questions were about the willingness to pay with binary answers "YES" and "NO" for an improvement in the water service for human consumption. Third, data processing and analysis is performed in the stata program version 2017 to obtain the WTP results. Fourth, to estimate the willingness to pay the parametric logit model was used, following the development proposed by (Atis, 2020), and random utility theory, it is assumed that the true maximum willingness to pay.

(M) Has a logistic probability distribution, also the survival function $1 - G(A)$ is equal to L , so the function of the logit model is denoted by L , therefore:

$$L_i = 1 - G(A) \rightarrow L = \frac{1}{[1 + e^{(\alpha + \beta A)}]} \text{ Equation (1)}$$

Where:

L = Probability of payment; when the answer is positive it takes a value of 1 and when the answer is negative it takes a value of 0.

A = Proposed payment varies among different users.

α = Coefficient, represents the constant.

β = Coefficient, represents the slope.

$$P_i = \frac{e^z}{1 + e^z} \text{ probability of success.}$$

$$1 - P_i = \frac{1}{1 + e^z} \text{ probability of failure.}$$

$$L_i = 1 - G(A) \rightarrow \ln = \frac{P_i}{1 - P_i} \text{ Equation (2)}$$

After calculating the values of the coefficients α and β , we proceed to calculate the mean of the maximum willingness to pay of the surveyed users.

The proposed payment is known as the median A so it has the same probability of being accepted as the probability of being rejected.

Assuming that the median is the proposed payment that has a probability L of 50%, then we operate the following function.

$$L = \frac{1}{[1 + e^{(\alpha + \beta A)}]} = \frac{1}{2} \text{ solving, } [1 + e^{(\alpha + \beta A)}] = 2 \text{ then, } [e^{(\alpha + \beta A)}] = 1 \text{ we apply natural logarithm.}$$

Therefore, $(\alpha + \beta A) = 0$, then the median value of the maximum willingness to pay of the surveyed users is:

$$WTP = A = -\frac{\alpha}{\beta} \text{ Equation (3)}$$

The WTP or A represents the price to be paid using the parametric logit model.

Results

The results were estimated according to the steps outlined in the research methodology; first the data from the surveys were processed in the Stata program, then the willingness to pay was

calculated using the parametric logit model, and finally the economic benefits of the project were estimated.

Data processing in the statistical program 17:

With the information collected from the surveys, we proceeded to perform the logit regression in the stata program version 2017 to estimate the willingness to pay. The results of the parametric regression show a chi-square of 0.000 less than 0.05 which means that the unknowns are not zero and the model is adequate. Also, Table 1 shows z-values for the logit β and α greater than 1.96 which represents 95% confidence which implies that the unknowns are very important. In addition, it can be specified that the probability of "z" for the logit β and α which is 0.0000 respectively showing that the model analyzed is highly significant; that is, they are not greater than 0.05 or 5%, which implies that the unknowns are different from zero.

Additionally, the relationship between the dependent and independent variables turned out as expected, since the logit β resulted with a negative sign, so the higher the price or position offered for the development of the project, the lower the probability of obtaining a positive response from the respondent, and the logit α resulted with a positive sign.

Table 1. Results of parametric logit regression for WTP.

WTP	Logit	Std. err.	Z	P>z
β	-0.5642932	0.1416567	-3.98	0.0000
α	2.410585	0.578151	4.17	0.0000

Source: Results obtained.

Calculation of WTP using the parametric logit model:

With the information in Table 1, the WTP was calculated by applying the parametric logit model formula; the logit coefficients were replaced in equation (1) by dividing the constant α by the slope β with their respective signs. As shown in equation (4).

$$WTP = -\frac{\alpha}{\beta} = -\left(\frac{2.410585}{-0.5642932}\right) = 4.27 \text{ Equation (4)}$$

Economic benefits of the project:

Once the WTP is found by the parametric logit model, the economic benefits projection is obtained for a period of 20 years, taking into account that the number of users increases at a rate of 0.86%. To find the potential monthly economic benefits, the WTP figure is multiplied by the number of users and for the annual benefits it is multiplied by the number of months per year. The economic benefits per month for period 1 are found to be S/ 26,209.2 and S/ 28,309 for period 10.

Table 2. 20-year projected economic benefits.

Period	1	2	3	4	5	6	7	8	9	10
Users	6135	6188	6241	6295	6349	6404	6459	6514	6570	6627
Benefits per month	26209.2	26434.6	26662.3	26891.3	27122.5	27355.8	27591.3	27828.3	28067.7	28309.2
Benefits per year	31451	31721	31994	32269	32547	32826	33109	33394	33681	33970

year	1	6	4	5	0	9	3	0	2	8
Period	11	12	13	14	15	16	17	18	19	20
Users	6684	6741	6799	6858	6917	6976	7036	7097	7158	7219
Benefits per month	28552.5	28798	29045.7	29295.5	29547.4	29801.6	30057.8	30316.3	30577.1	30840
Benefits per year	342630	345577	348549	351546	354569	357619	360694	363796	366925	370080

Source: Results

Discussion

Within the analysis of the discussion, the results of the article show a willingness to pay of S/ 4.27 for the development of the drinking water investment project, and annual economic benefits for the period 20 of S/ 370,080 means of the parametric contingent valuation technique. Likewise, the article by (Thakur et al., 2022) is in agreement with the present research, since it estimates a WTP of \$ 4.13 per household to provide arsenic-free drinking water in the city of Bihar - India, using contingent valuation. In addition, (Bui et al., 2022), shows favorable results with a WTP of \$12.2, which means 1.4% of the citizens' income for access to water service. Also, (Alcalá et al., 2022), finds results in agreement with this research, since they estimated a WTP of \$ 182.0 of the families of the city of Guanajuato, and an annual benefit of 1,034 million dollars to support the implementation of infrastructure, technologies in the water and sewerage service.

(Ahmad et al., 2005), obtains 14% of households willing to pay for arsenic-free drinking water in Bangladesh, using a multinomial logit model. (Orgill et al., 2013), finds a WTP of \$ 3 for improving the water quality of rural communities in Cambodia, applies a Logit regression and contingent valuation. (Morais et al., 2014), estimates a WTP of \$ 7.32 as a reservation price under the Logit technique and contingent valuation, and annual benefits of \$ 5,093,051.04. (Muhammad et al., 2020), studies the willingness to pay PKR 278 each month for good quality drinking water, uses contingent valuation for the surveys and regression of the Logit model to estimate the WTP. (Rodríguez-Limachi et al., 2024), finds a WTP of S/ 4.58 using the nonparametric Kriström model.

Conclusion

It is feasible to find the economic benefits of drinking water projects using the parametric Logit model, applying the contingent valuation technique within the Invierte.pe administrative system. In addition, the use of the parametric Logit model could be used to improve pre-investment studies at the standard technical file level or at the profile level of investment projects in the sanitation sector.

With the results obtained, we could recommend the inclusion of the parametric methodology to estimate the economic benefits of drinking water investment projects in the context of Invierte.pe, because it is the fundamental basis for carrying out the cost-benefit analysis of the project and recommending the approval of the investment for the benefit of the Peruvian user population, in addition, this technique of continent valuation through the regressions of the Logit model is a sophisticated methodology that helps formulators, planners and consultants to develop sanitation projects with more consistency and technical support.

Finally, continue improving the specific methodologies of Invierte.pe, especially the sectoral technical sheets for the housing and sanitation sector, the instructions, the electronic spreadsheet and the approval document of the standard technical sheet for sanitation projects in urban and rural areas of the country.

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