Economic valuation of the impact on the Gulf of Mexico ecosystems: The deepwater horizon case

Valoración económica del impacto sobre los ecosistemas del Golfo de México: El caso deepwater horizon

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Abstract

The value of nature does not escape the interests of those who cannot conceive the limits of such an important and vital element. The valuation on nature is developed to generate a reference and take actions accordingly. In this regard, the Contingent Valuation method is the most commonly referred to, but it involves the design of a structured survey in which the main question is whether there is a willingness to accept an amount of money in compensation (DAC) for the loss of an eco-friendly good or service. systemic or willingness to pay an amount of money to keep it (DAP). One or the other is defined without having a single referent and has been taken as a synonym of the total economic value. For this case, the problem of justifying the output value (DAP) was raised. The objective was to develop a methodology that based on data on household income and expenditure (ENIGH) in Mexico and applying a percentage to the expenditure per month, provided a basis for calculating that amount. The resulting methodology was accepted in the Valuation of goods and services provided by the Gulf of Mexico, after the Deepwater Horizon accident.

Contingent valuation, Deepwater Horizon, Gulf of Mexico

Resumen

El valor de la naturaleza no escapa a los intereses de quienes no logran concebir los límites de tan importante y vital elemento. La valuación sobre la naturaleza se desarrolla para generar un referente y tomar acciones en consecuencia. Al respecto, el método de Valoración Contingente es el más referido pero entraña el diseño de una encuesta estructurada en la que la pregunta toral es si hay disposición a aceptar una cantidad de dinero en compensación (DAC) por la pérdida de un bien o servicio eco sistémico o la disposición a pagar una cantidad de dinero para conservarlo (DAP). Una u otra se definen sin tener un referente único y se han tomado como un sinónimo del valor económico total. Para el caso, se planteó el problema de justificar el valor de salida (DAP). El objetivo consistió en desarrollar una metodología que a partir de datos sobre ingreso y gasto en hogares (ENIGH) en México y aplicando un porcentaje al gasto por mes, permitió disponer de una base para calcular esa cantidad. La metodología resultante fue aceptada en la Valoración de bienes y servicios que provee el Golfo de México, tras el accidente de la plataforma Deepwater Horizon.

Valoración contingente, Deepwater Horizon, Golfo de México

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Introduction

Establishing payment for ecosystem services (PES) is an essential step towards promoting environmental protection and building a society that is more aware of its relationship with nature. This has become relevant as we become aware of the serious consequences that human activity leaves in its wake on ecosystems that determine the stability of the climate and life on earth. Why have we lost sight of the importance of efforts to maintain the balance of nature? One reason for this is that the prevailing economic model on the planet seems insatiable in its identity, the process of accumulation and dispossession; its promoters did not find the intense use of cheap labour, the shrinking of the welfare state and the subjection of vulnerable sectors of the population to precarious conditions in housing, medical services, education, food, agricultural production and migration sufficient, and have now turned their attention to the goods and services provided by nature. This is the case of Latin American countries that are reaching the limit of their tolerance in their role as suppliers of raw materials with little or no added value, in order to seek, through capacity building and local investment, to make the most of their resources, but from the perspective of their own vision of development.

However, the critical situation has ceased to be located only in our continent and now we see how the insatiability of the economic model has moved to the geography of Central Asia, to show the world that this characteristic is not exclusive to neoliberalism, but also to the Soviet model, which goes beyond dispossession and shows the world the destructive and incomprehensible way of proceeding to take over territories, resources, people and nations.

There would be other interpretations of this last situation due to the interference of countries other than those directly involved in the conflict.

The commodification of ecosystem goods and services is largely explained by the transition from a classical economic model, which in its initial conception understood them as benefits to which a use value was associated, to a neoclassical economic model in which they are conceptualised as having an exchange value (Gómez-Baggethum *et al.*, 2010).

Putting the market interest on the goods and services provided by nature has been a challenge that did not measure the consequences. Nevertheless, there are efforts that, from Environmental Economics, Ecological Economics, Economic Valuation and other disciplines, generate knowledge that contributes to rethink economic activity and try to steer our destiny towards achieving what seems to be our only way out, a sustainable society.

In particular, I would like to point out that after serious accidents related to oil spills, be it the sinking of large ships such as the Exxon Valdez off the coast of Alaska (1989), the Prestige off the Galician coast (2002) or the collapse of oil platforms such as Deepwater Horizon (2010) in the northern Gulf of Mexico and others, it is after these accidents that interest has arisen in making available the knowledge that is available to the public, is that the interest arises in having a technique that allows estimating the economic value of environmental goods and services as a way of having a reference for the evaluation of the economic impacts caused by accidents such as those referred to, to seek remediation and, where appropriate, the economic sanction that contributes to compensate the impact of externalities and thus contribute to induce a rational use of natural resources.

The global economy seems to be moving towards one that is characterised by a high dependence on energy, mainly oil and gas; recently, interest in lithium as a raw material to produce batteries for electric cars has been raised, and speculation about the location and size of the deposits is the subject of debates and state policies. However, the efforts for the development and use of clean energy do not seem to reach the power of hydroelectric, thermoelectric and nuclear energy.

In this context, it is important to understand the movement of crude oil around the world and the technology used for it; large oil tankers, pipelines, etc. The medium is a determining factor in the capacity and risk associated with the transfer function. The size of the crude oil spilled by a ruptured pipeline is not comparable to an accident involving an oil tanker on the high seas.

In the latter case, approximately 81 accidents have been reported. (Libes, 2009). The highest frequency of accidents is located in the North Sea, the Mediterranean Sea, the Persian Gulf, the North Pacific, the Caribbean and the Gulf of Mexico. This dynamic generates a rational need that becomes a priority insofar as the global economy revolves around the availability of hydrocarbons, but the availability of hydrocarbons is not homogeneous; rather, it follows capricious routes that have allowed countries that have hydrocarbons in the subsoil or on the seabed to enjoy relatively comfortable economic situations, but not those that need to acquire them in a market that appears stable but also presents stages of high uncertainty, and with it, the value of crude oil.

Although technology has evolved to provide large oil pipelines, it is also recognised that there are physical limits that force the use of equipment, machinery, vessels, etc., which at some point give way due to the use and pressures to which they are subjected during the extraction, storage and transport operation, or due to human error; when this happens, we realise the magnitude of the implications thanks to the media, which report on the accidents and in some way help to raise awareness of the importance of events that were previously unknown. This work contributes in the sense of generating an option for the calculation of the exit value in a contingent valuation (CV) survey. The need consists of having valuation procedures that allow the circumstances associated with the type of claims mentioned above to be resolved.

To achieve this, it is possible to proceed by different techniques: Hedonic Pricing (PH), Travel Cost (CV), Contingent Valuation (VC). The VC technique is the most common; it was widely analysed and recommended by the Cordon Bleu panel convened by NOAA. (Carson T., 1997); However, the debate on the reliability of the VC technique is ongoing.

In the process of valuing goods and services provided by nature, it is important to be clear that the objective of the exercise is not to place them in a conventional market; the VC technique allows a market to be simulated and the exercise converges in the estimation of the total economic value.

Reference framework

Many exercises have been carried out by researchers and environmentalists to propose methods for estimating the economic value of the impacts of externalities on the goods and services provided by nature. An important experience was developed from the actions that Turkey decided to implement as a result of the repeated experience with British tourists arriving on its coasts. The research surveyed tourist users mainly on Olu Deniz beach, Turkey. The majority (70%) were British who used the beach for both recreational activities and to enjoy open spaces and scenery.

The main dislikes were found to be litter (41%), water quality (31%) and dog faeces (24%). Eighty-seven percent of British respondents expressed a positive willingness to pay (WTP). British tourists were willing to pay £1.03 per adult per visit. Significant variables in this determination were: age, gender, income level, social class and beach experience. The authors report a 10% decrease in tourists when an eco-tax was imposed in the Balearic Islands; this could mean a refusal to pay and is understood to be a market reaction to the increase or charge per beach visit (Blakemore & Williams, 2008).

This type of exercise is multiplied by several countries without any precision on the output value. Mexico is no exception. However, these experiences are minor in relation to the task that motivated the exercise of economic valuation of the impacts on ecosystems in the Gulf of Mexico. It was not only the magnitude, but also the consistency of the results because of the implications that could be derived from the econometric exercise.

Methodology

The output value to be proposed in the VC survey is decisive, as a Payment for Ecosystem Services (PES) project is not conceivable without the agreement between SE providers and buyers, which formalises compliance with the project as long as the established conditions are respected (Engel y otros, 2008).

One of the important agreements in a PES programme is to assess the willingness of the parties to participate in estimating the willingness to pay (WTP) of the SE buyers who will support the suppliers and the willingness to accept compensation (WTP) for the SE sellers to implement the PES programme (conservation and sustainable practices programme) (Ureta *et al*., 2022).

However, it is important to note that, in this type of study, the dimension of the area of influence of the study should not be lost. It will not be the same to estimate the WTP or the WFD in a community of fishermen who carry out their activity in Boca del Río, Veracruz, as it will be in a study that includes the citizens of a nation. In the latter case, it will be complex to estimate one or the other parameter because of the great diversity that arises due to cultural differences, even though it is a country, between the inhabitants of the north and those of the south and centre, or between those who live on the coast and those who live in the mountainous or desert areas of the centre of a country.

Making a methodological proposal for such an important work in Religious Life cannot be absent from relating it to at least one specific case. To illustrate the proposal, the problem generated after the collapse of the Deepwater Horizon oil platform in April 2010 off the coast of Louisiana in the northern Gulf of Mexico will be taken to illustrate the proposal. The proposed method for determining the output value is based on four fundamental steps:

a) The most recent information on quarterly expenditure on food, beverages and tobacco in Mexican households is available.

b) Organise the information by deciles and disaggregate the monthly proportion.

c) On each decile, apply a percentage (0.5, 1, 1, 3, 3, 5 10%) which is supposed to be the proportion of expenditure that the respondent in the household would be willing to contribute. The resulting values are rounded to the nearest whole number (Table 1).

d) On the information per decile and per percentage applied, for the case of the double bounded approach, half and double are taken, according to the respondent's answer to the question Are you willing to contribute <quota> per month and for one year, to help in the protection of the ecosystem service?

Decil	%				
	0.5	1	3	5	10
I	$7.00	$13.00	$38.00	$62.00	$125.00
II	$8.00	$16.00	$47.00	$78.00	$155.00
III	$10.00	$19.00	$56.00	$93.00	$186.00
IV	$11.00	$21.00	$61.00	$102.00	$203.00
V	$11.00	$23.00	$67.00	$111.00	$222.00
VI	$13.00	$25.00	$75.00	$124.00	$248.00
VII	$15.00	$29.00	$86.00	$142.00	$284.00
VIII	$16.00	$32.00	$94.00	$157.00	$313.00
IX	$19.00	$37.00	$110.00	$184.00	$367.00
X	$26.00	$51.00	$153.00	$254.00	$508.00

Table 1 Percentage applied to monthly expenditure on Food and beverages in Mexican households 2010
Source: Own Elaboration

The reason to support the calculation of the output value (EV) <quota> in a percentage of the monthly expenditure in Mexican households on food, beverages and tobacco is no other than to the extent that the interviewer knocks at the door of the household, the head of household who accepts to collaborate will take as a reference when requesting his or her response on the amount selected from Table 2 based on the last and penultimate digit of the folio of the survey, will take as a reference, when asked to respond, the amount selected from Table 2 based on the last and penultimate digit of the survey folio, the amount of expenditure on food, beverages and tobacco, since it is considered that by deciding to contribute the proposed amount, this will be immediately translated as part of the expenditure indicated.

– This methodology provides a reliable basis on which it is possible to establish a key element in research on the estimation of the value of ES where the VC-Double bounded technique is applied.

– So far, the fee is established from the estimates of damage or impairment to the ES and the cost of remediation or reversal of the damage.

The table generated allows, by choosing according to the last and penultimate folio number of the survey, to set the figure to be proposed as the availability to pay (WTP) for the loss of enjoyment of ES. But this proposed value is calculated on the basis of the logic that is estimated to occur at the time of making decisions on spending in the household.
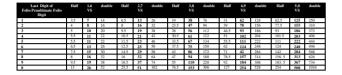
Last Digit of Folio Penultimate Folio Digit	Half	1.6 VS	double	Half	2.7 VS	double	Half	3.8 VS	double	Half	4.9 VS	double	Half	5.0 VS	double
1	3.5	7	14	6.5	13	26	19	38	76	31	62	124	62.5	125	250
2	4	8	16	8	16	32	23.5	47	94	39	78	156	77.5	155	310
3	5	10	20	9.5	19	38	28	56	112	46.5	93	186	93	186	372
4	5.5	11	22	10.5	21	42	30.5	61	122	51	102	204	101.5	203	406
5	5.5	11	22	11.5	23	46	33.5	67	134	55.5	111	222	111	222	444
6	6.5	13	26	12.5	25	50	37.5	75	150	62	124	248	124	248	496
7	7.5	15	30	14.5	29	58	43	86	172	71	142	284	142	284	568
8	8	16	32	16	32	64	47	94	188	78.5	157	314	156.5	313	626
9	9.5	19	38	18.5	37	74	55	110	220	92	184	368	183.5	367	734
0	13	26	52	25.5	51	102	76.5	153	306	127	254	528	254	508	1016

Table 2 Proposed output value in Mexican pesos <quota> for the double bounded model
Source: Own elaboration based on Gasto en Hogares Mexicanos en Alimentos, Bebidas y Tabacos (INEGI, 2010)

The table can be used as follows: If the enumerator randomly chooses a household from a given street in a city, he/she will notice that the questionnaire has a folio. Suppose it is 356. When the time comes, the interviewer asks: Would you be willing to contribute $11 per month for one year to a fund for the protection of the ecosystems of the Gulf of Mexico? Note that the value of $11 pesos is taken from table 2, noting that the penultimate digit of the folio is 5 and the last digit is 6, you will check the intersection of the fifth row with the first column.

Results

The Mexican state, through the then National Institute of Ecology (2012), issued the Terms of Reference to participate in the technical proposal for the Valuation of Environmental Services provided by the Gulf of Mexico (2012). This was in response to the state's own need for information from which it could take action against BP, in relation to the perception of Mexicans over the age of 18 regarding the effects on the Gulf of Mexico's ecosystems after the collapse of the Deepwater Horizon platform.

The INE technical committee and independent experts concluded that the most relevant proposal came from the Autonomous University of Zacatecas. After the definition, the activity to comply with the deliverables in due time and form began: 1). Biodiversity in the Gulf of Mexico 2). Methodology, 3). Results and discussion.

For the elaboration of the first two documents, things progressed without major setbacks; after the approval of the methodology and its implementation, the difficulties began. One of the components of the methodology, the structured questionnaire, took seven months to reach an agreement between the team responsible, INE and the team of independent experts. Once approved, doubts arose about the output value (EV) to be used for each interviewee. After discussions with the responsible persons in INE and the project director, it became clear that there was reasonable doubt about this VS. This paper demonstrates how important it is to have a sufficiently robust VS in the sense of having a consistent basis for calculation and in close relation to expenditure in Mexican households.

As explained in the methodology, a table was constructed that accompanied interviewers at all times and in all cities, and with which, based on the last two digits of the survey folio, the interviewer, when facing the person who agreed to collaborate by answering the survey, would choose the VS that would be proposed to the interviewee. This table is the contribution of this work and the basis of calculation is the data from INEGI-ENIGH (2010).

With the output value resolved, the stratified sample (n=3,200) was then drawn up, with 99% accuracy and reliability of .01. The logistics included the training of interviewers on the importance of the work and the relevance of clearly covering all the aspects indicated (use of visual materials, tone of the reading, not inducing the interviewee's response); the survey was carried out in the two most important cities in each state of the Mexican Republic. After a month of field work (Dec, 2012) in the country, a database was constructed that allowed, through the use of binary Logistic models, Mathematical Expectation, the procedure for the calculation of Confidence Intervals and the Double Bounded routine implemented in the STATA package, to estimate what Mexicans think is the value of the ecosystem services affected by the spill, under these four approaches.

Table 3 presents the methodology that guided the survey in 32 entities (64 cities).

Study Universe	Mexicans aged 18 and over living in Mexico.
Sample size	3200 people aged 18 and over, distributed in a sample of 32 entities (64 cities).
Sample design parameters	Confidence level 99%, maximum error δ= .01
Unit of analysis	Household
Sampling method	Stratified at random with proportional decomposition
Questionnaire	Seven sections, 23 single- and multiple-choice questions
Data collection	Personal interview, graphic information session, questionnaire application, direct questions in the household.
Survey period	From 3 to 31 December 2012.
Field strategy	Training for survey service providers in the country.
Analysis	Statistics: descriptive, bivariate, multivariate, logistic regression.
Non-response treatment	Random behaviour is considered. Not replaced by any transformation.
Rejection rate	No problem, isolated case (Tijuana), not representative.
Software	SPSS, STATA, STATGRAPHICS

Table 3 Methodological window
Source: Own Elaboration

Once the database was designed and available, the parameters were estimated under the binary logistic regression model, by virtue of the nature of the dependent variable P14: Output value and the instruction expressed in the Terms of Reference. Since the possible answers were Yes or No, we have a categorical, binary variable.

Confidence interval estimation

The first approximation to the estimation of the value perceived by Mexicans aged 18 years and older in the stratified sample, of the value of the impact on the Gulf of Mexico ecosystems was developed from a model that considered the variables: p14 (Output value), Age, Income, p11QualityAmb, Schooling. The range of values produced by the model was projected over the universe of households in the Mexican Republic 28'159,374 (INEGI, 2023) (Table 4).

The second approximation was constructed from the calculation of the most likely value to occur (Mathematical Expectation) of the variable of interest, which is a point estimate based on the probability distribution of the possible outcomes of the P14 variables (Table 4).

The third approach to the value of the ecosystem impact was the one that expressly occupied the interest of the work; it consisted of the construction of several binary logistic models. Before presenting the results, it is pertinent to review the characteristics of the models used.

Models with qualitative dependent variable

A multiple regression model (not necessarily linear) allows us to explain the behaviour of a dependent variable Y as a function of a series of independent variables X_1, X_2, ..., X_k and an error term. ξ_i, i.e.:

$$Y = f (X_1, X_2,…X_k, \xi_i), \, {}_{i=1,2,…,k}$$

In the particular case that the regression model is linear, we will have an expression of the form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 +... + \beta_k X_k + \xi_i \qquad (1)$$

The objective of the regression will be to estimate the parameters of the model (in the linear case: β_1, β_2, ..., β_k) so that the resulting model fits the data as well as possible. When the dependent variable is continuous, we proceed under a multiple linear regression model as above. In such a case the estimation of the parameters β_1, β_2, ..., β_k is carried out using the Ordinary Least Squares (OLS) method.

It may happen that the dependent variable is a qualitative or categorical variable, i.e., it can only take a reduced set of values as is the case, when the interviewer asks the respondent if he/she agrees to support with <exit value>, the answer was only (Yes; No). In such a circumstance, the linear regression model is not suitable because of the nature of the response variable (it is not continuous). The choice will be logistic regression (Logit model).

It is important to remember that linear regression estimates the parameters by OLS (unbiased, minimum variance and consistent). (Infante & Zárate de Lara, 2013); in logistic regression, the parameters are estimated by the Maximum Likelihood (MV) method (biased, minimum variance) (Judge y otros, 1986).

The Logit model

One solution to the difficulties presented by the linear regression model in explaining the behaviour of a binary dependent variable is a Logit model of the form:

$$Y = f(\beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_k X_k + \xi_i)$$

The logistic function is expressed in the form:

$$f(z) = (\exp(z))/(1+\exp(z)) \quad (2)$$

Therefore:

$$E(Y) = P(Y=1) = [\exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_k X_k)] / [1 + \exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + .. + \beta_k X_k)] \quad (3)$$

In this type of models it is not possible to directly interpret the estimates of the parameters β, as they are non-linear models. What is done in practice is to observe the sign of the estimators. If the estimator is positive, it will mean that increases in the associated variable cause increases in the probability of the desired event $P14(Y = Si)$ occurring, (although we do not know the magnitude of these); if the estimator shows a negative sign, this will mean that increases in the associated variable will cause decreases in the probability of occurrence of the desired event, which in this case is $P14(Y = Si)$. The latter expression represents the probability of a favourable response (Yes) to the WTP.

The following expression is the common form of a Logit model:

$$DAP = \frac{\exp^\beta}{1+\exp^\beta} \quad (3.1)$$

For the first model in table 4(c), the estimate by MV is:

β= 11.4844 - 0.00714539*p14 - 0.0207913*Age + 0.283374*Income=1 + 0.595038*Income=2 + 0.611854*Income=3 + 0.613429*Income=4 + 0.63947*Income=5 + 0. 691464*Income=6 + 0.65631*Income=7 + 0.458378*Income=8 + 1.10059*p11QualityAmb=1 + 0.728184*p11QualityAmb=2 + 0.830318*p11QualityAmb=3 + 0. 969274*p11AmbQuality=4 + 2.56101*p11AmbQuality=5 + 11.0014*Schooling=1 + 10.8948*Schooling=2 + 11.0819*Schooling=3 + 10.9141*Schooling=4 + 11. 418*Schooling=5 + 11.3148*Schooling=6 + 11.1519*Schooling=7 + 11.3955*Schooling=8 + 11.2963*Schooling=9 + 11.3351*Schooling=10 + 11.5046*Schooling=11

In the Logit model, other concepts are often used to further deepen the interpretation of the estimators. The Odds statistic is expressed by the following odds ratio:

$$\text{Odds} = [P(Y=Si)] / [1-P(Y=Si)] = [\exp(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k)] \quad (4)$$

Taking logarithms in the above expression, a linear expression for the model is obtained.:

$$\text{Logit}[P(Y=Si)] \equiv \ln\{P(Y=Si) / 1 - P(Y=Si)\} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k \quad (5)$$

In this case, the estimator of the parameter β_i can be interpreted as the variation in the Logit term (the logarithm of the odds ratio) caused by a unit variation in the variable Xi (assuming the rest of the explanatory variables are constant).

Therefore, when reference is made to the unit increase in one of the explanatory variables of the model, the concept of Odds-ratio appears as the quotient between the two associated Odds (the one obtained after the increase and the one before the increase). If we assume that there has been a unit increase in the variable Xi, we will have that:

$$\text{Odds-ratio} = \text{Odds1/Odds0} = [\exp(\beta_i)] \quad (6)$$

From expression (6) it follows that a coefficient β_i close to zero will mean that changes in the associated explanatory variable Xi will have no effect on the dependent variable and that an odds ratio close to one will indicate a significant effect on the probability of occurrence of $P(Y=Yes)$ in the dependent variable due to the effect of the independent variable.

Under the above logic, the models of option c in Table 4 were constructed. No emphasis is placed on the significance of the specific contribution of each explanatory variable on the probability of a positive response $P(Y=Yes)$.

Therefore, the results focus attention on the estimation of that probability, on the understanding that the models (Table 4, item c) are the best performing ones.

The fourth option for the estimation of the impact value was developed from an econometric model with application of the doubleb subroutine in STATA software (Lopez, 2012) (Table 4).

Approach	Estimated annual WTP (pesos)	Remarks
a). Confidence interval approach to WTP estimation.	[9 695´467 772.00; 10 101´728 665.00]	
b). Approach to WTP estimation by Mathematical Expectation	12 688´275,108.00	Point estimate based on the probability distribution. In this case it is important to consider that 64% of the households declared their refusal twice.
c). Econometric models	Estimates of WTP/year	Variables involved
Model 1	Total DAP = 8 841´607,094.00	p6, p7, p10, p14, age, income
Model 1 a (Yes Yes)	4 728´130, 669.00	
Model 1 b (Yes No)	3 456´133, 429.00	
Model 1 c (No Yes)	657´342 996.00	p3, p4, p5, p6, p7, p10, p11, p14, age, schooling, occupational status, income
Model 2	Total DAP = 9 112´003,386.00	
Model 2 a (Yes Yes)	4 869´372,825.00	
Model 2 b (Yes No)	3 627´442,442.00	
Model 2 c (No Yes)	615´188,118.00	p5, p6, p7, p10, p14, age, income
Model 3	Total DAP = 9 010´643,728.00	
Model 3 a (Yes Yes)	4 803´182,532.00	
Model 3 b (Yes No)	3 586´400,160.00	p14, age, income
Model 3 c (No Yes)	621´061,036.20	No information on environmental aspects is inserted in this model
Model 4	Total DAP = 4 026´306,293.00	
Model 4 a (Yes Yes)	2 053´559,760.00	
Model 4 b (Yes No)	1 537´128,060.00	
Model 4 c (No Yes)	435´618,473.20	
d), Econometric model with application of doubleb subroutine in STATA	Total expected contribution per year 12,644´684,403.00	income, age, p6_4, p6_7, p6_9, p7_2, p7_6, p10_1

Table 4 Approaches to calculating the estimated economic value of the impact of the Deepwater Horizon collapse on Gulf of Mexico ecosystems
Source: Own elaboration based on survey data

Nomenclature

Q3: How has your contact with the beaches of the GoM been; Q4: How do you consider the environmental quality of the GoM to be; Q5: Which of the following people or organisations do you consider contribute most to the pollution of the GoM? Q6: Of the following sea-related problems, which of them are you most concerned about? Q6_4: Spillage from ship manoeuvring; Q6_7: Oil spill; Q6_9: Other. Q7:The GoM has marine ecosystems, which of these have you had contact with and what type of contact? Q7_2: Coral reefs; Q7_Sea grasses; Q10: From your point of view, of the following problems and their influence on the state of marine and coastal ecosystems, what priority attention should be given to each of them? Q10_1: Urban Growth; OccupySavermar: Your current occupation is related to the sea; Q14_Output value.

As can be seen (Table 4), the estimation of the economic value by the Expected Value technique and the Double Bounded technique was very similar. In third place, for the estimated amount, appears the technique of estimation by Confidence Interval, and the lowest estimates for the amount, were precisely those that yielded the binary logistic econometric models that are in the VC methodology, the reason for the project. The idea behind the breadth of approaches to value estimation has to do with the actions and negotiations that will undoubtedly arise when steps are taken in the legal, environmental and diplomatic arenas.

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Conclusions

The economic policy approach, the development of economic valuation schemes and the development of payment for ecosystem services schemes have contributed to placing the conservation of ecosystem services at the centre of the debate, but also to commodifying an increasing number of ecosystem services and reproducing the neoliberal economic paradigm and the logic of the market to address problems related to the environment.

Exercises of the magnitude described here will enable the Mexican scientific community and society in general, the native communities, but above all the Mexican state, to have the necessary knowledge, hitherto absent, of a method for estimating the value of the services provided by nature, so that the latter can act accordingly. It will be more important to have developed a unique experience in terms of its magnitude, from which much was learned, especially given the seriousness of the losses caused by human activity and the lack of knowledge about the methods for valuing environmental goods and services. It is also important to note that the delay in publishing the results is due to the Terms of Reference and to the fact that the author is now authorised to openly disclose the estimates made.

After this type of study, consequent actions are beyond the scope and responsibility of the author. These are the elements available to the federal authority to act as they deem appropriate.

Finally, it is important to reiterate that the assignment only included the approach of econometric models, however, from the experience gained from the valuation practice, it is well known that it will always be better to have more than one approach to estimate the economic value of the subject in question, experience that is expressed in the complementary estimates. This breadth of procedures gives room for negotiation processes, which go beyond the domain of work and enter the field of diplomatic relations, in which the rigorous vision of the environmental movement is always in force, in order to avoid inaction after such a visible loss and from which unprecedented experiences were derived, which cannot remain in the writing of a work of this nature.

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