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ARTICLE INFO	Hubert Stahn and Agnes Tomini (2011). Individuals doubts and policy implementation: risk premium and contingent valuation. *Environmental Economics*, *2*(2)
RELEASED ON	Friday, 22 July 2011
JOURNAL	"Environmental Economics"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

NUMBER OF REFERENCES **0**

NUMBER OF FIGURES **0**

NUMBER OF TABLES **0**

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Individuals doubts and policy implementation: risk premium and contingent valuation

Abstract

This paper is concerned with discrete choice contingent value estimate when the respondents are uncertain about the environmental amenities. Within a class of indirect utility functions often used in empirical studies, the authors put forwards the effect of the risk premium on the willingness to pay (WTP). Then, it is shown how this risk premium also modifies the estimation procedure. A Monte Carlo simulation concludes the paper by putting forward a misestimation of the WTP. When this uncertainty is ignored, more precisely, the authors focus on the effect of the risk premium.

Keywords: contingent valuation, parametric models, risk premium, random utility.
JEL Classification: C81, D81, Q51.

Introduction

This paper investigates how a risk premium influences the willingness to pay (WTP) when respondents are uncertain about the final environmental outcome.

There is a substantial literature dealing with valuation under uncertainty. The majority of these studies aim at analyzing the impact of uncertainty on environmental value on both the theoretical level and empirical level. The oldest work dates back to the seminal paper of Weisbrod (1964) who defined an *option value* of the total economic value as a future use value which must be added to the current value. Carson and Mitchell (1989) explain that it is "an amount that people will pay for a contract which guarantees them the opportunity to purchase a good [...] and may be thought as a risky premium to compensate for uncertainty about future taste, income or supply." In parallel, Arrow and Fisher (1974) and Henry (1974) defined the *quasi-option value* as an opportunity cost of giving up future information available when we preserve a resource instead of consuming it. A more recent literature is rather interested in respondent's uncertainty when individuals are actually interviewed. Several methods are available to elicit individual preferences but since the National Oceanic and Atmospheric Administrations (NOAA) panel recommendations[1], the most commonly used is the contingent valuation (CV) method, especially the dichotomous discrete contingent valuation (DC-CV). This technique consists of asking directly subjects for their monetary valuation for a change in the public good. A theoretical foundation for the statistical model was yielded by Hanemann, Loomis and Kanninen (1989). However, individuals may be uncertain due to numerous causes including the lack of experience with the public good, the hypothetical scenario or the impossibility to make a trade-off between the amenity and the monetary good (Shaikh et al., 2007). This has led to extend the format of the survey including the choice of answers "don't know" or "probably" (Li and Mattsson, 1993; Ready, Navrud and Dubourd, 2001; or Alberini, Boyle and Welsh, 2003). Whatever the focus of the interest is, this overall literature highlights that the presence of uncertainty influences welfare estimations. Nevertheless, few attempts are made to take into account the fact that the provision of the environmental amenity is uncertain, whereas studies on preferences uncertainties are numerous.

This paper aims to fill part of this gap by coming back to the option value intuition. It was motivated by Manski (2004) who claims that individuals act with partial information. Accordingly, they form probabilistic expectations for unknown quantities. This assertion sounds adequate when we consider that the CV method has been applied to a wide variety of environmental commodities, not always directly observable such as marine resources or those living far from our own location. Even if the questionnaire provides some additional information[2], individuals are still incompletely informed on the "true state"[3]. In fact, it is quite intuitive to consider that the supply of environmental commodities is permeated by uncertainty which individuals can integrate in their valuation. Thereby, to predict choice behavior, Manski (2004) proposes to combine expectations data with choice data. Recently, Cameron (2004) uses data on respondents' perceptions about future climate conditions to estimate individual option prices. Based on a Borsch utility function, her approach proposes to elicit the mean and the variance of subjective probability distribu-

[1] The NOAA panel (1993) "recommends as the most desirable form of CV elicitation the use of a dichotomous question that asks respondents to vote for or against a particular level of taxation, as occurs with most real referenda."

[2] Contingent valuation is even accused for being an information providing process with influences the answers (see Spash, 2002). We, however, do not enter in this debate in this paper.

[3] Munro and Hanley (1999).

tions concerning future environmental quality. As far as we are concerned, we propose to investigate the effect of this uncertainty on the individual monetary valuation through the notion of risk premium which lowers the WTP.

The purpose of this study is three-fold. Based on a class of indirect utility function emphasized by Hanemann (1999), we will first see that the true WTP depends on a WTP for a situation without uncertainty and a risk premium. We even show that this risk premium drastically affects the functional form of the probability to accept a given offer in a random utility approach. This allows us in a second step to observe that ignoring respondent uncertainty leads to a missestimation of the parameters of the indirect utility function and therefore of the predicted WTP. Since the WTP under uncertainty is from a theoretical point of view reduced by a risk premium, we show in a third step that the same holds for the predicted WTP when uncertainty is ignored. To obtain this last result, we use a Monte Carlo simulation which points out that the true WTP distribution under uncertainty is stochastically dominated by a predicted WTP distribution neglecting respondent uncertainty.

The paper is organized as follows. Section 1 introduces some theoretical explanations of our intuition by combining WTP and risk premium. Section 2 goes closer to econometric setting to understand the effect of this risk premium on the estimation procedure. Section 3 yields of a Monte Carlo simulation to observe the miss-estimation of WTP distribution when the respondent uncertainty is ignored. Finally, the last Section concludes.

1. WTP and environmental uncertainty

This section sets out the theoretical model underlying the bid function in a simple setting. To fix ideas, we assume that the CV questionnaire proposes a change in provision of a non-market good from its present level q_0 to another level q_1. For the moment, we do not need to precise if this change is an improvement or not.

Then, we use a class of indirect utility function ensuring the equality between WTP is always equal to the willingness to accept (WTA) (Hanemann, 1999).

$$\begin{aligned} v(p,y,q) &= T(p,y+\psi(p,y,q)) = \\ &= a(p)(y+\psi(p,y,q))+b(p), \end{aligned} \tag{1}$$

where $p \in R^1{+}{+}$ denotes the price vector of 1 commodities, $y \in R+$ presents the income, and $q \in R$ measures the non-market environmental amenity. In fact, this class of indirect utility functions that the effect of a change in the environmental amenity has only a wealth effect (see the first equality) and is measured by $\psi(p,q)$. We even assume that this indirect utility function is linear in wealth (see the second inequality). The coefficients $a(p)$ and $b(p)$ of this linear relation can nevertheless be related to the prices. Moreover, the equality between WTP and WTA comes from the additive separability between the utility level and the non-market environmental amenity of the expenditure function.

As usually, individuals compare their utility assessed with the two levels of environmental goods provision q_0 and q_1. Then, there exists a monetary amount C ensuring that their well-being in the final situation is identical to their well-being in the initial situation:

$$v(p,y,q_0) = v(p,y-C,q_1). \tag{2}$$

By simple computation, we observe that the compensating variation for a change of the environmental amenity from q_0 to q_1 is given by:

$$c(p,q_0,q_1) = \psi(p,q_1) - \psi(p,q_0). \tag{3}$$

Now, let us introduce uncertainty about environmental amenity. To do this in the simplest way, we assume that consumers perfectly know the prices and their income[1]. They even observe the true value of the environmental amenity when they consume it but not *ex ante* when they are interviewed. To this end, assume that $q \in Q$ a connected subset R and each agent has a probability measure μ over this set. Under these simplifying assumptions, it is immediate that the *ex ante* indirect utility function is given by:

$$V(p,y,\mu) = \int_{q\in Q} (a(p)(y+\psi(p,q))+b(p))d\mu\,. \tag{4}$$

This function depends on the potential *ex post* outcomes and their probabilities.

From that point of view, a consumer who answers a CV questionnaire does not reveal her valuation for moving from a level of the environmental amenity to another one but a value for a change in the probability measure μ. Therefore, denoting by C the compensating variation measure, i.e., the quantity:

$$V(p,y-C,\mu_1) \equiv V(p,y,\mu_0), \tag{5}$$

we obtain by computation the following bid function:

$$C(p,\mu_0,\mu_1) = \int_{q\in Q} \psi(p,q)d\mu_1 - \int_{q\in Q} \psi(p,q)d\mu_0\,. \tag{6}$$

It is a matter of fact to observe that the equivalent variation E is measured by the quantity

[1] Our approach therefore departs from the one of Eeckhoudt, Godfroid and Gollier (1997) which requires uncertainty on the income stream of an agent.

$$V(p, y, \mu_1) \equiv V(p, y + E, \mu_0). \quad (7)$$

We keep again the property that

$$E(p, \mu_0, \mu_1) = C(p, \mu_0, \mu_1) \cdot$$

Within this risky environment, we now introduce the standard notion of risk premium. As usually, this quantity measures the reward for holding a risky environmental lottery rather than a risk-free one. It corresponds to a (negative) WTA for a lottery μ with respect to a situation, where the agent surely obtains $E(\mu) = \int_{q \in Q} q d\mu$ the expected value of the environmental amenity. This premium π is therefore given by:

$$V(p, y, \mu_1) \equiv V(p, y + \pi, \delta_{E(N)}) = v(p, y - \pi, E(\mu)), \quad (8)$$

where $E(\mu)$ denotes a Dirac measure which puts all the mass on $E(\mu)$. By using our previous remarks on the WTA and the WTP, we obtain:

$$\begin{aligned} \pi(\mu) &= -E(p, \delta_{E(N)}, \mu) = -C(p, \delta_{E(N)}, \mu) = \\ &= \psi(p, E(\mu)) - \int_{q \in Q} \psi(p, q) d\mu. \end{aligned} \quad (9)$$

At that point, we can now remark the following.

Fact 1. Under our assumptions, the WTP for moving from one risky situation μ_0 to another risky situation μ_1 corresponds to the WTP for moving from a riskless situation $E(\mu_0)$ to another riskless situation $E(\mu_1)$ up to some risk premium adjustments. More precisely:

$$C(p, \mu_0, \mu_1) = c(p, E(\mu_0), E(\mu_1)) = -(\pi(\mu_1) - \pi(\mu_0)). \quad (10)$$

Proof. By computation, we observe that:

$$\begin{aligned} & c(p, E(\mu_0), E(\mu_1)) - (\pi(\mu_1) - \pi(\mu_0)) = \\ & = \psi(p, E(\mu_1)) - \psi(p, E(\mu_0)) - \\ & - \left[\left(\psi(p, E(\mu_1)) - \int_{q \in Q} \psi(p, q) d\mu_1 \right) - \right. \\ & \left. - \left(\psi(p, E(\mu_0)) - \int_{q \in Q} \psi(p, q) d\mu_0 \right) \right] = \\ & = \int_{q \in Q} \psi(p, q) d\mu_1 - \int_{q \in Q} \psi(p, q) d\mu_0 = \\ & = C(p, \mu_0, \mu_1). \end{aligned}$$

The introduction of uncertainty allows us to yield a new writing of the bid function thanks to the presence of a risk premium and to capture the influence of risk aversion on CV responses. In effect, Fact 1 tells us, for instance, that an agent who actually knows the true state of the environment but is both risk averse and uncertain about the ability of the policy-maker to change the environmental amenity, systematically lowers her WTP with respect to a situation, where she is sure that the policy can be implemented. The risk premium reflects her personal estimation of the capability of the policy-maker to realize an announced change. Thereby, one can expect that any estimation of the WTP which neglects uncertainty systematically overestimates the WTP or at least misestimates this value.

2. WTP estimation under uncertainty

This section introduced the most used class of random utility function (RUM) to deal with the effect of a risk premium on estimated values. This approach shows how this risk premium modifies the probability-to-accept a given bid. Since this last concept is central to the estimation process, one can expect that parameters would be misestimated if this uncertainty is ignored.

2.1. WTP and random utility models. The RUM links the theoretical model to the statistical estimation by adding a stochastic term ε to the utility function representing unobservable components. The approach emphasized by Hanemann[1] (1984) consists of specifying first a form of the indirect utility function. Here, we restrict the class of state contingent indirect utilities $v(p, y, q)$ (see equation (1)) by assuming that $\psi(p, q) = \gamma(p) \cdot \varphi(q)$. Since prices are also taken as given in empirical studies, let us set $\beta_1 = a(p)$ and $\beta_2 = a(p)\ \gamma(p)$. Finally, let us observe the constant $b(p)$ cannot be identified within a discrete choice setting and that its value does not affect the estimation of the WTP, so let us set $b(p) = 0$. In order to deal with a RUM, we add a stochastic term ε. Under these additional restrictions, our state contingent indirect utility function becomes:

$$v(y, q) = \beta_1 y + \beta_2 \varphi(q) \quad (11)$$

and the associated expected utility function $V(y, \mu)$ is as usually obtained by integrating over q. Like various empirical studies, we assume that ε follows a Gumbel law. In this case, we know that the difference between two Gumbel distributions is a standard logistic distribution[2].

From that point of view, the WTP as well as the risk premium becomes random variables respectively defined by:

[1] This approach is usually called the *utility-difference model*.

[2] The reader, however, notices that this assumption is not crucial for the point made in this subsection. It is done by convenience in order to go closer to the applied econometric models.

$$\begin{cases} \tilde{C}(\mu_0,\mu_1) = \dfrac{\beta_2}{\beta_1}\left(\int\limits_{q\in Q} \varphi(q)d\mu_1 - \int\limits_{q\in Q} \varphi(q)d\mu_0 \right) + \\ + \dfrac{1}{\beta_1}\left(\varepsilon_{\mu_1} - \varepsilon_{\mu_0}\right) \\ \tilde{\pi}(\mu) = \dfrac{\beta_2}{\beta_1}\left(\int\limits_{q\in Q} \varphi(E(\mu)) - \int\limits_{q\in Q} \varphi(q)d\mu \right) + \\ + \dfrac{1}{\beta_1}\left(\varepsilon_{\mu_1} - \varepsilon_{\delta_{E(\mu)}}\right) \end{cases} . \quad (12)$$

It is quite obvious that the decomposition in Fact 1 does not apply to a random utility model. We nevertheless know that the stochastic term is additive and of zero mean. This leads us to conclude that Fact 1 can be maintained in expectation. It is a matter of computation to verify the following.

Fact 2. Under our assumptions, the relation exhibited in observation 1 holds in a random utility model as long as we consider the mean WTP and the mean risk premium. More precisely we have:

$$E\left[\tilde{C}(\mu_0, p, \mu_1)\right] = c\left[p, E(\mu_0), E(\mu_1)\right] - \\ - \left[E(\tilde{\pi}(\mu_1)) - E(\tilde{\pi}(\mu_0))\right] \quad (13)$$

with $c\left[p, E(\mu_0), E(\mu_1)\right] = \dfrac{\beta_2}{\beta_1}\left(\varphi(E(\mu_1)) - \varphi(E(\mu_0))\right)$.

Now, let us observe that $c\left(p, E(\mu_0), E(\mu_1)\right)$ can be identified to the expected WTP that is obtained in a RUM with no uncertainty about the environmental amenity and where the respondents know the initial situation $E(\mu_0)$ and take for sure the new proposal $E(\mu_1)$. So, if we assume that the initial situation is perfectly known and that the responds are risk averse, we can nevertheless maintain the idea that the WTP is overestimated. Our point is that even if this is not true for any realizations of the logistic noise, it holds in expectation and it is in fact the value which interests the policy-maker.

An econometrician would nevertheless argue that this story is true as long as one knows the real parameters of the model which is typically not the case. From that point of view, one can wonder whether this risk premium affects the estimation of the unknown parameters of the indirect utility function and if it induces an overestimation of the expected WTP.

2.2. RUM and acceptance probability. In order to identify the incidence of the risk premium on the estimation of the WTP, let us go a step further in the econometric approach and again simplify the argument[1]. In fact, we know that this DC-CV method consists of submitting a bid A to responds and ask them if they are willing to accept the change in the environmental amenity at this cost A (positive or negative). These responses are then used in an econometric model based on RUM whose purpose is to estimate several parameters of the indirect utility function in a way to maximize the likelihood of the sample. It, therefore, becomes important to know the probability that an agent responds "yes" to this question, or in other words reveals that her WTP is greater than A. This situation occurs if:

$$\left[V(y - A, \mu_1) + \varepsilon\mu_1\right] - \left[V(y - A, \mu_0) + \varepsilon\mu_0\right] \geq 0$$

and as $\varepsilon\mu_1$ and $\varepsilon\mu_0$ follow a Gumbel distribution, we can say that:

$$P(yes) = P(WTP \geq A) = \\ = P\left[-\beta_1 A + \beta_2\left(\int \varphi(q)d\mu_1 - \int \varphi(q)d\mu_0\right) \geq \varepsilon\mu_0 - \varepsilon\mu_1\right]$$

By bulding $\varepsilon\mu_0 - \varepsilon\mu_1 = -\eta$, we remember that η follows a logistic distribution, where $F\eta$ (·) represents its cumulative distribution function (cdf). If we have in mind Fact 2, we can state the following.

Fact 3. If there is some uncertainty about the value of the environmental amenity, the probability to accept a change at some cost A, i.e., the probability that the WTP is greater than A is given by:

$$P(WTP \geq A) = P\left(\beta_1\left(-E(\pi(\mu_1)) + E(\pi(\mu_0)) - A\right) + \right. \\ \left. + \beta_2\left(\varphi(E(\mu_1)) - \varphi(E(\mu_0))\right) \geq \varepsilon\mu_0 - \varepsilon\mu_1\right). \quad (14)$$

In particular, if the initial situation is known and given by q_0, this probability becomes[2]

$$P(WTP \geq A) = P\left[-\beta_1\left(E(\pi(\mu_1)) + A\right) + \right. \\ \left. + \beta_2\left(\varphi(E(\mu_1)) - \varphi(q_0)\right) \geq -\eta\right] = 1 - \\ - F_\eta\left[\beta_1\left(E(\pi(\mu_1)) + A\right) - \beta_2\left(\varphi(E(\mu_1)) - \varphi(q_0)\right)\right] = \\ = F_\eta\left[-\beta_1\left(E(\pi(\mu_1)) + A\right) + \beta_2\left(\varphi(q_0)\right) - \varphi(E(\mu_1))\right] .$$

This last observation is very informative. It tells us that the probability to accept a change of the environmental amenity at some cost A depends crucially on the expected effect of the proposed change $E(\mu_1)$ and the expected risk premium $E(\pi(\mu_1))$. If these elements are not taken into account, one can expect that the parameters of the indirect utility function as well as the WTP would be misestimated.

In order to illustrate this point, let us assume that the respondents think that the announced change is credi-

[1] In order to simplify the argument, we assume here that the same bid is proposed to the whole population. In our simulation, we however allow multi-bids each of them being proposed to a subclass of the respondents.

[2] This last equality exploits the symmetry of the logistic distribution: $F(x) = 1 - F(-x)$.

ble, i.e., $q_1 = E(\mu_1)$ and that the initial situation $q_0 = E(\mu_0)$ is well-known. In this certain world, we know that the probability to accept a bid A is given by:

$$P(WTP \geq A) = F_\eta - \beta_1 A + \beta_2 (\varphi(q_0) - \varphi(E(\mu_1))). \quad (14)$$

So, if the analyst takes this probability to accept formulation for granted even in a world where the respondents have some doubts on the announced policy, we can expect that her model misestimates the true value of β_1 and β_2. As the bid A is not corrected by the risk premium, we even expect that the true WTP distribution is stochastically dominated by the estimated one and, therefore, that the expected WTP is overestimated. However, this remains a conjecture because we are not able to predict theoretically the nature of the misestimation of the parameters β_1 and β_2. Nevertheless, the following Monte Carlo simulation allows us to verify this conjecture.

3. A Monte Carlo simulation

Monte Carlo experiments have already been used to deal with valuation topic, especially to compare dichotomous format and open-ended format or to study distribution probability (Poe-Vossler, 2002; and Arana-Leon, 2005). Here, we use it to compare the distribution of WTP under uncertainty with another one ignoring it. Let us first present the various steps of the experiment and then summarize our findings.

3.1. The design of the experiment. A CV survey actually generates database about responses on individuals' characteristics, opinions and values responses. Thus, to perform this experiment, we are going to generate an artificial population for which we know its true WTP distribution. We maintain the same assumptions for the indirect utility function. However, we assume that $\varphi(q) = \ln(q)$ is a concave function in order to ensure risk aversion. From that point of view, the state contingent indirect utility becomes:

$$v(y, q, \varepsilon) = \beta_1 y + \beta_2 \ln(q) + \varepsilon. \quad (16)$$

Then, we normalize the first parameter $\beta_1 = 1$ and we give a more important weight on the environmental parameter $\beta_2 = 2$.

The policy-maker proposes to improve the environmental amenity from an initial level q_0 to a higher level q_1. The valuation question leads individuals to reveal their maximum amount they would be willing to pay for this change. More precisely, in our DC-CV setting, each respondent states whether their WTP is above or below a bid level A. However, they may have some doubts about the outcome of the policy. Intuitively, these individuals are assumed to know the initial state q_0 which for computational simplicity is normalized to 1 and have in mind a probability distribution μ_1 over different outcomes. So, each individual compares the utility level in the initial situation with an expected utility level in the final situation. Therefore, given a bid A, a subject with income y will accept the project only if the utility with the CV program net of the required payment exceeds utility of the status quo:

$$V(y - A, \mu_1, \varepsilon\mu_1) \geq V(y, \delta q_0, \varepsilon\delta q_0) = \mathrm{v}(y, q_0, \varepsilon\delta q_0).$$

According to the RUM, we can calculate the agent's true WTP distribution. Each agent's WTP distribution is expressed as a function of the reference level of environmental amenity δq_0 and the target level μ_1:

$$WTP_i(\delta_{q_0}, \mu_1) = \left[\frac{\beta_2 \int_{q \in Q} \ln(q) d\mu_1 - \beta_2 \ln(q_0)}{\beta_1} \right] + \frac{1}{\beta_1}(\varepsilon_{\mu_1} - \varepsilon_{\delta q_0}) = 2\left(\int_{q \in Q} \ln(q) d\mu_1 \right) + \eta \quad (17)$$

Moreover, we can express the risk premium as following:

$$\tilde{\pi}(\mu_1) = \frac{\beta_2 \left[\ln E(\mu_1) - \int_{q \in Q} \ln(q) d\mu_1 \right]}{\beta_1} + \frac{1}{\beta_1}(\varepsilon_{\mu_1} - \varepsilon_{\delta q_0}) = 2\left[\ln E(\mu_1) - \int_{q \in Q} \ln(q) d\mu_1 \right] + \eta \quad (18)$$

Contrary to individuals, the analyst thinks that respondents compare the utility level in the initial riskless situation with the utility level in the final riskless situation. That is why he mis-specifies the WTP distribution like the following expression:

$$\tilde{WTP}_a = \frac{\ddot{\beta}_2 \ln(E(\mu_1)) - \ddot{\beta}_2 \ln(q_0)}{\hat{\beta}_1} + \frac{1}{\hat{\beta}_1}(\varepsilon_{\mu_1} - \varepsilon_{\delta q_0}). \quad (19)$$

The objective of this experiment is to observe what happens when the analyst ignores those doubts.

Now, we can generate the data for our population and build our experiment according the following steps:

1. We fix the distribution μ_1 by taking a finite support (q_1, q_2) with probability $P(q = q_1) = p$ and $P(q = q_2) = 1 - p$ which may change from an experiment to another. By convenience, all

agents are supposed to be homogeneous insofar they have the same probability distribution and they face with the same finite support.

2. We generate a sample of 1000 true WTP by randomizing over η which is distributed according to a standard logistic with mean 0 and standard deviation $\pi^2/3$.
3. We submit a bid to each agent and ask them if they are willing to accept or not. These bids are proposed randomly from a binomial distribution B (4; 0.5) which is adjusted in each experiment by a linear transformation $A = a * B$ (4; 0.5) − b in order to fit with the distribution of the WTP. This transformation will be clearer later.
4. We use this data to estimate the parameters of the indirect utility function by assuming that there is not uncertainty. In this case, we however have to specify the outcome proposed by the policy-maker. We assume that this outcome coincides with that agents expect[1]. In this case, the probability that an agent accepts the bid A_i is given by:

$$P(WTP > A) = F_\eta\left[-\beta_1 A + \beta_2 \ln\left(E\left(\mu_1\right)\right)\right].$$

The estimation is made by the maximization of the log-likelihood function over our sample.

5. For each experiment, we repeat 100 times step (2) to (4). The results for each experiment are presented with standard descriptive tools.

4. Results[2]

We perform two simulations. The first experiment consists of putting in evidence the existence of a risk premium in spite of no variation in q. The second simulation introduced an improvement in q.

Simulation 1. We assume that the analyst wants to know how much each individual is willing to pay to preserve the environmental initial level. In other words, we can imagine that individuals would be willing to pay to avoid a change in the quality of their environment. But, following our assumption, individuals do not believe this announcement. They imagine that environmental amenity could change even if the policy-maker proposes nothing because of natural process or as a result of human activities. Given this belief, they expect various events according a probability distribution, namely $P(q = q_1) = P\ (q = q_2) = 0.5$. We assume that these events occur around to the proposition and the expected value of these events is equal to the initial situation $E\left(\mu_1\right) = q_0$. To insure our result, we take three supports $(q_1, q_2) = \{(1.5; 0.5); (1.75; 0.25); (1.8; 0.20)\}$ which respect the assumption $E\left(\mu_1\right) = q_0 = 1$.

The bid design is $A = 0.5 * B$ (4; 0.5) − 1 to have 4 bids {−1; −0.5; 0; 0.5; 1}.

The following table presents our computation. We can observe that we find exactly the decomposition described in Fact 2 with $c = E\ (WTP_a) = 0$. As the policy-maker does not make an offer, it is intuitive to have the expected *WTP* without uncertainty equal to zero. Therefore, in this precise case, the expected risk premium is exactly the inverse of the true expected *WTP*: $E\ (WTP_i) = -E\ (\pi)$. Moreover, we can remark that we obtain $E\ (WTP_a) > \mathrm{E}\ (WTP_i)$. This gives information on what happens when the analyst ignores the uncertainty. He will overestimate the environmental value. The first result gives us the tendency of all experiments.

Table 1a. WTP expected value and risk premium expected value

	(1.5, 0.5)	(1.75, 0.25)	(1.8, 0.20)
$E\ (WTP_i)$	-0.287	-0.826	-1.021
$E\ (\pi)$	0.287	0.826	1.021
c	0	0	0
	0	0	0
Results	$E\ (WTP_a) > \mathrm{E}\ (WTP_i)$		

Now, let us observe the estimation results. As consequence of our status quo assumption, $\ln(E(\mu_1)) - \ln(q_0) = 0$ and therefore there is no value for parameter β_2.

Table 1b. WTP expected value and risk premium expected value

	(1.5, 0.5)	(1.75, 0.25)	(1.8, 0.20)
Mean($\hat{\beta}_1$)	1.002	0.883	0.815
Min($\hat{\beta}_1$)	0.544** (4.3)*	0.401** (3.20)*	0.339** (2.71)*
Max($\hat{\beta}_1$)	1.386** (9.76)*	1.21 (8.78)*	1.107 (8.17)*
Var($\hat{\beta}_1$)	0.14	0.13	0.13

Notes: *T-statistic significant at level 5%. ** Significant from our value $\beta_1 = 1$.

Using these results, we can compare the distribution of WTP given by the true parameters with the one of WTP obtained from estimated parameters. The following figures repreent both cumulative density[3]. These figures shows the probability to accept distribution according our various supports.

[1] This peculiar assumption relies on the idea that the agents believe the proposal of the policy-maker at least in expectation.

[2] All results come from the freeware of Russell Davidson *ects version* 3.3 (http://russell-davidson.arts.mcgill.ca/ects3/).

[3] We use the average parameter to draw the graph; it is quite representative because of its little variance.

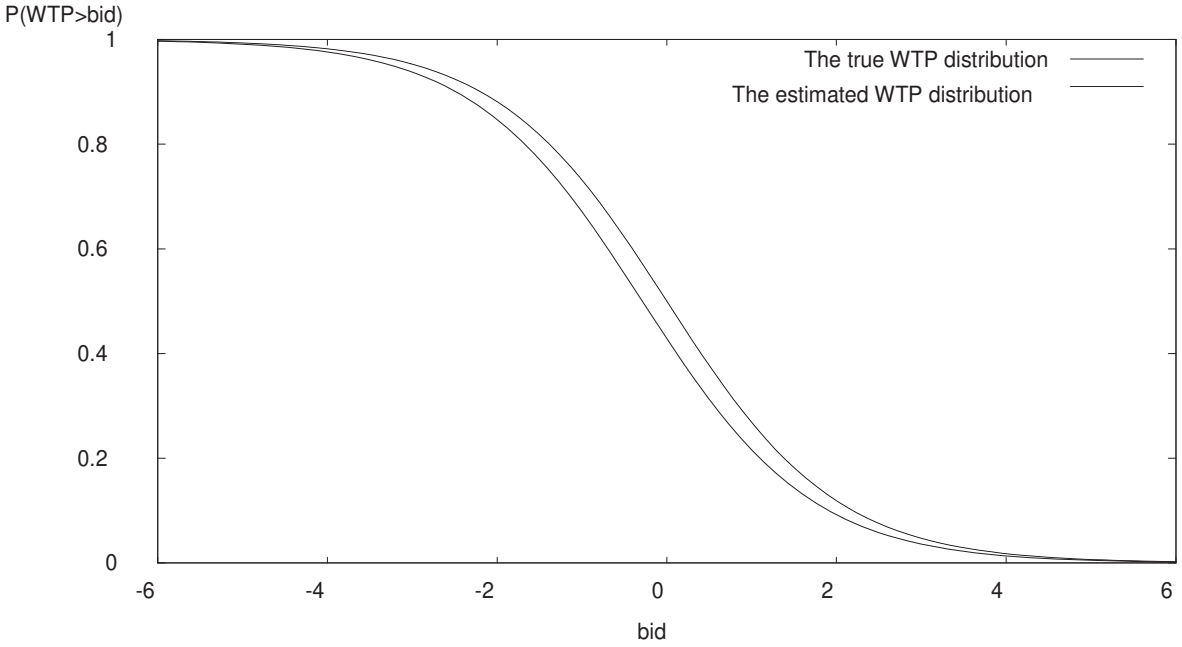

Fig. 1. Probability to accept with the first support

On Figure 1, both curves have the same shape and are very close. However, we observe that the distribution of the estimated WTP dominates stochastically at first order the distribution of the true *WTP*: $P(WTP_a > \text{bid}) > P(WTP_i > \text{bid})$ $FWTP_a(\text{bid}) < FWTP_i(\text{bid})$. Therefore, $E(WTP_a) > E(WTP_i)$.

On the two last figures, this result is always verified and the difference between both curves increasing. This is due to a greater slope of the true WTP distribution. When the bid rises up, the probability that an individual accepts the offer decreases faster.

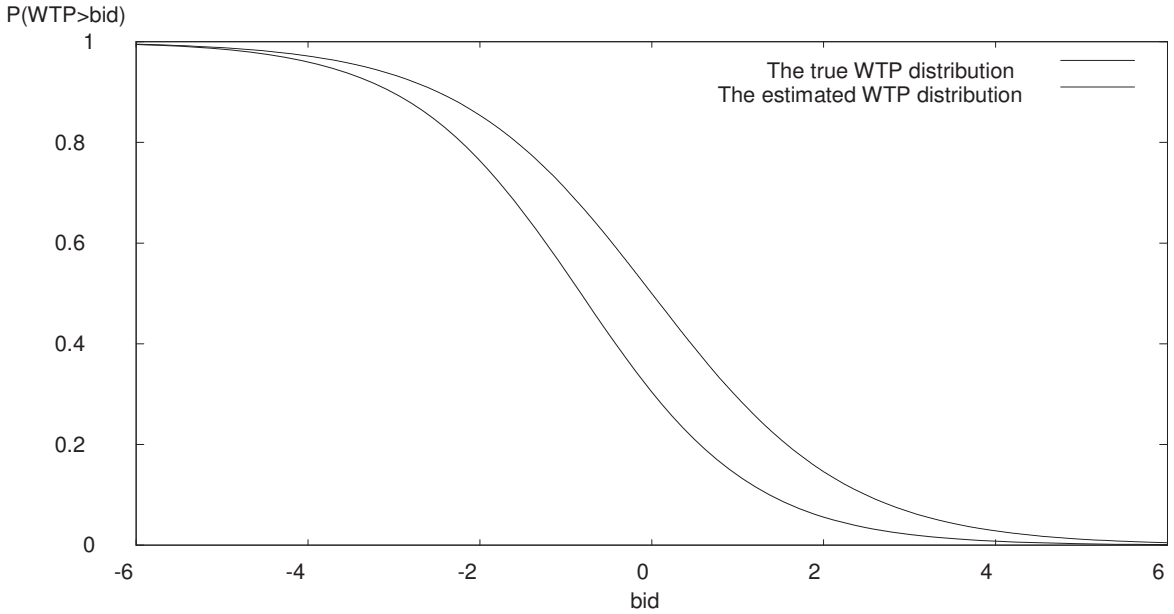

Fig. 2. Probability to accept with the second support

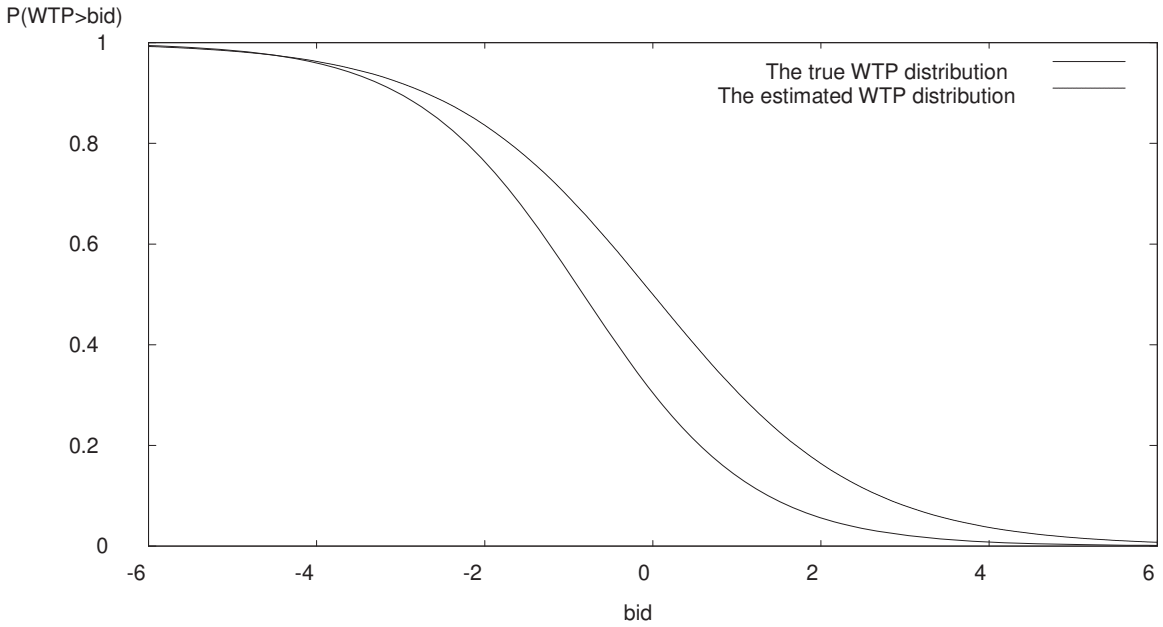

Fig. 3. Probability to accept with the third support

From these three cases, we can make three observations:

1. We notice that our intuition is verified by the simulation and this later confirms our theoretical remark 2. Indeed, we find that $E(WTP_i) + E(\pi) = \frac{\beta_2 \ln(E(\mu_1))}{\beta_1}$. This numerical illustration sets forth that the expected WTP with uncertainty adds up to the expected WTP without uncertainty lower an expected risk premium. Ignoring respondent uncertainty leads the analyst to overestimate the environmental value.
2. $E(WTP_i)$ is negative. In average, individuals are not willing to pay any amount. We remind ourselves that, given $q_0 < q_1$, when we obtain a positive value, it is a WTP and a negative value gives a WTA. When the proposed scenario is an improvement, it is intuitive to ask individuals for their WTP, however, in a risky context, if they are risk-averse, it is intuitive that individuals do not want to pay for a change. As we assume a concave utility function, our population is risk-averse and they have a WTA. This result leads us to conclude that the proposed bids may be inappropriate.
3. Observe the risk premium. It increases when the variance of the support $(q_1; q_2)$ increases. Observing the distributions, we see that both curves are quite more separated. The more the individuals envisage scattered values, the more the risk premium is important. It is also intuitive because the variability of payoffs increases the risk premium.

This benchmark case allows us to confirm our theoretical observation. When individuals have some doubts on the outcome policy, the risk premium affects the valuation of the amenity. In this particular case, we can also say that the value of WTP without taking in account this uncertainty is overestimated.

Simulation 2. Now, let us observe what happens when we give up our first assumption on the status quo. Imagine that the analyst wants to know how much individuals are willing to pay for an improvement, namely to change from the initial situation $q_0 = 1$ to $q_1 = 2$. However, individuals imagine different possible outcomes because of their doubts toward the policy-maker. So, here, the finite support is fixed by taking {1; 3}. Individuals believe they can stay at the initial situation or have much better than the announcement for a probability distribution $P(q = q_1) = P(q = q_2) = 0.5$ and the expected value is equal to the proposition $E(\mu_1) = 2$. To do this computation, we have to make an adjustment on the bid design, the linear transformation is $A = 0.5 * B(4, 0.5) - 0.5 = \{-0.5, 0, 0.5, 1, 1.5\}$ to fit with the new distribution of the true WTP. Contrary to the first one, as we give up the status quo assumption, we are going to estimate the constant $\beta_2 \ln(E(\mu_1))$. First, let us observe what happens on the following figure.

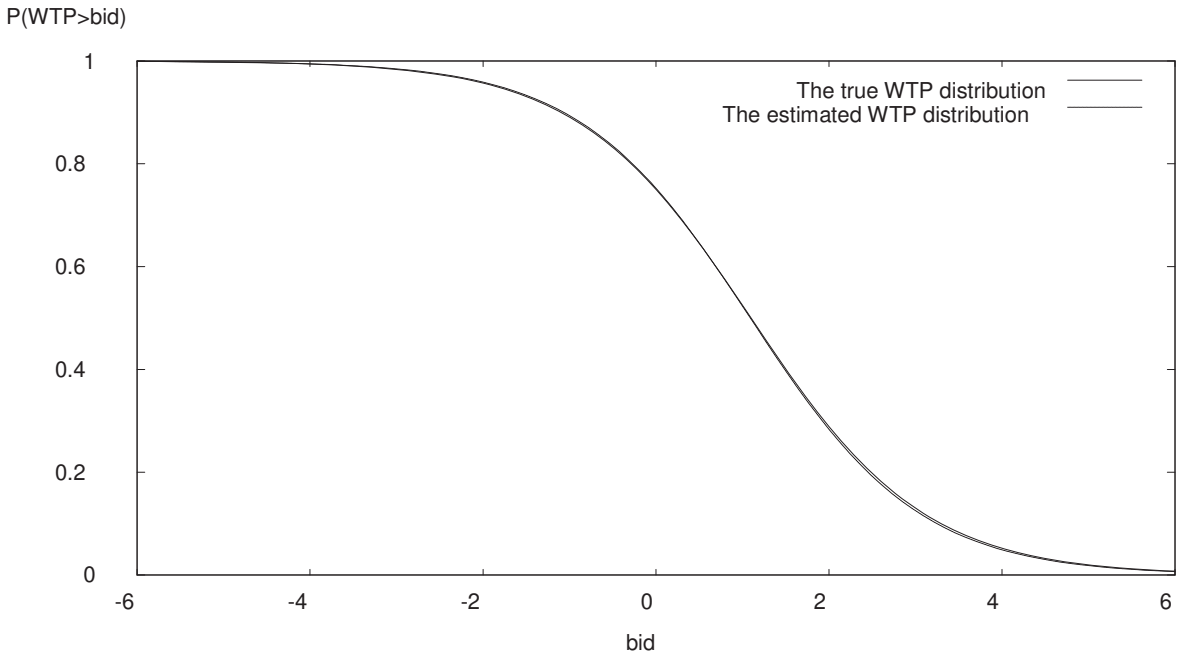

Fig. 4. Probability to accept with improvement on environment variable

This figure shows us that both curves are merged. Therefore, *a priori*, the true model and the mispecified model yield the same WTP distribution. This is explained by a perusal of the following results. Table 2a gives us the expected value of both WTP and the risk premium and Table 2b gives us estimates results.

Table 2a. Expected value of both WTP and risk premium

	$(q_1, q_2) = (1, 3)$
$E(WTP_i)$	1.0986
$E(\pi)$	0.2876
$E(WTP_a)$	1.089
Results	$E(WTP_a) \approx E(WTP_i)$

Table 2b. Estimates results

Mean(β_1)	1.019
Min(β_1)	0.705* (5.29)
Max(β_1)	1.39* (9.56)
Var(β_1)	0.138
Mean(β_2)	1.602
Min(β_2)	1.14** (8.14)
Max(β_2)	1.99 (12.2)
Var(β_2)	0.15

Notes: *significatively different from β_1, **significatively different from β_2.

As we can expect it from the figure, both the expected value $E(WTPa)$ and $E(WTP_i)$ are quite similar and $E(\pi)$ is positive. Therefore, we no longer have not the decomposition highlighting in the Fact 2 anymore. However, we can find an explanation by focusing on the econometric model. Indeed, if we observe the estimates, we remark that the parameter mean (β_1) is not significantly different from our true value but mean (β_2) is. In the context of our experiment, the constant $mean(\beta_2) * \ln(E(\mu_1))$ is crucial because of our linear model in income. In fact, this constant captures the risk premium and as all agents are homogenous, they have the same risk premium. So, this constant is identical for each individual and, therefore, can enter the estimation. To be convinced, we compare the probability to accept $P(WTP_a \geq A)$ the other one $P(WTP_i \geq A)$. The former can be written in the following form:

$$F\left[-mean(\beta_1) * A + mean(\beta_2) * \ln(E(\mu_1))\right] = \\ = \frac{1}{1 + exp(1.019A - 1.602\ln(2))}$$

and the latter is also given by the followings form:

$$F\left[-\beta_1(E(\pi(\mu_1)) + A) + \beta_2 \, ln(E(\mu_1))\right] = \\ = \frac{1}{1 + exp(A + 0.2876 - 2\ln(2))}.$$

If we focus our attention on both terms -1.602ln (2) = -1.11 and 0.2876-2ln (2) = -1.09, we remark that t is almost the same value. So, this simple simulation allows us to conclude that, in our experiment, the constant captures the risk premium. However, in the probability to accept, we succeed in putting forward its role. This experiment has been repeated with others supports and all tests reveal the same conclusion. Under our specific data, we cannot observe this role but the theoretical model highlights a risk of mis-specification of the model and, by knowing that in the real world, the risk premium would be heterogeneous, we can expect to have a real mis-specification of the true WTP distribution.

Conclusion and directions for future research

This paper was motivated by a simple intuition to say that people can be uncertain about the public program implementation because of their limited knowledge on the public good valuated. They imagine various events that imply an impact on their valuation. Using an expected utility-difference derived from a common indirect utility function, we have been allowed to decompose the expected WTP into an WTP in case of certainty and an expected risk premium. After having obtained this first theoretical specification, we focus our attention on the effect of this risk premium and we wanted to know if it has a really impact? To test this result, we perform a simple experiment to highlight the role of the risk premium. This experiment allows us to conclude that the risk premium lowers the WTP value in our benchmark case.

Such information is quite interesting for the design of the CV questionnaire. Indeed, analysts collect data from this questionnaire to discover the value placed on changes of a non-market good and explain individuals' responses. Therefore, it must be drawn to provide sufficient information and, in our case, precisely information on individual expected value of the outcome and the probability distribution. Whereas writing a questionnaire seems to be simple and trivial, the right formulation has to be found to provide sufficient information. From our point of view, information on individual expected value of the outcome and the probability distribution allows the analyst to identify people who have some doubts and others who believe the proposition. This distinction could be important in the sense that it could allow to fit better the estimation model and therefore to converge towards the true environmental value. Further resolving the role of individual uncertainty should be an important improvement in determining environmental policies.

To conclude, this study is a convenient suggestive starting point for more general empirical specifications. Indeed, our method for computing welfare measure is based on a simple logistic linear model but, according to the literature on various estimation models, we could extend and refine this method in specifying another model.

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