E C O N O M I C S B U L L E T I N

Does Uncertainty Affect the Divergence between WTP and WTA Measures?

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Abstract

Many empirical studies have demonstrated large discrepancies between willingness to accept (WTA) and willingness to pay (WTP) measures. This paper examines the extent to which uncertainty about the environmental quality improvement can lead to a divergence between WTP and WTA measures. Indirect utility function parameters and uncertainty about the environmental quality change affect the extent to which WTP and WTA measures can differ. These results have implications for design and implementation of contingent valuation surveys.

Citation: Isik, Murat, (2004) "Does Uncertainty Affect the Divergence between WTP and WTA Measures?." *Economics Bulletin*, Vol. 4, No. 1 pp. 1−7
Submitted: September 22, 2003. **Accepted:** January 5, 2004.
URL: http://www.economicsbulletin.com/2004/volume4/EB−03D80011A.pdf

1. Introduction

Many empirical studies in environmental and resource economics have demonstrated large discrepancies between the dollar value people are willing to accept in order to sell an item (WTA) and the dollar value they are willing to pay to purchase it (WTP) (Horowitz and McConnell, 2002). To date, various explanations have been provided for these observed discrepancies. Hanemann (1991) shows that the discrepancy between WTP and WTA depends on an income and a substitution effect. Hanemann (1991) concludes that if one private good is a perfect substitute with a public good, then WTP is equal to WTA. Thaler (1980) attributes the gap between WTP and WTA to an endowment effect, while Dubourg and Jones-Lee (1994) focus on the uncertainty over preferences. Horowitz and McConnell (2002) review several studies of WTP/WTA and find that the less the good is like an ordinary market good, the higher is the ratio of WTA/WTP. The ratio is highest for non-market goods, next highest for ordinary private goods, and lowest for experiments involving some forms of money.

Most treatments of WTP and WTA disparity assume that subjects have full information and there is no uncertainty about the value or characteristics of goods. Uncertainty may be particularly large for goods which incorporate stochastic elements such as insurance, where consumption does not imply direct knowledge of all the relevant outcomes. In the case of environmental amenities, judgments are made difficult by the fact that benefits may accrue over an extended period of time in uncertain future and often benefits are uncertain. Uncertainty and therefore the ratio of WTA/WTP may be high for non-market goods.

We suggest that when individuals face WTA or WTP decisions, the actual private value of an object or the environmental amenities they are asked to evaluate may be uncertain. Additionally, an important source of uncertainty is the lack of knowledge about the cost of an acceptable substitute and the difficulty of locating it. Thus, incomplete knowledge about prices effectively creates uncertainty. This is significant because such uncertainties have the potential to cause individuals to display a disparity between WTA and WTP. The disparity between WTA and WTP does tend to grow when it is difficult to estimate an object's value. In fact, a number of experimental studies show that uncertainty is likely to contribute to the gap between WTA and WTP (Horowitz and McConnell, 2002).

The purpose of this paper is to examine the extent to which uncertainty about the environmental quality improvement can lead to a discrepancy between WTP and WTA measures. The paper presents a general model to show how uncertainty about the environmental quality change and indirect utility function parameters affect the WTP and WTA measures. The results from this paper show that the indirect utility function parameters, uncertainty about the qualities of public goods, and risk aversion are likely to contribute to the divergence between WTP and WTA.

2. Theoretical Model

We assume that an agent's utility function is represented by $U(x, y, q)$, where x is a vector of the quantities of market goods, q is the qualities of public good (or environmental quality), and y is the income. The utility maximization problem is expressed as: $\underset{x}{Max}\ U(x, y, q)$ s.t. $px = y$, where p is the vector of prices. The solution to this problem leads to a set of demand function $x^* = x(p, y, q)$. The indirect utility function is then defined as $V(p, y, q) = U(x^*, y, q)$

with $V_q > 0$ and $V_y > 0$. We assume that the consumer is risk averse in q, i.e., $V_{qq} < 0$. It is also assumed that y and q are compliments in the indirect utility function, and therefore V_y increases with an increase in q ($V_{yq} > 0$). This assumption indicates that a high environmental quality enhances the marginal value of the income.

We define WTP as the maximum price in which the agent is willing to buy the good or pay for an environmental quality improvement and WTA as the minimum price at which the agent is willingly to sell the good or give up for the environmental improvement Δ. It is well known that the concepts of WTP and WTA can be derived from the Hicksian welfare measures of the compensating variation (*C*) and the equivalent variation (*T*) (Freeman, 2003). The compensating variation can be interpreted as the maximum willingness to pay. The Hicksian equivalent variation is defined as the minimum amount of money a household would require without a change in environmental quality.

2.1. WTP and WTA under Certainty

We first determine the compensating variation and the equivalent variation assuming that there is no uncertainty about Δ. We show that under certainty the compensating variation is equal to the equivalent variation if and only if the agent's indirect utility function is linear in both *y* and *q*. We derive the compensating variation (*C*) from $V(p, y, q) = V(p, y - C, q + \Delta)$. Using a second-order Taylor series approximation around C and Δ ($V(p, y - C, q + \Delta) \cong V(p, y, q) - CV_y + \Delta V_q - C\Delta V_{yq} + 0.5C^2 V_{yy} + 0.5\Delta^2 V_{qq}$) and assuming for simplicity that $V_{yy} = 0$, we obtain the compensating variation as: $C = \dfrac{\Delta V_q + 0.5\Delta^2 V_{qq}}{V_y + \Delta V_{qy}}$.

The equivalent variation is obtained from $V(p, y + T, q) = V(p, y, q + \Delta)$. Using a Taylor series approximation around T and Δ ($V(p, y, q) + TV_y \cong V(p, y, q) + \Delta V_q + 0.5\Delta^2 V_{qq}$), we acquire the equivalent variation as: $T = \dfrac{\Delta V_q + 0.5\Delta^2 V_{qq}}{V_y}$. Thus, if the indirect utility function is linear in both *y* and *q* ($V_{qq} = V_{yy} = V_{yq} = 0$), the compensating variation is equal to the equivalent variation ($C = T = \dfrac{\Delta V_q}{V_y}$).

2.2. Impact of Uncertainty on WTP and WTA

We now identify the factors influencing the compensating variation and the equivalent variation under uncertainty. Assume that the environmental quality improvement Δ is a random variable with the mean $\overline{\Delta}$ and variance d. The compensating variation is derived from $V(p, y, q) = EV(p, y - C, q + \Delta)$, where E is the expectation operator defined over Δ. The equivalent variation is acquired from $V(p, y + T, q) = EV(p, y, q + \Delta)$.

Proposition 1: Under uncertainty about the environmental quality improvement, the compensating variation is higher than the equivalent variation. The discrepancy between the compensating variation and the equivalent variation increases with an increase in the degree of uncertainty and the agent's risk aversion.

Proof: We derive the compensating variation (*C*) from $V(p,y,q)=EV(p,y-C,q+\Delta)$, where $EV(p,y-C,q+\Delta)=V(p,y-C-R^C,q+\overline{\Delta})$ and R^C is the risk premium. The risk premium is the amount of money that an individual is willingly to pay to avoid uncertainty about Δ and get the expected value of the environmental quality improvement $\overline{\Delta}$ for sure. The equivalent variation (*T*) is determined using $V(p,y+T-R^T,q)=V(p,y,q+\overline{\Delta})$, where R^T is the risk premium for the equivalent variation. Using a second-order Taylor series approximation, the compensating variation is obtained as: $C=\dfrac{\overline{\Delta}V_q+0.5\overline{\Delta}^2V_{qq}}{V_y+\overline{\Delta}V_{qy}}-R^C$. The equivalent variation is given by: $T=\dfrac{\overline{\Delta}V_q+0.5\overline{\Delta}^2V_{qq}}{V_y}+R^T$.

The risk premium for the compensating variation (R^C) is acquired from $EV(p,y-C,q+\Delta)=V(p,y-C-R^C,q+\overline{\Delta})$. Note that $V(p,y-C,q+\Delta)\cong V(p,y-C,q+\overline{\Delta})$ $+(\Delta-\overline{\Delta})V_q+\frac{1}{2}(\Delta-\overline{\Delta})^2V_{qq}$ and $V(p,y-C-R^C,q+\overline{\Delta})\cong V(p,y-C,q+\overline{\Delta})-RV_y$. Taking expectation and re-arranging the terms lead to the risk premium: $R^C=\dfrac{-d}{2}\dfrac{V_{qq}}{V_y}>0$. Similarly, the risk premium for the equivalent variation (R^T) is obtained from $V(p,y+T-R^T,q)=EV(p,y,q+\Delta)$ as: $R^T=\dfrac{-d}{2}\dfrac{V_{qq}}{V_y}>0$. The term $\dfrac{-V_{qq}}{V_y}$ can be considered as the agent's risk aversion in *q* toward uncertainty about Δ. The risk aversion is positively related to the risk premium.

The compensating variation with the risk premium is:

$$C=\frac{\overline{\Delta}V_q+0.5\overline{\Delta}^2V_{qq}}{V_y+\overline{\Delta}V_{qy}}+\frac{d}{2}\frac{V_{qq}}{V_y}. \qquad (1)$$

Equation (1) indicates that an increase in the degree of uncertainty about Δ (d) and risk aversion in *q* decreases the compensating variation. The equivalent variation is given by:

$$T=\frac{\overline{\Delta}V_q+0.5\overline{\Delta}^2V_{qq}}{V_y}-\frac{d}{2}\frac{V_{qq}}{V_y}. \qquad (2)$$

Equation (2) shows that the uncertainty about Δ and the degree of risk aversion are positively related to the equivalent variation. Note that the equivalent variation in (2) is always higher than the compensating variation in (1) [1].

[1] The assumption that $V_{yy}=0$ and $V_{yq}>0$ are not required for Proposition 1 to hold. When $V_{yy}\neq 0$, the compensating variation and the equivalent variation can be derived from a quadratic equation.

The discrepancy between the equivalent variation and the compensating variation is positively related to the uncertainty about Δ (d) and risk aversion ($\frac{-V_{qq}}{V_y}$). An increase in d reduces C and increases T, which results in an increase in the difference between the equivalent variation and the compensating variation. The divergence between the equivalent variation and the compensating variation also increases with an increase in the degree of risk aversion. If the indirect utility function is linear in both y and q (i.e., $V_{qq} = V_{yy} = V_{yq} = 0$), uncertainty about Δ does not have any impact on the compensating variation and the equivalent variation, and therefore WTP is equal to WTA.

3. Numerical Simulation

We now provide a numerical example using a constant elasticity of substitution model, which generates an indirect utility function of the form $V(p, y, q) = \left[y^{1-x} + K(p)q^{1-x}\right]^{1/(1-x)}$, where x is the price flexibility of income and $K(p) > 0$, which is homogenous of degree $1-x$ (Hanemann, 1991). Table 1 presents the estimated compensating variation and the equivalent variation measures for various values of K and x, for the cases where q=1 and $\overline{\Delta} = 2$. The results obtained under certainty replicate those of Hanemann (1991). Two alternative coefficients of variation of Δ, 30% and 60%, are used to represent the uncertainty about Δ. The results show that as the degree of uncertainty increases, WTP decreases while WTA increases, thereby increasing the discrepancy between WTA and WTP. Thus, in the presence of uncertainty about Δ, the difference between WTP and WTA significantly increases. These results extend those of Hanemann (1991) by showing that the ratio of WTA/WTP augments with an increase in uncertainty about the environmental quality change. When $x = 0$ (i.e., no substitution effect), y=100 and $K(p) = 1$, WTP is equal to WTA under both certainty and uncertainty (WTP=WTA=2).

4. Conclusions

This paper examines the extent to which uncertainty about the environmental quality improvement can cause the observed discrepancies between WTP and WTA measures. The paper provides an alternative explanation for the observed WTP and WTA discrepancies. The results show that the indirect utility function parameters and uncertainty associated with the environmental quality are likely to contribute to the observed discrepancies between WTP and WTA.

The results have implications for design and implementation of contingent valuation surveys and for understanding the observed discrepancies between WTP and WTA. The WTP and WTA disparity identified in many contingent valuation surveys have been viewed as the evidence of the failure of the survey methods. It is believed that contingent valuation method is a flawed methodology for measuring nonuse values (Diamond and Hausman, 1994). On the other hand, practitioners of contingent valuation methods recommend using the WTP format always for practical valuation surveys. The reason is that WTP is smaller than WTA in most contingent valuation surveys so that WTP is the conservative choice. However, large discrepancies between WTP and WTA should be expected from a theoretical point of view. Using WTP measures for all kinds of environmental changes implies a systematic underestimation of environmental damages.

The model developed in this paper may not explain all the factors affecting the WTP and WTA disparity. Experimental studies have shown that there are discrepancies between WTP and WTA even when the value and characteristics of goods are well defined (Kahneman, Knetsch, and Thaler, 1990; Knetsch and Sinden, 1984). There may be some cognitive issues that do not fit into an expected utility maximization framework. Future research should consider alternative models that can take into account uncertainty over preferences and effects of endowment, learning, and information. Experiments could also be used to study the empirical relevance of the findings of this paper.

Table 1. Impacts of Uncertainty on WTP and WTA Measures

Utility Function Parameters			WTP	WTA	WTA/WTP
x	*y*	**K(p)**			
Certainty					
14	**1**	**0.95**	5.0	25.9	5.17
1.01	**100**	**1.4**	79.6	402.6	5.06
0.677	**100**	**0.1**	2.9	3.0	1.02
Uncertainty: Coefficient of Variation=30%					
14	**1**	**0.95**	4.5	28.8	6.39
1.01	**100**	**1.4**	71.6	446.9	6.24
0.677	**100**	**0.1**	2.6	3.3	1.28
Uncertainty: Coefficient of Variation=60%					
14	**1**	**0.95**	3.6	35.0	9.71
1.01	**100**	**1.4**	57.3	543.5	9.48
0.677	**100**	**0.1**	2.1	4.1	1.94

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