THE EONOMIC BEHAVIOR OF CHARITABLE GIVING FOR QUALITY OF LIFE: THEORY OF PUBLIC GOOD AND UNCERTAINTY*

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Abstract

This paper analyzes the effects of changes in uncertainty for various types of changes in cumulative distribution function using alternative impure public good model of charity that encompasses the traditional pure public good model of charitable contributions. Uncertainty is introduced into the public nature of the charitable contributions by others. This paper also examines the impact of an increase in risk aversion on individual's own charitable contributions. We show that the comparative statics effects of the mean of the distribution and mean-preserving spreads of the distribution on an individual's own charitable contributions depend on the normality of consumption and the monotonicity of the index of absolute risk aversion.

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1. Introduction

One has the general prediction that an increase in the public nature of the charitable contributions by others induces more free-riding behavior. However, under some conditions on risk preferences, the introduction of uncertainty into the public nature of the charitable provisions by others can ameliorate the collective action problems. This paper shows this situation by introducing both uncertainty and impure public good model of charitable contributions.

There have been interested in analyzing the "free riding" effects on the charitable contributions by others as one of important topics in the theory of public good. Most of previous studies have carried out charity as a pure public good in the context of a traditional pure public good model receiving utility without exclusion from charity supported by the contributions of all individual. One of the examples of voluntary provision of public goods is charitable contributions – denotations to public radio and television, aid for local, national and international disaster victims or poor peoples, or volunteer activity for community. In particular, researchers have introduced uncertainty into the traditional model and investigated the impact of various kinds of uncertainty to state that individuals voluntarily contribute to public good with the theoretical prediction of free-riding behavior. For example, uncertainty may enter the contributions of others to the provision of the public good, the response of others to an individual's own public-good contribution, the price of the public good, production technology, or income or endowment of the contributors.

Specifically, Austen-Smith (1980) examined the effect on an individual's public good provision of uncertainty about other individuals' contributions and showed that an individual is more apt to increase his provision of the public good in the presence of such uncertainty, given risk aversion. Sandler, et al., (1987) and Shogren (1987) introduced uncertainty about the amount of spillovers and provided that the comparative-statics effects of uncertainty depend on the signs of third-order derivatives of utility, rather than on simple risk aversion. Sandler, et al. (1987) also extended the analysis of the effects of uncertainty to the case of non-Nash conjectures and showed that, with such conjectures, the effect of increased uncertainty about others' contributions is theoretically ambiguous. However, Shogren (1990) established a condition of an individual's attitude towards increased uncertainty as to others' non-Nash responses that is sufficient to ensure that the individual's contribution rises, thereby reducing free-riding behavior. Gradstein et al. (1993) analyzed the effect of on the private provision of real or nominal commitments toward purchase of public good facing price uncertainty of the public good. The framework of these papers is based on the traditional pure public good model. In various types of uncertainty, their result depends on different assumptions on risk preferences describing the convex of the marginal utility function, decreasing absolute risk aversion, the degree of risk aversion, and other conditions.

This paper examines the effect on the charitable contribution in the theory of public good under uncertainty along two respects. First, we present the impure public good introduced by Feldstein (1980) incorporating uncertainty into the public nature of provisions of others that is considerably more realistic than the pure public good model used in previous studies of this kind. The model used in this paper emphases that an individual obtains greater utility from own charitable contributions than the contributions of others. Second, we provide the comparative statics effects of three families of changes in the initial cumulative distribution functions, rather than limit our analysis to the case of a single type of risk increase. We also present the effect of an increase in risk aversion. Hence, this paper extends the previous studies to a framework with more realistic specifications of both the model and increased uncertainty. This analysis is sufficiently general to encompass most previous finds as special cases, and enables us to broaden the circumstances under which increased uncertainty lessens free-riding behavior.

In the next section, we set out a model of an individual's charitable contribution and describe the definitions of changes in the cumulative distribution function. Section 3 derives the comparative-statics effects of increased uncertainty on an individual's contribution under Nash conjectures. Finally, section 4 provides a summary of our main results.

2. The Model and Definitions

Following the framework provided by Feldstein (1980), we generalize the traditional pure public good model by allowing for the public nature of the provisions by others and by incorporating uncertainty. In this model, the degree of publicness of public good φ, weighted on charitable contributions of other individuals is uncertain. This implies that the substitutability of the charitable contributions by other individuals for the impure public good is weighted on charitable contributions. Each individual from a group size n consumes private consumption with numeraire good c^i and the total quantity of charitable good Q composed of the i-th individual's charitable contribution q^i and the overall level of contributions $Q^j = \varphi\sum_{j\neq i}^{n} q^j$ of the $n-1$ other individuals, where $0 < \varphi < 1$, so that $Q = Q^j + q^i = \varphi Q + (1-\varphi)q^i$. Thus, the random variable φ can be interpreted as indicating the (constant) marginal product of other individuals' contributions to the overall level of charitable contributions and an individual considers his charitable contribution as being more weight than the contributions by others.

When $\varphi = 0$, we have a private good model in which Q is a private good. On the other hand, when $\varphi = 1$, we have a pure public good model in which Q is a pure public good.

We assume that a von Neumann-Morgenstern utility function $U^i(c^i, Q)$ is continuous, increasing and strictly concave (implying risk aversion) in both c^i and Q, and at least three times differentiable and the i-th individual has income which divided between consumptions on the private good and contributions to the impure public good. The i-th individual's budget constraint is written

(1) $$c^i + pq^i = Y^i,$$

where Y^i is the i-th individual's income, and p is the per-unit price of the impure public good.

The i-th individual therefore chooses q^i to maximize

(2) $$V^i(c^i, q^i) = \int U^i(Y^i - pq^i, q^i + \varphi \sum_{j \neq i}^{n} q^j) dF(\varphi; \gamma),$$

where $F(\varphi;\gamma)$ is the cumulative distribution function (CDF) for φ, indexed by an exogenous parameter γ, with a support contained in the interval [0, 1]. Increases in the index γ change the CDF $F(\varphi;\gamma)$. Without loss of generality and for notational simplicity, we henceforth suppress subscripts indexing the i-th individual. The first-order and second-order conditions for an individual optimum with respect to q^i , respectively, are

(3) $$V_q = E\{-pU_c + U_Q[1 + \varphi \sum (dq^j / dq^i)^e\} = 0$$

and

(4) $$V_{qq} = E\{p^2 U_{cc} - 2p[1 + \varphi \sum (dq^j / dq^i)^e] U_{cQ} + [1 + \varphi \sum (dq^j / dq^i)^e]^2 U_{QQ}\} < 0,$$

where the superscript 'e' denotes the individual's conjecture of changes in the charitable contributions by others in response to a change in his own contribution level, and where subscripts denote partial derivatives. When the price of the public good p is random, this model is similar to the case of price uncertainty in a game-theoretic, Nash equilibrium model analyzed by Gradstein, et al. (1993). When the degree of publicness of other individuals' charitable contributions is certain with $\varphi=1$ and the charitable contributions of others are uncertain, this model is similar to the case examined by Sandler, et al. (1987).

We are interested in three families in cumulative distribution function; first-order stochastic dominant (FSD) shift, mean-preserving spread (MPS) shift, and second-order stochastic dominant (SSD) shift. With reference to φ as random variable, we have three definitions of families in cumulative distribution function;

Definition 1: $G(\varphi)$ is first-order stochastically dominant $F(\varphi)$ if and only if $G(\varphi)-F(\varphi)\leq 0$, for all $\varphi\in[0,1]$.

The distribution $G(\varphi)$ is generated from $F(\varphi)$ by carrying out rightward shifts of probability mass. The FSD shifts, which involve a rightwards shift in the distribution of the random variable φ can be interpreted as indicating the effects of increases in φ or increases in the mean value of φ in a particular manner.

Definition 2: $F(\varphi)$ is second-order stochastically dominant $G(\varphi)$ if and only if $\int_a^t [G(\varphi)-F(\varphi)]\,d\varphi \geq 0$, for all $t\in[0,1]$.

The distribution $F(\varphi)$ differs from $G(\varphi)$ implying mean-increasing and mean preserving reductions in spread of distribution of φ. The SSD shifts can be interpreted as describing the effects of increases in mean φ accompanied by reduction risk.

Rothschild and Stiglitz (1970) proposed a definition of ‘increased risk’ which leads to the definition of a mean preserving spread (MPS): a random variable *Y* is riskier if it has more weight in the tails than a random variable *X*. This definition is well-known as ‘integral conditions’ being the restrictions imposed on the difference between two cumulative distribution functions. Rothschild and Stiglitz provided a general definition of an ‘increase in risk’ in the following:

Definition 3: $G(\varphi)$ is said to be riskier than $F(\varphi)$ in the Rothschild-Stiglitz (R-S) sense if and only if

(a) $\int_0^1 [G(\varphi) - F(\varphi;)]\,d\varphi = 0$

(b) $\int_0^t [G(\varphi) - F(\varphi)]\,d\varphi \geq 0$, for all $t \in [0,1]$.

The distribution $G(\varphi)$ differs from $F(\varphi)$ implying mean preserving spreads in the distribution of φ. Condition (a) means that CDF’s $F(\varphi)$ and $F(\varphi)$ have the same mean. Condition (b) is the SSD condition used in definition 2. The MPS (or R-S increases in risk) is a shift of probability mass when probability is moved from the center of the distribution to the tails without affecting the mean. This implies that probability mass is taken from a certain set of points and redistributed to points to the left and the right in such a way that the mean value of the random variable is kept unchanged. An R-S increase in risk is a special case of SSD change with equal means and also gives a partial ranking with the property of transitivity on a set of probability distributions.

3. Comparative Statics Analysis

We consider the case of Nash behavior where each individual contributes the amount q, taking as given the charitable contributions of the other $n-1$ individuals. In the Nash case, then, it is assumed that there are no strategic interactions among individuals, so that $\sum(dq^j/dq^i) = 0$, given identical individuals. With Nash conjectures, the first-order and second-order conditions for an individual optimum with respect to q can be rewritten

(3)′ $$V_q = E(-pU_c + U_Q) = 0 \text{ if } q^* > 0$$

(4)′ $$V_{qq} = E(p^2 U_{cc} - 2pU_{cQ} + U_{QQ}) < 0.$$

From (3)′, we derive the conditions whether the individual contributes to the charitable provision or not. Two extreme cases are given by a) individual never denotes the charitable contributions ($q^* \leq 0$) if $E(-pU_c + U_Q) < 0$, that is, when income decreases or the charitable contributions by others increase, and b) individual more denotes the charitable contributions ($q^* > 0$) if $E(-pU_c + U_Q) \geq 0$, that is, when income increases or the charitable contributions by others decrease.

3-1. The Certainty Case

Before considering the comparative statcis effect under uncertainty, in the case of certainty, we briefly examine the effects of an increase in income and in the charitable contributions by others on individual's own charitable contributions. To find these effects, under certainty, differentiating the first-order condition (3)′ with respect to Y and $\sum q^j$, setting $\sum q^j = 0$ and $dY = 0$, respectively and solving for dQ/dY and $dQ/d\sum q^j$, respectively, we obtain

(5) $$dQ/dY = dq/dY = (pU_{cc} - U_{cQ})/D$$

(6) $$dQ/d\sum q^j = 1 + dq^i/d\sum q^j = [(p^2U_{cc} - (2-\varphi)pU_{cQ} + (1-\varphi)U_{QQ}]/D,$$

where $D = (p^2U_{cc} - 2pU_{cQ} + U_{QQ}) < 0$ is the second-order condition for a maximum without uncertainty. In the pure public good model (when φ=1), assuming that p=1, the effect of an increase in the charitable contributions by others from (6) is identical to that of an increase in income from (5). On the other hand, in this model, since the charitable contributions by others are discounted by φ, i.e, 0 < φ < 1, the effect of an increase in charitable contributions by others from (6) is greater than that of an increase in income from (5), given the normality of a private consumption.

To analyze the effect of an increase in income and in the charitable contributions by others on optimal contributions, from (5) and (6), we obtain $dq/dY = (pU_{cc} - U_{cQ})/D$ and $dq^i/d\sum q^j = \varphi(pU_{cQ} - U_{QQ})/D$, respectively. Assuming that a private consumption is normal, since 0 < φ < 1, so that $(pU_{cc} - U_{cQ}) < 0$ and $(pU_{cQ} - U_{QQ}) > 0$. Thus, an individual increases the charitable contributions with income and decreases the charitable contributions with the contributions by others. An increase in the charitable contributions by others causes an individual to raise the free-riding behavior. This implies that income and the charitable contributions by others are substitutes in the sense of the effect on optimal contributions.

Next the effect on the charitable contributions of an increase in publicness of the charitable contributions by others is found by totally differentiating the first-order condition (3)′ without uncertainty with respect to φ. This gives

(7) $$dq/d\varphi = \sum q^j (pU_{cQ} - U_{QQ})/D.$$

Again, assuming that a private consumption is normal, so that $(pU_{cQ} - U_{QQ}) > 0$, thus $dq/d\varphi < 0$. This implies that an increase in the public nature of others' contributions induces more free-riding behavior under the case of certainty, since φ plays a role in dampening the importance of others' provisions.

3-2. The Uncertainty Case

Now we analyze the comparative-statics effects of an increase in uncertainty about public nature of others' contributions on individual's charitable contributions. Totally differentiating the first-order condition $(3)'$ with respect to γ, we obtain

$$\frac{\partial q}{\partial \gamma} = -\frac{\int(-pU_c + U_Q)dF_\gamma}{\int(p^2 U_{cc} - 2pU_{cQ} + U_{QQ})dF}. \tag{8}$$

The sign of left-hand side of (8) depends on the sign of numerator in right-hand side of (8) since the denominator of (8) is negative with $V_{qq} < 0$ by the second-order condition for a utility maximum $(4)'$.

1) FSD Shifts

We first consider the effect of a first-order stochastically dominating (FSD) shift on individual's own contributions. Integrating the numerator term in (8) by parts once, we obtain $\int(-pU_c + U_Q)dF_\gamma = -\int(-pU_{cQ} + U_{QQ})F_\gamma d\varphi$. From definition 1, following Machina (1983), for FSD shifts with respect to φ, since an increase in γ will induce an FSD shift in $F(\varphi;\gamma)$ if and only if $F_\gamma \leq 0$, for all φ, it follows that

$$sign(\frac{\partial q}{\partial FSD}) = sign[(-pU_{cQ} + U_{QQ})\sum q^j]. \tag{9}$$

Assuming c is normal, so that $(-pU_{cQ}+U_{QQ})$ < 0, we obtain $dq/dFSD$ < 0. This states that individual's own charitable contributions q decrease with FSD shifts in the distribution of public nature of others' contributions φ when a private consumption c is normal.

To express the sign of (9) in terms of index of risk aversion, we measure the marginal value of the random good Q in terms of the concept of the marginal rate of substitution $MRS_{c,Q}$ of Q for c. This gives $\overline{A}(c,Q)$ = $-(1/MRS_{c,Q})[\partial(MRS_{c,Q})/\partial Q]$ which, when expressed in terms of the derivatives of the utility function, gives $\overline{A}(c,Q)$ = $-U_{QQ}/U_Q+U_{Qc}/U_c$ = $-U_{QQ}/U_Q$ + $(U_Q/U_c)(U_{Qc}/U_Q)$. When evaluated at a optimum, where $p=U_Q/U_c$, we obtain the index of endogenous absolute risk aversion, $\overline{A}(Q)$ = $-U_{QQ}/U_Q+pU_{Qc}/U_Q$. Note that since $\partial(MRS_{c,Q})/\partial Q$ < (>) 0 characterizes whether good c is normal (inferior) then, by $\overline{A}(c,Q)$, we have $\overline{A}(Q)$ > 0 in the case of a normal good. From (9), using the index of $\overline{A}(Q)$, the term $(-pU_{cQ}+U_{QQ})$ can be expressed as $-\overline{A}(Q)$ and sign of $\overline{A}(Q)$ is negative when good c is normal. This also implies that individuals increase their free-riding on the charitable provisions by others indicating that an increase in the public nature of the charitable contributions by others reduces individual's own charitable contributions.

2) Increases in Risk

We now turn to the analysis of a mean-preserving spread of the distribution of φ about the public nature of others' charitable contributions. The appropriate concept of increased uncertainty for such an analysis is described by a Rothschild-Stiglitz (1970) spread in the distribution for φ, where the mean of this distribution is held constant but the probability weight in the tails of the distribution increases. To examine the effect of an increase in risk in Rothschild and Stiglitz sense, integrating the numerator term in (8) by parts twice and using the definition of an increase in risk proposed by Diamond and Stiglitz (1974), i.e., from definition 3, an increase in γ (the shift parameter) induces a mean preserving increase in risk if two conditions; (a) $\int_0^1 F_\gamma(\varphi,\gamma)d\varphi = 0$ and (b) $\int_0^s F_\gamma(\varphi,\gamma)d\varphi \geq 0$, $s \in [0,1]$, we obtain

(10) $$sign(\frac{\partial q}{\partial MPS}) = sign[(-pU_{cQQ} + U_{QQQ})(\sum q^j)^2].$$

To analyze this effect, consider the Arrow-Pratt index of absolute risk aversion,

(11) $$A(c,Q) = -U_{QQ}(c,Q)/U_Q(c,Q).$$

First of all, the Arrow-Pratt index of absolute risk aversion is denoted as simply $A(Q)$ to reflect the assumption of additive separability. When $U(c,Q)$ is additively separable in c and Q [i.e. $U_{cQ}(c,Q) = 0$] , if utility function exhibits decreasing absolute risk aversion (DARA) in the Arrow-Pratt index $A(Q) = -U_{QQ}/U_Q$ [i.e., $A_Q(Q) < 0$], from (10), the condition $U_{QQQ} > 0$, then the effect of a mean-preserving spread in the distribution for φ on individual's own charitable contributions q is positive. If utility function is not additively separable, we need plausible assumption on attitudes toward risk and state the following proposition:

Proposition 1: If the absolute risk aversion index $A(c,Q)$ is a decreasing (increasing) function of the total quantity of charitable contributions Q $[i.e., A_Q(c,Q) < (>) 0]$ and a private consumption c is normal (inferior), an individuals' own charitable contribution q increases (decreases) with a mean-preserving spread in the distribution for the public nature of others' contributions φ.

Proof: from (10), $(U_{QQQ} - pU_{cQQ}) = -U_Q(\partial A(c,Q)/\partial q) + A(c,Q)(pU_{cQ} - U_{QQ})$.

For the reference, we note that

$$\text{(12)} \qquad \frac{\partial A(c,Q)}{\partial q} = \frac{(pU_{cQQ} - U_{QQQ})U_Q - U_{QQ}(pU_{cQ} - U_{QQ})}{(U_Q)^2}.$$

Assuming that c is normal (inferior), so that $(pU_{cQ} - U_{QQ})$ > (<) 0, and that $\partial A(c,Q)/\partial q$ < (>) 0, thus, the term $(U_{QQQ} - pU_{cQQ})$ is positive (negative).

This proposition states that an increase in uncertainty about the public nature of contributions by others to the impure public good increases individual's own charitable contributions. This result implies that individuals reduce their free-riding on the charitable provisions by others.

3) SSD shifts

We investigate the effect of a second-order stochastic dominant (SSD) shift. From definition 2, following Machina (1983), an increase in γ will induce an SSD shift in $F(\varphi;\gamma)$ if and only if the two conditions; (a) $\int_0^1 F_\gamma(\varphi,\gamma)d\varphi < 0$ and (b) $\int_0^s F_\gamma(\varphi,\gamma)d\varphi < 0$, $s \in [0,1]$. To derive the effects of an SSD shift, integrating the numerator term of the right-hand side of (8) by parts twice and using $F_\gamma(0,\gamma) = F_\gamma(1,\gamma) = 0$, we obtain

$$\text{(13)} \qquad sign(\frac{\partial q}{\partial SSD}) = sign\{[(pU_{cQ} - U_{QQ})\sum q^j \int_0^\varphi F_\gamma(\delta,\gamma)d\delta]_1$$

$$+\int(-pU_{cQQ} + U_{QQQ})(\sum q^j)^2[\int_0^s F_\gamma(\delta,\gamma)d\delta]d\varphi\}.$$

Observe that, from (13), under (9) and $\int_0^1 F_\gamma(\varphi,\gamma)d\varphi < 0$, the first term on the right-hand side of (13) is negative. The first term effect indicating the effect of an increase in the mean of φ

induces to reduce the individual's own charitable provisions if a private consumption is normal. The second term in (13) is also negative under (10) and $\int_0^s F_\gamma(\varphi,\gamma)d\varphi < 0$.This second term effect representing the effect of the reduction in the spread of the distribution of φ also causes individual's own charitable contributions to decrease.

4) Changes in Risk aversion

We analyze the effects of changes in risk aversion by applying the fundamental Theorem 4 of Diamond and Stiglitz (1974, p. 349). In general, note that a more risk-averse individual has a less risky position. Consider that two utility functions U and Z. An increase in risk aversion is represented by replacing the utility function U with the transformation function $Z = \Phi(U;\theta)$, where an increase in the preference parameter θ indicates that the transformation function Φ is an increasing and more concave, thereby increasing the index of risk aversion. Thus, Z is greater risk averse than U. Following an application of Diamond and Stiglitz's Theorem 4, Proposition 2 demonstrates the effect of an increase in risk aversion on the individual's own charitable contributions.

Proposition 2: Let an increase in θ induce an increase in risk aversion. Then, under uncertain degree of publicness about charitable contributions by others, an individual's own charitable contribution increases with an increase in risk aversion; that is, $\partial q / \partial \theta > 0$.

Proof: For the utility function Z, the first-order condition is

(14) $$Z_q = E[(\Phi_U(U(\theta))(-pU_c + U_Q)] = 0.$$

Differentiating the first-order condition (14) with respect to the risk-aversion index θ, we obtain

(15) $$Z_{q\theta} = E\{[(\Phi_{U\theta}/\Phi_U) - (\Phi_{U\theta}(\varphi^*)/\Phi_U(\varphi^*))]\Phi_U(-pU_c + U_Q)\},$$

where $\Phi_{U\theta}(\varphi^*)/\Phi_U(\varphi^*)$ is evaluated at the public nature φ^* such that $[-pU_c(\varphi) + U_Q(\varphi)]$ is positive (negative) for φ < (>) φ^*, since $(-pU_c + U_Q)$ is a decreasing function of φ. Since increases in θ cause increases in risk aversion, $\partial^2 \ln\Phi_U / \partial\theta\partial U < 0$, as proposed by Diamond and Stiglitz (1974), implying that $[(\Phi_{U\theta}/\Phi_U) - (\Phi_{U\theta}(\varphi^*)/\Phi_U(\varphi^*))]$ is positive (negative) for φ < (>) φ^*. It follows that $Z_{q\theta} > 0$.

This proposition implies that a more risk-averse individual provides more charitable contributions than a less risk-averse individual. Moreover, following corollary of Diamond and Stiglitz (1974, p. 351), from (7), if, under certainty, individual's own charitable contribution decreases with the public nature of provision by others φ, individual's own charitable contribution increases with an increase in risk aversion.

4. Concluding Remarks

This paper has presented comparative statics effects about FSD shifts, R-S increases in risk, and SSD shifts on an individual's voluntary contribution to the supply of a charitable good. This paper also examined the effect of changes in risk aversion. These results are obtained for the Nash case in a single-agent model. Uncertainty is introduced into the degree of publicness of charitable contributions by others.

For the comparative statics effects, we show that the effects of the mean of the distribution and mean-preserving spreads of the distribution on an individual's own contribution to the charitable good depend on the normality of consumption and the monotonicity of the index of absolute risk aversion. Specifically, the effect of increased risk about the public nature of others' contributions on the individual's own charitable provisions is positive if the index of absolute risk aversion is decreasing and a private consumption is normal. We also find that under uncertain degree of public nature about charitable contributions by others, an individual's charitable contribution increases with an increase in risk aversion.

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