THE PRICE ELASTICITY OF CHARITABLE GIVING: ADDITIONAL EVIDENCE FROM PANEL DATA VIA THE EM ALGORITHM

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1. Introduction

A large body of literature has evolved regarding the sensitivity of charitable giving to changes in tax rates. Since charitable contributions can be deducted (by taxpayers who itemize deductions), a change in tax rates changes the "cost" of charitable giving. The net after-tax cost of a $100 contribution to an itemizer in the 40 percent tax bracket is only $60; if the marginal tax rate declines to 30 percent, the net cost to the taxpayer of that same $100 gift increases to $70. A large number of scholarly studies have suggested that, all else equal, taxpayers who itemize deductions will be less (more) generous as their marginal tax rates fall (rise).[1]

The confounding effects of change in tax rates on taxpayer incomes, unfortunately, complicate this issue. Charitable giving is also sensitive to changes in income level. Since a decrease in tax rates generally increases taxpayers' disposable incomes, the price effect of a change in tax rates on charitable giving will depend on the relative magnitudes of the price and income effects. If taxpayers are more sensitive to changes in price than to changes in income, decreased tax rates may result in decrease levels of charitable giving. If the income effect is more dominant, however, decreases tax rates may increase charitable giving.

In a prior study, Ricketts and Westfall (1993) analyzed individual taxpayer data from the University of Michigan/Ernst & Young individual taxpayer panel data set for the years 1979-1986, with results suggesting that the income elasticity of charitable giving is far more significant than the price elasticity. In fact, when used to predict contributions for a holdout sample of taxpayers based on changes in income and price from a prior year, the most reliable model assumed a price elasticity of zero for charitable contributions.[2]

In this study, we extend that analysis in two ways. First, we analyze data from a longer panel of tax returns, covering the period 1979 through 1990, allowing analysis of twelve years of data rather than only eight as used in the original study. Second, we use the expectation maximization (EM) algorithm to estimate the price and income elasticity of giving from a sample containing *all itemizers appearing in the UM/EY panel in one or more years*. This approach, which constitutes a significant departure from the practice of including only those taxpayers present in every year (i.e., a linked panel of taxpayers), increases our sample from approximately 673 to 21,396 taxpayers. Our results are consistent with those reported by Ricketts and Westfall (1993), yielding an estimated income elasticity of giving of about 1.0, as compared to an estimated price elasticity near zero. Moreover, these results are comparable to those derived from a similar analysis based on the linked panel sample of 673 taxpayers, suggesting that reliable estimates of taxpayer behavior can be derived from samples in which panel participants are not all present in each year of the period covered by the sample. In addition, including participants who are not present in the panel in all years may alleviate the potential "attrition bias" alluded to by Christian and Frischmann (1989). Our research methodology, and a summary of our results and conclusions, follows.

2. Research Method

2.1 Sample

The sample is drawn from the UM/EY Panel of Individual Taxpayers for the year 1979-1990. Following prior research, we restrict our sample to include only those taxpayers in a given year who itemized deductions, and for whom itemization was independent of the charitable contributions deduction. Moreover, taxpayers with negative disposable incomes were eliminated to accommodate a logarithmic transformation of the data. Unlike prior studies using the UM/EY panel data set, however, we do restrict our sample to those individuals present in each of the twelve years 1979 through 1990. Thus, our final sample consists of 21,396 individuals, yielding total 82,570 usable observations over the twelve-year panel period. Table 1 (on next page) summarizes the average participation of individuals in the sample over the 12-year period of study.

TABLE 1 Average Participation in the Sample			
Present in:	No. of Indiv.	Cumul. %	Usable Obs.
1-yr only	4,547	.21	4,547
2-yr only	3,316	.31	6,632
3-yr only	6,551	.67	19,653
4-yr only	1,012	.72	4,048
5-yr only	1,065	.77	5,325
6-yr only	863	.81	5,178
7-yr only	740	.85	5,180
8-yr only	872	.89	6,976
9-yr only	1,029	.93	9,261
10-yr only	314	.95	3,140
11-yr only	414	.97	4,554
all 12 yrs	673	1.00	8,076
Total size	21,396		82,570

2.2 Model

We use random coefficient regression (RCR) model to estimate the parameters of the following general model of charitable contributions:

$$ln(G_{i,t}) = a_i + b_{1i}ln(Y_{i,t}) + b_{2i}ln(P_{i,t}) + e_{i,t} \quad (1)$$

where the observable quantities are:

- i = taxpayer identifications, i = 1, 2, 3, ..., n (n = sample size);
- t = year, 1979-1990;
- $G_{i,t}$ = contributions reported by taxpayer i in year t, plus $10;
- $Y_{i,t}$ = disposable income for taxpayer i in year t; and
- $P_{i,t}$ = after-tax price of giving (first dollar) for taxpayer i in year t.

As in prior studies, we measure charitable contributions as reported current-year contributions plus $10. The figure includes both cash and noncash contributions made in the current year. Contribution carryovers from prior years are not included. The $10 adjustment accommodates the logarithmic transformation of this variable.

Disposal income is computed after tax, but before deductions for net partnership and rental losses, certain statutory adjustments (e.g., the IRA deduction, disability income exclusion, marital deduction when both spouses work, etc.), and itemized deductions, including charitable contributions. The reduction for taxes paid is computed as if no charitable contributions had been made.

Finally, the price variable used in this study is the after-tax price of the first dollar of charitable contributions made by an individual taxpayer. It is computed as the complement of the marginal tax rate faced by a taxpayer prior to claiming the contribution deduction.

2.3 The Random Coefficient Regression Model

As noted in Ricketts and Westfall (1993), the RCR model is uniquely suited for the analysis of panel data on individual taxpayer behavior because it allows the intercept term and the coefficients for both the income and price variable to vary across individuals. That is, the RCR model assumes that the parameters of the charitable giving model are stable across time for each individual in the sample, but vary across individuals in the sample. In effect, it allows each individual in the sample to have his or her own individual model of giving. The model thus estimates the *average* responsiveness of the individuals in the sample to variation in the independent variables of interest – income and price in this analysis.[3]

The RCR model is particularly appropriate for analysis of the relationship between charitable giving and changes in income and tax rates because it is known that other unmeasured variables are likely to significantly influence charitable giving. Religious affiliation, level of education, wealth, and other factors likely play major roles in individuals' decisions to give, yet information on these variables is not present in the sample data. Other analyses (e.g., Broman, 1989) have used a first-differences model to control for these variables, analyzing the difference in contributions between years as a function of differences in income level and price, under the assumption that factors such as wealth, religious affiliation, etc. do not change substantially. By effectively estimating separate contributions models for each individual in the sample, the RCR model similarly controls for differences across individuals in these unmeasured variables, while simultaneously making use of all the information provided by the panel for the entire period of study. The resulting estimates are thus more reliable than estimates based on first-differenced models or estimates based on models in which responses to changes in income or price are assumed constant across all individuals in the sample, regardless of religious affiliation, education level, etc.[4]

2.4 Estimation Using the EM Algorithm

An efficient method for estimating parameters in RCR models was developed by Swamy (1970). This method requires an entirely linked and balanced panel, and therefore wastes data and is subject to biases from the missing observations. Recent developments in statistical methodology and software have moved the

restriction to balanced data. As noted by Little (1995, p. 1112),

> "[The recent] analysis tools are valuable in that they incorporate all the available information in the data and can reduce or even eliminate the bias resulting from an analysis confined to the complete cases."

The most widely accepted method that is currently available for estimating the parameters of the RCR model, one that is not restricted to balanced data, is the maximum likelihood method. Statistical software available for implementing such estimation includes PROC MIXED of SAS/STAT® (SAS Institute, Inc. 1992); as well as BMDP-5V, GENMOD, HLM, ML3, and VARCL, reviewed by Kreft, de Leeuw, and van der Leeden (1994). To obtain the maximum likelihood estimates, the software packages commonly use either a Newton-Raphson iterative procedure, or a one based on the expectation-maximization (EM) algorithm. We found that, for the large data sets considered in this study, the Newton-Raphson method as implemented by PROC MIXED of SAS/STAT® was too memory-intensive.[5] We therefore programmed the estimation procedure ourselves in SAS/IML (SAS Institute Inc., 1989), using the EM algorithm of Lindstrom and Bates (1988) and the computing formulas provided by Laird, Lange and Stram (1987). The EM program can be found in Wu (1995) and the software is available freely upon request from the author.

3. Results

3.1 Static Model of Giving

We first report the estimates from a "static" model of giving as described in equation (1) previously. These estimates are derived from the full, unbalanced sample, consisting of 21,396 taxpayers present in any one or more years in the twelve-year panel period. The results are summarized in Table 2.

TABLE 2
Static Model Parameter Estimates
(n = 21,396 individuals)

	Full model	Income only	Price only	Ricketts/ Westfall (1993)
Const.	-3.91 (.1362)	-3.93 (.1243)	5.23 (.0178)	-3.14 (.3524)
$Ln(Y_t)$	0.94 (.0141)	0.94 (.0122)	--	0.93 (.0364)
$Ln(P_t)$	0.12 (.0469)	--	-1.35 (.0438)	0.96 (.0852)
R^2	.312	.249	.071	.469

(Standard errors in parentheses)

Table 2 compares the parameter estimates from the static model described in equation (1) to those previously reported by Ricketts and Westfall (19930 from a balanced panel of 1,418 taxpayers present in all eight years from 1979 through 1986. Also reported for comparison' s sake are the parameter estimates from two additional models applied to the unbalanced sample of 21,396 taxpayers: (1) a model including only the intercept and income terms; and (2) a model including only the intercept and price terms. R^2s reported in the Table represent the average R^2 values from the individual models estimated for each taxpayer in the sample panel.

Several points are noteworthy from Table 2. First, the estimated income elasticity of 0.94 is both statistically significant and consistent with the estimate derived from the eight-year panel and previously reported by Ricketts and Westfall (1993). Second, the estimated price elasticity of giving, though positive and statistically significant, is very near zero. Though still theoretically unjustified, this result is much more palatable than the 0.96 figure previously reported by Ricketts and Westfall (1993).[6] These results suggest that the price of giving is not an important determinant of charitable contributions, on average, for taxpayers in our sample.

Additional evidence that price is not an important factor in the giving decision for this is provided by a comparison of column 1 in Table 2 (full model) with columns 2 (income only) and 3 (price only). The results summarized in columns 2 suggest that the estimated income elasticity of giving be not affected when price is added to, or deleted from, the model. In contrast, adding the income variable to the price only model dramatically changes the estimated price elasticity of giving from −1.35 (consistent with prior "traditional" estimates) to +0.12. Including the income variable in the model also substantially reduces the statistical significance of the estimated price coefficient. Finally, note that the price variable alone explains very little of the variation in giving across years and taxpayers in this sample (avg. R^2 = .071), especially compared to either the income only model (avg. R^2 = .249) or the full model (avg. R^2 = .312).

3.2 Dynamic Model of Giving

Prior studies have argued that taxpayers take into account both the current and the future price of giving in making charitable contributions (e.g., see Barrett, 1991). For example, it is likely that in 1986, knowing that their tax rates were going to fall in the following year, many taxpayers may have accelerated planned 1987 contributions into December, 1986 (or earlier) so

as to receive greater tax benefits. Table 3 summarizes the parameter estimates derived from the following "dynamic" model of charitable giving:

$$ln(G_{i,t}) = a_i + b_{1i}ln(Y_{i,t}) + b_{2i}ln(P_{i,t}) + b_{3i}ln(P_{i,t+1}) + e_{i,t} \quad (2)$$

where $ln(P_{i,t+1})$ represents next year' s price of giving and the other variables are as defined in equation (1). In order to measure next year' s price of giving, taxpayers had to be present in at least two consecutive years. Taxpayers not meeting this criterion were deleted from the sample, reducing the sample size for purposes of fitting this model to 16,362 individuals (56,062 usable records).

Table 3 compares the results of our "dynamic" analysis to those results obtained from a static analysis based on the smaller sample of 16,362 taxpayers present in at least two consecutive years, and to the results previously reported by Ricketts and Westfall (1993) from analysis of a balanced panel consisting of 1,418 taxpayers present in eight consecutive years.[7] The results are generally supportive of the conclusions drawn from Table 2. The estimated income elasticity of giving is a statistically significant .99 and is unaffected by the addition of future price to the model. The estimated price elasticity of giving in the static model is not statistically distinguishable from zero. Unfortunately, it becomes significant, and has the "wrong" sign, when future price is added to the model. (Note that the future price coefficient also has the theoretically wrong sign). Both of these estimated price elasticities, however, are fairly close to zero.

TABLE 3
Dynamic Model Parameter Estimates
(n = 16,362 individuals)

	Dynamic model	Static model	Ricketts/ Westfall
Constant	-4.45	-4.41	-3.74
	(.1639)	(.1630)	(.7377)
$Ln(Y_t)$	0.99	0.99	0.96
	(.0167)	(.0167)	(.0696)
$Ln(P_t)$	0.17	0.06	0.31
	(.0599)	(.0552)	(.2385)
$Ln(P_{t+1})$	-0.20	--	0.40
	(.0511)		(.2516)
R^2	.483	.492	.149

(Standard errors in parentheses)

Also note that all parameter estimates are comparable in magnitude to those previously reported by Ricketts and Westfall (1993), though only the estimated income elasticity of giving was statistically significant in the prior analysis. In summary, none of the results are consistent with prior "traditional" estimates that price is more important than income in determining taxpayer contributions. To the contrary, our results suggest that price is not a particularly important factor for the average taxpayer.

3.3 Estimates from a "Balanced" 12-year Panel

Finally, we report parameter estimates derived from a balanced panel consisting of 673 itemizers present in all twelve years 1979 through 1990. These results are summarized in Table 4.

TABLE 4
Parameter Estimates – Balanced Panel Data Set
(n = 673 individuals)

	Static Model	Dynamic Model
Constant	-3.82	-3.68
	(0)	(0)
$Ln(Y_t)$	0.98	0.97
	(0)	(0)
$Ln(P_t)$	0.41	0.24
	(.0007)	(.0673)
$Ln(P_{t+1})$	--	0.33
		(.0078)
R^2	?	?

(Standard errors in parentheses)

The results summarized in Table 4 are generally consistent with those reported previously. The estimated income elasticity of giving is statistically significant and approximates 1.0 in magnitude in both the static and dynamic models, suggesting that charitable giving tends to move with income. In contrasts, the influence of price of giving is not statistically significant at the .05 level in the dynamic model. The estimated elasticity of giving to changes in future price is also significant, and has the theoretically expected sign, but appears to be far less important than income in determining the level of giving, at least for taxpayers in our sample.

3.4 Balanced vs. Unbalanced Panel Estimates

Comparison of the estimates reported in Table 4 with those reported in Table 2 and 3 not only strengthens the conclusions drawn previously, it also provides some evidence regarding the reliability of the estimates drawn from unbalanced panel data sets. This is important for at least two reasons. First, each addition of a year' s data to the panel reduces the number of taxpayers who can be "linked" across all years in the panel. Ricketts and Westfall (1993), for example, were able to link 1,418 itemizers present in the panel in each of the eight years from 1979 through 1986. Adding the years 1987 through 1990 to the panel reduces this

figure to only 673 itemizers present in all years represented in the panel. As more years are added to the panel data set, even fewer individuals will be fully represented in all years. Comparison of the results summarized in Tables 2, 3 and 4 suggests that reliable estimates of the elasticity of taxpayer behavior to changes in income level and tax rates can be derived from "unlinked" or "unbalanced" data sets, thus allowing researchers to analyze much larger data sets. This may become especially important as more years are added to the UM/EY panel data set.

Second, and equally important, is the question of attrition bias. Christian and Frischmann (1989) note that attrition in the panel data set can be ascribed primarily to three factors: (1) differences in the size of the sample drawn by the IRS each year due to change in budget constraints; (2) change in marital status as single filers become married and drop out of the sample; and (3) age, as some taxpayers die off, leaving the sample due to natural causes. Since the latter two factors, changes in age and marital status, influence the level of charitable giving (and perhaps other behavior), Christian and Frischmann suggest that attrition in the panel may lead to biased estimates of taxpayer sensitivity to changes in tax rates, income level, etc. Although use of unbalanced panel data does not entirely resolve this potential bias, by allowing taxpayers to remain in the sample even if they do not remain in the panel, it does alleviate this concern.

4. Summary and Concluding Remarks

The results of this study confirm prior estimates reported by Ricketts and Westfall (1993), and supported in much contemporary literature, that change in tax rates affect charitable giving by individuals primarily through their effects on after-tax income. On average, individuals charitable contributions appear to move ratably with changes in their after-tax incomes, whether the government "pitches in" 28 percent or 50 percent or somewhere in between. This is not suggest that the deductibility of charitable contributions does not influence charitability, merely that the rate at which the deduction reduces taxpayers' tax liabilities appears relatively unimportant, at least over the time period analyzed in this study.

These results also provide important methodological insights for future research. Although panel data of the type provided by the UM/EY Tax Research Center provide a much richer context within which to study taxpayer behavior than either cross-sectional micro-level data sets or longitudinal macro-level time series, the shrinking number of observations which can be "linked" as additional years are added to the panel creates potential problem for researchers. The result reported here suggest that reliable estimates of taxpayer elasticities can be derived from unbalanced panel data sets, thus allowing researchers to analyze much larger samples and potentially alleviating some of the attrition bias present in longitudinal panel data.

Footnotes

[1] See Clotfelter (1985) for a thorough review of these studies prior to 1985. See also Feenburg (1988) and Choe and Jeong (1993) for more recent analyses.

[2] See also Broman (1989), Christian and Boatsman (1990), Christian, et al. (1990), and Robinson (1990) for other studies questioning "traditional" estimates of the price elasticity of charitable giving.

[3] Gumpertz and Pantula (1989) show that where the time period covered by the panel is sufficient long, a simple average of the estimated coefficients derived from individual regression for each participant in the sample yields reliable estimates. Thus, where the time period is long enough, the parameters of the RCR model can be simply estimated by estimating separate models for each individual in the sample and averaging the estimated coefficients.

[4] See Ricketts and Westfall (1993) for a comparison of the RCR model to OLS and other models commonly used in analyzing longitudinal data, such as the seemingly unrelated regressions approach.

[5] See Wu, Westfall and Ricketts (1995) for comparisons between PROC MIXED procedure and the EM algorithm.

[6] Note the figure previously reported by Ricketts and Westfall became statistically insignificant when the model was expanded to include next year' s price of giving as well as this year' s. See Table 3 below for current parameter estimates from this so-called "dynamic" model of giving based on the twelve-year panel.

[7] The "dynamic" model estimates previously reported by Ricketts and Westfall were based on an analysis of only seven years of data. No measure of the next year' s price of giving was available for the eighth year in their data set.

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