AN ECONOMETRIC ANALYSIS OF CHARITABLE GIVING WITH INTERDEPENDENT PREFERENCES

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Many economists and social scientists have conjectured that individual gifts to charity may be interdependent. This paper explores empirically how an individual's charitable contributions may be affected by the giving of others in a "reference group" of similar individuals. We find modest evidence of interdependence of preferences through these reference groups, although the aggregate effects are not large. Hence, we conclude that the inferences from standard models, which ignore interdependence of preferences, are not likely to be misleading. (*JEL* H31, H41, D12)

"In practice we are in a situation ... where one's own [contribution] is expected to influence the [contributions] of others. ... *A* will expect that *B* and *C* may also be induced by his gifts to the same or similar objectives."

—Vickrey [1962, p. 40]

"The estimates ... provide no support for the view that the total amount that an individual contributes is a function of the amount that is given by others. Although these results are clearly not definitive evidence against the notion of such interdependence among individuals, we believe that the burden of proof now rests with those who support a theory of interdependent giving."

—Feldstein and Clotfelter [1976, p. 19]

I. INTRODUCTION

It is widely believed that one person's charitable contributions can be significantly influenced by the contributions of others. The National Survey of Philanthropy, for instance, indicates that a sizable fraction of the population believes that people "pay attention" to what others give when determining their own contribution.[1] Fundraisers also feel that large "leadership contributions" by wealthy individuals can be influential in encouraging more and larger contributions by others [Bakal 1979]. Moreover, interdependence among givers is central to social scientists outside of economics who study altruistic or charitable behavior. Psychologists, for instance, have learned that those who have recently witnessed an altruistic act are more likely to be altruistic, and that people will be more altruistic the more others contribute.[2] Sociologists studying reference groups have shown that choices individuals make often depend on the choices of others who are similar in age, education, social status, and other characteristics, and that such reference groups appear to be important in determining altruistic and charitable activity.[3]

Economic theorists have also made interdependent preferences the focus of their theoretical models of giving. In some of the earliest writing on philanthropy, Vickrey [1962] gives an extensive discussion of the role of

ABBREVIATION
CEX: Consumer Expenditure Survey

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1. The fraction ranges from around 30% for the lowest income group to 60% for the highest income group. See Morgan, Dye, Hybels [1979].

2. See Krebs [1970], Bryan and Test [1967], and Hornstein [1970].

3. For theoretical reviews on relative deprivation, see Williams [1975], and on social reference groups, see Gruder [1977]. For applications of these to altruistic activity, see Schwartz and Howard [1981].

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"neighborhood effects" on contributions. Formal models of altruism, beginning with Becker [1974], also assume any one contributor's choice depends on the contributions of all others, largely because of the public goods aspect of charity.[4] Other models have generalized Becker's approach to include impurely altruistic motives for giving, such as a desire for acclaim, status, or simply a "warm glow" from giving, where the impure altruism also depends on the contributions of others [Andreoni 1989, 1990]. Outside of the literature on charity, there is a long history, beginning with Duesenberry [1949], of economic models that assume the consumption choices of one agent are directly affected by the choices and characteristics of other agents.[5] Yitzhaki [1982], Stark [1990], and Stark and Yitzhaki [1988] have shown the importance of "relative deprivation" in understanding economic phenomena and, in related reasoning, Frank [1984, 1985a,b] has shown that there is a theoretical and empirical basis for assuming that individuals care about how their consumption ranks relative to some group of peers. In addition, Manski [1993a] has shown the importance of "role models" and "reference groups" in the study of dynamic choice.

Despite this emphasis on interdependent preferences elsewhere, the empirical literature on charitable giving has been unsuccessful at finding any empirical relevance of interdependence. Feldstein and Clotfelter [1976] are the only economists who have attempted to include variables to capture the interdependence of preferences. Their effort was unsuccessful. As a result, a large literature has developed in which equations for charitable contributions have been estimated without accounting for interdependence. This method has led to a consensus that the tax-price of charitable contributions and donor's income are both important in determining gifts. But other demographic variables have also been surprisingly important, especially age and education which tend to have positive coefficients. There is no compelling theory for why these later variables should be so important, hence their effects have been attributed to tastes or as proxies for unmeasured wealth or permanent income. Perhaps coincidently, these are also the same variables that other social scientists consider as relevant for interdependence and "social reference spaces."

It is not clear a priori how peer group or interdependence effects would be expected to affect charitable giving. In simple models of private giving to public goods, utility is typically defined over private consumption goods and total services of the public good. Increases in contributions to the public good by one person will lead to reductions in contributions by others. A similar phenomenon suggests that increased contributions by a family's reference group may reduce family contributions, leading to a negative interdependence effect. Andreoni [1988], however, shows that in large economies this effect is small, and thus would be expected to have little empirical relevance. The few references to interdependent preferences in the academic charitable contributions literature at least implicitly suggest that the expected effect is positive.

This paper attempts to include the effects of interdependent preferences in an empirical model of charitable giving. We do so by taking seriously the broader social science perspective of social reference spaces. We assume that contributions of any one person may depend on those who are similar to that person in age, education, and other characteristics. We examine the empirical importance of effects that span this social space by using a statistical technique first developed by geographers to account for effects that may span physical space. We find significant evidence of interdependence. Depending on our definition of the social reference space, our results indicate that if contributions of those in one's social reference space go up by an average of 10%, then we would predict one's own contribution should rise by about 2% to 3%. The effect of this interdependence is that a policy change that directly affects only a subset of the population, such as raising the top marginal tax rate, will have indirect effects on the entire space of givers. For instance, if people in person A's social reference space increase

4. Hochman and Rodgers [1969] discuss the implications of interdependent preferences on the structure of taxation in a model with no voluntary transfers and no free riding. For further analysis of Becker's model of voluntary transfers, see Cornes and Sandler [1984], Roberts [1984, 1987], Bergstrom, Blume and Varian [1986], and Andreoni [1988].

5. See also Arrow [1975], Ben-Porath [1978], Johnson [1952], and Pollack [1976].

their contributions, then so will A, and then so will those who refer to A, and so on. Considering such "general equilibrium" policy experiments, we find that our approach will predict larger responses to policy changes than the conventional approach, generally about 25% larger but at times as much as 40% larger.

Despite these findings, our results do not lead us to call for a major overhaul of the literature on charitable giving. Although interdependence does increase the predicted responsiveness to policy changes, these results are still well within the range of estimates from the previous literature. Hence, our estimates do not alter the consensus view on the signs and magnitudes of the price and income elasticities of contributions. Furthermore, our estimation method could also be interpreted as a very complex fixed-effects model, hence it is possible that individual heterogeneity could be mistakenly attributed to interdependent preferences.[6]

II. PREVIOUS RESEARCH

The primary focus of the empirical research on charitable giving has been to estimate price and income elasticities of contributions.[7] The most common empirical model in the literature regresses the log of contributions against the log of income and price defined as one minus the relevant marginal tax rate on contributions, and demographic characteristics that generally include age, education, and marital status. Reece [1979] provides an alternative to the double-log model by using a Tobit model for the limited dependent variable while Reece and Zieschang [1987] develop a structural model of giving that accounts for the nonlinear budget set caused by the individual income tax.

A wide range of price and income elasticities has been found in the literature. Price elasticities generated using the Consumer Expenditure Survey (CEX), the data used in this study, are in the range –.91 to –1.19, while price elasticities from studies using tax return data range from –.42 to –1.34.[8] While the range of estimates is broad, the majority of price elasticities fall at or above 1 in absolute value. Income elasticities from the CEX are between .88 and 1.31, while the complete range of income elasticities are from .24 to 1.31. Most of these studies find income elasticity estimates that are less than one. In contrast to this, price elasticities of 0.35 to 0.5 in absolute value have been found in the more recent research of Randalph [1995] and Andreoni, Gale and Scholz [1995]. Both of these studies estimate models of individual preferences. Randalph explores the relative effects of permanent versus transitory effects of the tax-price of giving, and Andreoni, et al. estimate a joint model of charitable giving and volunteer labor supply.

A smaller literature has focused on the degree to which government spending "crowds out" private giving. Roberts [1984] presents evidence of complete crowding out, while Abrams and Schmitz [1978, 1984] and Kingma [1989] suggest there is only partial crowding out. Evidence on the degree of crowding out can be interpreted as providing evidence for competing models of public goods, the pure public goods model would imply complete crowding out, the impure altruism model would imply incomplete crowding out. Kingma [1989] interprets his evidence as providing strong support for the model of impure altruism, however, these models do not necessarily imply that individuals' levels of giving are affected by the giving of those in similar circumstances.

6. This is not a criticism of our method in particular, but could be applied to any attempt to include such interdependence. The sociological and psychological theories are not of the form that would suggest structural models, and are not formulated to make them so. Hence, any specification of these effects will, in this sense, necessarily be *ad hoc*. In addition, Manski [1993b] argues forcefully that identification in models such as these is a delicate issue. The construction and definition of the reference group studied can affect whether the interdependence effect can be identified. As we discuss later, we believe our approach meets the conditions for identification.

7. For an extensive and complete survey of the literature see Clotfelter [1985].

8. Far more studies have used data from tax returns than the CEX. Tax data have the advantage of having accurate price and income information, but lack demographic information (such as age) and contribution information for nonitemizers when compared to the CEX. Reece [1979] and Reece and Zieschang [1987] use the CEX, Clotfelter [1985] provides a table (p. 57–59) that summarizes studies that use tax return data and estimate contributions using the double-log model. A third data set, the National Survey of Philanthropy, yields estimates of price elasticities that exceed 2 in absolute value.

Only two empirical papers have noted the potential importance of peer or reference groups in determining a household's charitable contributions. Schwartz [1970] writes "To the extent that donations are positively related to own income and to the donations of others..., donations would be positively related to the income of the other *donor* population" (p. 1,273). While he notes this possibility, Schwartz does not try to capture this effect in his pooled, time series equations. After noting the presumed importance of "leadership gifts" in fundraising drives and the evidence of interdependent giving in the psychological literature, Feldstein and Clotfelter [1976] write

> "The existence of an interdependence among individual behavior is both an interesting question in itself and a matter of substantial importance for the impact of alternative tax treatments of charitable contributions. If each individual's giving does depend positively on the gifts of individuals with the same or greater income, an increase in the price of giving for the highest income groups will not only depress their giving but would depress the giving of lower income individuals as well" (p. 18).

Feldstein and Clotfelter implement a test of the interdependent giving hypothesis by including a weighted average of others' contributions in the double-log model. Others' contributions are measured as the average contributions in seven separate income classes and the weights are a measure of "economic proximity" of a household, where proximity is measured by income. Specifically, they include g^* in the regression where

$$g_i^* = \frac{\sum_j \omega_{ij} \ln \bar{G}_j}{\sum_j \omega_{ij}},$$

where

$$\omega_{ij} = (\bar{Y}_i / \bar{Y}_j)^\lambda, \lambda \geq 0$$

and $\bar{G}_j$ is the mean giving per household in income class j, $\bar{Y}_j$ is the mean income in income class j, and $\bar{Y}_i$ is the mean income in the income class of individual i. The summation is carried out for i's own income class and those above. Lambda is computed through a grid-search and is optimized at a value of ten. This indicates that the giving of other income classes can be ignored in their context, moreover, the coefficient of g^* is insignificant (0.22, S.E. = 0.24).[9]

III. METHODOLOGY TO TEST FOR INTERDEPENDENT GIVING

The methodology we use to investigate the hypothesis that the contributions of a given household may be influenced by the giving of "neighbors" is similar to that used in several previous empirical papers that examine the effects that geographic or spatial interdependence have on economic phenomena. Haining [1984] examines the spatial distribution of retail gasoline prices where gasoline retailers were considered interdependent if adjacent on major highways or clustered at major intersections. Case [1991] examines the extent to which geographic factors are important in her analysis of rice demand in a data set of 141 districts in Indonesia. Bronars and Jansen [1987] present evidence on the spatial pattern of U.S. unemployment rate fluctuations over a seven year period. Deaton [1987, 1988] uses the fact that households in expenditure surveys are often geographically clustered to separate the effects of measurement error from variation in prices. Using a cluster specific error component he estimates the price elasticity of demand for beef, meat, fish, cereals, and starches from an expenditure survey from Côte d'Ivoire. Finally, Case, Hines, and Rosen [1993] examine the degree to which states' expenditures depend on the spending of similarly situated states. Their paper is similar to ours in the sense that neighbors are not defined by geographical proximity. Rather, Case, Hines and Rosen define neighbors in terms of states being economically and demographically similar. Thus, they hypothesize that citizens of New York will find comparisons to Illinois more relevant than comparisons to Vermont.

In this paper we define neighbors using "socioeconomic space" rather than geo-

9. Feldstein and Clotfelter also develop a measure of giving relative to income by replacing $\ln \bar{G}_j$ by $\ln (\bar{G}_j / \bar{Y}_j)$ with little change in their results. This result lead to their conclusion quoted in the introduction about the lack of empirical relevance of interdependent preferences.

graphic location. Of particular importance to this research is a paper by Van Praag, Kapteyn, and Van Herwaarden [1979][10] on the definition and measurement to social reference spaces. Their work attempts to formalize and measure the intuition noted by Vickrey, and Feldstein and Clotfelter in the introduction. They write that

> "One of the most important behavior-determining factors is certainly the behavior of other people in an individual's environment. Norms, values, attitudes and behavior seem to be influenced to a large extent by other people. However, some people are more influential than others. We say that people who have influence constitute the *reference group* of the individuals" (p. 13).

Using survey data from the Netherlands, they determine that a person's reference group includes those who are similar in age, education, job type, and the degree of urbanization of their place of residence. While people generally refer to those who are most similar to them, they are also influenced by those who are in categories just "above" or just "below" their own. Hence, by sorting people by their characteristics, Van Praag, et al. [1979] are able to map out these interdependencies into what they call a *social reference space*. They are then able to see how changes within one group of people will spill over through the social reference space to affect, directly or indirectly, all other people, much like one might track how a major plant closing in one county may lead to decreased employment throughout a state. The categories identified by Van Praag, et al. will form the basis of our investigation of interdependence.

A. *Estimation*

Our empirical model of charitable giving can be written

$$C = X\beta + \varphi WC + u \tag{1}$$

where $u = \tau Wu + \varepsilon$

and ε is an i.i.d. normal error term, C is the log of charitable contributions, X is a vector of household characteristics, and W is a weighting matrix that allows interdependence in charitable giving.[11] The model in equation (1) is written so that the contributions in a household's social reference space will affect the household's contributions through the term φWC. In addition, the error term, u, allows unobservable factors to have a systematic component that varies between reference groups. This treatment may mitigate, for example, the problems caused by an unobserved (or omitted) variable that induces correlations among the errors of neighbors in the social reference space. Finally, in order to obtain an unbiased estimate of φ, the social reference group is defined to include those of neighboring types, and not those of identical types.[12]

The weighting matrix, W, is a $N \times N$ matrix whose W_{ij} element equals $1/N_i$ if j is in i's social reference group and zero otherwise, where N is the sample size and N_i is the number of people in i's social reference group. Thus, WC will be a $N \times 1$ vector whose elements are the average contributions of each individual's reference group. If there are k types in the social reference space, then the weighting matrix will have rank k. Appendix 1 presents details for maximum likelihood estimation of the parameters in (1), as well as a complete example of the construction of the W matrix and subsequent manipulations.

As discussed in Manski [1993b], identification in models such as this is potentially problematic. In the language of Manski, our model can be interpreted sensibly as estimating a "pure endogenous-effects model." This case is covered in his [1993b, p. 535] proposition 2. The approach taken here, which uses characteristics included among the exogenous X variables in determining the non-zero elements of the weighting matrix, implies that the conditions for identification are met through the functional form assumptions (see Manski [1995, chapter 7]). The alternative of

10. Also see Alessie and Kapteyn [1985].

11. The methodology we adopt is more fully described in Miron [1984] and Case [1991].

12. Including one's own contribution on the right hand side results in a positive bias in φ. This definition of social reference groups is necessary in order to avoid attributing positive bias to interdependence.

assuming that the variables determining the social reference space exert no independent influence on charitable giving seems untenable.

One final point should be made about the relationship between our estimation technique and the use of a "fixed effects" estimator. The elements of β can be consistently estimated by the model

$$C = X\beta + D\eta + e \quad (2)$$

where D is a matrix of dummy variables corresponding to each of the different household types that comprise our weighting matrix. The model estimated in this paper is equivalent to a fixed effects model with specific restrictions on the η's. The general unconstrained fixed effects model is, of course, less restrictive than this.[13] However, one of the central issues in this paper is to distinguish the influence reference groups have on giving, and how changes in giving from one group will influence the contributions of another. The structure we impose through W allows us to identify such effects. Moreover, we can use these results to perform detailed policy simulations, where tax changes directed at one group are allowed to spill-over through the interdependent reference groups. It would be impossible to recover a parameter analogous to φ and to analyze the effects of such interdependence from a fixed effects framework.[14]

B. *Data and Variables*

The ideal dataset for this study would allow researchers to identify people in specific communities, neighborhoods or workplaces who form respondents' reference groups. For example, one might be able to examine interdependencies by looking at donations to a college capital campaign as a function of the percentage of fellow alumni that also give to the campaign, exploiting variation across capital campaigns to help identify the effects of interdependence. A similar strategy would be to focus on United Way campaigns within a workplace over time or across workplaces at a given time. The data demands for such studies are formidable, since not only contributions data but also information on economic and demographic characteristics thought to influence contributions must be collected. At this point, no large dataset with this type of information along with charitable contributions exist to our knowledge. Consequently, we rely on the sociological findings and on the reported characteristics of individuals to artificially place people into reference groups, hoping that our definitions are sufficient to capture the effects of interdependence.[15]

We estimate the model given by equation (1) using data from the 1985 CEX of the Bureau of Labor Statistics. The CEX was chosen for the extensive household-level demographic information that can be used to define social reference spaces, but which is not available in other data. The survey contains five quarterly interviews. Unfortunately questions about charitable contributions are asked only for a subset of interviews. Thus, we exclude all observations that lack information on contributions leaving a sample of 5512 households. A standard practice in the empirical contributions literature is to limit the sample to households with incomes that exceed some lower limit (see Clotfelter [1985, pp. 57–59]). We follow this practice by excluding households with gross income under $10,000, leaving a sample of 3373 households.

We employ a standard specification of the charitable contributions regression. The dependent variable is the log of ten plus the household's charitable contributions. Independent variables include the logs of price, income and liquid wealth, family size, dummy variables for marital status, region of the country, race, educational attainment, and age dummies for ten year intervals beginning with 25. Sample statistics and variable definitions are given in Appendix Table A1. The CEX does not contain any direct information on the price of charitable contributions, thus we have

13. In section IV we present evidence that this structure does not significantly alter the parameters that are the focus of the charitable contributions literature (see footnote 24).

14. See Case [1991] for a more detailed discussion of this point.

15. To the extent reference groups are poorly measured by the CEX our estimated reference group effects are likely to be biased downward. As noted in the text, when we define reference groups randomly we find no independence effect.

constructed a detailed simulation program to calculate household marginal tax rates, and hence, price of contributions. Detailed data on household's sources of income are used to construct adjusted gross income. Data on family size, expenses, and taxes paid are used to calculate the relevant deductions and exemptions. The 1985 rate schedules are then applied to taxable income to calculate marginal tax rates. Following Feldstein [1975] we define the relevant price of contributions as being the "first-dollar" price of contributions, or one minus the marginal tax rate (or 1–.5 [marginal tax rate] for nonitemizers) assuming the household has not made any contributions.[16] In general, the tax simulation closely matches published statistics on the distribution of Adjusted Gross Income, taxable income, and tax liabilities [IRS 1986] except for the highest income classes where underreporting of income sources and topcoding lead to discrepancies. Details of the tax simulation routine and comparisons to IRS aggregates are given in Appendix Table A2.

IV. RESULTS

The final two columns of Table I list the results of standard OLS regressions that do not account for interdependence. The price elasticity of –1.012 and income elasticity of .410 are within the range of standard results reported earlier. Furthermore, the coefficients on the dummy variables for the age and education classes are positive and, with the exception of Age25–34, are highly significant. This is also consistent with the previous literature. In addition, we used this data to recreate the Feldstein and Clotfelter technique discussed earlier for examining interdependence. We find results similar to theirs. The regression sum of squares leveled off after $\lambda = 10$, with the coefficient on g^* small and insignificant (0.014, S.E. = 0.143).[17]

The first step in accounting for interdependence is to define the social reference space and then construct the weighting matrix W described earlier. Van Praag, Kapteyn, and Van Herwaarden [1979] found that age and education are particularly important in determining social reference groups, so we begin with a social reference space based on these variables. We use 20 age classes and six education classes, for a total of 120 types of individuals.[18] Construction of the W matrix can be visualized by imagining a 20 by 6 grid mapping the age and education space. If person i falls in element (a, e) of the grid then i is assigned a social reference group consisting of all other people in the sample who fall in cells $(a + 1, e)$, $(a - 1, e)$, $(a, e + 1)$ and $(a, e - 1)$. If there are N_i total people in i's reference group, then the i^{th} row of W will contain a $1/N_i$ in the j^{th} column if j is in i's social reference space, and 0 otherwise.

Van Praag, Kapteyn, and Van Herwaarden [1979] found that people in urban areas identify more closely to other urban dwellers, and those in rural areas refer more directly to other rural dwellers. Hence, we also explored a social reference space identical to the above, with 20 age classes and six education classes, except that we allow urban dwellers to have only other urban dwellers in their reference group, and rural dwellers to have only other rural dwellers in their reference group. This gives us a total of 240 types of individuals. The W matrix is identical to the above except that it is block diagonal, with all the urban dwellers in the first block and the rural dwellers in the second block. In addition, we also added a dummy variable for urban dwellers in the list of right hand side variables. This is to assure that possible fixed effects of urbanization are not mistakenly attributed to interdependence.

Finally, Van Praag, Kapteyn, and Van Herwaarden [1979] also found that people refer to others of similar job type. For instance, they found that "lower/middle executives" weight other people of similar status most highly in their reference group. The same is true for other job types they consider. To try to capture this, we divided our sample into seven occupation categories (labor, man-

16. In 1985 50% of charitable contributions were deductible for nonitemizers. This provision expired after 1985.

17. Recall that Clotfelter and Feldstein found λ maximized at 10, with a coefficient of 0.22, S.E. = 0.24.

18. The age classes were formed breaking the age distribution at the points 23, 25, 27, 29, 31, 33, 35, 37, 39, 41, 43, 46, 50, 54, 58, 62, 66, 70, 74, and 75. The education classes were elementary school or less, some high school, high school graduate, some college, college degree, and more than college degree.

TABLE I
Comparison of Age × Education Interdependence Weighting Matrix and OLS Regressions*

	Interdependence		OLS	
	coeff.	st.err.	coeff.	st.err.
constant	−2.370	1.065	−1.824	1.038
lnP	−1.041	0.409	−1.012	0.410
lnIncome	0.397	0.113	0.410	0.112
lnWealth	0.070	0.008	0.071	0.008
Family Size	0.032	0.025	0.032	0.025
Married	0.337	0.083	0.341	0.083
Northeast	−0.183	0.089	−0.182	0.089
Midwest	0.456	0.081	0.458	0.081
South	−0.024	0.079	−0.023	0.079
White	−0.141	0.096	−0.147	0.097
HS Grad	0.335	0.098	0.421	0.091
SomeColl	0.493	0.125	0.664	0.100
CollGrad	0.751	0.183	1.024	0.102
Age25–34	0.108	0.126	0.234	0.134
Age35–44	0.395	0.189	0.676	0.139
Age45–54	0.539	0.232	0.885	0.146
Age55–64	0.814	0.254	1.233	0.147
AgeOver65	1.199	0.264	1.595	0.148
φ	0.239	0.135		
τ	−0.398	0.157		
σ^2	3.025	0.074	3.051	
ln L	−6656.291		−6658.405	

*Data is from the 1985 Consumer Expenditure Survey. The Dependent variable is the log of ten plus charitable contributions.

ager, military, agriculture, self employed, not working, and retired) and combined this with age and education. However, to limit the number of different types, and hence limit the dimensionality of W_k, we reduced the number of age classes to ten and the education classes to five. This gives us a total of 350 types.[19] In this social reference space, we again identified reference groups as those in neighboring age and education classes, but restricted inclusion to those of the same occupation class. Hence, laborers only referred to other laborers, and agricultural workers to other agricultural workers. The W matrix is again block diagonal, with seven blocks, one for each occupation. As above, we also added six occupation dummy variables to the right hand side variables.

The results of these three social reference spaces are reported in Tables I, II and III. The estimates of φ in the three equations range from 0.204 to 0.295. The coefficient $\hat{\varphi}$ is highly significant in the Age × Education × Urban/Rural equation ($a < 0.01$), and marginally significant in Age × Education and the Age × Education × Occupation equations ($\alpha < 0.07$ for both). However, a likelihood ratio test indicates only marginally significant increases in the likelihood for the Age × – Education and Age × Education × Urban/Rural equations ($\alpha < 0.013$ for the first and $\alpha < 0.12$ for the second), and an insignificant increase for the Age × Education × Occupation equation ($\alpha < 0.26$). This indicates that accounting for the social reference space provides some, albiet weak, explanatory

19. Age classes were formed by combining every pair of the original 20 age classes. Education classes were formed by combining the first two education classes of the original six education classes. Since some cells had no elements (such as young retired people), we actually had a total of 241 types represented in the sample.

TABLE II
Comparison of Age × Education × Urban/Rural Interdependence Weighting Matrix and OLS Regressions*

	Interdependence		OLS	
	coeff.	st.err.	coeff.	st.err.
constant	−2.470	1.044	−1.845	1.039
lnP	−1.020	0.408	−1.018	0.410
lnIncome	0.391	0.113	0.404	0.112
lnWealth	0.070	0.008	0.071	0.008
Family Size	0.031	0.025	0.033	0.025
Married	0.344	0.083	0.346	0.083
Northeast	−0.211	0.095	−0.212	0.095
Midwest	0.428	0.087	0.430	0.088
South	−0.052	0.085	−0.052	0.086
White	−0.137	0.096	−0.142	0.097
HS Grad	0.312	0.093	0.418	0.091
SomeColl	0.451	0.115	0.655	0.101
CollGrad	0.684	0.162	1.017	0.102
Age25–34	0.083	0.122	0.238	0.134
Age35–44	0.337	0.174	0.683	0.139
Age45–54	0.462	0.210	0.892	0.147
Age55–64	0.725	0.230	1.240	0.147
AgeOver65	1.099	0.237	1.600	0.148
Urban	0.019	0.099	0.104	0.119
φ	0.295	0.117		
τ	−0.379	0.129		
σ^2	3.018	0.074	3.051	
$\ln L$	−6655.889		−6658.025	

*Data is from the 1985 Consumer Expenditure Survey. The Dependent variable is the log of ten plus charitable contributions.

power above a simple fixed effects model.[20] One can interpret these φ coefficients by noting that if the contribution of every other member of one's reference group were to rise by 10%, then this would induce one's own contribution to rise by about 2% to 3%. Hence, changes that encourage contributions by one group in society will encourage contributions by others.[21]

Comparing these results to their OLS counterparts, also listed in Tables I, II, and III, we find that accounting for interdependence did not alter the coefficients on the log of price and the log of income in any meaningful way. This would indicate that these variables were not absorbing the effects of interdependence that are captured in the W matrices. However, the reduction in the coefficients on age and education indicates that perhaps the coefficients on these variables in previous studies

20. To be sure that the significance of φ cannot be attributed to the restrictions inherent in the specification, we also estimated the fixed effects model (2). Coefficients and standard errors on the key policy variables were virtually unchanged, and a Hausman-Wu test of the models presented in Tables I, II, and III, rejects the hypothesis of bias beyond the 5% level for all models.

21. When thinking about the economic magnitude of the coefficients, recall first that the a priori sign of the measured effect is ambiguous. The fact that we find a positive, but relatively small effect could result from the possibility that large negative effects for some groups are being offset by large positive effects for others. We find no evidence of this in the large number of variations reported in the paper, but we have no way of definitively ruling out this possibility. Second, as noted above, it seems likely that measurement error in defining reference groups biases toward zero our estimated interdependence effect. We have no way to assess the magnitude of the potential bias.

TABLE III
Comparison of Age × Education × Occupation Interdependence Weighting Matrix and OLS Regressions*

	Interdependence		OLS	
	coeff.	st.err.	coeff.	st.err.
constant	–2.196	1.075	–1.580	1.043
lnP	–0.948	0.410	–0.956	0.411
lnIncome	0.403	0.112	0.408	0.112
lnWealth	0.070	0.008	0.069	0.008
Family Size	0.035	0.025	0.036	0.025
Married	0.341	0.083	0.340	0.083
Northeast	–0.179	0.089	–0.172	0.089
Midwest	0.470	0.081	0.471	0.081
South	–0.020	0.079	–0.019	0.080
White	–0.158	0.096	–0.158	0.097
HS Grad	0.353	0.091	0.415	0.091
SomeColl	0.528	0.112	0.643	0.100
CollGrad	0.730	0.144	0.920	0.107
Age25–34	0.186	0.132	0.228	0.134
Age35–44	0.502	0.160	0.658	0.139
Age45–54	0.652	0.194	0.884	0.149
Age55–64	0.942	0.210	1.208	0.150
AgeOver65	1.213	0.225	1.468	0.179
Manager	–0.079	0.144	–0.006	0.155
Labor	–0.239	0.126	–0.249	0.143
Military	0.318	0.322	0.463	0.369
Farmers	–0.071	0.307	–0.138	0.362
NotWork	–0.191	0.160	–0.268	0.181
SelfEmp	–0.241	0.149	–0.258	0.173
φ	0.205	0.116		
τ	–0.193	0.133		
σ^2	3.014	0.074	3.043	
$\ln L$	–6649.426		–6650.807	

*Data is from the 1985 Consumer Expenditure Survey. The Dependent variable is the log of ten plus charitable contributions.

have reflected some of the effects of interdependence.

The three social reference spaces just considered were not based on income in any way, in contrast to the method of Feldstein and Clotfelter. It appears natural that income could be an important factor in reference groups. Therefore, it seems appropriate to define social reference spaces using income to see whether income is an important attribute in social reference spaces, and if the price and income elasticities are robust to other definitions of the social reference space. To do this we created a W matrix using six age classes, five education classes, and seven income classes, for a total of 210 types.[22] We treat this as a three dimensional space. Hence, if someone is in age, education and income cell (a, e, y), then her reference group includes all those of types $(a + 1, e, y)$, $(a - 1, e, y)$, $(a, e + 1, y)$, $(a, e - 1, y)$, $(a, e, y + 1)$, and $(a, e, y - 1)$. The estimation results with this definition of W are listed in Table IV.

22. These classes were under 25, 25–34, 35–44, 45–54, 55–64, 65 and over. The education classes were identical the five classes listed previously. The income classes were (in thousands of dollars) 10–20, 20–30, 30–40, 40–60, 60–80, 80–100, 100+. All 210 types were represented in the sample.

TABLE IV
Age × Education × Income
Interdependence Weighting Matrix*

	coeff.	st.err.
constant	–2.101	1.280
lnP	–1.051	0.405
lnIncome	0.458	0.173
lnWealth	0.071	0.008
Family Size	0.033	0.025
Married	0.342	0.083
Northeast	–0.185	0.089
Midwest	0.456	0.081
South	–0.019	0.079
White	–0.146	0.096
HS Grad	0.445	0.090
SomeColl	0.695	0.116
CollGrad	1.083	0.157
Age25–34	0.260	0.132
Age35–44	0.721	0.165
Age45–54	0.968	0.203
Age55–65	1.317	0.247
AgeOver65	1.702	0.286
φ	–0.070	0.174
τ	–0.221	0.212
σ^2	3.029	0.074
$\ln L$	–6655.750	

*Data is from the 1985 Consumer Expenditure Survey. The Dependent variable is the log of ten plus charitable contributions.

The results in Table IV are very different from those given previously. In particular, φ is near zero, while neither φ nor τ are significant. In addition, basing the W matrix on income did not affect either the income or price elasticities. Since this result differs from the first three regressions above, we examined other social reference spaces formed, in part, by income. However all such attempts led to similar results. For instance, we repeated the estimation just described by substituting five income class dummy variables for ln*Income* (φ =0.056, S.E. = 0.146). We repeated the above with six age classes, four education classes and nine income classes, however the social reference space was defined for only those with income one and two classes above, that is, we replaced $(a, e, y-1)$ in the last paragraph with $(a, e, y+2)$ ($\varphi = -0.048$, S.E. = 0.191). We also defined W by 20 age classes and nine income classes (φ=0.143, S.E=0.127), and by six education classes and nine income classes (φ= –0.033, S.E.=0.152). Finally, we defined W on income alone, constructing 200 income classes and defining reference groups as one income class below and two classes above ($\varphi = 0.079$, S.E. = 0.153). There was no significant evidence of interdependence in any of these attempts.

There are three possible ways we could interpret these divergent findings. First, we could conclude that income is not a direct determinant of one's social reference space for charitable giving, hence basing weighting matrices on income will add noise by misassigning reference groups. This may be because age, education, occupation and urban/rural are more salient than income. Second, including income in the definition of W requires a reduction in the number of age and education classes. This is because of the computational constraints on the dimensions of W_k. Hence, these new definitions of W may be too imprecise to capture the effect of interdependence.

A final possibility is that the regressions that show significant interdependence are somehow mistakenly generating phantom correlations and that, in fact, there are no interdependent effects in any of these regressions. To examine this hypothesis we ran one final specification of W. We constructed a space that is identical to the Age × Education space defined earlier, except that people are assigned to the 120 cells randomly, rather than on the basis of age and education. Insignificant estimates of φ and τ from these runs could be considered evidence against the hypothesis of phantom correlations. As hypothesized, the coefficient estimates from this random W matrix were insignificant (φ=0.011, S.E.=0.184, τ= –0.014, S.E. = 0.194) and the other regressors were not affected.

This result suggests that Feldstein and Clotfelter's technique for finding interdependence, while appearing quite natural, may not have been sensitive enough to interdependence and, moreover, by being based on income rather than socio-demographic characteristics such as age and education, it may not have identified the appropriate social reference space.

V. SIMULATIONS

One of the consequences of interdependent preferences is that we must account for the indirect as well as the direct effects of policy changes. The price and income elasticities estimated above, for instance, only account for the direct effect of changes in prices, and do not account for the spillover effects caused by interdependent giving. These spillovers would appear to magnify the direct effect. To illustrate this, we can think of a "general price elasticity" as the percent change in total giving that would result from a 1% change in the price faced by every member of the sample. To calculate this, we first find the fitted values of C, the log of contributions, and then convert these to dollars. We then multiply the tax price of every member of our sample by 1.01 and repeat the same steps. Converting this to a percentage change, we find the general price elasticity for the Age × Education, Age × Education × Urban/Rural, and Age × Education × Occupation regressions, respectively, to be –1.45, –1.37, and –1.20. These, compared to their respective OLS (or partial) price elasticities of –1.02, –1.02, and –.96, imply that interdependence will increase price elasticities by between 25% and 42%. We can perform the same experiment with respect to income. This yields a general income elasticity for the three regressions of .56, .53, and .51 respectively, as compared to the OLS income elasticities of .41, .42 and .41. Interdependence causes these income elasticities to grow by 24% to 36%.[23]

A second consideration of interdependence is that changes that directly affect one subsection of the economy will have "ripple effects" on the other sectors. To illustrate this, we simulated increasing the marginal tax rate for those in the .38 to .50 marginal tax brackets to .70. Interdependence requires that we now not only account for the direct affect on those in the .38–.50 tax brackets, but that we also account for the spillover to those in lower tax brackets. Accounting for interdependence, our simulation produces much higher increases in contributions, especially among the highest income classes. Since these people tend to be in each others reference space, their increased giving tends to reinforce itself among their piers. In addition, contributions rise for all income classes, even the lowest, as the reference group effects trickle down the income distribution. This is much different than predictions from OLS regressions, which would indicate virtually no change for those with income less than $40,000. Overall, incorporating interdependence generates a 25% larger response than OLS.[24]

As can be seen from these simulations, accounting for interdependence can alter both the size and the distribution of the effects of policy changes.

VI. CONCLUSION

Theoretical discussions of charitable giving have emphasized the importance of interdependent preferences in explaining charita-

23. Note that these are not true general equilibrium elasticities since they do not account for the reactions of fundraisers to changes in policy. In addition, they are not balanced-budget changes.

24. We also simulated replacing the current tax deduction for charitable contributions with an equivalent uniform flat subsidy. Interdependence results in about the same overall effect, but predicts greater impacts on those in both the very high and very low income brackets. Details of these simulations are available from the authors upon request.

ble behavior. This literature is embedded in a larger theoretical literature that suggests an individual's choices may be directly affected by the characteristics or activities of other households. The theoretical emphasis in the contributions literature appears to be supported by the prominence given to "leadership gifts" in fundraising campaigns, or the "team" aspects of local United Way campaigns and blood drives. Despite the intuitive appeal of a theory of interdependent giving, it has been very difficult to find empirical support for the proposition that an individual's level of charitable contributions is influenced by factors other than the individual's own personal characteristics.

In this paper we examine this proposition using a methodology originally employed by geographers that allows us to see how the giving of a household's "neighbors," defined here by socio-demographic space rather than geographic space, affects the household's giving. Our results give modest support for a theory of interdependent preferences. When a household's "social reference space" is defined to include households with similar age and education, occupation, or urban/rural location of residence, increases in giving of others in the household's reference space imply the household's gifts would increase by an additional 20% to 30%. We conjecture that demographic characteristics, such as age and education, that are commonly significant explanatory variables in previous reduced form contributions regressions, may be proxies for the omitted effects of interdependence. A troubling finding that may weaken our results, however, is the fact that income is not by itself an important variable in constructing social reference spaces.

While we do find support for the theory of interdependent preferences, the coefficients of primary interest in the empirical contributions literature—the price and income elasticities—remain qualitatively similar. When general price and income elasticities are calculated to account for the spillover effects caused by interdependent giving, the elasticities increase (in absolute value) by between 25% and 40%. Nonetheless, these results fit comfortably within the range of estimates in the previous literature, even though previous estimates do not account for interdependence.

Incorporating interdependent preferences raises an additional consideration into the evaluation of policy toward charitable giving. Policies directed toward one portion of the population may have wider impacts on the general population than previously expected. This occurs due to the "ripple effect" where the targeted policy will have not only a direct effect on the intended population, but will also affect the behavior of those who view the target group as a reference group. This in turn will affect those who view the latter group as a reference group, and so on. Hence, an increase in the top marginal tax rate would also affect the contributions of many people whose tax rates were unchanged. By the same token, interdependence can sometimes work to mitigate the effects of policy. If a policy raises the price of giving to one group and lowers the price of giving to another, as would be the case of converting the contributions deduction to a credit, then interdependence may dampen the changes of both groups.

While this additional consideration adds to the already difficult task of analyzing the effects of tax policy of charitable contributions, it is our belief, based on the empirical work described above, that the empirical importance of these channels are not sufficiently strong to overturn the qualitative results in the existing substantial literature on taxes and charitable contributions. However, they do provide the first empirical support for the theory of interdependent giving.

APPENDIX 1

Estimation

Case [1991] provides a proof that $(I - \varphi W)$ and $(I - \tau W)$ are invertible when $-1 \leq \varphi, \tau \leq 1$. Given that, in fact, $(I - \varphi W)$ and $(I - \tau W)$ are invertible, equation (1) can be written

$$\text{(A1)} \quad C = (I - \varphi W)^{-1} X\beta + (I - \varphi W)^{-1}(I - \tau W)^{-1} \varepsilon$$

which in turn can be rewritten as

$$\text{(A2)} \quad FEC = FX\beta + \varepsilon \text{ where } E = (I - \varphi W)$$

$$\text{and} \quad F = (I - \tau W)$$

We estimate the empirical model given in (A1) by maximum likelihood. The likelihood function for this model (see for example, Miron [1984], Case [1991] or Cramer [1986, p. 129] among others) is

APPENDIX TABLE A1
Sample Statistics from the 1985 Consumer Expenditure Survey*

Variable	Mean	Std.Dev	Minimum	Maximum
Gift	536.06	2728.83	0.00	145000.00
ln(Gift+10)	4.54	1.99	2.30	11.88
P	0.82	0.12	0.50	1.00
lnP	−0.22	0.16	−0.69	0.00
Income	34424.20	26081.32	10000.00	435328.00
lnIncome	10.25	0.61	9.21	12.98
Wealth	11408.07	27472.68	0.00	200000.00
lnWealth	5.08	4.31	0.00	12.21
Family Size	2.83	1.53	1.00	12.00
Married	0.66	0.47	0.00	1.00
Northeast	0.18	0.38	0.00	1.00
Midwest	0.24	0.42	0.00	1.00
South	0.25	0.43	0.00	1.00
White	0.88	0.32	0.00	1.00
HS Grad	0.31	0.46	0.00	1.00
SomeColl	0.23	0.42	0.00	1.00
CollGrad	0.27	0.44	0.00	1.00
Age25–34	0.25	0.43	0.00	1.00
Age35–44	0.24	0.43	0.00	1.00
Age45–54	0.16	0.36	0.00	1.00
Age55–64	0.14	0.35	0.00	1.00
AgeOver65	0.15	0.36	0.00	1.00
Age	45.03	16.06	16.00	90.00
Urban	0.91	0.29	0.00	1.00
SelfEmp	0.06	0.24	0.00	1.00
Manager	0.26	0.44	0.00	1.00
Military	0.01	0.09	0.00	1.00
Farmer	0.01	0.09	0.00	1.00
Labor	0.49	0.50	0.00	1.00
NotWork	0.05	0.21	0.00	1.00
Retired	0.13	0.33	0.00	1.00

*Sample Size = 3373

$$L = -\frac{N}{2}\ln(\sigma^2) + \ln|E| + \ln|F| - \frac{1}{2\sigma^2}(EC - X\beta)'F'F(EC - X\beta) \qquad \text{(A3)}$$

where $(\ln|E| + \ln|F|)$ is the log of the Jacobian of the transformation of ε into the dependent variable C.

To evaluate the Jacobians we use the fact that $|I - \varphi W|$ is equal to $\prod_{i=1}^{N}(1 - \varphi\lambda_i)$ where λ_i are the eigenvalues of W. To see this let δ_i be the eigenvalues for $(I - \varphi W)$, that is $|I - \varphi W - \delta I| = -|\varphi W - (1 - \delta)I| = 0$. Since λ_i are the eigenvalues of W, it must be that $\lambda_i = (1 - \delta_i)/\varphi$ which implies $1 - \varphi\lambda_i = \delta_i$. Therefore, $\det(1 - \varphi W) = \prod_{i=1}^{N}\delta_i = \prod_{i=1}^{N}(1 - \varphi\lambda_i)$.

Notice that W can be very large, for example in our empirical work W is 3373 × 3373. Since it is prohibitively time consuming to calculate eigenvalues for matrices of this dimension we exploit a variant of a common theorem of matrix algebra that allows us to reduce the dimensionality of the W matrix to a square matrix of equal rank with all nonzero eigenvalues, as is shown below. The eigenvalues of this smaller dimension weighting matrix, called W_s, are equal to the nonzero eigenvalues of W. Specifically, the proposition is that there exists a "shrinking" matrix P such that $P'P = I$ and $P'WP = W_s$ where W is the big weighting matrix, W_s is the small weighting matrix and the eigenvalues of W and W_s are equal. The power of the proposition is that we can specify the form of W_s and P *a priori*. If W is $N \times N$ and W_s is $k \times k$, P' is $k \times N$ where each row, which represents household types, has q entries of $1/\sqrt{q}$ where q is the total number of neighbors of that household type. Each column has only one nonzero entry. W_s is equivalent to W_k except the (i,j) nonzero element is (number of type i's × number of type j's)$^{.5}$ / (total number of neighbors of type i). Note that we write the specific form of both W_s and P for the example the next subsection of Appendix 1. Using these facts to evaluate the Jacobians we simply calculate $\prod_{i=1}^{k}(1-\varphi\lambda_i)$ and $\prod_{i=1}^{k}(1-\tau\lambda_i)$ where λ_i are the eigenvalues of W_s, and k (the rank of W) is the number of non-zero eigenvalues.

Consistent estimates of all the parameters can be obtained with greater computational efficiency by first concentrating the likelihood function. Differentiating (A3) with respect to σ^2 and β and solving for the respective parameters yields

(A4) $$\hat{\beta} = (X'F'FX)^{-1}(X'F'FEY)$$

$$\hat{\sigma}^2 = \frac{1}{N}(EY - X\beta)'F'F(EY - X\beta)$$

These expressions then replace β and σ^2 in the likelihood function and the resulting expression can be maximized with respect to φ and τ. When consistent estimates of φ and τ are obtained, β and σ can be calculated from (A4). These estimates are then substituted into (A3) and used as starting values in a maximum likelihood routine, which then calculates the appropriate standard errors.

One additional numerical issue arises when calculating φ and τ from the concentrated likelihood function. The size of the matrices which need to be manipulated when doing the optimization problem is computationally inefficient. Without any loss in accuracy and generality we are able to "compress" and "expand" matrix manipulations that involve the 3373 × 3373 W matrix to overcome this problem. To see this, consider the portion of the likelihood function $EC = (I - \varphi W)C = C - \varphi WC$. Evaluating the expression φWC is problematic due to the dimensionality of W. Recall however that WC is a $N \times 1$ vector whose elements are the average contribution of each individual's social reference group. Thus, we can compress C into a $k \times 1$ vector C_k where k is the number of household types and the ith element of the C_k is equal to the total contributions of households of type i. Multiplying this by W_k, a $k \times k$ version of the weighting matrix like that defined in the subsection below, yields a $k \times 1$ vector with the ith entry equal to the average contribution of the ith household type. This vector is then multiplied by φ and expanded to a $N \times 1$ vector where each element i of the $k \times 1$ vector is repeated for each household of type i. We compress and expand all matrix multiplications involving W. Note that W_k and W_s have the same dimensions but are different matrices. W_s is used to evaluate the eigenvalues of W. W_k is used to reduce the dimensionality of matrix multiplications involving W. The (i,j) element of W_k is zero if person j is not in the social reference space of person i. The nonzero elements of W_s equal $1/N_i$ where N_i is the number of households in the reference group of household i.

An Example

Here we present a simple example where we define a social reference space, construct the weighting matrix W, the small weighting matrix, W_k, that we use to compress and expand our matrix manipulations and the P and W_s matrices used to calculate the eigenvalues of W.

Suppose the contributions of household i are influenced by the contributions of households that have similar education and age. We analyze this conjecture through our construction of the weighting matrix. Consider the following figure, where we have defined, for the purposes of this example, two age and three education classes and numbered each of the resulting six types of households.

		Education		
		Ed<HS	HS<Ed<CollGrad	CollGrad<Ed
Age	Young	1	2	3
	Old	4	5	6

For this example we will define neighbors as those cells "above" and "below" the cell in question. Thus, the neighbors for cell 1 are cells 2 and 4, the neighbors for cell 5 are cells 4, 2, and 6, and so on. Furthermore, assume there are 13 people in our data set, 2 type 1's, 3 type 2's, 1 type 3, 2 type 4's, 4 type 5's, and 1 type 6. This implies, for example, that there are five neighbors for household's of type 1 and six neighbors for type 5 households.

Before writing the weighting matrix it is helpful to define a "compressed weighting matrix," W_k. W_k is useful both in defining W and when we compress and expand when evaluating the likelihood function. W_k is calculated by transforming the previous grid of household types into a 6 × 6 matrix where the ith row of W_k refers to the ith household type, and the jth entry is a zero if the jth type is not a neighbor of the ith type, and 1/(total number of neighbors) if it is. W_k for our example is given by

$$W_k = \begin{bmatrix} 0 & .2 & 0 & .2 & 0 & 0 \\ a & 0 & a & 0 & a & 0 \\ 0 & .25 & 0 & 0 & 0 & .25 \\ b & 0 & 0 & 0 & b & 0 \\ 0 & b & 0 & b & 0 & b \\ 0 & 0 & .2 & 0 & .2 & 0 \end{bmatrix}$$

where $a = (1/7)$ and $b = (1/6)$.

The "big weighting matrix," W, is defined, in this example, as a 13 × 13 matrix (recall that we have 13 people of types 1 through 6) where the (i,j) element of the W_k matrix becomes a $N_i \times N_j$ block with the (i,j) element in each cell of W and N_m is the number of households of type m. For example, the first element of W_k (which is zero) will become a 2 × 2 block of zeros in W, while the (1,2) element (.2) will become a 2 × 3 submatrix of .2's. W for our example is written as

$$W=\begin{bmatrix}
0 & 0 & .2 & .2 & .2 & 0 & .2 & .2 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & .2 & .2 & .2 & 0 & .2 & .2 & 0 & 0 & 0 & 0 & 0\\
a & a & 0 & 0 & 0 & a & 0 & 0 & a & a & a & a & 0\\
a & a & 0 & 0 & 0 & a & 0 & 0 & a & a & a & a & 0\\
a & a & 0 & 0 & 0 & a & 0 & 0 & a & a & a & a & 0\\
0 & 0 & .25 & .25 & .25 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .25\\
b & b & 0 & 0 & 0 & 0 & 0 & 0 & b & b & b & b & 0\\
b & b & 0 & 0 & 0 & 0 & 0 & 0 & b & b & b & b & 0\\
0 & 0 & b & b & b & 0 & b & b & 0 & 0 & 0 & 0 & b\\
0 & 0 & b & b & b & 0 & b & b & 0 & 0 & 0 & 0 & b\\
0 & 0 & b & b & b & 0 & b & b & 0 & 0 & 0 & 0 & b\\
0 & 0 & b & b & b & 0 & b & b & 0 & 0 & 0 & 0 & b\\
0 & 0 & 0 & 0 & 0 & .2 & 0 & 0 & .2 & .2 & .2 & .2 & 0
\end{bmatrix}$$

As emphasized in the text, WC is an $N \times 1$ vector whose elements are the average contribution of each individual's social reference group.

To find the eigenvalues of W we rely on the proposition that there exists a matrix P (13×6 in our example) such that $P'P = I$, $P'WP = W_S$, and the eigenvalues of W_S are equal to the eigenvalues of W. As described in the text (see footnote 15), we have a numerical algorithm for determining P, the shrinking matrix, and W_S *a priori*. For our example P' is written as

$$P'=\begin{bmatrix}
c & c & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & d & d & d & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & c & c & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & .5 & .5 & .5 & .5 & 0\\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}$$

where $c = (1/2)^{.5}$, and $d = (1/3)^{.5}$.

In the text we state that the $(i,j)^{th}$ nonzero entry of W_S is (number of type i's $\times$ number of type j's)$^{.5}$/(total number of neighbors of i). For our example, W_S is

$$W_S=\begin{bmatrix}
0 & e & 0 & .4 & 0 & 0\\
f & 0 & g & 0 & h & 0\\
0 & i & 0 & 0 & 0 & .25\\
j & 0 & 0 & 0 & k & 0\\
0 & l & 0 & k & 0 & j\\
0 & 0 & .2 & 0 & .4 & 0
\end{bmatrix}$$

where $e = \sqrt{6}/5$, $f = \sqrt{6}/7$, $g = \sqrt{3}/7$, $h = \sqrt{12}/7$, $i = \sqrt{3}/4$, $j = 1/3$, $k = \sqrt{8}/6$, $l = \sqrt{12}/6$. The eigenvalues of W_S are equal to the nonzero eignevalues of W.

APPENDIX 2

In this appendix we define the variables used in the empirical work and simulations. The basic empirical model regresses the log of contributions (plus ten dollars) against the log of income, log of price, log of liquid wealth, and a set of demographic variables. The primary contributions variable is a broad measure of contributions that includes gifts to charity, religious, educational and miscellaneous organizations. Income is defined broadly in order to reflect gross or economic income. This measure includes salaries, farm income, business income, social security, railroad retirement, unemployment benefits, workmen's compensation, welfare benefits, interest, dividends, royalties, pensions, food stamps, alimony, child support, net rental income, gifts and lump sum payments, insurance refunds and proceeds from asset sales. Households were included in the sample only when this measure of income exceeded \$10,000. Liquid wealth is defined as savings accounts and stocks and bonds.

The demographic variables include family size, and a series of dummy variables: married; region of the country (northeast, midwest, south); race (white or nonwhite); education (high school graduate, some college, college graduate); age (ten year intervals between 25 and 65 and an "over 65" category); and an urban-rural dummy. All these variables came directly from the Consumer Expenditure Survey, sample statistics are given in Appendix Table 1.

The price of contributions is constructed using an elaborate tax simulation routine. A household's marital status and presence of children is used to determine the filing type: single, joint, or head of household. (We are not able to distinguish the roughly 500,000 households that file "married filing separate" returns.) We incorporate over-65, dependent, and personal exemptions valued at \$1040. Total dividends are calculated assuming the yield on stock is 4.25% (Economic Report of the President, 1987, Table B-91). Taxable dividends are total dividends less the dividend exclusion. Taxable capital gains are assumed to equal 8% of the sales of capital assets. This implies the top marginal tax rate on capital gains is 4%, a rate slightly lower than the estimates of Protopapadakis (1983) (4.8% to 6.6% over the period 1960–1978) but reasonable, given the decline in inflation since 1978. The two-earner deduction is calculated as 10% of the lower earning spouse's wage and salary income (not to exceed \$3,000). Adjusted Gross Income (AGI) is then defined as wages and salaries, farm and nonfarm income, interest income, rents and royalties, alimony, child support and lump sum payments, other income, taxable dividends and capital gains, gifts, pensions, less the two-earner deduction. Additional calculations are made to include the taxable portion of unemployment and social security benefits in AGI, and to subtract contributions to Keogh plans.

When possible, we use survey information to determine a taypayer's itemization status. We calculate itemized deductions for each household, and then compare these deductions with the standard deduction to determine whether the household will

APPENDIX TABLE A2
Aggregate Comparison Between Simulations and Actual Individual Income Items*

Items	Simulation (in billions)	Statistics of Income (in billions)
Deductions:		
Mortgage	115	115
Health	22	23
S&L income tax	60	66
Sales taxes	15	16
Miscellaneous	31	32
Interest Paid	52	64
Real Estate Tax	40	36
Personal Property	3	2
Gifts	29	48
Total Itemized Deductions	367	405
Percentage of Itemizers	44	39
Exemptions	243	253
AGI	1980	2300
Taxable Income	1500	1800
Taxes	306	326

*Simulation data are from the 1985 Consumer Expenditure Survey. The simulations are discussed in Appendix 2.

itemize. For certain categories of deductions we give households the average deductions by income class. For example, we give taxpayers the average sales tax deduction, adjusting for family size, income (19 income classes), and region of the country. We also assign the average deduction for miscellaneous, motor vehicle tax, and casualty and theft deductions, for each of 22 income classes. The average real estate deduction is assigned only to homeowners, again by income class. Deductible interest is assumed to be 15% of consumer debt. Health care expenses in excess of 5% of AGI are deductible. Finally, state and local taxes paid, mortgage interest, occupational expenses, and property taxes are taken directly from the survey.

The aggregate itemized deductions generated by the simulation routine closely matches the aggregate reported in the Statistics of Income volume. However, the percentage of households that itemize is too high. Since the accurate identification of itemizers is crucial to accurately calculating the appropriate tax price, we make the following *ad hoc* assumption. A household itemizes only when their itemized deductions are 25% higher than the relevant standard deduction.

After determining the household's itemization status, taxable income is calculated by subtracting deductions and exemptions from AGI. Marginal tax rates are then calculated by applying the tax schedules to taxable income. The "first-dollar" tax price of charitable giving is one minus the marginal tax rate for itemizers and one minus one-half the marginal tax rate for nonitemizers.

The tax simulation fairly closely matches published tax return data. Appendix Table A2 summarizes some of the aggregate comparisons.

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