Two Essays on the Empirical Analysis of Microeconomic Data:

Household Donation and Individual Body Weight

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To my grandmother

Chunmei Zhou

and to the memory of my grandfather

Kang'en Yu

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ABSTRACT

This thesis consists of two essays on empirical analysis of microeconomic data for household donation and individual body weight.

The first essay investigates determinants of donations to religious, charitable, and educational/political organizations among U.S. households using data from the 2010 and 2011 Consumer Expenditure Survey. To address issues of censoring, selection biases, and correlations among different types of donations, a sample selection system is estimated. Average marginal effects are calculated to further explain the effects of covariates on household donations. Price is negatively associated with charitable and educational/political donations but not with religious donations. The effects of household income differ by types on probabilities of donations but are positive and significant on levels of donations. Demographic backgrounds of a household, such as household size, home ownership, knowledge of death, principle of care, and religious proportion in the state, have positive impacts on household donations. Similarly, households headed by individuals who are female, older, better educated, and married, are more likely to donate than others.

The second essay investigates the effect of walking on body weight of older adults in China using data from the 2008 CHARLS Pilot Survey. An ordered probability model of BMI with ordered endogenous walking is estimated. Daily walking is found to be an effective means for sedentary older adults to manage body weight. However, overweight and obese older adults who already have a walking plan of 30 minutes a day or less have to extend walking time to more than 2 hours a day to lose weight. Walking and body weight decrease with age, while income and residing in rural areas are positively associated with body weight but not walking. Visits with friends, presence of community outdoor fields, and weather conditions affect body

weight by influencing the time of walking.

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CHAPTER 1: INTRODUCTION

Microeconomic data often feature discrete and censoring variables of interest. To address the issues of discrete choice and selection bias, limited dependent variable (LDV) models are usually used in empirical analysis of microeconomic data. The applications of two specialized LDV models are explored in two essays of this thesis.

In the first essay, the determinants of household donations in the United States are investigated. To address zero observations in household donations to different organizations, the dependent variables, the sample selection system (Yen 2005), a multivariate extension of Heckman's (1979) bivariate sample selection model, is used. The sample selection mechanism releases parametric restrictions of the Tobit and two-part models and allows correlations between any pair of selection and outcome equations and, in fact, among all selection and outcome equations. Thus, it facilitates investigation of the differential effects of covariates on the probability, conditional level, and unconditional level of each outcome variable. Moreover, the sample selection system captures the joint-decision nature of household donations to different organizations and achieves more statistical efficiency by using full information about the error correlations. With the assumption of joint distribution of errors terms in the selection and outcome equations, the sample selection system is estimated by the method of maximal likelihood. To investigate the effects of determinants on household donations, average marginal effects of covariates on each probability, conditional level, and unconditional level are calculated, as are standard errors of these marginal effects for statistical inference.

In the second essay, the effects of walking on body weights among older adults in China are examined. Both walking and body weight variables are ordinal, and walking is potentially endogenous in the body weight equation. Failure to accommodate endogeneity of walking can lead to simultaneous equation bias in estimates of the body equation. To address both endogeneity of walking and ordinality of walking and body weight variables, an endogenous treatment effect model is developed and estimated—an ordered probit model for BMI with ordinal endogenous treatment (walking). This model is an extension of the model proposed by Maddala (1983), which consists of a reduced form equation of the endogenous variable (probit model) and a structural form equation of the dependent variable. With the assumption of bivariate normal distribution of error terms in the walking and body weight equations, the endogenous treatment effect model is estimated by the method of maximum likelihood. Then average treatment effects of walking on the probabilities of body weight categories are calculated, as are average marginal effects of exogenous explanatory variables on marginal probabilities of walking and body weight categories and probabilities of body weight categories conditional on walking.

Chapter 2 presents the sample selection system with application to household donations in the United States. Chapter 3 presents the treatment effect model with application to the effects of daily working on body weight of older adults in China.

CHAPTER 2: WHO IS GOING TO DONATE? DETERMINANTS OF HOUSEHOLD DONATIONS IN THE UNITED STATES

1. Introduction

After a dramatic increase of 16.1% from 2002 to 2007, total giving in inflation-adjusted dollars in the United States (U.S.) reached the highest level in 2007 since the 1970s (Giving USA Foundation 2010, 2013). During the Great Recession from 2007 to 2009, total donation decreased by 5.5%—the worst hit in recent decades—but experienced a cumulative increase of 2.2% from 2009 to 2011 (Giving USA Foundation 2010). In spite of good or bad economic conditions, charitable giving by individuals leads the way and remains at 70% or above of the total. In 2011, total giving was $298.42 billion in current dollars, 73% of which (or $217.79 billion) was individual giving. The Center on Philanthropy at Indiana University (2007) finds that 65.5% of all households in the U.S. gave to charity in 2006, with a median level of $870 per household.

Non-profit organizations are major players in the U.S. charitable market, private donations being the primary sources of revenue (Auten, Sieg, and Clotfelter 2002). During the research and silent phase of a capital (fundraising) campaign, fundraisers ought to identify potential large donors and attempt to complete one third of their budgets (Andreoni 2006).[1] As a result, success of a capital campaign depends on identification of potential donors. To that end, fundraisers need to account for household characteristics and understand the mechanisms behind donations. Thus, variables reflecting household socioeconomic status (SES) and demographic background are often incorporated in studies of donations.

[1] Andreoni (2006) divides capital campaigns into three phases: research phase, silent phase, and general campaign phase. The organization will identify potential large donors in the research phase, attempts to collect about one third of its ultimate goal from a small number of these identified donors in the silent phase, and collects the rest from the public in the general campaign phrase.

Besides identifying characteristics of households who donate, policymakers are also interested in price and income elasticities of household donations. Theoretically an increase in household income predicts an increase in household donations, while a policy of reducing the individual marginal tax rate increases the price of donation and thus decreases the amount of donations. Conversely, a policy of increasing the individual marginal tax rate and enhancing tax deductibility will promote household donations. Therefore, by amending the tax deductibility of donations, policymakers can adjust and improve performance of households and non-profit organizations in the charitable market, and consequently balance benefits and costs of tax policy.

Household donations to different organizations are potentially dependent and inseparable. Hence, it is generally insufficient to consider these donations in isolation (Brown and Ferris 2007; Feldman 2010). This study extends the empirical literature by estimating a system of equations for household donations to different organizations. In existing studies, household donations are usually divided into religious and secular donations. However, with the detailed information available in the Consumer Expenditure Survey (CEX) used in this study, secular donation can be further divided into donations to charitable organizations and to educational/political organizations.[2] As a result, three types of household donations are considered in this study: religious donation, charitable donation, and educational/political donation. The differentiated effects of household SES and demographic variables on household donations by types are investigated.

Survey data for microeconomic behaviors often feature zero observations (censoring) in the dependent variables of interest. In order to address censoring in household donations,

[2] In the CEX, compared to the proportions of households who donate to religious and charitable organizations, which are around 40%, proportions of households who donated to educational and political organizations were lower than 10%. Donations to educational and political organizations are combined to avoid the lack of variations caused by the small proportions of donating households.

existing studies often employ the Tobit (censored regression) model and two-part model (Andreoni, Brown, and Rischall 2003; Brooks 2005; Mesch et al. 2006; Thornton and Helms 2013), while a few use the sample selection model (Jones and Posnett 1991a, b; Smith, Kehoe, and Cremer 1995). However, the Tobit model is known to be restrictive, because the same set of covariates is used to explain both the probability of donating and the level of donation. Moreover, the relative effects of two explanatory variables on the probability of a positive value, conditional level, and unconditional level are identical and equal to the ratio of the corresponding coefficients. In the two-part model, although there is no such constraint on the effects of variables, the probability of donating and the level of donation are assumed to be uncorrelated. As a result, the sample selection model (Heckman 1979) is a preferred alternative to these previously used models, since it not only relaxes the aforementioned restrictions but also accommodates correlation between the two stochastic processes which govern the binary decision to donate and the level of donation, ameliorating biases due to non-random selection of households who donate. In economic terms, the selection bias can be thought of as the correlation between unobservable variables in the selection equation and those in the outcome equation. For example, social rewards for generosity, guilt for the poor, and understanding of philanthropy can affect both the probability and the level of donation. Moreover, the selection bias can also be caused by omitted variables in the outcome equation, such as the number and strength of solicitation, history of donation in a household, influence of giving from household members, and internal value of giving inherited from parents. All of these omitted variables are usually not measured and excluded in empirical analysis of household donations. Therefore, the sample selection model is appropriate in the analysis of household donations. In this study, to accommodate the multiple donation activities as well as the censoring in household donations, a multivariate sample selection model (or sample selection system) (Yen 2005) is used. By using full information about the error correlations, the sample selection system improves statistical efficiency by simultaneously estimating the selection and outcome equations for different types of donations.

Previous studies have investigated the relations between household donations and its characteristics by sophisticated econometric methods, but they remain superficial “variable sociology” and have limited implications for fundraisers, policymakers, and social researchers (Goldthorpe 2001; Bekkers and Wiepking 2011). Although some recent studies explicate the mechanisms behind donations by the method of economic experiment (Landry et al. 2006; List and Price 2009), few studies investigate these mechanisms by the analysis of microeconomic data. Moreover, after the Great Recession, the effects of covariates on household donation might have changed. Therefore, the empirical studies of household donations on microeconomic data are needed. The purpose of this study is to update the effects of price, SES, and demographic variables on household donations by using data from the 2010 and 2011 CEX, explicitly explain the mechanisms behind donations, and generate a more timely and comprehensive analysis of household donations in the U.S. after the Great Recession.

Section 2 reviews the empirical literature on household donation. Section 3 presents the theoretical framework, empirical model, and data used in this study. Section 4 reports and discusses empirical results. Section 5 draws conclusions and provides suggestions for further studies.

2. Literature and background

Most studies investigate the effects of SES and demographic variables on household donations and explain household donations by using household income, home ownership, employment, education, age, gender, race, and marital status. After controlling for household characteristics, insights can be gained about the heterogeneity of donations across households and about the effects of these characteristics on household donations.

As expected, wealthy people are more likely to be generous and benevolent. Household income, as the main source of wealth, is associated with household donation (Jones and Posnett 1991a, b; Farmer and Fedor 2001; Auten, Sieg, and Clotfelter 2002; Gruber 2004; Rooney et al. 2005; Bekkers and Wiepking 2006; Feldman 2010). Farmer and Fedor (2001) conclude that an individual's donation is partly a function of his own income, and that the lack of income information can possibly cause a bias in the analysis of monetary donation. Jones and Posnett (1991a) find the effect of household income well-determined in their analysis with the Tobit and generalized Tobit (sample selection) models. The level of donation is found to differ by household income. Mesch et al. (2006) find that household income has a small positive effect on the probability of donating, with an increase of $21.4 in donations for a $1,000 increase in income. In a panel analysis with a series of biennial survey data, Tiehen (2001) finds income elasticity ranges from 0.24 to 0.35. However, by isolating the transitory effect of income, Auten, Sieg, and Clotfelter (2002) argue that the permanent income elasticity lies between 0.40 and 0.87. These elasticity estimates fall in the range of those in most cross-sectional and panel data studies. Based on an analysis with cross-sectional data, Brooks (2005) concludes that secular donation is more sensitive to income fluctuations than religious donation, with an income elasticity of 1.3 for nonreligious donation and 0.8 for religious donation. Home ownership is a proxy for stability of household income (Feldman 2010) and reflects household wealth. The effect of home ownership, in line with that of income, is positive on household donation (Jones and Posnett 1991a; Bekkers and Wiepking 2006).

Drawing on human capital theory, highly educated, married, and older people are likely to engage in more donations than those who do not have these characteristics (Bryant et al. 2003; Mesch et al. 2006). Education is one of the ubiquitous determinants of household donations and is expected to be positively related to giving behavior (Tiehen 2001; Andreoni, Brown, and Rischall 2003). Mesch et al. (2006) find that people with a some college or higher degree are 6% more likely to donate compared to people with a high school or less degree. This effect of education is consistent with finding by Brown and Ferris (2007) that people with a some college degree donate $218 more per year to religious organizations than people with a high school or less degree, but $116 less than people with a college or higher degree. Furthermore, being married contributes to household donations. Andreoni, Brown, and Rischall (2003) nonetheless demonstrate that the final “compromise” donation consists of 68% of the male preference and 26% of the female preference, and that bargains and disagreements between husband and wife decrease the level of household donations by 6%. However, most studies support that married people are still more likely to donate than single persons. In the study by Mesch et al. (2006), evidence shows that the probability of donating of married men is 6% higher, and probability of married women 11% to 12% higher, than that of single men. Similarly, Rooney et al. (2005) find that, compared to single men, married men are 5% more likely and married women 11.6% more likely to donate on average. Age is another common covariate in the equation of household donation. Auten and Joulfaian (1996) conclude that people age between 40 and 84 donate more on average than those younger or older. According to sample statistics from the 1995

Independent Sector survey, Andreoni (2006) observe that the proportion of individuals who donate among the population increases until age 75, after which a decreasing trend appears. Corroborating observation by Andreoni (2006), Bryant (2003) finds that for people who donate without asking, the probability of donating rises until age 75. Mesch et al. (2006) note that age has a small but significant impact on the probability of donating and each additional year in age leads to an increase in donation by $20.6. Brown and Ferris (2007) find a positive but declining relationship between age and the amount of secular donation but not the amount of religious donation. Moreover, the heterogeneity of household donations exists among different racial groups. Both Gruber (2004) and Brooks (2005) suggest that black people donate more to religious charities than people of other races, since black people have significantly higher levels of religious engagement. However, Rooney et al. (2005), Mesch et al. (2006), Brown and Ferris (2007), and Yörük (2011) find a limited effect of race on the levels of donations. The role of gender in household donation is also under debate. Andreoni, Brown, and Rischall (2003) present significant differences in both participation and level of giving between men and women, whereas Yörük (2011) shows that in terms of monetary donation, women and men are equally likely to donate, though in terms of voluntary work, women are 6% more likely to volunteer than men. Additionally, household size and presence of children are found to be associated with household donations. Brooks (2005) finds household size positively relates to religious donation but negatively to secular donation, while Bryant et al. (2003) and Brown and Ferris (2007) find presence of children has no effect on household donations.

With the interest in tax reforms, researchers have continued to estimate income and price elasticities and explore the effect of tax deductibility. Existing studies show that income elasticity of household donations remains positive but less than unity, while price elasticity is less than –1 (elastic) (Tiehen 2001; Auten, Sieg, and Clotfelter 2002; Brooks 2005; Feldman 2010). Although Reece and Zieschang (1985) and Jones and Posnett (1991b) have cast doubt on the effects of price, they conclude that the lack of demographic variables, such as age and education, might have caused the insignificant effects of price in their results. From an analysis of a system of donating in time and money, Feldman (2010) concludes that a decrease in price will increase the probability of donating after controlling for common demographic variables. Based on an experiment, Andreoni and Vesterlund (2001) find price elasticities of donations differ by gender. Men are price-elastic and could be either perfectly selfish or perfectly selfless, whereas females are insensitive to price and keep a stable level of donation. Thus, the influences of tax deduction policy may differ by gender as well. Tiehen (2001) finds a range of price elasticity from–0.94 to –1.15, and that price elasticity depends on self-reported sensitivity to tax deductions. People most sensitive to tax deductions are the most price-elastic, and vice versa. By isolating the influence of transitory price effect, Auten, Sieg, and Clotfelter (2002) find persistent price elasticity ranging from –0.79 to –1.26, with the lower limit smaller in absolute value than most cross-sectional estimates. Brooks (2005) finds price elasticity of nonreligious donation significant and inelastic (–0.52); he also finds price elasticity of religious donation insignificant and attributes this insignificant price elasticity to religious engagement.

In empirical studies, limited dependent variable models are popular vehicles to address censoring in household donations. Jones and Posnett (1991a, b) employ standard Tobit and generalized Tobit (sample selection) models to analyze the determinants of household donation in the United Kingdom (UK). They find the selection equation of donations varies with price, education, housing status, and region of residence, while the outcome equation varies with household income and resident regions. Smith, Kehoe, and Cremer (1995), using sample selection model to analyze household donations toward a local health care foundation, conclude that household income affects level but not probability of household donations. Using a trivariate Tobit system and data from the 1995 CEX, Yen (2002) find that income, age, and education have significant impacts on household donation to religious organizations, charities, and other organizations in the U.S. After controlling for the differences in age, income, and education, Andreoni, Brown, and Rischall (2003) and Mesch et al. (2006) apply the Tobit model to confirm the differences in philanthropic behaviors by gender and marital status. Using the Tobit and two-part models, Thornton and Helms (2013) find that religion matters in the decision of donations rather than the level of donations, and that nonreligious donation is more price-elastic than religious donation.

Different households have different preferences concerning philanthropy, which explains the different household donations toward different organizations. Andreoni and Payne (2003) suggest that how much an individual will donate to a charity depends on how close the charity is to his or her ideal type. As a result, different preferences of household donations by types are attributed to different ideal types of charities among different households. Gruber (2004) concludes that religious organizations might be closer to the ideal charity type of low-income people. Smith, Kehoe, and Cremer (1995) find that compared to people who donate to religious organizations, people who donate to national charities are more likely to make another donation to a health care foundation. This finding corroborates results reported by Brown and Ferris (2007) and Feldman (2010) that donations to one charity affects donations to others and household donations to different organizations are inseparable.

3. Method and procedure

3.1. *Theoretical framework*

Private benefits are found to be the primary motive for donation (Vesterlund 2006). Therefore, the empirical specification is motivated with a utility maximization framework for the household and the aim of this study is to investigate the effects of price, SES, and other demographic characteristics on household donations.

Utility function of a household, $U(G, C)$, is defined over household donations (G) and a composite good (C). A household with fixed income (I) determines the optimal levels of donations and composite good by solving the constrained utility maximization problem

$$Max\{U(DG, C, H) \mid P'DG + C = I\}, \tag{1}$$

where $G = [g_1, ..., g_n]'$ is a vector of levels of household donations to different organizations with prices $P = [p_1, ..., p_n]'$, $D = \mathrm{diag}(d_1, ..., d_n)$ is a diagonal matrix such that $d_i = 1$ if a household donates to organization i and 0 otherwise for all i, C is a composite good with price normalized at unity, H is a vector of household characteristics, and I is household income. The utility function is assumed to be quasi-concave with diminishing marginal utility with respect to each donation and the composite good, that is, $U_{g_i g_i} \leq 0$ and $U_{CC} \leq 0$. The necessary first-order condition for an interior solution is

$$\partial U / \partial G: \; U_G = PU_C \text{ (household donation).} \tag{2}$$

Equation (2) shows that with a constant marginal utility of the composite good (U_C) on the right-hand side, a decline in price of donation (P) will lead to a decrease in the marginal utility of household donation (U_G). Because of the diminishing marginal utility of donation, a decrease in U_G implies an increase in G. Thus, household donations will increase when price decreases. Because tax deductibility is identical for household donations to different organizations, prices of household donations to different organizations are the same. As a result, the price vector (P) reduces to a scalar (p) in this analysis. However, this does not mean that the price elasticities of household donation to different organizations are identical.

According to the utility-maximizing framework, optimal level of household donation can be written as $G = G(p, I, H)$. Therefore, the household donations to different organizations (y_i^*) can be written as a system of equations:

$$y_i^* = x'\beta_i + v_i,\ i = 1, \ldots, n, \tag{3}$$

where x is a vector of covariates which include price (p), household income (I), and other household characteristics (H), β_i is a vector of parameters, and v_i is an error term which reflects unobservable disturbances (e.g., social rewards for generosity, guilt for the poor, and understanding of philanthropy).

3.2. *Econometric procedure*

To investigate household donations to different organizations, we use the (multivariate) sample selection system (Yen 2005), an extension of Heckman's (1979) bivariate sample selection model, and estimate the system with the method of maximum likelihood (ML). Compared to a separate estimation of bivariate selection model for each type of donations, the sample selection system not only captures the joint-decision nature of household donations to different organizations, but also achieves a better statistical efficiency by using full information about the error correlations. We use sample selection system in which the level of household donations to organization i (i = 1 for religious organizations, i = 2 for charitable organizations, and i = 3 for educational/political organizations) is governed by a binary selection mechanism such that

$$
\begin{aligned}
y_i &= y_i^* \quad \text{if} \quad z'\alpha_i + u_i > 0, \\
y_i &= 0 \quad \text{if} \quad z'\alpha_i + u_i \le 0, \; i = 1, 2, 3,
\end{aligned} \tag{4}
$$

where the equation of y_i^* is defined in equation (3), z is a vector of explanatory variables in the selection equation, and α_i is a vector of parameters. Assume the concatenated random error vector $[u', v']' = [u_1, u_2, u_3, v_1, v_2, v_3]'$ is from a six-dimensional normal distribution with zero means, variances $[1, 1, 1, \sigma_1^2, \sigma_2^2, \sigma_3^2]'$, and covariance matrix Σ. Partition the covariance matrix

$$
\Sigma = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} \\ \Sigma_{21} & \Sigma_{22} \end{bmatrix} \tag{5}
$$

into 3 × 3 sub-matrices $\Sigma_{11} = \mathrm{E}(uu') = R_{uu}$, $\Sigma_{21} = \Sigma_{12}' = \mathrm{E}(vu') = SR_{vu}$, and $\Sigma_{22} = E(vv') = SR_{vv}S$ where $S = \mathrm{diag}(\sigma_1, \sigma_2, \sigma_3)$ and $R_{uu} = [\rho_{ij}^{uu}]$, $R_{vu} = [\rho_{ij}^{vu}]$, and $R_{vv} = [\rho_{ij}^{vv}]$ are 3 × 3 correlation matrices such that ρ_{ij}^{vu} is the correlation between u_i and v_i and likewise for ρ_{ij}^{uu} and ρ_{ij}^{vv}. In equation (4), each dependent variable y_i is log-transformed to ameliorate potential non-normality and heteroscedasticity of the error term v_i (Yen and Rosinski 2008).

To construct the likelihood function, define three-dimensional diagonal matrix K with elements $\kappa_i = 2I(y_i > 0) - 1$ such that $\kappa_i = 1$ if $y_i > 0$ and $\kappa_i = -1$ if $y_i = 0$, and define the normalized error term $w_i = (\log y_i - x'\beta_i) / \sigma_i$, for i = 1, 2, 3. First, consider an all-positive regime in which the household makes all three types of donations, that is, $y_1 > 0, y_2 > 0, y_3 > 0$. Denote $r = [r_1, r_2, r_3]' = [z_1'\alpha_1, z_2'\alpha_2, z_3'\alpha_3]'$, and let $f(v) = f(v_1, v_2, v_3)$ be the marginal probability density function (pdf) of $v \sim \mathrm{N}(0, \Sigma_{22})$, and $h(u \mid v) = h(u_1, u_2, u_3 \mid v_1, v_2, v_3)$ the conditional pdf of $u \mid v \sim \mathrm{N}(\mu_{u|v}, \Sigma_{u|v})$, where $\mu_{u|v} = \Sigma_{12}\Sigma_{22}^{-1}v$ and $\Sigma_{u|v} = \Sigma_{11} - \Sigma_{12}\Sigma_{22}^{-1}\Sigma_{21}$. Then, the likelihood contribution of this sample regime is

$$
\begin{aligned}
L_1 &= \Big(\prod_{i=1}^{3} y_i^{-1}\Big) f(v_1,v_2,v_3) \int_{-z'\alpha_1}^{\infty}\int_{-z'\alpha_2}^{\infty}\int_{-z'\alpha_3}^{\infty} h(u_1,u_2,u_3 \mid v_1,v_2,v_3)\,du_3\,du_2\,du_1 \\
&= \Big(\prod_{i=1}^{3} y_i^{-1}\Big)\Big(\prod_{i=1}^{3} \sigma_i^{-1}\Big)\phi_3(w_1,w_2,w_3)\Phi_3(r+\mu_{u|v};\Sigma_{u|v}),
\end{aligned}
\tag{6}
$$

where $\prod_{i=1}^{3} y_i^{-1}$ is the Jacobian of the transformation from $[v_1,v_2,v_3]'$ to $[y_1,y_2,y_3]'$, $\phi_3(\cdot)$ is the standard trivariate normal pdf, and $\Phi_3(r+\mu_{u|v};\Sigma_{u|v})$ is the trivariate normal cumulative distribution function (cdf) with zero means, covariance matrix $\Sigma_{u|v}$, and finite upper integration limits $r+\mu_{u|v}$.

Second, for an all-zero regime in which the household does not make any type of donation, that is, $y_1 = y_2 = y_3 = 0$, the likelihood contribution is identical to that of a trivariate probit model for an all-zero regime:

$$
L_2 = \int_{-\infty}^{-z'\alpha_1}\int_{-\infty}^{-z'\alpha_2}\int_{-\infty}^{-z'\alpha_3} f(u_1,u_2,u_3)\,du_3\,du_2\,du_1 = \Phi_3(-r;\Sigma_{11}). \tag{7}
$$

Third, consider a mixed regime in which household donates to the first organization but not to the other two, viz., $y_1 > 0$ and $y_2 = y_3 = 0$. Denote the marginal pdf of $v_1 \sim \mathrm{N}(0,\sigma_1^2)$ as $f(v_1)$ and conditional pdf of $u \mid v_1 \sim \mathrm{N}(\mu_{u|v_1},\Sigma_{u|v_1})$ as $h(u \mid v_1) = h(u_1,u_2,u_3 \mid v_1)$. Then, the likelihood contribution is

$$
\begin{aligned}
L_4 &= y_1^{-1} f(v_1) \int_{-z'\alpha_1}^{\infty}\int_{-\infty}^{-z'\alpha_2}\int_{-\infty}^{-z'\alpha_3} h(u_1,u_2,u_3 \mid v_1)\,du_3\,du_2\,du_1 \\
&= y_1^{-1}\sigma_1^{-1}\phi(w_1)\Phi_3[K(r+\mu_{u|v_1});K'\Sigma_{u|v_1}K],
\end{aligned}
\tag{8}
$$

where $\phi(\cdot)$ is the standard normal pdf, and $\Phi_3[K(r+\mu_{u|v_1});K'\Sigma_{u|v_1}K]$ is the trivariate normal cdf with zero means, covariance matrix $K'\Sigma_{u|v_1}K$, and integration limits $K(r+\mu_{u|v_1})$. Then, consider a regime in which household donates to the first two organizations and but not to the third one, *viz.*, $y_1 > 0, y_2 > 0,$ and $y_3 = 0.$ Denote the marginal pdf of $\tilde{v} \sim \mathrm{N}\,(0,\tilde{\Sigma}_{22})$ as $f(\tilde{v}) = f(v_1,v_2)$ and conditional pdf of $u\,|\,\tilde{v} \sim \mathrm{N}\,(\mu_{u|\tilde{v}},\Sigma_{u|\tilde{v}})$ as $h(u\,|\,\tilde{v}) = h(u_1,u_2,u_3\,|\,v_1,v_2).$ Then, the likelihood contribution is

$$
\begin{aligned}
L_3 &= \Big(\prod_{i=1}^{2} y_i^{-1}\Big) f(v_1,v_2)\int_{-z'\alpha_1}^{\infty}\int_{-z'\alpha_2}^{\infty}\int_{-\infty}^{-z'\alpha_3} h(u_1,u_2,u_3\,|\,v_1,v_2)\,du_3\,du_2\,du_1 \\
&= \Big(\prod_{i=1}^{2} y_i^{-1}\Big)\Big(\prod_{i=1}^{2} \sigma_i^{-1}\Big)\phi_2(w_1,w_2)\Phi_3[K(r+\mu_{u|\tilde{v}});K'\Sigma_{u|\tilde{v}}K], \qquad (9)
\end{aligned}
$$

where $\phi_2(\cdot)$ is the standard bivariate normal pdf, and $\Phi_3[K(r+\mu_{u|\tilde{v}});K'\Sigma_{u|\tilde{v}}K]$ is the trivariate normal cdf with zero means, covariance matrix $K'\Sigma_{u|\tilde{v}}K$, and integration limits $K(r+\mu_{u|\tilde{v}}).$ The likelihood of other sample regimes with one or two zeros are identical to (8) and (9) after permuting the error terms *u*'s and *v*'s. The sample likelihood function is the product of the likelihood contributions introduced above over the whole sample, depending on the regime each observation belongs to.

By imposing restrictions in the correlation matrix, the sample selection system reduces to two nested specifications. First, with the restrictions that all error correlations are zeros, that is, $\rho_{ij}^{uu} = \rho_{ij}^{vv} = 0$ for all $i > j$ and $\rho_{ij}^{vu} = 0$ for all i and j, the sample selection system reduces to an independent system, which consists of three separate two-part models (Newhouse, Phelps, and Marquis 1980). This independent system can be estimated as a probit based on the binary outcome of each y_i by using the full sample, and ordinary least-squares (OLS) for the corresponding $\log y_i$ by using the positive observations. The other nested specification is a pairwise selection system in which error correlations are allowed only between the selection and outcome equations of each donation, that is, $\rho_{ij}^{uu} = \rho_{ij}^{vv} = 0$ for all $i > j$ and $\rho_{ij}^{vu} = 0$ for all $i \neq j$. This pairwise selection system can be estimated as the bivariate selection model (Heckman 1979) for each type of donations. Tests for the two nested specifications against the full model can be done with the Wald test, likelihood ratio test (LR), or Lagrange multiplier (LM) test (Engle 1984).

The following equations, derived by Yen and Rosinski (2008), are the probability of a positive observation, conditional level, and unconditional level of household donations to organization i:

$$\Pr(y_i > 0) = \Phi(z'\alpha_i), \tag{10}$$

$$E(y_i \mid y_i > 0) = \exp(x'\beta_i + \sigma_i^2/2)\Phi(z'\alpha_i + \rho_{ii}^{uv}\sigma_i)/\Phi(z'\alpha_i), \tag{11}$$

$$E(y_i) = \exp(x'\beta_i + \sigma_i^2/2)\Phi(z'\alpha_i + \rho_{ii}^{uv}\sigma_i), \tag{12}$$

where $\Phi(\cdot)$ is the cdf of the standard normal distribution. Marginal effects of each continuous (discrete) explanatory variable on the probabilities, conditional levels, and unconditional levels are calculated by differentiating (differencing) equations (10), (11), and (12). These marginal effects are evaluated at each observation and averaged over the whole sample. For statistic inferences, standard errors of marginal effects are calculated by the delta method (Spanos 1999).

3.3. *Identification strategy*

For ML estimation of the sample selection system, the parameters can be identified due to the nonlinear functional form inherent in the distributional assumption. However, the assumption of nonlinear functional form is usually challenged by insufficient variation in the identification process. Better identification can be achieved by imposing exclusion restrictions on the parameters. Specifically, unique variables are included in each of the selection equations: two proxy variables for the knowledge of death and the principle of care, along with percentage of religious members in the state population.

Jonas et al. (2002) demonstrate that having knowledge of death is positively associated with benign thoughts and favorability of charities. Compared to wealthier households without such knowledge, those with the knowledge of death usually have more benign thoughts and consequently make more donations on average. However, the story of poor households is different. Due to the shortage of income and the constraint on budget, even with the knowledge of death and more benign thoughts, the level of donation by a poor household nonetheless might be less than that of wealthy households without the knowledge of death, and might not be significantly different from that of poor households without the knowledge of death. Therefore, by affecting benign thoughts of households, the knowledge of death can infer the chance of whether to donate but not explain the variance of how much to donate. Generally, having life insurance coverage in case of death or disability reflects one's own knowledge of death. Even for people receiving their life insurances as benefits from their employers, having life insurance also reflects their knowledge of death, since the provision of life insurances by employees might be a factor influencing their choices on job offers.

Variable reflecting the principle of care for role identity of a helper is another identification variable, which predicts the probability but not the level of donation. According to the role identity model, Grube and Piliavin (2000) and Piliavin, Grube, and Callero (2002) demonstrate that role identity of a helper is associated with the action of these helping behaviors rather than the performance, and that one will keep up with helping behaviors to consistently act as a helper. Thus, participation in donation can be explained by the identity of a helper. Looking after pets, as another helping behavior, relates to the identity of a helper and shows one's principle of care, which is an internalized value of people that one should help others in need (Wilhelm and Bekkers 2010). Therefore, having pets is a good proxy variable for the principle of care, which is a good identification variable in the selection equation.

Finally, it is common to hypothesize that the proportion of religious members in the state population is positively associated with household donations in the state, since the religious usually have stronger feeling of social responsibility and altruistic values than the non-religious. Thornton and Helms (2013) find that religion does matter in the probability of donation but not in the level. Therefore, the percentage of major traditions members in the state population, as the measure of religiosity in the state, is justified as an identification variable in the selection equation. Besides, the proportion of religious members in the state population can also accommodate the regional and social heterogeneities of household donations.

3.4. *Data and variables*

Data for this study come from the 2010 and 2011 CEX (U.S. Bureau of Labor Statistics 2011, 2012). The CEX provides the levels of donations to different organizations (religious, charitable, and educational/political organizations), information of SES (e.g., household income, education, and home ownership), and demographic background (e.g., gender, race, age, household size, children, marital status, and employment) at the household level. The reference people in the CEX are regarded as the household head. Thus, the personal characteristics of the reference people (e.g., education, gender, race, age, and presence of children) are used as the household characteristics in this study. Households who do not continuously attend all four waves of interviews of CEX are excluded from the sample. To avoid unfavorable effects of income volatility on donations, only households whose reported annual incomes are stable during all four waves of interviews are included. After deleting observations with missing values on important variables, the final sample contains 4,321 households, 51% of which are from the 2010 CEX. Also merged into the dataset is the percentage of major traditions members in the state population in 2010, which is obtained from the Religion 2010 (Social Explorer 2012).[3] According to the stable social context of religion, it is assumed that the percentage in 2010 will remain in 2011. The variable has a sample mean of 33%.

Sample statistics of the dependent variables are presented in Table 1. About 41.9% of the sample donated to religious organizations with an average of $675.62 per year, 43.2% to charitable organizations with average $221.73, and only 10.7% to educational/political organizations with average $58.07. These statistics show that households were more likely to participate in capital campaign of charitable organizations but donated more to religious organizations. Among the donating households, the average level of religious donation was $1611.11 per year, which is much greater than the average levels of the other two types of household donations. The average level of educational/political donation among the donating households is $543.10 per year, about $30 more than that of charitable donation, though only 10.69% of households donated to educational/political organizations.

The optimal level of household donations, $G\ (p, I, H)$, derived from the utility maximization theory above, suggests that price of donation and household income are two determinants of household donations. In the U.S., household donations are tax deductible with certain limitations. Thus, the effective price of a dollar in household donation (the last dollar price of household donation) is $\$(1-t_0)$, where t_0 is the marginal tax rate after the deduction of household donations (Jones and Posnett 1991a; Andreoni 2006). However, this last dollar price

[3] Religion 2010 is collected by the InfoGroup, organized by the Association of Religion Data Archives, tabulated and processed by Social Explorer in 2012. The definition of major traditions in this survey includes Evangelical Protestant, Mainline Protestant, Historically Black Protestant, Roman Catholic, Jewish Congregations, Latter-day Saint, Islamic, Hindu, Buddhist, Orthodox Christian, Jehovah's Witnesses, and others. Religion 2010 is available at http://www.socialexplorer.com/pub/ReportData/.

of household donation is likely to be endogenous in both the selection and outcome equations of donation, due to the correlation between t_0 and unobservable variables.[4] To address this potential endogeneity issue, previous researchers typically use the first dollar price of household donation instead, \$$(1-t_1)$, where t_1 is the marginal tax rate before the deductibility of household donations. Although Reece and Zieschang (1985) propose a more sophisticated approach by considering the full range of household constraints, it is sufficient to use the first dollar price of household donation to deal with the endogeneity here, since only 3.96% of households in this study donate enough to alter their tax brackets in our sample compared to 15.4% in the study by Reece and Zieschang (1985). Both marginal tax rate t_0 and t_1 are calculated by the NBER's Internet TAXSIM (v9) model.[5] Household wealth depends not only on household income but also on household size. For example, although a household of three and a household of two both have total incomes of \$60,000 per year, the household of two might have a relaxed income constraint and consequently may donate more in general. Thus, both household size and income are incorporated in this study. In addition, there may exist nonlinear effects of age on household donations, since people in different age groups have different constraints (Auten and Joulfaian 1996; Bryant et al. 2003; Andreoni 2006). For example, after accumulation of household wealth in past decades and release from their duties for children, older adults might have abundant assets and thus donate more on average than younger adults. In order to investigate these nonlinear effects of age, five categories of age are used: ≤ 24, between 25 and 34, between 35 and 54, between 55 and 64, and ≥ 65.

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[4] Marginal tax rate (t_0) is associated with the level of giving: the more a household donate, the lower t_0 will be. As a result, there is a correlation between t_0 and unobservable variables in both the selection and outcome equations of giving.

[5] Internet TAXSIM (v9) is available at http://users.nber.org/~taxsim/taxsim-calc9/index.html. The model inputs include the tax year, income, state of residence, marital status, number of children, itemized deductions, and short term and long term capital gains or losses, and outputs are the tax liabilities and marginal tax rates. Information on all of these attributes is available in the CEX, except for short term and long term capital gains or losses.

4. Results and discussion

The sample selection system is estimated by the method of ML. To validate the identification strategy discussed above, three exclusion variables in the selection equations are tested for weak instruments. Both nested specification tests of sample selection system against independent system and pairwise selection system and non-nested specification test against the Tobit system are presented in the following section. Average marginal effects of explanatory variables on the probability, conditional level, and unconditional level of donations are evaluated.

4. 1. *Model specification tests*

Although the three exclusion variables (knowledge of death, principle of care, and religious proportion in state) are justified by previous literature, their validity in the identification of sample selection system remains to be examined. Test results based on pairwise selection models (Heckman 1979) show that these exclusion variables are jointly significant in the selection equations for religious (Wald = 47.61, LR = 47.81, LM = 47.69), charitable (Wald = 91.41, LR = 92.06, LM = 91.67), and educational/political (Wald = 16.89, LR = 16.99, LM = 16.93) donations, all with 3 degrees of freedom and a p-value < 0.001. Further, these instruments are jointly insignificant in the level equations for religious (LM = 2.86), charitable (LM = 0.51), and educational/political (LM = 4.20) donations, with df = 3. Results based on the sample selection system also suggest validity of the instruments in the selection equations (Wald = 134.34, p-value < 0.001) and their exclusion from the level equations (LM = 10.83, p-value = 0.29), with df = 9. In sum, results suggest validity of the exclusion variables for model identification.

The sample selection system is then tested again three more restricted specification.

Results suggested the sample selection system performs better than the pairwise selection system (Wald = 224.98, *LR* = 278.57, *LM* = 232.87, *df* = 12) and the independent system (Wald = 3544.30, *LR* = 322.09, *LM* = 257.76, *df* = 15) in fitting the data, both with a *p*-value < 0.0001. In addition, Vuong's (1989) non-nested test suggests the model performs better than the Tobit system. In sum, the sample selection system is preferable to all econometric models used in existing studies of donations.

4.2. *Maximum-likelihood estimates*

ML estimates are presented in Table 3. Twelve of the 15 estimates of error correlations are significant. The error correlations are jointly significant among the selection equations (Wald = 147.68) and outcome equations (Wald = 44.61), both with 3 degrees of freedom and *p*-value < 0.0001, corroborating the joint-decision nature of household donations to different organizations (Brown and Ferris 2007; Feldman 2010). Moreover, there exist across correlations between the selection of one type of donations and the level of another type of donations. For example, the probability (level) of religious donation is related (unrelated) to the levels (probabilities) of charitable and educational/political donations. In addition, the error correlations between the selection equation and corresponding outcome equation are significant at the 1% level for religious and educational/political donations but insignificant for charitable donations, implying that the selection mechanism probably exists in religious and educational/political donations while not in charitable donations.

Although the Tobit and two-part models can address the censoring data of household donations, only the sample selection model allows the correlations of unobservable variables among the selection and outcome equations, as well as the differential effects of common variables on the probability and level of donations. The coefficient of HH size is positive in the selection equation but negative in the level equation for religious donation, and its statistical significance also differs between selection and level equations for charitable donation. Gender of household heads plays different roles in the selection and outcome equations of donations (Andreoni, Brown, and Rischall 2003). The coefficients of Male are negative in the selection equations of religious and charitable donations but insignificant in the corresponding level equations. Similarly, the coefficients of White are negative in the selection equations of religious and educational/political donations but insignificant in the corresponding outcome equations. Compared to households headed by individual age below 24, households headed by individual age between 25 and 34 donate more in the level of religious donations at the 10% significance, although they have no difference in the probability. These quantitative and qualitative differences between the selection and level equations are bound to be masked by the Tobit parameterization and highlight an important advantage of the sample selection system over the Tobit system.

The coefficients of exclusion variables in the selection equations differ by type of household donations. Knowledge of death is positively associated with all three probabilities at the 1% level of significance, while religious proportion in the state and principle of care only positively relate to the probability of religious and charitable donations, respectively, at the 1% significance. In line with findings by Brooks (2005) and Wilhelm et al. (2008), religious proportion in the state affects religious donations rather than secular (charitable or educational/political) donations. People with knowledge of death are more likely to donate to all types of organizations which corroborates findings by Jonas et al. (2002), while people with principle of care are only prone to participate in capital campaigns led by charitable organizations.

4.3. *Average marginal effects*

Marginal effects allow further exploration of the effects of covariates on the probabilities, conditional levels, and unconditional levels of donations. All marginal effects are calculated for all sample observations using the procedure described above and then averaged over the sample. To compare with results from existing studies, the effects of price and income are presented in terms of elasticities. All elasticities and marginal effects are presented in Table 4.

4.3.1. *Effects of price*

Price has different effects on household donation by types, significant role in charitable donation, partly significant in educational/political donation, but not in religious donation. These findings are in line with Brooks (2005) that price is significantly associated with secular donations rather than religious donations. The lower price is, the more a household will donate to secular organizations. However, price does not affect religious donations. This finding implies that households who donate to religious organizations might receive the psychological benefits from their religions and make religious donations as the demonstration for their religious engagement. The implication of these results is that, by amending the policy of tax deductibility, policymakers can adjust secular donations but not religious donations. The price elasticities suggest that when price decreases by 1%, the probability of donation to charitable organizations increases by 0.36%, while the level of donations increases by 0.30% conditional on donation and by 0.66% unconditionally (overall). Although price does not affect the conditional level of educational/political donations, it has a significant effect on the probability and, consequently, on unconditional level. A 1% decrease in price is followed by a 1.12% increase in the probability of educational/political donations and a 1.62% increase in the unconditional level. The price elasticity of educational/political donations on probability falls into the range of estimates reported in the literature, while the price elasticity of educational/political donations on unconditional is above the range (Tiehen 2001; Auten, Sieg, and Clotfelter 2002). By construction, the price elasticities of secular donations on unconditional level are larger than those on conditional level. This finding demonstrates that price might affect the level of secular donations overall, but once when households decide to donate, price will have limited effects on donations.

Although the sample statistics suggests only 3.96% of households in the sample donate enough to lower their tax brackets, lowering tax brackets has a significant impact on all three types of donations. The charitable donation of households who donate enough to lower their tax brackets are 15.3% higher in probability, $459 more in conditional level, and $381 unconditional than that of households without a bracket change. Although lowering tax brackets by donation (*viz.*, reducing marginal tax rate of earnings by donation) may be not a common motivation of household donation for the public, it is an important factor for large donors, who are more responsive to solicitations and donate more in various capital campaigns.

4.3.2. *Effects of income*

Income affect all three types of donations. The income elasticity of religious donation is 0.109 conditional on donation and 0.112 unconditional. Contrary to common expectations, an increase in household income does not affect the probability of religious donations. However, once a household decides to donate, an additional 1% in household income increases religious donations by 0.109%. Income elasticity of religious donation is significantly different from those of secular donations. Echoing finding by Jones and Posnett (1991a), income has a significant effect on secular donations in terms of levels but not probabilities. The income elasticities of charitable (educational/political) donation are 0.295 (0.313) conditional on donation and 0.413

(0.489) unconditional. This finding shows that unconditional income elasticity is greater than conditional elasticity in magnitude, implying that relative to the effects of household income among the donating households, the same increase in household income will lead to a higher increase in household donations overall.

The conditional income elasticities of secular donations are consistent to the range of income elasticity (between 0.24 and 0.35) by Tiehen (2001). Compared to estimates by Auten, Sieg, and Clotfelter (2002), the conditional income elasticities of secular donations (0.295 for charitable donations and 0.313 for educational/political donations) fall into the range of transitory income elasticity (between 0.29 and 0.45), and the unconditional ones (0.413 for charitable donations and 0.489 for educational/political donations) fall into the range of permanent income elasticity (between 0.40 and 0.87).

Therefore, household income has a clear positive relation with all types of household donations. Specifically, a 1% increase in household income will lead to a 0.109% (0.112%) increase in religious donations, a 0.295% (0.413%) increase in charitable donations, and a 0.313% (0.489%) increase in educational/political donations in conditional (unconditional) levels.

4.3.3. *Effects of household characteristics*

The literature suggests a positive relationship between age and household donations (Auten and Joulfaian 1996; Bryant et al. 2003; Andreoni 2006). Relative to households headed by individuals age below 24, those headed by individuals age ≥ 65 are 24.4% more likely to donate religious organizations, 23.4% more likely to charitable organizations, and 12.1% more likely to educational/political organizations. The age effects on the levels of donations are particularly notable in magnitudes. Consistent with findings by Bryant (2003) and Andreoni (2006), the increasing trend in levels of religious and charitable donations appear in households headed by individual age over 54 and 34, respectively. Relative to younger households, older households are not only more likely to donate but also donate more on average. For example, households headed by individuals age 55–64 donate $1089 ($479) more to religious (charitable) donations conditional on donation and $780 ($370) unconditional, though they do not donate much more in educational/political donations, than households headed by individual age below 24. The larger amounts of donation by older households may be attributable to their greater wealth, higher level of religion engagement, and released burden of families. After release from duties for children, older households can be more responsive to the needs of distant others (Bekkers and Wiepking 2007). Therefore, older households are important targets of solicitation in all kinds of capital campaigns, and the aging society predicts a steady increase in household donations in the next few years. Additionally, the age effects do not influence educational/ political donations, implying that household preferences in education and politics are stable.

As expected, white households are more likely to donate than households of black and other races in general. However, we find that, compared to black households, white households are less likely to donate to religious organizations. In terms of secular donations, white households are more like to donate than black households, but less likely than households of other races. These differences by race are also found in conditional and unconditional levels of donations. For example, religious (charitable) donation by white households are $568 less ($95 more) than that of black households in unconditional level. Consistent to findings by Gruber (2004) and Brooks (2005), our estimates demonstrate that black households likely have higher levels of religious engagement so they prefer to donate more to religious organizations. Due to stronger feeling of social responsibility, better educated households are known to have a stronger desire give back to their community (Feldman 2010). Moreover, these better educated households often have abundant human capital and broader social networks, and consequently tend to donate more in general. Compared to households headed by people with less than high school, college-educated households are 8.0% more likely to donate to religious organizations, 14.6% more likely to charitable organizations, and 11.0% more likely to educational/political organizations. As for the levels of religious (charitable) donations, households headed by people with a graduate degree contribute $476 ($305) more conditional on donations and $283 ($263) more unconditional than households headed by people with a college degree. Previous studies also find positive effects of education (Tiehen 2001; Mesch et al. 2006; Brown and Ferris 2007).

The literature suggests household size is positively associated with religious donations but negatively with charitable donation (Brooks 2005). A household of three members is 1.9% more likely to donate to religious organizations but 2.6% less likely to donate to charitable organizations than a household of two. As in Bryant et al. (2003), Brown and Ferris (2007), presence of children has no effect on the probabilities, conditional levels, or unconditional levels of religious donations, and affects only the probability of educational/political donation. However, households with children contribute $72 less to charitable organization conditional on donations and $49 less unconditional, than households without children. Compared to female-headed households, male-headed households are 4.5% (3.1%) less likely to donate to religious (charitable) organizations. As for the levels of donations, gender has limited effects on all three types of donations. Furthermore, marriage has different effects on religious and charitable donations, but has no effect on educational/political donations. The religious donations of married households (households headed by a married person) is 7.9% higher in probability, $846 more in condition level, and $573 unconditional than that of unmarried households. Although marriage does not affect the probability of charitable donation, married households donate $76 more conditional to charitable organizations and $50 more unconditional than unmarried ones. In general, married people would like to donate more to religious and charitable organizations, probably because they have stronger feelings of responsibility for family and society than single persons. Finally, home ownership reflects the wealth of a household and is found to have a positive impact on household donations (Jones and Posnett 1991a; Bekkers and Wiepking 2006; Feldman 2010). Households with ownership of a home are 5.2% more likely to donate to charitable organizations, and contribute $116 more conditional on donations, and $85 more unconditional.

Among the exclusion variables, religious proportion in the state affects only household donations to religious organizations. An increase of 1% in the state's religious proportion increases the probability of religious donation by 0.357%, the level by $12.93 conditionally, and $12.05 unconditionally. These marginal effects are significant at the 1% level, though small in magnitudes. A higher religious proportion in the state reflects higher level of religious engagement its residents and implies a tradition of religious donations. As a result, residents in states with higher religious ratio are more likely to donate to religious organizations. Similarly, the principle of care only plays a role in charitable donations. With a helping behavior, households can show their principle of care and identify themselves as helpers. Looking after pets is one of such helping behaviors. Compared to those without pets, households with pets are 7.2% more likely to donate to charitable organizations and contribute $27 more in unconditional level. In contrast to religious proportion which is only associated with religious donations and the principle of care which is only associated with charitable donations, knowledge of death is associated with all three types of donations. For example, compared to those without knowledge of death, households with knowledge of death are 6.3% more likely to donate to religious organizations, contribute $223 more conditional on donations, and $208 more unconditional. Knowledge of death also have positive effects on the probability (11.5%) and unconditional level ($43) of charitable donations. These results corroborate finding by Jonas et al. (2002) that household with knowledge of death are more likely to donate than their “ignorant” counterparts.

5. Conclusions

This paper investigates the determinants of household donation to religious, charitable, and educational/political organizations, using data from the 2010 and 2011 CEX. A sample selection system is proposed in this study to address censoring in the dependent variables, selection biases caused by unobservable and omitted variables, and correlations among types of donations.

Our findings provide evidence that price and income elasticities of household donation differ by type. Price is negatively associated with secular (charitable and educational/political) donations, but not with religious donations. Therefore, an increase in marginal tax rate will lead to an increase in secular donations but not religious donations. Household income plays a positive role in all types of donations.

In order to achieve the goals of capital campaigns, fundraisers have to identify potential donors by household characteristics. Our findings suggest that older or better educated households are not only more likely to donate but also donate more on average than their younger and less-educated counterparts. Specifically, older households (age 65 or above) donate more than their younger counterparts, while households headed by college-educated people donate more than households headed by high school-educated people. Donations also differ by race, with black households being more likely to donate to religious organizations, and households of white and other races more likely to donate to charitable and educational/political organizations. Relative to households headed by women, male-headed households donate less to religious and charitable organizations. However, in terms of levels, marriage has positive effects on religious and charitable donations, but not on educational/political donations. Household size has a positive effect on the probability of religious donations but a negative effect on that of charitable donations. Larger households are more likely to donate to religious organizations, but less likely to charitable organizations. Home ownership is positively associated with religious donations, while presence of children does not affect religious donations. Among the exclusion variables, religious proportion in the state plays a limited role and contributes only to household donations to religious organizations, and the principle of care for identity of a helper only has positive impacts on charitable donations, but the knowledge of death has positive effects on all three types of donations.

Although this paper is one of the first to investigate the determinants of donations among U.S. households after the Great Recession, one important caveat pertains. The influences of unobservable household characteristics such as social rewards for generosity, guilt for the poor, and understanding of philanthropy, usually limit the reliability of cross-section analysis. Therefore, an analysis with panel data is a likely alternative to ameliorate these unfavorable influences of unobservable variables. Although studies might use household donation surveys in 2001, 2003, 2005, and 2007 from the Center on Philanthropy Panel Study, a more recent series of household surveys after the Great Recession are needed to update the effects of price, SES and demographic variables on household donations.

Table 1

Sample statistics of dependent variables: Household donations per year.

Type of donations	% donating	Mean	SD
Religious organizations	41.93%	$675.62	$1925.97
Among the donating		1611.11	2709.31
Charitable organizations	43.16%	221.73	1408.53
Among the donating		513.73	2109.01
Educational/political organizations	10.69%	58.07	646.20
Among the donating		543.10	1910.25

Table 2

Sample statistics of explanatory variables.

Variable	Definition	Mean
Continuous variables		
HH size	Household size	2.57
		(1.51)
Price	Marginal (federal) tax rate: price of donation at 1st dollar	0.91
		(0.24)
Income	Household income in $10,000	6.94
		(7.99)
Religious proportion	% of major traditions members in state population	0.33
		(0.09)
Binary variables (yes = 1, no = 0)		
Bracket change	Household donation decreases marginal federal tax rate	0.04
Children	Presence of children	0.31
Home owner	Owns a home	0.72
Year 2011	Interview took place in 2011	0.49
Principle of care	Has pets	0.47
Knowledge of death	Has life insurance coverage in case of death or disability	0.44
Household head statistics (binary variable, yes = 1, no = 0)		
Age ≤ 24	Age ≤ 24 (reference)	0.03
Age 25–34	Age 25–34	0.14
Age 35–54	Age 35–54	0.39
Age 55–64	Age 55–64	0.20
Age ≥ 65	Age ≥ 65	0.25
Male	Who is male	0.48
White	Who is White people	0.81
Black	Black (reference)	0.12
Other race	Of other race	0.08
Married	Who is married person	0.54
< High school	Who has a less than high school degree (reference)	0.13
High school	Who has a high school degree	0.26
College	Who has some college, associate, and bachelor’s degree	0.48
Graduate	Who has a graduate degree	0.12
Sample size		4321

Note: Standard deviations in parentheses.

Table 3

ML estimates of sample selection system of household donations.

	Selection			Level		
Variable	Religious	Charitable	Educ/ political	Religious	Charitable	Educ/ political
Constant	–0.993***	–1.037***	–1.917***	–0.713*	–4.136***	–8.909***
	(0.216)	(0.224)	(0.353)	(0.420)	(0.555)	(1.261)
HH size	0.053***	–0.074***	–0.040	–0.068**	–0.010	0.0005
	(0.017)	(0.018)	(0.034)	(0.031)	(0.039)	(0.100)
Price	–0.108	–0.403***	–0.634***	0.116	–0.325	–1.496***
	(0.111)	(0.114)	(0.171)	(0.201)	(0.206)	(0.523)
Income	0.0005	0.022***	0.016***	0.015***	0.042***	0.066***
	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)	(0.010)
Bracket change	1.310***	0.437***	0.563***	1.068***	0.785***	1.558***
	(0.162)	(0.116)	(0.117)	(0.226)	(0.142)	(0.287)
Age 25–34	–0.080	0.052	–0.238	0.518*	0.410	–0.008
	(0.147)	(0.153)	(0.252)	(0.278)	(0.313)	(0.855)
Age 35–54	0.018	0.104	0.0002	0.232	0.644**	0.408
	(0.142)	(0.147)	(0.242)	(0.267)	(0.307)	(0.823)
Age 55–64	0.219	0.346**	0.168	0.401	0.848***	0.560
	(0.145)	(0.152)	(0.244)	(0.276)	(0.320)	(0.832)
Age ≥ 65	0.676***	0.679***	0.639***	0.165	1.292***	1.848**
	(0.148)	(0.155)	(0.246)	(0.287)	(0.338)	(0.843)
Male	–0.128***	–0.090**	–0.001	0.113	–0.021	0.253
	(0.041)	(0.042)	(0.060)	(0.079)	(0.070)	(0.167)
White	–0.351***	0.255***	0.230*	–0.080	0.304**	0.413
	(0.066)	(0.070)	(0.120)	(0.131)	(0.140)	(0.369)
Other race	–0.180*	0.294***	0.320**	–0.390**	0.420**	0.770*
	(0.094)	(0.099)	(0.150)	(0.177)	(0.180)	(0.456)
Married	0.222***	0.033	0.078	0.401***	0.191**	0.189
	(0.051)	(0.053)	(0.076)	(0.096)	(0.088)	(0.217)
Children	0.079	–0.046	0.172*	–0.080	–0.181*	0.260
	(0.056)	(0.058)	(0.089)	(0.108)	(0.097)	(0.257)
Home owner	0.158***	0.150***	0.060	0.235**	0.314***	0.526**
	(0.052)	(0.055)	(0.090)	(0.105)	(0.104)	(0.263)
High school	0.015	0.179**	0.290*	0.373***	0.182	0.632
	(0.070)	(0.075)	(0.152)	(0.135)	(0.148)	(0.544)
College	0.226***	0.425***	0.702***	0.378***	0.694***	1.813***
	(0.068)	(0.071)	(0.144)	(0.130)	(0.158)	(0.548)
Graduate	0.165*	0.617***	1.050***	0.556***	1.060***	2.698***
	(0.088)	(0.092)	(0.156)	(0.165)	(0.188)	(0.590)

Year 2011	0.066	–0.071*	–0.118**	0.039	0.043	–0.322*
	(0.041)	(0.041)	(0.059)	(0.075)	(0.068)	(0.168)
Religious proportion	1.013***	0.328	–0.192			
	(0.210)	(0.236)	(0.253)			
Principle of care	0.0001	0.207***	0.047			
	(0.039)	(0.044)	(0.048)			
Knowledge of death	0.175***	0.325***	0.188***			
	(0.038)	(0.044)	(0.048)			
Error std. dev. (σ_i)				1.696***	1.401***	2.387***
				(0.068)	(0.024)	(0.197)
Error corr. (ρ_{ij})						
Charitable (sel.)	0.159***					
	(0.026)					
Educ/political (sel.)	0.168***	0.360***				
	(0.036)	(0.035)				
Religious (level)	–0.718***	–0.016	–0.025			
	(0.054)	(0.029)	(0.037)			
Charitable (level)	0.154***	–0.001	0.182***	0.067**		
	(0.034)	(0.188)	(0.051)	(0.032)		
Educ/political	0.116***	0.304***	0.928***	0.076*	0.297***	
(level)	(0.043)	(0.046)	(0.026)	(0.043)	(0.048)	
Log likelihood	–7928.209					

Note: All donation amounts are divided by 1000 in estimation. Asymptotic standard errors in parentheses.

* Significance at the 10% level.

** Significance at the 5% level.

*** Significance at the 1% level.

Table 4

Effects of explanatory variables on probabilities, conditional levels, and unconditional levels of donations.

Variable	Religious organizations			Charitable organizations			Educ/political organizations		
	Prob-ability	Cond. level	Uncon. level	Prob-ability	Cond. level	Uncon. level	Prob-ability	Cond. level	Uncon. level
Elasticities									
Price	–0.095	0.015	–0.080	–0.362***	–0.298*	–0.660***	–1.123***	–0.499	–1.622***
	(0.098)	(0.164)	(0.196)	(0.104)	(0.173)	(0.201)	(0.311)	(0.373)	(0.513)
Income	0.003	0.109***	0.112***	0.118***	0.295***	0.413***	0.176***	0.313***	0.489***
	(0.019)	(0.030)	(0.035)	(0.013)	(0.027)	(0.030)	(0.035)	(0.060)	(0.073)
Average marginal effects of continuous explanatory variables									
HH size	0.019***	–0.040	0.0004	–0.026***	–0.004	–0.012	–0.006	0.018	0.0003
	(0.006)	(0.045)	(0.028)	(0.006)	(0.015)	(0.009)	(0.005)	(0.032)	(0.013)
Religious proportion	0.359***	1.293***	1.205***	0.113	0.0001	0.042	–0.031	0.085	–0.002
	(0.074)	(0.306)	(0.273)	(0.082)	(0.019)	(0.032)	(0.040)	(0.114)	(0.002)
Average marginal effects of binary explanatory variables									
Bracket change	0.434***	8.072***	7.437***	0.153***	0.459***	0.381***	0.116***	0.696	0.457
	(0.038)	(2.079)	(1.905)	(0.040)	(0.105)	(0.084)	(0.030)	(0.450)	(0.351)
Age 25–34	–0.028	0.861	0.459	0.018	0.202	0.133	–0.034	0.120	–0.004
	(0.052)	(0.539)	(0.312)	(0.053)	(0.184)	(0.120)	(0.033)	(0.402)	(0.114)
Age 35–54	0.007	0.407	0.250	0.036	0.304*	0.204*	0.00003	0.174	0.056
	(0.050)	(0.391)	(0.232)	(0.051)	(0.172)	(0.114)	(0.039)	(0.355)	(0.123)
Age 55–64	0.078	1.089**	0.780**	0.121**	0.479*	0.370**	0.028	0.186	0.098
	(0.052)	(0.543)	(0.346)	(0.053)	(0.245)	(0.175)	(0.043)	(0.445)	(0.194)
Age ≥ 65	0.244***	1.333**	1.215***	0.234***	0.843**	0.707***	0.121**	0.848	0.549
	(0.051)	(0.598)	(0.427)	(0.050)	(0.337)	(0.266)	(0.054)	(1.009)	(0.653)
Male	–0.045***	0.015	–0.047	–0.031**	–0.009	–0.017	0.0002	0.103	0.034
	(0.015)	(0.111)	(0.068)	(0.015)	(0.028)	(0.018)	(0.010)	(0.068)	(0.032)
White	–0.126***	–0.636***	–0.568***	0.087***	0.113**	0.095***	0.034**	0.059	0.049
	(0.024)	(0.236)	(0.164)	(0.024)	(0.045)	(0.026)	(0.016)	(0.122)	(0.049)
Other race	–0.062*	–0.680***	–0.451***	0.102***	0.209**	0.179**	0.058*	0.232	0.156

	(0.032)	(0.168)	(0.103)	(0.034)	(0.105)	(0.075)	(0.031)	(0.283)	(0.172)
Married	0.079***	0.846***	0.573***	0.011	0.076**	0.050**	0.012	0.041	0.025
	(0.018)	(0.134)	(0.089)	(0.018)	(0.034)	(0.021)	(0.012)	(0.070)	(0.030)
Children	0.028	–0.025	0.019	–0.016	–0.072*	–0.049**	0.028*	0.031	0.037
	(0.020)	(0.150)	(0.092)	(0.020)	(0.038)	(0.024)	(0.015)	(0.092)	(0.043)
Home owner	0.056***	0.509***	0.351***	0.052***	0.116***	0.085***	0.009	0.160*	0.057
	(0.018)	(0.121)	(0.074)	(0.019)	(0.033)	(0.020)	(0.014)	(0.088)	(0.040)
High school	0.005	0.693***	0.421***	0.061**	0.080	0.074	0.050*	0.168	0.121
	(0.025)	(0.257)	(0.162)	(0.025)	(0.068)	(0.046)	(0.028)	(0.294)	(0.162)
College	0.080***	0.913***	0.645***	0.146***	0.309***	0.252***	0.110***	0.745	0.553
	(0.024)	(0.215)	(0.141)	(0.024)	(0.074)	(0.054)	(0.022)	(0.690)	(0.552)
Graduate	0.059*	1.389***	0.928***	0.217***	0.614***	0.515***	0.243***	1.073	0.679
	(0.032)	(0.398)	(0.259)	(0.031)	(0.134)	(0.101)	(0.045)	(0.774)	(0.484)
Year 2011	0.023	0.146	0.115*	–0.024*	0.018	0.001	–0.019**	–0.082	–0.047
	(0.014)	(0.107)	(0.066)	(0.014)	(0.027)	(0.017)	(0.009)	(0.069)	(0.039)
Principle of care	0.00004	0.0002	0.0001	0.072***	0.0001	0.027***	0.007	–0.021	0.0004
	(0.014)	(0.050)	(0.046)	(0.015)	(0.012)	(0.009)	(0.008)	(0.022)	(0.0004)
Knowledge of death	0.063***	0.223***	0.208***	0.115***	0.0001	0.043***	0.030***	–0.084***	0.002***
	(0.014)	(0.056)	(0.050)	(0.016)	(0.019)	(0.012)	(0.008)	(0.031)	(0.001)

Note: All levels are in $1,000. Asymptotic standard errors in parentheses.

* Significance at the 10% level.

** Significance at the 5% level.

*** Significance at the 1% level.

CHAPTER 3: DOES WALKING AFFECT BODY WEIGHT? AN EMPIRICAL ANALYSIS FOR OLDER ADULTS IN CHINA

1. Introduction

China, an emerging economy once with one of the world's leanest populations in the 1980s (WHO MONICA Project et al., 1989), has now caught up with her western counterparts in national income and the prevalence of overweight and obesity. Thanks to economic growth, urbanization, health care reform, and nutrition transition, the prevalence of overweight and obesity has increased and become a public health concern in China (Egger et al., 2012; Van de Poel et al., 2009; Zhao and Kaestner, 2010). Using the 2002 China National Nutrition and Health Survey, Wang et al. (2006) find 60% of the adult residents in Beijing overweight and 20% obese, according to the body mass index (BMI, defined in data section).

Overweight and obesity generally raise mortality and medical expenditures and stress the health care system (Andreyeva et al., 2004; Quesenberry et al., 1998). In the United States (US), in 2000, a conservative estimate of overweight mortality is about 385,000 deaths (Mokdad et al., 2004); an estimate of obesity mortality is between 112,000 to 300,000 deaths (Flegal et al., 2005; US Department of Health and Human Services, 2001); and total cost of obesity is estimated to be US$117 billion (US Department of Health and Human Services, 2001). Wang et al. (2005) estimate that obesity-related heart disease, stroke, and diabetes cost China US$18 billion in national income in 2005, with a cumulative loss of US$556 billion over the period 2005–2015.

Awareness of health concerning body weight may differ between generations. Such generational heterogeneity may confound previous studies of the determinants of obesity for all adults (Ulijaszek, 2007). Moreover, the likelihood of overweight and obesity grows rapidly with age. Baum and Ruhm (2009) find that in the US, along with an increase in age from 18 to 40, average BMI increases from 21.6 to 26.9 and prevalence of obesity increases from 1.0% to 23.2%. Like the rest of the world, China's population is aging. By 2040, adults age 65 or above are expected to account for 20% of the population (Wang et al., 2005). This is consistent with the estimate by Kinsella and He (2009) that adults age 60 or above will increase from 128 million (10% of population) in 2000 to about 431 million (30%) in 2050. However, the elderly support ratio (number of adults age 25–64 divided by number of adults age ≥ 65) in China will drop from about 9:1 in 2010 to 3:1 in 2050 (Population Reference Bureau, 2010). Therefore, obesity among older adults, which may raise household financial burden of medical care, is becoming an important household issue in the aging society of China.

Physical activity is a common recommendation for health promotion and body weight management. A daily schedule of physical activity, especially for older adults, is suggested by many health professionals (Pate et al., 1995). Siegel et al. (1995) conclude that walking is an acceptable and accessible form of physical activity and promotion of walking among inactive people is important. The US Centers for Disease Control and Prevention (CDC) suggests that adults age 65 or above need at least 150 minutes of brisk walking a week to meet the physical activity guidelines (US Department of Health and Human Services, 2008). However, along with rapid shifts toward more sedentary occupations and accelerating mobilization with automobiles, many people have grown addicted to a sedentary lifestyle and blind to the risk of inactivity. Even worse is that economy transitions away from agriculture and rapid process of urbanization are exacerbating the lack of regular physical activity, as well as walking, in China (Monda et al., 2007).

Although a number of studies have investigated the relationship between walking and obesity, many of them incorporate walking or other form of physical activity into the body weight equation as an exogenous variable. The joint effects of walking and other determinants of obesity are unclear. Walking could be associated with other omitted variables, such as lifestyle, diet, genetic and physical characteristics, understanding of health behavior, social norms, and expectation of benefits of physical activity, in the body weight equation. Thus, walking is very likely to be an endogenous variable in the body weight equation. In this study, variable of body weight is categorized by WHO Expert Consultation's (2004) criteria for Asian people, while walking is an ordinal variable from the survey. Therefore, to address the endogeneity of walking, we employ an endogenous treatment effect model, *viz.*, an ordered probability model for body weight with ordinal endogenous treatment (walking).

Few economic studies of body weight are motivated by a utility-theoretic framework; exceptions include Philipson and Posner (1999) and Schroeter et al. (2008). To our knowledge, there is no such a utility-theoretic framework for older adults. Thus, this study extends the general theoretical framework, proposed by Philipson and Posner (1999), to a specialized one for older adults by considering their characteristics in time allocation and physical activities. Moreover, due to absence of high quality data, few studies have investigated the effects of individual socioeconomic status (SES) and demographic background on physical activity or walking in China (Strauss et al., 2010). Most existing studies of body weight and health status for the Chinese people are based on the China Health and Nutrition Survey (CHNS), which is not strictly a survey of the aging population and only contains a small proportion of older adults. Also in CHNS, total expenditure of household consumption is unavailable and income not well measured (Strauss et al., 2010). To overcome these shortcomings in data, we turn to the 2008 China Health and Retirement Longitudinal Study (CHARLS) Pilot Survey. The CHARLS also provides information about individual social contact (e.g., visiting friends, participating indoor, and outdoor activities), neighborhood environment (e.g., community physical activity fields and facilities, and indoor entertainment fields), and regional weather conditions (e.g., days of rain). This information allows better identification of the effect of walking on body weight.

This study contributes to existing literature by proposing a theoretical framework for older adults, comparing differential effects of common variables of individual SES and demographic background on walking and body weight, and examining transmission mechanisms of individual social contact, neighborhood environment, and regional weather conditions on body weight. Section 2 reviews previous studies on walking and obesity and provides a theoretical framework for older adults. Section 3 presents the empirical model and data. Section 4 reports empirical results, and section 5 draws conclusions and provides suggestions for further work.

2. Literature and background

2.1. *Determinants of walking*

Increasing physical activity is usually identified as an efficient way to reduce the risk of obesity-related diseases, such as heart disease, diabetes, and hypertension. Simpson et al. (2003) extend previous studies by demonstrating that walking contributes to an increase in participation rate of regular physical activity among adults in the US, and that walking either alone or along with other forms of physical activity is an important way to meet the CDC physical activity guidelines. Dunn et al. (2012) conclude that daily walking is an alternative to meeting the CDC regular physical activity guidelines for older adults and other sedentary individuals. Relative to other forms of physical activities, walking is cheaper in cost, easier in doing, and lower in risk of injury. As a low-cost physical activity, walking is the most common physical activity among adults in the US (Siegel et al., 1995; Simpson et al., 2003). So is walking in China. However, Monda et al. (2008) find leisure-time physical activity relatively unusual in China, and that the Chinese people expend the majority of calories during working hours. Exacerbating the dismal scenario are the abundant TV shows and online businesses which increase inactivity time (Hill and Peters, 1998), and advances in transportation which reduce the need for physical activity in general. French et al. (2001) find that from the 1990s to the 2000s, frequency of walking decreased and people became less likely to take other short trips and commute to work by walking. These situations are also staging in China. Older adults are doing fewer physical activities in leisure and working hours. Erlichman et al. (2002) suggest that physical inactivity and low levels of physical activity are associated with unhealthy weight gain. Ulijaszek (2007) finds overweight and obesity uncommon among people who undertake high levels of physical activity during working hours. Bell et al. (2001) conclude that occupational inactivity is the strongest predictor of weight gain and find that increases in light work, which requires few physical activities, is associated with the dramatic increase in the prevalence of overweight individuals from 1989 to 1997 in China.

In a review of potential environmental determinants of physical activity, Wendel-Vos et al. (2007) demonstrate that the availability of exercise facilities only relates to intensive physical activities. However, they suggest that it is possible to find different effects of environmental variables on physical activity in other countries, since 80% of studies in their systematical review are from the US and Australia. Nagel et al. (2008) conclude that presence of retail establishments and other potential walking destinations in living areas increases walking time among older adults who do walk, but does not affect their decisions on walking. This finding implies that a friendly neighborhood design plays a role in promoting walking among moderately active older adults but may not change the walking decisions of sedentary elderly. Addy et al. (2004) conclude recreational facilities, parks, playgrounds, and sports fields are more likely to influence regular physical activity, while peer effect, accessibility to sidewalks, and location of malls are associated with walking. Rasinaho et al. (2007) find unsuitable environment such as long distance away from exercise facilities and unfavorable weather conditions have negative impacts on walking.

Although a better environmental plan of neighborhood can remove environmental barriers, daily walking is still not an easily adopted activity for older adults. Social norms and cultural contexts can interfere with their walking decisions through self-efficacy, and cause different expectations, perceptions, and priorities regarding walking (Clark, 1995; Ferraro, 1993; Rushing et al., 1992). Christakis and Fowler (2007) suggest that social networks facilitate the spread of obesity, and that behaviors are influenced by cultural contexts. Social support, human interactions, and positive experience are found to be powerful motivators of exercise (McAuley et al., 2003; Rasinaho et al., 2007). Wendel-Vos et al. (2007) find social supports and companionship positively associated with physical activity. Usually, an older adult’s awareness of health and physical activity will be confirmed and strengthened by his peers in the community activity group. As a result, this older adult is going to spend more time in daily walking for health promotion, and probably has more potential companions to do exercise with.

Characteristics of older adults such as individual SES and demographic backgrounds are also correlated with walking. Ross (2000) finds individual characteristics play a more important role than neighborhood environments in walking decisions. Clark (1995) finds that adults of all ages in the 1980s and 1990s with lower income and less education are less likely to engage in physical activity, since less-educated people usually lack the knowledge of health and are not aware of the benefits of physical activity. On the contrary, people with better education and from wealthy families have more opportunities to engage in activities. However, Ross (2000) and Nagel et al. (2008) find that neighborhood poverty rate contributes to an increase in likelihood of walking, since people from poor families rely on walking and non-automobile transport, such as bicycling.

2.2. *Obesity in China*

Obesity, as a global "epidemic", is also prevalent in China. Data from the China Health and Nutrition Survey (CHNS) suggest the percentage of overweight adults increased over 8 years from 1989, from 11% to 21% for women and 6% to 17% for men. Physical studies have found that an increase in the prevalence of obesity will follow an increase in the risk of chronic illnesses, such as hypertension, cardiovascular disease, type 2 diabetes, and high cholesterol (e.g., McTigue et al., 2006; Must et al., 1999). Wang et al. (2006) find that the prevalence of hypertension increased from 14.4% in 1991 to 18.8% in 2002 for all adults, and from 19.7% to 28.6% for adults age 35 to 74. They also find that the prevalence of cardiovascular disease (diabetes) increased from 31.4% (1.9%) in 1993 to 50.0% (5.6%) in 2003 for all adults. These obesity-related diseases reduce life quality of older adults in China.

China, in the meantime, is experiencing a new stage of nutrition transition. Diets in urban China are becoming high-fat, high-energy, and low-fiber, with about 60% of urban residents deriving over 30% of their energy from fat in 1997 (Du et al., 2002; Popkin and Du, 2003). These dietary changes imply a higher prevalence of overweight and obese persons in urban areas than rural areas (Reynolds et al., 2007).

Perceptions of appropriate body size for health and beauty have significant impacts on the prevalence of obesity. Ulijaszek (2007) shows that, in some societies, larger body size and plumpness have traditionally been seen as attraction and indication of health, wealth, and power; consequently such cultural valuation contributes to the prevalence of obesity. Due to globalization in recent decades, younger people in China exposed to western concepts on health have come to recognize that thinness is a better body image, while overweight and obesity present health risks. However, these western concepts are not rooted in older adults, who have been affected more by some special cultural contexts and historical experience. Wu (2006) suggests that China's recent history, where famine and chronic malnutrition caused deaths, especially during famine in the 1950s, has shaped a widespread belief that excess body weight represents health and prosperity. Besides, there is another cultural misconception on health that the elderly are expected to have a sedentary living style in order to slow the process of metabolism, lower the risk of injury, and consequently prolong life.

Little empirical evidence exists on the determinants of body weight in China. Studies of body weight in western countries find that education has a positive impact on body weight (Smith, 1999; Strauss and Thomas, 1998). People with better education are more likely to recognize the risk of obesity and give credit for healthy weight maintenance, whereas the less-educated would spread unhealthy life style and live in a depressed socioeconomic circumstance (Christakis and Fowler, 2007; Trogdon et al., 2008). In the US, Mokdad et al. (2004) find that 26% of high school dropouts are obese versus 22% of high school graduates and 15% of college graduates. However, in China, for historical and social reasons, only a small proportion of older adults hold a high school degree or above. Therefore, education is likely to play only a limited role in body weight management of older adults. Using data from the 2008 CHARLS Pilot Survey, Strauss et al. (2010) find education positively correlated with BMI of women but not men.

Household income is another factor, since a wealthy household can usually afford more healthy food and better health care which affect body weight. In the US, there is an inverted U-shaped relationship between body weight of a male and his income (Lakdawalla and Philipson, 2009). Chang and Lauderdale (2005) find that 23% (14%) of white women (men) with family incomes above four times of the poverty line were obese during 1999 to 2002, compared to 40% (34%) of their poorer counterparts. Although the poor are more likely to be overweight and obese in developed countries, the opposite is found for developing countries (Kim et al., 2004). Van de Poel et al. (2009) find that after controlling for the offsetting effect of education advantage in urban areas, higher income still explains about 10% of the urban concentration of overweight in China. Due to uncertainty of farm product markets and weather conditions, household income of rural families varies greatly from year to year. Therefore, household income of rural family in China is subject to measurement errors, and use of household income might cause problems in estimation and consequently weaken the reliability of cross-sectional analysis. With 83% of our sample from rural areas, we use household per capita expenditure (PCE) as a proxy for household income. To further reduce measurement errors, the value of self-grown self-consumed food, as a part of the household income, are included in PCE (Strauss et al., 2010).

2.3. *Walking and obesity for the elderly*

Relative to younger adults, older adults are more likely to attribute their health problems to aging rather than illness (Sarkisian et al., 2005). Thus, older adults will underrate the health benefits of physical activity and daily walking, and consequently be less likely to walk in general. Studies have documented that daily walking is an economical option to manage body weight and promote physic health (Pate et al., 1995; Siegel et al., 1995). However, many people are blind to the benefits of physical activity and prefer a sedentary life. Using data from the 2001 Behavioral Risk Factor Surveillance System (BRFSS), Brown et al. (2005) find that only 43.4% of adults age 50 or above without disabilities meet the CDC recommendation, while only 28.8% of those with disabilities meet the recommendation. Due to a lack of physical activity, retired older adults are vulnerable to obesity-related diseases and other health problems. Even for working older adults, work demanding intense physical activity is often not required. Hence, compared to younger adults, older adults would expend fewer calories during working hours and are more likely to live in an inactivity circumstance. Moreover, because of household modernization and mechanization, people of all ages now have fewer opportunities for activity-intensive housework. Lanningham-Foster et al. (2003) demonstrate that the energy expenditure of doing housework without the assistance of machines is substantially greater than that with the assistance. Thus, the popularity of labor-saving machinery partly contributes to weight gain and speeds the spread of obesity. Additionally, this “housework revolution” might have different effects on older adults by gender, since duties on housework differ by gender. In China, women usually take responsibility for housework, such as child care and cleaning (Short et al., 2002). Upon retirement and release from duties on child care, the level of physical activity of older women will decrease much more than older men.

2.4. *Theoretical framework*

Drawing on the obesity framework proposed by Philipson and Posner (1999), individual body weight depends on (a balance between) the intake and expenditure of calories. Let individual body weight be $W(F, P)$, where F is the intake of calories from food consumption and P represents calories expended in physical activities. Obesity is the result of energy imbalance, *viz.*, excess of calorie intake over expenditure, since $W_F \geq 0$ and $W_P \leq 0$. To keep a balance of calorie intake and expenditure, the more physical activities people do, the more food is consumed, and vice versa. The marginal effect of calorie intake is diminishing, $W_{FF} \leq 0$, while the marginal effect of calorie expenditure is increasing, $W_{PP} \geq 0$. For older adults, expenditure of calories in physical activities consists mainly of two parts: housework expenditure (ηH) and exercise expenditure (θE), where η and θ are calories expended per hour in housework and exercise, and H and E are housework time and exercise time; thus, calorie expenditure $P = \eta H + \theta E$, where walking is assumed to be a major activity in exercise time (E). Utility of older adults, $U(W(F, P), F, C, L, E; G)$, is defined over body weight, consumption of food (F), consumption of a composite good (C), inert leisure time (L), exercise time (E), and individual characteristics (G) (*viz.*, individual SES and demographic backgrounds) which accommodate individual heterogeneity. Time (T) of older adults includes inert time (with little calories expenditure), housework time, and exercise time; that is, $L + H + E \leq T$. We assume utility is a quasi-concave function with diminishing marginal utility of body weight, food consumption, composite consumption, leisure time, and exercise time, *viz.*, U_{WW}, U_{FF}, U_{CC}, $U_{LL,}$ and $U_{EE} \leq 0$.

The utility-maximization framework can be written as

$$\begin{aligned}
&\underset{F,H,E}{Max}\ U(W(F,P),F,C,L,E;G) \\
&\text{s.t.} \quad p_F F + C = I \\
&\qquad\ \ \eta H + \theta E = P \\
&\qquad\ \ L + H + E = T,
\end{aligned}$$

where p_F is price of food and I is income. The utility model can be rewritten as

$$U(W(F,\eta H + \theta E),F,I - p_F F,T - H - E,E;G) = U(F,H,E;G)\,. \qquad (1)$$

The necessary first-order conditions for an interior solution are

$$\partial U / \partial F: \quad U_W W_F + U_F = p_F U_C \quad \text{(calorie intake)} \qquad (2)$$

$$\partial U / \partial H: \quad U_W W_P \eta = U_L \qquad \text{(housework)} \tag{3}$$

$$\partial U / \partial E: \quad U_W W_P \theta + U_E = U_L \qquad \text{(exercise).} \tag{4}$$

Due to the popularity of labor-saving machines used in housework, calories expended per hour in housework (η) and housework time (H) decline. To maintain body weight ($\Delta W = 0$) without change in intake calories from food consumption (F), the individual has to keep calories expended in physical activities (P) constant. Thus, a decrease in calories expenditure in housework (ηH) will lead to an increase in calories expenditure in exercise (θE). Besides, with the time constraint, a decrease in housework time (H) will lead to additional increase in time for leisure (L) and exercise (E). In equation (4), without changes in U_W and W_P, an increase in leisure (L) results in a decrease in U_L and might consequently lead to decreases in U_E and θ. The decline in U_E represents an increase in E, since $U_{EE} \leq 0$. It implies that older adults have to lower the strenuous level of exercise (θ) but increase the time of exercise (E). Thus, among all potential activities for exercise, walking is an optimal alternative, because it has a lower strenuous level and older adults also can easily walk in a long time. Additionally, with development of technology and growth of economy, the food price (p_F) will decline. Equation (2) suggests that after controlling for U_W, W_F, and U_C, a decrease in food price might lead to a decrease in U_F, which implies an increase in food consumption, since $U_{FF} \leq 0$. As a utility-maximizing individual, an older adult will consume more foods and consequently be exposed to a higher risk of obesity. Therefore, under the circumstances with popularity of labor-saving machinery and decline in food price, it is necessary to examine the effect of daily walking on body weight and propose optimal daily walking suggestions for current older adults in China.

According to this theoretical framework, the optimal level of individual body weight is $W^* = W(F^*, P(H^*, E^*))$, such that optimum level of calorie intake F^* is a function of food price

(p_F), income (*I*), and individual characteristics (*G*) including SES and demographic backgrounds, *viz*., $F^* = F(p_F, I, G)$, and optimum level of calorie expended *P* is a function of optimal housework (*H**) and exercise time (*E**). Both coefficients of calories expended per hour in housework (η) and exercise (θ) are constant. Housework time $H^* = H(G)$ is a function of individual characteristics, and exercise time $E^* = E(N, G)$ is a function of individual characteristics (*G*) and neighborhood environment (*N*) which includes weather and accessibility to physical activity fields and facilities. Therefore, the long-run body weight function can be written as $W^* = W(F^*, P(H^*, E^*)) = W(p_F, I, N, G)$. However, in this study, daily walking of an older adult is given; hence, optimal body weight function is re-written as $W^* = W(p_F, I, E^*, G)$.

3. Empirical model and data

3.1. *Empirical model*

Due to correlation with omitted and unobserved explanatory variables among individual characteristics (*G*), time of daily walking (*E**) is endogenous in the body weight equation, $W^* = W(p_F, I, E^*, G)$, which is derived from the theoretical framework in Section 2.4. In this study, body weight is divided into four levels by BMI, and daily walking into four levels by time. To accommodate these two ordinal variables, an endogenous treatment effect model is used.

3.1.1. *Econometric specifications*

Maddala (1983) proposes a reduced form equation for the endogenous variable (binary probit model) and a structural form equation for the dependent variable. In this study, daily walking is ordinal and specified as ordered probit. Define vector $d = [d_1, \ldots, d_J]'$ containing binary indicators d_j of walking levels, such that $d_j = 1$ if $E = j$ and $d_j = 0$ otherwise for *j* =

1,..., J. The extended model consists of an ordinal treatment equation for daily walking (E) governing walking categories (d), which enter the ordinal outcome equation for body weight (W):

$$E = j \quad \text{if} \quad \mu_{j-1} < x'\beta_1 + z_1'\gamma_1 + \varepsilon_1 < \mu_j \;\; (j = 0,1,\ldots,J) \tag{5}$$

$$W = k \quad \text{if} \quad \xi_{k-1} < x'\beta_2 + z_2'\gamma_2 + d'\delta + \varepsilon_2 < \xi_k \quad (k = 0,1,\ldots,K), \tag{6}$$

where x, z_1, and z_2 are vectors of explanatory variables, $\beta_1, \beta_2, \gamma_1, \gamma_2$ and δ are parameter vectors, and the μ's and ξ's are threshold parameters such that $\mu_{-1} = -\infty, \mu_0 = 0, \mu_J = \infty$, $\xi_{-1} = -\infty, \xi_0 = 0, \xi_K = \infty$, and that $\mu_1,...,\mu_{J-1}$ and $\xi_1,...,\xi_{K-1}$ are estimable. The error terms $(\varepsilon_1, \varepsilon_2)$ are assumed to be distributed as standard bivariate normal with zero means, unitary variances, and correlation ρ. Vector x contains common explanatory variables in both equations, vector z_1 contains unique variables for identification of the walking equation, and vector z_2 contains unique variables in the body weight equation. The model can be estimated by the method of maximum likelihood (ML). Except the treatment variables (d) in equation (6), the sample likelihood function is identical to that of the bivariate ordered probit model, with likelihood contributions (probabilities) (Greene and Hensher, 2010, pp. 219–220)

$$\begin{aligned}
\Pr(E = j, W = k) = {} & \Phi_2(\mu_j - x'\beta_1 - z_1'\gamma_1, \xi_k - x'\beta_2 - z_2'\gamma_2 - d'\delta) \\
& - \Phi_2(\mu_j - x'\beta_1 - z_1'\gamma_1, \xi_{k-1} - x'\beta_2 - z_2'\gamma_2 - d'\delta) \\
& - \Phi_2(\mu_{j-1} - x'\beta_1 - z_1'\gamma_1, \xi_k - x'\beta_2 - z_2'\gamma_2 - d'\delta) \\
& + \Phi_2(\mu_{j-1} - x'\beta_1 - z_1'\gamma_1, \xi_{k-1} - x'\beta_2 - z_2'\gamma_2 - d'\delta), \\
& j = 0,1,\ldots,J; k = 0,1,\ldots,K,
\end{aligned} \tag{7}$$

where $\Phi_2(\cdot)$ is cumulative distribution function of the bivariate standard normal. Exogeneity of daily walking (E) corresponds to parametric restriction ρ = 0, under which the likelihood function reduces to the product of likelihood function of two independent ordered probability models. Therefore, the independent (exogenous) model can be estimated by separate ordered probability models: for the treatment equation of daily walking (E) and for the outcome equation of body weight (W) with binary variables in d. Exogeneity of walking ($\rho = 0$) can be investigated by regular tests for a nested hypothesis, such as Wald, likelihood-ratio (LR), and Lagrange multiplier (LM) test.

Following the joint probabilities in equation (7) are various marginal probabilities for walking categories $\Pr(E = j)$ and body weight categories $\Pr(W = k)$, and probabilities of body weight categories conditional on a walking category such as $\Pr(W = k \mid E = j)$. These marginal and conditional probabilities can be differentiated (differenced) to obtain the marginal effects of each continuous (discrete) explanatory variable. The conditional probabilities also allow calculation of the treatment effects of walking on the probability of each body weight category:

$$TE_{hj}^{k} = \Pr(W = k|E = h) - \Pr(W = k|E = j),\ k = 0,1\ldots K, h > j. \tag{8}$$

All marginal and treatment effects will be evaluated at all sample observations and averaged over the sample. For statistical inference, standard errors of marginal and treatment effects can be derived by a mathematical approximation procedure called the delta method (Spanos, 1999, p. 493).

3.1.2. *Possible sources of bias*

Given potential endogeneity of neighborhood selection, identification of neighborhood effects is under debate. This self-selection on neighborhood could cause an inconsistent and biased estimation of any model especially in which the outcome of interest is possibly associated with neighborhood choice, such as health (Bilger and Carrieri, 2013). Although many studies have ignored the potential identification problems (Clark, 1995; Nagel et al., 2008; Rasinaho et al., 2007; Wendel-Vos et al., 2007), two economic studies, Katz et al. (2001) and Kling et al. (2007), address the identification issue by using experimental data from the Moving To

Opportunity (MTO) program in the US and draw the conclusions of neighborhood effects. It is common to hypothesize that older adult interested in doing physical activity prefers to live in a neighborhood with well-built exercise fields and physical activity facilities. Thus, without an effective identification strategy, the effects of neighborhood on walking and the transmission effects of neighborhood on body weight might be contaminated by self-selection bias. However, such selection bias has little influence in our study of body weight for older adults. First, the age of individuals in our sample is 45 or above. In this age group, those in urban areas usually obtained their apartments or flats by the assignment of their factories and companies when they married earlier in life (in the 1980s or earlier), while those in rural areas always built houses on their own land in villages. Neither of them could select their neighborhood. Second, construction campaigns of exercise infrastructure in communities are undertaking in China to improve the life quality of citizens. Even in poor areas, the central government provides funding for such construction. Third, the financial burden of buying an apartment or building a house is so heavy in China that most urban or rural families are unlikely to change their residences and neighborhoods once they have settled down. In addition, this study incorporates variables of neighborhood environment, such as outdoor fields, indoor fields, and outdoor facilities, to control for the heterogeneities among different areas. Thus, the effects of neighborhood environment on walking can be identified.

Another source of bias is household income. Since many older adults are off the job market and others are expected to retire or have retired, their household income may not reflect household wealth. For example, older adults from wealthy household might have retired and thus do not have income, but they have enough saving and deposits for retirements. As a result, household per capita expenditure (PCE) becomes an appropriate proxy variable, which not only reflects the effect of income but also represents a level of household wealth for older adults, which consequently influences body weights.

3.2. *Data and variables*

Data in this study come from the China Health and Retirement Longitudinal Study (CHARLS) pilot survey in 2008, which is a collaborative effort of researchers from the National School of Development (China Center for Economic Research) at Peking University, University of Southern California, and University of Oxford. The CHARLS is a survey of older adults in China, covering households with members age 45 or above. This pilot survey investigated 2,685 individuals from 95 communities or villages in two provinces: Gansu, a poor inland province, and Zhejiang, a rich coastal province. Data are available at the individual level and the community level. Variables of neighborhood environment (e.g., outdoor fields, indoor fields, and outdoor exercise facilities), social contact (e.g., visiting friends, participating indoor, and outdoor activities), and regional weather conditions are uniquely present in CHARLES survey but not in other popular surveys such as the China National Nutrition and Health Survey. After deleting observations with missing values on important variables, the final sample contains 1,523 individuals from 93 communities or villages. Sample statistics (Table 1) suggest 51% of the sample are male, 84% rural, 55% from Zhejiang, and 45% from Gansu. Age ranges from 45 to 87 with a mean of 58.2.

BMI is commonly used as a measure for body shape and an indicator of obesity. It is defined as weight in kilograms divided by height in meters squared (kg/m^2). Both body weight and height information are from biomarkers of CHARLS. Most previous studies refer to the WHO (2000) classification of body weight. However, BMI cut-off points are influenced by the nutritional and economy conditions and hence vary with race, countries, and time. Thus, body weight of older adults is categorized into four levels using WHO Expert Consultation's (2004) criteria for Asian people: underweight (BMI < 18.5), normal weight (18.5 ≤ BMI < 23), overweight (23 ≤ BMI < 27.5), and obesity (BMI ≥ 27.5). According to this categorization, 6% of the sample are identified to have underweight, 47% normal weight, 37% overweight, and 10% obese. The prevalence of overweight and obesity in this sample differs from that reported by Wang et al. (2006), who report 60% of overweight and 20% of obesity based on a sample of adults age 18 or above. This difference reflects heterogeneities of body weight among individuals between age groups and motivates an analysis of body weight among older adults.

Walking is divided into four levels by time, according to the US CDC guidelines (US Department of Health and Human Services, 2008). About 9% of the sample have no daily walking, 25% less than 30 min, 35% between 30 min and 2 h, and 31% more than 2 h per day. At least 66% of the sample walk over 30 min a day. This fact suggests that older adults in China do usually participate in regular physical activity in their daily life, and to some extent explains the lower prevalence of overweight and obesity among them.

Binary variables of neighborhood environment, social contact, and regional weather conditions are used. Variables of neighborhood environment reflect the characteristics of communities where individuals usually live and walk (Manski, 1993). Characteristics of community include outdoor fields (e.g., basketball field and swimming pool), indoor fields (e.g., room for card games, chess games, or Ping-Pong, activity center for the elderly, and other entertainment facilities), and outdoor exercise facilities (e.g., outside exercising facilities and other outdoor sport facilities). Variables of social contact include visits with friends (interacting with friends almost daily or weekly), participation in indoor activities (attending an educational or training course, playing Ma-jong, chess, and cards, investing stock, and surfing on the Internet almost daily or weekly), and participation in outdoor activities (going to a sport, social, or other kind of club and took part in a community-related organization almost daily or weekly). Regional weather conditions are reflected in the chance of rain in a community in 2008—number of rainy days divided by 366 days. The higher the chance of rain is in an area, the more likely an older adult is to stay at home, since walking usually does not take place on a rainy day. On the other hand, older adults in an area with more rain may be used to the weather conditions and extend the time of daily walking on non-rainy days. Thus, the effect of weather conditions on walking remains unclear.

Household PCE is defined as household total expenditure divided by household size. Household total expenditure includes fees (e.g., fees paid for utilities, fuel, matron, housekeepers and servants, heating, and communication) and expenditure on foods, durable goods, education and entertainment, clothing, medicine, and transportation. Household food expenditure, as a part of household total expenditure, includes the value of consumption of self-grown foods, since many older adults in rural areas prefer to consume self-grown foods. Few studies include the value of self-grown, self-consumed foods as a part of household income. Omission of this component may not cause a measurement error in household income for older adults from urban areas, which constitute only 16% of the sample; however, for those from rural areas, this omission can lead to serious measurement errors in income. Therefore, the value of self-grown, self-consumed foods is included in household total expenditure. Considering heterogeneities of household wealth in different regions, household PCE is divided by the local average PCE. In 2008, average per capita expenditures were CN¥2400.95 in rural areas and CN¥8308.62 in urban areas in Gansu, while the corresponding figures were CN¥7534.09 and CN¥15158.3 in Zhejiang (China Statistics Bureau, 2009).

4. Results

The endogenous probability treatment model is estimated by ML procedure. Average treatment effects are calculated to examine the effects of daily walking on body weight. Then, average marginal effects of explanatory variables are calculated to compare the differential effects of explanatory variables on walking and body weight category probabilities. Presence of instruments in the treatment equation also allows examination of the effects of these variables on body weight category probabilities conditional on walking categories (transmission effects).

4.1. *Test for endogeneity of daily walking*

The primary specification test, for endogeneity of walking, is done by examining statistical significance of the error correlation coefficient (ρ). Results (Wald = 37.82, *LR* = 17.41, *LM* = 19.62, *df* = 1, *p*-value < 0.0001) suggest rejection of the null hypothesis that $\rho = 0$ at 1% level of significance, implying that daily walking is endogenous to in the body weight equation. Thus, failure to accommodate such endogeneity can produce inconsistent (biased) estimates for the body weight equation. Use of the endogenous treatment effect model is warranted.

Validity of the identification variables in the walking equation is then investigated. Among the instruments, outdoor fields and chance of rain are individually significant at the 1% level and visiting friends at the 10% level, and they are jointly significant at the 1% level (Wald = 38.11, *df* = 3, *p*-value < 0.0001).[6] As for excludability of these variables from the body weight equation, outdoor fields and visiting friends are jointly insignificant (LM = 2.04, *df* = 2, *p*-value

[6] Additional neighborhood environment (indoor fields, outdoor facilities) and social contact (participating indoor, outdoor activities) variables were used initially as instruments in the walking equation. However, only outdoor fields, visiting friends, and chance of rain are found significant and retained as instruments. Removal of these insignificant instruments did not cause discernible differences in ML estimates and, more importantly, in the treatment effects. Wendel-Vos et al. (2007) also find that outdoor exercise facilities do not affect walking of older adults.

= 0.361), justifying their exclusion from the body weight equation, while chance of rain is significant (LM = 7.455, *df* = 1, *p*-value = 0.006). Although exclusion of chance of rain from the body weight equation is not supported by statistical test, robustness analysis with the variable included in the body weight equation did not produce discernible differences in coefficients in the two equations and, more importantly, the treatment effect estimates. Moreover, the literature suggests weather conditions affect the walking rather than body weight (Rasinaho et al., 2007). In sum, use of outdoor fields, visiting friends, and chance of rain as identification variables is justified.

4.2. *Maximum-likelihood estimates*

ML estimates are presented in Table 3. Estimate of the error correlation (0.622) is significant at the 1% level, confirming result above of the Wald, LR, and LM tests for endogeneity of walking. The threshold parameters in both equations are positive and significant at the 1% level, capable of delineating categories in walking and BMI. A negative threshold parameter estimate(s) would have suggested misspecification of the ordered probability models.

All three walking time (treatment) variables are individually significant and jointly significant (Wald = 50.44, df = 3) at the 1% level, suggesting that daily walking at any level is an effective means to manage (decrease) body weight. The coefficient of age is negative in both equations which suggests, contrary to finding by Reynolds et al. (2007), an increase in age has a negative effect on body weight. Although older adults are not very likely to walk more than 2 h per day, their body weights do not increase with age. Different from finding in previous literature that education is an important determinant of body weight (Christakis and Fowler, 2007; Clark, 1995; Trogdon et al., 2008), our estimates of coefficients of the education variables are individually insignificant in both equations, though they are jointly significant at the 5% level

(Wald = 8.85, *df* = 3, *p*-value = 0.031) in the body weight equation. This fact suggests that education might not be a key determinant of daily walking and body weight for current older adults in China, which can be attributed to the lower education level of older adults. Only 20% of the sample hold a middle school degree or higher. Corroborating finding that income has a positive effect on body weight in developing countries (Kim et al., 2004), the total expenditure index (as a proxy for income) has a positive effect on body weight, implying that older adults with higher income have a higher risk of obesity than their lower-income counterparts. Older adults from rural areas have lower body weight than those from urban areas. Van de Poel et al. (2009) also find a higher proportion of overweight in urban areas than rural areas in China. In contrast to the finding that unfavorable weather conditions are a barrier to walking (Rasinaho et al., 2007), our result suggests that, surprisingly, there is a positive correlation between unfavorable local weather conditions (rain) and the time of daily walking. This result implies that a higher chance of rain in an area may increase the time of daily walking for old adults. Prices of pork and eggs, as proxies for food prices, do not affect body weight. Insignificance of these prices, as in Wu et al. (1995), is likely due to the fact that both pork and eggs are essential foods for households and have low own-price elasticities.

4.3. *Average treatment effects*

Table 4 reports the average treatment effects (ATEs), that is, average change in the probability of body weight falling into each category for one category of daily walking relative to another. These estimates suggest that sedentary older adults should extend walking time to lose weight. Compared with those without daily walking, an older adult walking < 30 min a day is 6.1% more likely to have a normal weight, and 4.1% (3.8%) less likely to be overweight (obese) at the 10% level of significance or lower. Compared to those walking 30 min – 2h, an older adult walking ≥ 2 h a day is 1.9% more likely to be underweight and 3.5% less likely to be overweight; and they are 2% more likely to be underweight and 4.3% less likely to be overweight than those without daily walking. Contrary to expectation that daily walking brings about weight loss, compared to older adults who walk < 30 min a day, those walking 30 min – 2 h a day are 1.7% (3.9%) less likely to be underweight (normal), but 3.2% (2.3%) more likely to be overweight (obese); all ATEs are significant at the 5% level. The unexpected weight gain of these older adults is likely attributable to a misconception that the calories expenditure of walking 30 min – 2 h a day is enough. With this misconception, older adults walking 30 min – 2 h a day might have excess of calories and consequently become heavier.

Whereas sedentary older adults can effectively lose weight by walking any level of time a day, overweight or obese elderly who walk 30min or less a day have to extend walking time to more than 2h a day to lose weight.

4.4. *Average marginal effects*

Average marginal effects of explanatory variables on the probabilities of walking and body weight categories are presented in Table 5, and average marginal effects on the probabilities of body weight categories conditional on walking are presented in Tables 6 and 7. In Table 5, older adults in a community with outdoor fields are less likely to walk more than 30 min a day. Relative to those in a community without outdoor fields, older adults in a community with outdoor fields are 3.3% and 3.9% more likely to stay sedentary and walk less than 30 min a day, respectively, and 0.4% (6.8%) less likely to walk for 30 min – 2 h (more than 2 h) a day. Those without access to outdoor fields may choose to walk around their residence areas, which are much vaster than the outdoor fields of a community. Hence, they are more likely to walk a longer time. In terms of social contact, visits with friends promote the probability of longer walking time. At the 10% level of significance, older adults who usually interact with friends almost daily or weekly are 4.0% more (2.2% less) likely to walk ≥ 2 h (< 30 min) than those without such social activity. The more opportunities an older adult has to interact with friends or participate in outdoor activities, the more likely he is to extend his walking time. This is because older adults who usually visit friends might have more companions for walking, and companionship is an important factor in walking (Wendel-Vos et al., 2007). In contrast, an older adult who usually plays cards and chesses is prone to stay sedentary at tables. As for weather conditions, a 1% increase in the chance of rain leads to a 0.45% increase in the probability of daily walking ≥ 2 h, but a 0.25% decrease in the probability of daily walking < 30 min. Although small in magnitudes, the effect of rain in this study is contrary to finding by Rasinaho et al. (2007) that unfavorable weather is a barrier for walking.

The literature suggests long run technological changes lower food prices through agricultural innovations, induce the increase in food consumption, and consequently cause overweight and obesity (Cutler et al., 2003; Lakdawalla and Philipson, 2009; Philipson and Posner, 1999). We however found marginal effects of pork and egg prices insignificant. Although pork and eggs are main sources of protein in Chinese diets, as essential (staple) food items, they tend to have lower own-price elasticities and do not affect body weight (Philipson and Posner, 1999; Wu et al., 1995).

Baum and Ruhm (2009) find that BMI increases with age for adults age 18–40. We find that age has an opposite effect on BMI for older adults. A ten-year increase in age leads to a 3.2% (2.7%) increase in the probability of underweight (normal) weight, but a 2.1% (3.7 for adults age 18–40, %) decrease in the probability of overweight (obesity), at the 1% level of significance. As ability in physical activity decreases with age, older adults will likely reduce walking time and prefer to stay sedentary. Compared with a 55-year-old adult, a 65-year-old adult is 1.9% more likely to walk < 30 min and 3.3% less likely to walk ≥ 2 h a day.

Gender plays a role in the body weight equation at the 1% level, but insignificant in the walking equation. The body weight of older males is 5.6% (4.8%) more likely to be underweight (normal), but 3.8% (6.6%) less likely to be overweight (obese) than that of older females. Older females are found to have higher risks of being overweight and obese than older males (Reynolds et al., 2007).

Although living in an urban or rural area does not affect the probabilities of walking categories, it affects body weight. In Tables 6 and 7, compared to that of older adults from urban areas, the body weight of those from rural areas are 13.5% more likely to be underweight but 6.4% less likely to be overweight conditional on no daily walking, while 5.4% more likely to be underweight but 5.0% less likely to be overweight conditional on daily walking between 30 min and 2 h.

Household expenditures affect body weight but not daily walking. In Table 7, conditional on walking 30 min – 2 h (≥ 2 h) a day, older adults with PCE twice as the local average level are 1.1% (1.8%) higher in the probability of falling into obesity category than those at the local average level. Kim et al. (2004) and Van de Poel et al. (2009) also find positive effects of expenditure on the probabilities of body weight being overweight and obese. Education does not play a role in walking or body weight. This may be because, reflecting China's population, only about 20% of the sample have middle school education or higher. Our result does not imply that education is not a determinant of daily walking or body weight. Thanks to the social reform since the early 1980's in China, the younger generations usually have better access to higher education. As a result, education will equip the younger generations with more health knowledge, and consequently play a significant role in walking decision and weight management of older adults in the future.

The transmission effects of neighborhood environment, social contact, and weather conditions on body weight are also investigated because they affect body weight category probabilities (indirectly) by affecting walking. We show above that the marginal effects of explanatory variables in Table 5 and demonstrated that outdoor fields are associated with a lower level of walking, while visiting friends and a higher chance of rain will extend the time of walking. Conditional on walking 30 min – 2 h (Table 6), the probability of older adults falling into underweight (normal) category increases by 0.132% (0.157%), when chance of rain increases by 1%. At the same walking level (Table 7), older adults who usually visit friends almost daily or weekly are 1.1% (1.4%) less likely to be overweight (obese) than those who do not. In Table 6, relative to older adults without access to an outdoor field, those in a community with outdoor fields are 3.9% (2.0%) less likely to be underweight conditional on no walking (walking 30 min – 2 h). This result explains the transmission mechanism of outdoor fields. An older adult with access to outdoor fields walks less which in turn decreases the probability of underweight. However, when this older adult spends more time walking, the negative effects of outdoor fields on walking time are partly offset by the positive effects of walking conditional on having a lighter weight. Thus, with the increase in the given level of walking, the transmission effects of outdoor fields on the probability of underweight become smaller in magnitude. Similarly, in Table 7, the probability of obesity of older adults who visit friends daily and weekly is 0.7% (1.8%) lower than those who do not, conditional on daily walking < 30 min (≥ 2 h). This result explains the transmission mechanism of visiting friends. An older adult who visits friend daily or weekly walks more which in turn decreases the probability of obesity. However, when this older adult spends more time walking, the positive effects of visiting friends on walking time are partly reinforced by the positive effects of walking on having a lighter weight. Thus, with the increase in the given level of walking, the transmission effects of visiting friends on the probability of obesity become greater in absolute value. By influencing the time of daily walking, variables of neighborhood environment, social contact, and weather conditions have indirect impacts on body weights.

5. Conclusions

This paper investigates the effects of daily walking on body weight for older adults in China by using the recently collected CHARLS data. Drawing on existing utility-maximizing framework, we develop a theory of body weight for older adults by accounting for their characteristics in time allocation and physical activity. To accommodate endogeneity of walking in the body weight equation, we estimate an ordered probability model of body weight with ordered endogenous walking. Our findings provide evidence that daily walking is an effective means for sedentary older adults to manage body weights, but overweight and obese older adults who already have a plan for walking < 30 min a day have to extend walking time to more than 2 h to lose weight. Therefore, in order to keep a healthy weight, there are different suggestions for older adults in different body weight categories with different levels of daily walking.

Age is found to play significant roles in both body weight and daily walking of older adults. For old adults age over 45, an increase in age will lead to an increase in the probability of taking a short time walking and a decrease in body weights. Household per capita expenditure (as a proxy for income) and residing in rural areas influence body weight but not daily walking. For an older adult in China, higher income implies a higher risk of obesity, whereas residing in rural areas lowers the risk. Education does not affect body weight or walking, which may be due to the fact that many older adults in China have limited education. The lack of education among the majority of the sample prevents a thorough investigation of educational effects on body weight. Since both pork and eggs are essential foods with lower own-price elasticities (Wu et al., 1995), their prices do not affect body weight. For identification of walking effects on body weight, we use neighborhood environment, social contact, and weather conditions as instrument in the walking equation. Our results show that outdoor fields are significantly associated with shorter time of daily walking, while outdoor exercise facilities and indoor fields do not affect walking. Among the social contact variables, only interaction with friends promotes walking, and participation in outdoor and indoor activities does not. A higher chance of rain encourages an older adult to set an intensive schedule for daily walking, which implies a positive relationship between the chance of rain and daily walking. Additionally, we find transmission effects of outdoor fields, visiting friends, and chance of rain on body weights of older adults, by affecting walking.

While this study is one of the first to investigate the effects of walking and SES on body weight of older adults in China, a few caveats pertain. First, omitted variables and unobserved individual fixed effects, such as genetic and physical characteristics, individual life style, and understanding of health behavior, will limit the reliability of cross-section analysis. To overcome these shortcomings, further studies might employ a panel dataset when successive CHARLS surveys become available. Second, due to limitation of current dataset, this paper does not explore the effects of other characteristics of neighborhood environment, such as neighborhood poverty rate, criminal rate, and employment rate. These characteristics might affect walking of older adults which can in turn influence body weights. Finally, with availability of more food prices, the effects of these prices on body weight can be further investigated.

Table 1

Frequency distribution of walking and body weight categories.

	Body weight category				
Walking	Underweight	Normal	Overweight	Obesity	Total
No walking	8	58	54	19	139
< 30 min	35	168	144	31	378
30 min – 2 h	24	247	202	58	531
≥ 2 h	26	240	165	44	475
Total	93	713	565	152	1523

Table 2

Sample statistics.

Variable	Definition	Mean
Dependent variables		
Walking		
No Walking	No daily walking	0.09
< 30 min	Daily walking < 30 minutes (min)	0.25
30 min – 2 h	Daily walking between 30 min and 2 hours (h)	0.35
≥ 2 h	Daily walking ≥ 2 h	0.31
Body weight		
Underweight	BMI < 18.5 kg/m^2	0.06
Normal	18.5 ≤ BMI < 23	0.47
Overweight	23 ≤ BMI < 27.5	0.37
Obese	BMI ≥ 27.5	0.10
Continuous explanatory variables		
Age	Age in years	58.26 (9.23)
Expenditure index	Household per capita expenditure per year divided by local poverty line	1.70 (1.92)
Chance of rain	Chance of rain in 2008 (rainy days in 2008 divided by 365)	0.16 (0.09)
Pork price	Average price for the liji part of pork in village or community per half kilogram	14.47 (2.36)
Egg price	Average price for chicken eggs in village or community per half kilogram	4.47 (1.50)
Binary explanatory variables		
Male	Gender is male	0.51
Zhejiang	Residence in Zhejiang Province	0.55
Village	Residence in a village	0.84
Married	Married	0.83
No educ	No education experience	0.40
Elementary sch	Element school	0.40
Middle sch	Middle school (reference)	0.13
High sch	High school or above	0.08
Outdoor fields	(Presence of) basketball field or swimming pool in community	0.38
Visiting friends	Interaction with friends almost daily or weekly	0.22
Sample size		1523

Note: Standard deviations in parentheses.

Table 3

Maximum-likelihood estimates of ordered probability model of body weight with ordered endogenous walking.

Variable	Walking	Body weight
Constant	2.068 (0.257)***	4.230 (0.319)***
Age / 10	–0.099 (0.035)***	–0.177 (0.034)***
Expenditure index	0.008 (0.023)	0.057 (0.022)**
Male	0.017 (0.063)	–0.310 (0.070)***
Zhejiang	–0.634 (0.067)***	–0.285 (0.082)***
Village	0.103 (0.083)	–0.321 (0.094)***
Married	–0.096 (0.085)	–0.005 (0.085)
No educ	0.059 (0.099)	–0.057 (0.107)
Element sch	0.099 (0.093)	0.096 (0.101)
High sch	–0.039 (0.130)	–0.170 (0.130)
Outdoor fields	–0.205 (0.054)***	
Visiting friends	0.117 (0.063)*	
Chance of rain	1.343 (0.324)***	
Price of pork		–0.002 (0.011)
Price of eggs		–0.018 (0.016)
Walking < 30 min		–0.787 (0.127)***
Walking 30 min – 2 h		–1.220 (0.209)***
Walking ≥ 2 h		–2.005 (0.309)***
μ_1		0.955 (0.044)***
μ_2		1.916 (0.053)***
ξ_1		1.398 (0.124)***
ξ_2		2.456 (0.205)***
ρ		0.622 (0.101)***
Log likelihood	–3536.361	

Note: Asymptotic standard errors in parentheses.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 4

Average treatment effects of daily walking on the probabilities of body weight.

	Underweight			Normal weight		
Walking	No walking	< 30 min	30 min – 2 h	No walking	< 30 min	30 min – 2 h
< 30 min	0.017			0.061**		
	(0.011)			(0.030)		
30 min – 2 h	0.001	–0.017**		0.022	–0.039**	
	(0.010)	(0.008)		(0.029)	(0.019)	
≥ 2 h	0.020*	0.003	0.019**	0.043	–0.018	0.021
	(0.012)	(0.011)	(0.010)	(0.030)	(0.020)	(0.020)

	Overweight			Obesity		
Walking	No walking	< 30 min	30 min – 2 h	No walking	< 30 min	30 min – 2 h
< 30 min	–0.041*			–0.038**		
	(0.022)			(0.019)		
30 min – 2 h	–0.008	0.032**		–0.014	0.023**	
	(0.020)	(0.016)		(0.019)	(0.011)	
≥ 2 h	–0.043*	–0.003	–0.035**	–0.019	0.018	–0.005
	(0.023)	(0.019)	(0.018)	(0.020)	(0.014)	(0.014)

Note: Asymptotic standard errors in parentheses.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 5

Marginal effects on the probabilities of walking and body weight.

	Probabilities of walking level				Probabilities of body weight level			
Variable	No walking	< 30 min	30 min – 2 h	≥ 2 h	Underweight	Normal weight	Overweight	Obesity
Continuous explanatory variables								
Age / 10	0.016***	0.019***	–0.001	–0.033***	0.032***	0.027***	–0.021***	–0.037***
	(0.006)	(0.006)	(0.001)	(0.012)	(0.007)	(0.008)	(0.006)	(0.008)
Expenditure index	–0.001	–0.002	0.000	0.003	–0.010***	–0.009**	0.007**	0.012***
	(0.004)	(0.004)	(0.000)	(0.008)	(0.004)	(0.004)	(0.003)	(0.005)
Chance of rain	–0.212***	–0.252***	0.016	0.448***				
	(0.053)	(0.061)	(0.013)	(0.107)				
Price of pork					0.000	0.000	0.000	0.000
					(0.002)	(0.002)	(0.001)	(0.002)
Price of eggs					0.003	0.003	–0.002	–0.004
					(0.003)	(0.003)	(0.002)	(0.003)
Binary explanatory variables								
Male	–0.003	–0.003	0.000	0.006	0.056***	0.048***	–0.038***	–0.066***
	(0.010)	(0.012)	(0.001)	(0.021)	(0.012)	(0.018)	(0.014)	(0.013)
Zhejiang	0.094***	0.125***	–0.001	–0.218***	0.051***	0.043***	–0.033***	–0.061***
	(0.011)	(0.013)	(0.006)	(0.022)	(0.019)	(0.010)	(0.008)	(0.020)
Village	–0.017	–0.019	0.002	0.034	0.052***	0.055**	–0.034**	–0.074***
	(0.014)	(0.015)	(0.003)	(0.027)	(0.012)	(0.025)	(0.013)	(0.022)
Married	0.015	0.018	0.000	–0.032	0.001	0.001	–0.001	–0.001
	(0.012)	(0.016)	(0.001)	(0.029)	(0.015)	(0.013)	(0.010)	(0.018)
No educ	–0.009	–0.011	0.001	0.020	0.010	0.008	–0.007	–0.012
	(0.015)	(0.019)	(0.001)	(0.033)	(0.019)	(0.016)	(0.013)	(0.022)
Element sch	–0.016	–0.019	0.001	0.033	–0.017	–0.015	0.011	0.020
	(0.014)	(0.017)	(0.001)	(0.031)	(0.018)	(0.016)	(0.012)	(0.022)

High sch	0.006	0.007	–0.001	–0.013	0.033	0.023	–0.022	–0.034
	(0.021)	(0.024)	(0.003)	(0.043)	(0.027)	(0.017)	(0.019)	(0.024)
Outdoor fields	0.033***	0.039***	–0.004*	–0.068***				
	(0.009)	(0.010)	(0.002)	(0.018)				
Visiting friends	–0.018*	–0.022*	0.000	0.040*				
	(0.009)	(0.012)	(0.001)	(0.021)				

Note: Asymptotic standard errors in parentheses.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 6

Marginal effects of explanatory variables on the probabilities of body weight.

Variable	Probability of underweight conditional on				Probability of normal weight conditional on			
	No walking	Walking < 30 min	Walking 30 min – 2 h	Walking ≥ 2 h	No walking	Walking < 30 min	Walking 30 min – 2 h	Walking ≥ 2 h
Continuous explanatory variables								
Age / 10	0.046***	0.034***	0.020***	0.008***	–0.022***	0.004	0.024***	0.033***
	(0.010)	(0.008)	(0.005)	(0.002)	(0.007)	(0.007)	(0.008)	(0.009)
Expenditure index	–0.019***	–0.015***	–0.009***	–0.003***	0.009***	–0.002	–0.011**	–0.013***
	(0.007)	(0.005)	(0.003)	(0.001)	(0.004)	(0.003)	(0.004)	(0.005)
Chance of rain	0.256***	0.222***	0.132***	0.040***	–0.116**	0.025	0.157***	0.155***
	(0.070)	(0.075)	(0.045)	(0.011)	(0.056)	(0.042)	(0.039)	(0.037)
Price of pork	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.004)	(0.003)	(0.002)	(0.001)	(0.002)	(0.000)	(0.002)	(0.003)
Price of eggs	0.007	0.005	0.003	0.001	–0.003	0.001	0.004	0.005
	(0.006)	(0.005)	(0.003)	(0.001)	(0.003)	(0.001)	(0.003)	(0.004)
Binary explanatory variables								
Male	0.118***	0.092***	0.054***	0.018***	–0.056***	0.010	0.067***	0.081***
	(0.021)	(0.017)	(0.010)	(0.004)	(0.015)	(0.020)	(0.019)	(0.019)
Zhejiang	–0.017	–0.023	–0.014	–0.002	0.006	–0.003	–0.016	–0.002
	(0.022)	(0.018)	(0.011)	(0.004)	(0.011)	(0.005)	(0.013)	(0.015)
Village	0.135***	0.099***	0.054***	0.017***	–0.052**	0.031	0.089***	0.090***
	(0.025)	(0.020)	(0.011)	(0.003)	(0.022)	(0.028)	(0.026)	(0.023)
Married	–0.017	–0.015	–0.009	–0.003	0.008	–0.001	–0.010	–0.010
	(0.025)	(0.020)	(0.012)	(0.004)	(0.012)	(0.003)	(0.014)	(0.017)
No educ	0.032	0.026	0.016	0.005	–0.015	0.003	0.018	0.021
	(0.034)	(0.026)	(0.016)	(0.006)	(0.016)	(0.006)	(0.019)	(0.023)

Element sch	–0.016	–0.011	–0.007	–0.003	0.008	–0.001	–0.008	–0.012
	(0.032)	(0.025)	(0.015)	(0.005)	(0.015)	(0.004)	(0.018)	(0.022)
High sch	0.055	0.044	0.027	0.010	–0.028	0.001	0.028	0.038
	(0.040)	(0.034)	(0.021)	(0.008)	(0.022)	(0.008)	(0.020)	(0.029)
Outdoor fields	–0.039***	–0.034***	–0.020***	–0.006***	0.018**	–0.004	–0.025***	–0.024***
	(0.011)	(0.012)	(0.007)	(0.002)	(0.009)	(0.007)	(0.007)	(0.006)
Visiting friends	0.023*	0.020*	0.012*	0.004*	–0.011	0.002	0.013*	0.014*
	(0.012)	(0.012)	(0.007)	(0.002)	(0.007)	(0.004)	(0.007)	(0.007)

Note: Asymptotic standard errors in parentheses.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

Table 7

Marginal effects of explanatory variables on the probabilities of body weight.

Variable	Probability of overweight conditional on				Probability of obesity conditional on			
	No walking	Walking < 30 min	Walking 30 min – 2 h	Walking ≥ 2 h	No walking	Walking < 30 min	Walking 30 min – 2 h	Walking ≥ 2 h
Continuous explanatory variables								
Age / 10	–0.019***	–0.025***	–0.019***	0.004	–0.005***	–0.013***	–0.026***	–0.045***
	(0.007)	(0.007)	(0.006)	(0.006)	(0.002)	(0.003)	(0.006)	(0.010)
Expenditure index	0.008**	0.011***	0.008**	–0.002	0.002**	0.006***	0.011***	0.018***
	(0.004)	(0.004)	(0.003)	(0.002)	(0.001)	(0.002)	(0.004)	(0.006)
Chance of rain	–0.110***	–0.160***	–0.121***	0.009	–0.029***	–0.087***	–0.168***	–0.204***
	(0.028)	(0.039)	(0.030)	(0.027)	(0.007)	(0.023)	(0.051)	(0.060)
Price of pork	0.000	0.000	0.000	0.000	0.000	0.000	0.000	–0.001
	(0.002)	(0.002)	(0.002)	(0.000)	(0.000)	(0.001)	(0.002)	(0.004)
Price of eggs	–0.003	–0.004	–0.003	0.001	–0.001	–0.002	–0.004	–0.006
	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.002)	(0.004)	(0.006)
Binary explanatory variables								
Male	–0.049***	–0.067***	–0.051***	0.009	–0.013***	–0.036***	–0.070***	–0.109***
	(0.017)	(0.016)	(0.015)	(0.013)	(0.004)	(0.007)	(0.011)	(0.018)
Zhejiang	0.008	0.017	0.013	0.005***	0.002	0.009	0.017	–0.001
	(0.009)	(0.013)	(0.010)	(0.002)	(0.002)	(0.007)	(0.013)	(0.020)
Village	–0.064***	–0.079***	–0.050***	0.024*	–0.019***	–0.051***	–0.094***	–0.131***
	(0.022)	(0.019)	(0.014)	(0.013)	(0.007)	(0.012)	(0.020)	(0.027)
Married	0.007	0.010	0.008	0.000	0.002	0.006	0.011	0.013
	(0.010)	(0.014)	(0.011)	(0.002)	(0.003)	(0.007)	(0.014)	(0.023)
No educ	–0.013	–0.019	–0.014	0.002	–0.003	–0.010	–0.020	–0.028
	(0.014)	(0.019)	(0.015)	(0.004)	(0.004)	(0.010)	(0.020)	(0.031)

Element sch	0.007	0.008	0.006	–0.002	0.002	0.004	0.008	0.017
	(0.014)	(0.018)	(0.014)	(0.004)	(0.004)	(0.010)	(0.019)	(0.030)
High sch	–0.022	–0.030	–0.025	0.002	–0.005	–0.015	–0.030	–0.050
	(0.016)	(0.023)	(0.020)	(0.007)	(0.004)	(0.010)	(0.021)	(0.035)
Outdoor fields	0.017***	0.025***	0.019***	–0.001	0.005***	0.013***	0.026***	0.032***
	(0.005)	(0.006)	(0.005)	(0.004)	(0.001)	(0.004)	(0.008)	(0.009)
Visiting friends	–0.010*	–0.014*	–0.011*	0.001	–0.002*	–0.007*	–0.014*	–0.018*
	(0.005)	(0.007)	(0.006)	(0.002)	(0.001)	(0.004)	(0.008)	(0.010)

Note: Asymptotic standard errors in parentheses.

* Significant at the 10% level.

** Significant at the 5% level.

*** Significant at the 1% level.

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