NBER WORKING PAPER SERIES

# LIFE-CYCLE CONSUMPTION AND THE AGE-ADJUSTED VALUE OF LIFE

Thomas J. Kniesner
W. Kip Viscusi
James P. Ziliak

Working Paper 10266
http://www.nber.org/papers/w10266

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
January 2004

Address correspondence to tkniesne@maxwell.syr.edu. We wish to thank DeYett Law and Gerron McKnight for research assistance. Viscusi's research is supported by the Harvard Olin Center for Law, Economics, and Business. The views expressed herein are those of the authors and not necessarily those of the National Bureau of Economic Research.

Life-Cycle Consumption and the Age-Adjusted Value of Life
Thomas J. Kniesner, W. Kip Viscusi, and James P. Ziliak
NBER Working Paper No. 10266
January 2004, Revised version November 2005
JEL No. J17, I12

## ABSTRACT

Our research examines empirically the age pattern of the implicit value of life revealed from workers' differential wages and job safety pairings. Although aging reduces the number of years of life expectancy, aging can affect the value of life through an effect on planned life-cycle consumption. The elderly could, a priori, have the highest implicit value of life if there is a life-cycle plan to defer consumption until old age. We find that largely due to the age pattern of consumption, which is non-constant, the implicit value of life rises and falls over the lifetime in a way that the value for the elderly is higher than the average over all ages or for the young. There are important policy implications of our empirical results. Because there may be age-specific benefits of programs to save statistical lives, instead of valuing the lives of the elderly at less than the young, policymakers should more correctly value the lives of the elderly at as much as twice the young because of relatively greater consumption lost when accidental death occurs.

Thomas J. Kniesner
Center for Policy Research, 426 Eggers Hall
Maxwell School of Citizenship and Public Affairs
Syracuse University
Syracuse, NY 13244-1020
tkniesne@maxwell.syr.edu

James P. Ziliak
Department of Economics
University of Kentucky
Lexington, KY 40506-0034
jziliak@uky.edu

W. Kip Viscusi
Hauser Hall 302
Harvard Law School
Cambridge, MA 02138
and NBER
kip@law.harvard.edu

## 1. Introduction

How the value of life varies over the life cycle has long been of substantial theoretical interest. Although the quantity of one's future expected lifetime diminishes with age the resources one can allocate toward reducing fatality risks change as well. Except in models based on highly restrictive assumptions, the value of life does not peak at birth and steadily decline, as would be the case based solely on one's expected future lifetime. Perhaps the principal insight of the life-cycle models is that the value of life at any given age is highly dependent on the lifetime pattern of consumption. Here we examine empirically how the shape of the age-related value of life trajectory is governed largely by the life-cycle consumption relationship.

Despite the strong theoretical linkage between the value of life and consumption, no study of implicit values of life revealed by market decisions has included consumption in the empirical framework. Hedonic studies using labor market or product market risks have abstracted completely from the theoretical dependency of the value of life over the life cycle and the life-cycle pattern of consumption, creating a potential source of bias. The discrepancies between the estimated and actual values of life may be especially acute for examining how the value of life varies with age rather than for estimates focusing on average estimates for a sample. Perhaps because they ignore consumption, hedonic labor market studies of age variations in the value of life generally yield the implausible result that the value of life turns negative at some age before retirement.[1] Explicitly including consumption in stated preference assessments of the value of life by age does not arise as

[1] For example, the value of life becomes negative at age 42 for the results in Thaler and Rosen (1975) and at 48 for the estimate in Viscusi (1979). Viscusi and Aldy (2003) provide a comprehensive review of value of life studies, all of which imply a negative value of life by age 60. An interesting exception is the recent research of Smith, et al. (2004), who found that the oldest workers in their Health and Retirement Study sample received significantly higher compensation for fatality risks posed by their jobs.

an issue because the survey values are elicited directly, not imputed based on market tradeoffs. Our research provides the first consumption-dependent estimates of the value of life using hedonic labor-market data.

Reliable estimates of age-related variations in the value of life are of theoretical and policy interest. The empirical shape of the life-cycle patterns of consumption and the value of life not only provide a test of the life-cycle models of the value of life but also provide evidence indicative of the particular theoretical regime that is pertinent. Imperfect markets models and perfect markets models yield quite different estimates of the time path of the value of life.[2] Models in which there are imperfect markets imply an inverted U-shaped relationship between the value of life and age, while perfect markets models imply a steadily declining value of life with age. Theoretical models also yield predictions of life-cycle consumption patterns, which are the foundation of our study because the value of life is derived by decreasing the individual's hazard rate within the context of a life-cycle consumption model. On an empirical basis, the observed relationship between consumption and age is more consistent with the trajectory embodied in the imperfect markets case than the flat consumption profile in the perfect markets models.

For policy purposes, there has been increasing interest in age adjustments to the value of life for benefit assessment, as exemplified by the evaluation of the Environmental Protection Agency's Clear Skies initiative. Although U.S. government agencies routinely use market-based estimates for the value of life to assess the risk reduction benefits of regulations, available market data are not instructive in making age adjustments because the estimated values of life are often negative. A consequence is that

[2] For more details on hedonic pricing under imperfect markets see Lang and Majumbar (2003).

policy evaluations have sometimes coupled market estimates of the overall value of life with survey estimates of how the values should vary with individual age. The results presented here will provide more meaningful estimates of the age variation in the value of life using market data, thus putting the baseline value of life and the age variation on comparable terms.

In what follows we begin with the canonical theoretical and empirical specification of a hedonic wage function for fatal work-related injury risk. Even in the canonical specification the implicit value of life can vary with age through an aging effect on the wage. We then consider an enriched specification of wage hedonics where the individual's market wage function reflects that the willingness of a worker to accept risk may depend on the planned life-cycle path of consumption, which will be another avenue for age differences in the value of life. The importance of the consumption channel for aging effects is that the value of life can be constant, increasing, decreasing, or non-monotonic with age depending on the age profile of consumption. Our empirical results are consistent with a value of life that follows an inverted U shape. The age pattern of the implicit value of life that we find is largely due to the importance of consumption in the wage equation with the peak of the value of life occurring at about age 50. Our focal result is robust to the measure of consumption and to controlling for industry and endogeneity of consumption in the expanded hedonic wage equation we estimate. Our finding that the estimated value of life for the elderly is higher than the average value of life in the data and also higher than the value of life for the youngest workers in the data is important for policy, which may use an age-dependent value of life that incorrectly assumes a monotonic decline with age when valuing a program's benefits.

## 2. How Consumption Influences the Value of Life

Most models of labor market tradeoffs regarding the value of statistical life are single-period. Let the utility associated with bequests be zero, the wage be $w$, the probability of not being killed on the job be $\pi$, and the utility function when healthy be $V(w)$, which has the usual shape where $V_w > 0$ and $V_{ww} \leq 0$. A worker selecting from a market opportunities locus in which the wage is a positive but diminishing function of the fatality risk will select a wage-risk tradeoff, or an implicit value of life, that is equal to $V(w)/(1-\pi)V_w$, because all wages in any period are consumed.[3] Because von Neumann-Morgenstern utility functions are unaffected by positive linear transformations, division by the expected marginal utility of income normalizes the value of life in marginal utility units, eliminating any effect of the scale of the utility function.

If workers' risky job decisions were just a sequence of single-period choices dependence of the value of life on consumption would be quite simple. The estimated value of life would track the consumption pattern over time, which rises and then later falls over the life cycle. High levels of consumption for more experienced workers will raise the numerator of the value of life given by the wage-risk tradeoff, and the high consumption levels will also lead to lower marginal utility of income. Thus, for any given level of job risk, both of the life-cycle consumption influences boost the implicit value of life, at least during the middle age years of high consumption, and the value of life will not be a steadily declining function of age.

The substantial theoretical literature on the value of life over the life cycle has utilized models of optimal consumption decisions over time. Within the context of life-

[3] For more discussion of single-period models, see, among many others, Viscusi (1979) and Rosen (1988).

cycle consumption frameworks, what is the value of the individual's willingness to pay for a reduction in the hazard rate, and how does the value vary with age? Although models differ considerably in their overall structure and their predictions regarding the shape of the value of life-age relationship, they all share a common recognition that the value of life is a function of consumption, the rate of discount, various probabilistic terms, and, in some models, the worker's wage rate.

It is instructive to consider the results in an early contribution by Shepard and Zeckhauser (1984), which provides approximations of the value of life, as well as the model by Johansson (2002a, 2002b), who provides exact estimates.[4] Each model considers the willingness to pay for temporary reductions in the hazard rate within the context of life-cycle consumption models for two extreme cases:  no insurance available and perfect annuities markets. With perfect markets the model implies invariant consumption levels over the life cycle, whereas if there is no annuity insurance consumption will display an inverted U-shape pattern.[5] Thus, the first role of our examination of empirical consumption patterns is to provide information on which insurance market regime is pertinent. As is well documented in the literature and will be shown to be the case below, the age profile of consumption rises then falls over the life cycle. Our empirical results are consistent with the types of consumption patterns that have been derived in life-cycle model simulations for the no annuity insurance case and are inconsistent with the consumption predictions of the perfect insurance models.

The second general role of consumption is that for either the no annuities model or perfect markets case, the willingness to pay for small changes in risk (the value of a

[4] See Arthur (1981), Johansson (2001), Johannesson, Johansson, and Lofgren (1997), Jones-Lee (1989), and Rosen (1988). A simulation analysis of the value of life over the life cycle is Ehrlich and Yin (2005).
[5] See Shepard and Zeckhauser (1984), especially pp. 427–428 and p. 433.

statistical life) is highly dependent on consumption levels. Consider the results for the discrete time case from Johansson (2002b).[6] For the no insurance case the value of statistical life *VSL* for a person age $\tau$ years is given by

$$VSL_t = \frac{1}{V_c}\sum_{t=\tau}^{T}\frac{\pi_t V(c_t)}{(1+r)^{t-\tau}}, \tag{1}$$

where *t* is the age counter, *T* is the maximum age, *r* is the rate of interest, $\pi_t$ is the conditional survival probability to year *t* having reached age $\tau$, $V(c_t)$ is the utility of consumption in year *t*, and $V_c$ is the current period marginal utility of consumption.

Consumption also enters in models when insurance markets are perfect, though as noted above, such models yield predictions that are inconsistent with consumption patterns. The counterpart expression for $VSL_\tau$ in equation (1) will include an additional term equal to the present value of the expected difference between the worker's wages and consumption, which some have labeled the excess of wages over consumption. Then the value of life is given by

$$VSL_t = \frac{1}{V_c}\sum_{t=\tau}^{T}\frac{\pi_t V(c_t)}{(1+r)^{t-\tau}} + \sum_{t=\tau}^{T}\frac{\pi_t (w_t - c_t)}{(1+r)^{t-\tau}}. \tag{2}$$

For both the no insurance and the perfect insurance cases there is a strong dependency of *VSL* on consumption entering via the supply side of the labor market.

Studies of the dependence of the value of life on age have generally relied on numerical simulations for specific classes of models. The imperfect markets simulation by Shepard and Zeckhauser (1984) indicated that the value of life rises then falls over the life cycle. With perfect markets, the value of life is a steadily decreasing function of age. Using econometric estimates from Thaler and Rosen (1975) coupled with a life cycle

---

[6] The discrete time results are similar in spirit to the continuous time results in Johansson (2002a) and Shepard and Zeckhauser (1984).

model, Rosen's (1988) simulation suggested a steadily decreasing value of life for the age range he considered, 36 to 48.

The failure to develop a clear-cut relationship between the value of life and age may in part have fostered the continuing economic debate over the shape of the relationship. Whether the value of life rises or falls with age cannot be determined conclusively on a theoretical level. Johansson (2002a) has shown that the age-*VSL* relationship is indeterminate in general. However, it is also clear that consumption levels are the driving force of age-related variations, and no previous empirical research has considered the dependency of the value of life on consumption.

## 3. Econometric Framework

To resolve the nature of the consumption-age-*VSL* relationship, our empirical research begins by estimating the canonical hedonic wage equation used in the value of statistical life literature augmented with household consumption expenditures. The economic interpretation of the consumption-augmented wage equation is as a conditional on consumption hedonic equilibrium. As noted first by Pollak (1969) and more recently by Browning and Meghir (1991) a conditional model is a parsimonious way to relax separability and yet maintain focus on the primary outcome of interest. The implication is that rather than the typical unconditional results found in the wage-fatality tradeoff literature the interpretation here is of the effect of a change in fatal job risk on wages, conditional on the quantity of consumption.

For worker $i$ ($i = 1,\ldots,N$) in industry $j$ ($j = 1,\ldots,J$) and occupation $k$ ($k = 1,\ldots,K$) the hedonic tradeoff between the wage and risk of fatality including consumption is

$$\ln w_{ijk} = \alpha\, fatal_{jk} + \delta C_i + X_{ijk}\gamma + u_{ijk}\,, \qquad (3)$$

where $\ln w_{ijk}$ is the natural log of the hourly wage rate, $fatal_{jk}$ is the industry and occupation specific fatality rate, $C_i$ is the household expenditure level, $X_{ijk}$ is a vector containing a set of dummy variables for the worker's one-digit occupation (and industry in some specifications) and region of residence plus the usual demographic variables pertaining to worker education, race, marital status, and union status. Finally, $u_{ijk}$ is an error term that admits conditional heteroskedasticity and within fatality risk autocorrelation.

We begin with the maintained hypothesis that $E[u_{ijk} \mid fatal_{jk}, X_{ijk}] = 0$, which is the standard zero conditional mean assumption used in least squares regression. Because consumption is a choice variable we expect that $E[u_{ijk} C_i] \neq 0$; not only is the zero conditional mean assumption likely violated, but so too is the weaker zero correlation assumption because of the endogeneity of consumption. We need an instrumental variables estimator to estimate the model's parameters consistently. Selecting an instrument is always a challenge in IV models, but in our case we can rely on standard results from the theory of the consumer. Specifically, based on human capital theory we take nonlabor income as having no direct effect on the log wage, but from static models of consumption and labor supply we take nonlabor income as helping determine consumption.[7] In other words, if $V_i$ is nonlabor income, then we use for identification the assumptions that $E[u_{ijk} V_i \mid C_i] = 0$ and that $E[C_i V_i] \neq 0$. Although the conditional

[7] To elaborate, there is no contemporaneous correlation between the wage and nonlabor income produced by construction because nonlabor income is the difference between total family income and family labor market income. Although past earnings contribute to current saving, nonlabor income is not, a priori, a determinant of the current labor market equilibrium wage. Interest earnings could be high or low due to a high or low return on financial capital investment, which does not directly determine the market equilibrium wage. The hedonic wage equation in (3) is an equilibrium equation and, as such, is dynamically complete by construction. Conditional on consumption, nonlabor income has no effect on the equilibrium wage except through the supply side of the labor market via worker consumption. See Heckman, Lochner and Todd (2005) for more extensive discussion of estimating wage (Mincer) equations with endogeneity.

exogeneity of nonlabor income is not testable, the needed covariation of consumption with nonlabor income is testable via the first-stage regression of $C_i$ on $V_i$ and the other exogenous variables in the model.

Accounting for the fact that fatality risk is per 100,000 workers and that the typical work-year is about 2000 hours, the estimated value of a statistical life is

$$VSL_i = \left[ \frac{\partial \hat{w}}{\partial fatal} = \hat{\alpha} \times \exp(\ln \hat{w}_i) \right] \times 2000 \times 100,000 \tag{4}$$

where exp(•) is the exponential function and $(\ln \hat{w})$ is the predicted log wage from the regression model in (3). The *VSL* function in (4) can be evaluated at various points in the wage distribution, but most commonly researchers report the mean effect.[8] In the standard framework $\delta \equiv 0$ in (3) so that age affects *VSL* only through its direct effect on the wage. When we allow for $\delta \neq 0$ in (3), changes in the fatality risk implicitly affect both the wage and consumption levels. Thus, age affects *VSL* through both a direct effect on the wage and an indirect effect through consumption (which affects the wage and is itself age-dependent). We not only report a distribution of value of statistical life estimates, but also graphically illustrate the fitted value of life profile over the life cycle.

## 4. Data and Sample Description

We use two data sources for our research. The first is the 1997 wave of the Panel Study of Income Dynamics (PSID), which provides individual-level data on wages, consumption, industry and occupation, and demographics. The PSID survey has followed a core set of households since 1968 plus newly formed households as members of the

[8] For more on the nuances of estimating *VSL* see Blomqvist 2002 and Johansson 2002c.

original core have split off into new families. The sample we use consists of male heads of household between the ages of 18 and 65 who (i) are in the random Survey Research Center (SRC) portion of the PSID, excludes the oversample of the poor in the Survey of Economic Opportunity (SEO) as well as the Latino sub-sample, (ii) worked for hourly or salary pay at some point in the previous calendar year, (iii) are not a student, permanently disabled, or institutionalized, (iv) have an hourly wage greater than $2 per hour and less than $100 per hour, (v) have annual food expenditures of at least $520 and combined food and housing expenditures less than $100,000, and (vi) have no missing data on wages, consumption, education, industry, and occupation. After sample filter (i) there are 2,872 men in the sample, while imposing filters (ii)–(vi) eliminates 997 men so that our final sample size is 1,875.

The focal variables in our models are the hourly wage rate, consumption expenditures, and demographics. For workers paid by the hour the survey records the gross hourly wage rate. The interviewer asks salaried workers how frequently they are paid, such as weekly, bi-weekly, or monthly. The interviewer then norms a salaried worker's pay by a fixed number of hours worked depending on the pay period. For example, salary divided by 40 is the hourly wage rate constructed for a salaried worker paid weekly. We then take the natural log of the wage rate to minimize the influence of outliers and to aid in interpreting the model parameters.

A limitation of the PSID relative to the Consumer Expenditure Survey (CE) is the scope of consumption data. The PSID only records on a regular basis food expenditures (including food stamps) on food eaten inside and outside the household, as well as housing expenditures for renters and homeowners with mortgage payments. We consider two measures of consumption, combined food and housing expenditures and total consumption. The total consumption measure uses an imputation method found in Ziliak (1998). Specifically, he shows that given an estimate of saving, $\hat{S}_i$, one can derive an estimate of total consumption as the residual of disposable income and saving, $\hat{C}_i = Y_i - \hat{S}_i$.[9] Here we estimate saving as $\hat{S}_i = 17,915(0.8169/1.019) + 0.599A_i$, where the inflation adjustment factor on the constant term places the estimate in 1997 dollars and $A_i$ is liquid assets defined as the capitalized value of rent, interest, and dividend income.[10] For models based on predicted total consumption we impose the additional sample selection filter that $\hat{C}_i > \$1000$, which reduces the sample to 1,596 men. Although the quality of wage data and demographic information in the PSID strongly dominates that found in the CE, we recognize that our consumption data are less than ideal. It is hoped that using two separate measures of consumption will offer added robustness. Appendix Table 1 provides the sample average and quartile values for consumption.[11]

The demographic controls in the model include years of formal education, a quadratic in age, dummy indicators for region of country (northeast, north central, and west with south the omitted region), race (white = 1), union status (coverage = 1), marital status (married = 1), and one-digit industry and occupation.

---

[9] Note that *Y* contains wage income, which is an additional reason to instrument consumption in the hedonic wage equation.

[10] Browning Crossley, and Weber (2003) argue that such imputation methods are a fruitful approach to deal with limited consumption data.

[11] It is instructive to note how our estimate of total expenditures aligns with estimates from the CE. Meyer and Sullivan (2003, Table 2) estimate total expenditures for all families with heads 21–62 years of age at the 30th percentile to be \$20,314 and at the 50th percentile to be \$28,217. Our estimates of total expenditure in Appendix Table 1 are \$19,876 at the 25th percentile and \$35,734 at the 50th percentile. Our estimates will exceed Meyer and Sullivan's because we restrict our sample to working prime-age men.

The fatality risk measure here is the fatality rate for the worker's industry-occupation group. Because published fatality risk measures are available only by industry, we constructed a worker fatality risk variable using unpublished U.S. Bureau of Labor Statistics data from the Census of Fatal Occupational Injuries (CFOI).[12] The CFOI provides the most comprehensive inventory of all work-related fatalities. The CFOI data come from reports by the Occupational Safety and Health Administration, workers' compensation reports, death certificates, and medical examiner reports. In each case there is a records examination determining that the fatality was in fact a job-related incident. The number of fatalities in each industry-occupation cell is the numerator of the fatality risk measure.

The denominator used to construct the fatality risk is the number of employees for that industry-occupation group.[13] Workers in agriculture and in the armed forces are excluded. Because there is less reporting error in the worker industry information than in worker occupation information, our formulation should lead to less measurement error than if the worker's occupation were the primary basis for the matching.[14] We have 720 industry-occupation groups using a breakdown of 72 two-digit SIC code industries and the 10 one-digit occupational groups. With 6,238 total work-related deaths in 1997, our procedure created 290 industry-occupation cells with no reported fatalities.

Because the total number of fatalities was quite stable from 1992 (the first year of the CFOI data) through our sample year 1997, we used the average annual number of

[12] The fatality data are available on CD-ROM from the U.S. Bureau of Labor Statistics. The procedure used to construct fatality risk follows Viscusi (2004), who compares fatality risk to other death risk variables.
[13] For the estimate we used the 1997 annual employment averages from the U.S. Bureau of Labor Statistics, Current Population Survey, (unpublished) Table 6, Employed Persons by Detailed Industry and Occupation. For 13 of the 720 categories there was no reported employment for the cell.
[14] For further discussion see Mellow and Sider (1983) and Black and Kniesner (2003).

fatalities for a cell during 1992–1997 when calculating the fatality risk.[15] The intertemporal stability of total fatalities means that the averaging process will reduce the influence of random fluctuations in fatalities as well as the small sample problems that arise with respect to many narrowly defined job categories. Using the average fatality rate from 1992–1997 reduces the total number of industry-occupation cells with no fatalities to 90 and also makes the fatality risk measure less subject to random events.

The mean fatality risk for the sample is 4/100,000. The range of risk levels by occupation goes from 0.6/100,000 for administrative support occupations, including clerical, to 23.5/100,000 for transportation and material moving occupations. The riskiest industry was mining, with a fatality risk of 24.6/100,000.

## 5. Wage Equation Estimates

As indicated in (3), the basic regression equation we estimate is a semi-log equation where the worker's wage is regressed on a series of personal characteristics, job characteristics, the fatality risk for the worker's industry-occupation cell, and consumption. Our regressions explore two different series of specifications. One set does not include control variables for the worker's industry and another parallel set of regressions includes dummy variables for one-digit industry.

Inclusion of industry control variables potentially can capture omitted industry-specific differences with respect to job characteristics and market offer curves. However, here a difficulty arises because the fatality risk variable uses the worker's industry as the basis for the matching. Including industry variables will then partly be inducing multicollinearity with respect to the fatality risk variable. There has been extensive

[15] For example, in 1992 the total number of fatalities was 6,217, as compared to 6,238 in 1997.

discussion of the use of industry control variables within the context of compensating differentials research. The consensus is that if the risk variable is constructed based on the worker's reported industry then including detailed industry controls tends to mask the influence of compensating wage differentials for risk rather than reflecting inter-industry wage differentials that may arise apart from risk-related considerations.[16]

Tables 1 and 2 report the main coefficients of interest; the standard errors corrected for conditional heteroskedasticity and for clustering based on the fatality risk variable. Consider first the results in each table that do not include consumption and are the most comparable to results found in the literature. Worker wages increase with age, although there is a negative age squared effect in the baseline estimates. Using the regression coefficients in Table 1, the direct effect of worker age is to increase worker wages until age 49 after which there is a negative influence of age on wages. For the base case excluding the industry controls, there is evidence of a statistically significant compensating differential for fatality risk, whereas the fatality risk variable is not statistically significant for the base case including industry controls in Table 2.

The next set of four equations in each table adds consumption-related variables, first through ordinary least squares and then using an instrumental variables estimate for the consumption effect. We record the results of the first-stage consumption regressions with and without industry controls for our two consumption measures in Appendix Table 2. There is a strong nonlinear effect of age on the level of consumption. Critical for identification, nonlabor income is an excellent predictor of consumption in all specifications; the first-stage $R^2$ is about 0.30, and the corresponding $F$-test is about 29 with a $P$-value of 0.0000 in each model.

[16] For a detailed review of the studies pertaining to this issue, see Section 1 of Viscusi and Aldy (2003).

The coefficient of the food and housing consumption variable in the second and third columns of Tables 1 and 2 is always strongly statistically significant, with coefficients that are somewhat larger in the instrumental variables estimates than in the ordinary least squares estimates. The coefficients of total consumption reported in the final two columns of Tables 1 and 2 also have positive signs, where the effects are somewhat larger for the OLS results than for the instrumental variables results. In each instance the IV total consumption coefficient is not statistically significant at the 95 percent level in Table 2.

Including consumption has a much smaller influence on the fatality risk coefficient for the Table 1 estimates than for the Table 2 estimates. Fatality risk coefficients range from 0.0061 to 0.0071 for all five specifications in Table 1. In Table 2, including consumption increases the magnitude of the fatality risk coefficient. In the case of the food and housing consumption variable, adding consumption as a regressor in the wage equation boosts the significance of the fatality risk coefficient so that it becomes statistically significant and at least double the size of its standard error.

Taking the results of the estimation in conjunction with the characteristics of each individual worker in the sample we use (4) to calculate a distribution of the value of life estimates implied by our regression results. The average of the individual values of life in the base case is $20.9 million for the Table 1 results (without industry controls) and $8.9 million for the Table 2 results (with industry controls). Although the implied values of life estimates may appear to be high, such results may be a consequence of the particular mix of workers represented in the Panel Study of Income Dynamics. For example, using different years and different sample selections, Garen (1988) found estimates of the implicit value of life of $17.3 million using the PSID, while Moore and Viscusi (1990) generated estimates of $20.8 million using the PSID.

Table 3 presents the implied values of life for the different specifications, making it possible to see the effect of recognizing the influence of consumption on the estimated value of life, as well as the influence of industry controls. Remember that all the estimates in Table 3 that are based on regressions without industry controls have underlying them a statistically significant fatality risk coefficient (see Table 1). The four sets of results for the consumption-adjusted value of life from the regressions without industry controls range from $21.7 million to $24.1 million on average. The only estimates in Table 3 based on regressions with industry controls that also have statistically significant estimates for the fatality risk variable use the food and housing consumption regressor (see Table 2). The implicit value of life is $14.8 million, on average, from the OLS regression including food and housing consumption and industry controls; the implicit value of life is $20.3 million, on average, using instrumented food and housing consumption.

Table 3 also reports the distribution of the values of life for the 25$^{th}$ percentile of the value of life estimates, the 50$^{th}$ percentile, and the 75$^{th}$ percentile. Rather than focusing on just the average of the value of life in the sample it is possible to examine the heterogeneity of the values as well. There is, as one might expect, substantial variation in the value of life estimates. Consider the results based on the IV estimates for food and housing consumption. Between the 25$^{th}$ and 75$^{th}$ percentile the value of life increases from $14.7 million to $28 million without industry controls and increases from $12.4 million to $23.5 million with industry controls.

## 6. Age Variations in the Value of Life

An interesting aspect of the heterogeneity of the value of life is the effect of worker age. The estimates above only reflect the heterogeneity that arises because of different worker risk levels and differences in worker wages, taking into account that the overall equation generating the estimates also incorporated differences in individual consumption. Estimates discussed up to now do not flesh out any systematic difference in the fatality risk-wage tradeoff that might occur with age. Some studies have found age variations in the fatality risk-wage tradeoff whereas others have not. In our case, including an age-fatality risk interaction never yielded statistically significant interaction effects (nor were consumption-fatality risk interactions significant). As a result, our examination of the life-cycle variations in the value of life will focus on the effect of age in terms of changes in risk levels, changes in wages over the life cycle, and the effect of age on consumption based on the consumption-adjusted estimate of the value of life.[17]

The role of life-cycle consumption is essential to inferring whether there is a senior discount with respect to the value of life and, if so, how much of a senior discount is there. Table 4 presents estimates of the implied value of life for different age ranges within the sample where the comparisons are relative to the value of life for 18–21 year olds. The results for the base case without industry controls are illustrative of the following pattern. The value of life increases to a peak value at age 47–51 that is 2.53 times the value of life of 18–21 year olds. Then there is a tailing off of the value of life relative to the 47–51 year olds for the most senior age group in the sample, which consists of workers age 57–65. Even for the elderly the value of life is 2.12 times as great

[17] The research of Aldy and Viscusi (2004), which does not consider consumption, finds an inverted U-shaped pattern for the relationship between *VSL* and age that is consistent with our estimates below.

as for 18–21 year olds. *VSL* for the oldest group is virtually identical to the relative value of life for 37–41 year olds (2.13) and even greater than the estimated value of life for all younger workers in the sample.

Below we consider a series of simulations that calculate the value of life for each worker in the sample using the estimates from Tables 1 and 2 with the worker specific values of the variables in equation (4). After generating a distribution of implied values of life for all workers at each individual age in the sample, we then do a nonparametric regression (using a cubic smoothing spline with about 180 observations per band) of the variation in the value of life with age. The nonparametric estimates that appear in Figures 1–4 enable us to characterize the life-cycle distribution of the value of life and how the distribution is affected by admitting consumption to the hedonic wage equation.[18]

Figures 1a and 1b illustrate the age profiles of *VSL* for the (no consumption) base case results without and with industry controls. The figures show a fairly steep rise in the value of life until a peak at around age 51. The age profile of the implied value of life based on OLS regression estimates including food and housing consumption in Figures 2a and 2b is considerably flatter than that shown for the no-consumption base case in Figures 1a and 1b. Recognizing the role of life cycle consumption consequently mutes the extent to which there is a life-cycle effect. The results in Figures 2a and 2b, as well as in Figures 2c and 2d where food and housing consumption has been instrumented, indicate that the value of life rises with age and declines somewhat. There is a flattening of the value beyond age 51 that is less steep than the decline for the base case where consumption is ignored.

[18] Appendix Table 3 also summarizes the numerical values associated with the *VSL* distribution by age.

A third set of estimates that are depicted in Figures 3a–3d illustrate how the value of life varies over the lifetime for models in which actual versus predicted total consumption appears in the hedonic wage equation with and without industry controls. The shift to using total consumption has two types of effects in the model with the most econometric structure, the hedonic wage equation with industry controls and instrumented total consumption. Note that the decline for seniors is relatively severe in Figure 3c, more than elsewhere, so our subsequent illustrative example is conservative in terms of the senior premium. The results reflect a considerable flattening throughout the age distribution of the value of life, which peaks at $14.9 million, and illustrates the age distribution of value of life estimates reported in Appendix Table 3 and in the final column of the bottom panel of Table 4. For the instrumented total consumption hedonic wage equation case the value of life for 57–65 year olds is 1.94 times the value for 18–21 year olds, and is below the peak multiplicative factor of 2.36 for 47–51 year olds.

On a theoretical basis the estimates for the value of life should depend strongly on individual consumption. For that reason it is instructive to compare the life-cycle distribution of the estimated values of life with the life-cycle distribution of consumption. Based on the first-stage consumption estimates in Appendix Table 2, illustrations for two pertinent consumption distributions are the fitted food plus housing consumption case shown in Figures 4a and 4b and the fitted total consumption distribution shown in Figures 4c and 4d.

As is indicated in Figures 4a and 4b, consumption of food and housing rises and then falls over the life cycle. In much the same way, there is an increase and subsequent decline in the implied value of life, although the decline was not as steep for the value of life in Figures 2b and 2d as the subsequent decline in the nonparametric estimates of the consumption-age distribution plotted in Figure 4b, for example.

Estimates for fitted total consumption as a function of age in Figures 4c and 4d imply that consumption does rise over the life cycle but the decline is much flatter for the senior age groups than it is for food and housing consumption. In much the same way as consumption, there is a flattening of the implied value of life curve as a function of age as was shown in Figure 3d, for example.

The implications of the results concerning the age pattern of consumption are twofold. There is the expected variation in the value of life over the life cycle. The value of life is not constant but does in fact rise with age, after which it ultimately declines. However, the decline is not as steep as the earlier increase. There is a tendency toward a flattening of the value of life-age relationship. The flattening is particularly great for models recognizing the dependency of the value of life on total consumption. The character of the flattening for the value of life-age profile mirrors the shape of the distribution of lifetime consumption. Recognition of the role of life-cycle consumption in estimates of the value of life consequently illuminates how *VSL* varies over the life cycle, as a variety of theoretical models have stressed.

Examining the life-cycle pattern of consumption for workers reveals that consumption also is not constant over the life cycle. Rather, it rises and falls, displaying an inverted U shape that is very similar to the pattern of the value of life with a flattening at the upper age ranges rather than a decline that mirrors the earlier increase. The life-cycle consumption pattern is more consistent with the imperfect markets life-cycle consumption models of the value of life rather than with the perfect insurance markets models. The imperfect markets models imply that the value of life will rise and then fall over the life cycle, which is the pattern in Figures 4a–4d. Even though there is a predicted decline in the value of life, the value of life nevertheless is closely linked to consumption and there is a flattening of the consumption trajectory for the more senior age groups. One would also expect a similar flattening of the estimated value of life, which is reflected in the empirical estimates.

## 7. Conclusion and Environmental Health Policy Implications

The previous literature has a major disconnect between the theoretical models of the variations of value of life over the life cycle and market-based estimates of the age distribution of the value of life. The life-cycle approaches all use a life-cycle consumption framework in which the value of life is an explicit function of individual consumption levels. In contrast, no hedonic models of the value of life have ever included consumption, thus ignoring the fundamental dependency of VSL indirectly through life-cycle consumption. The neglect of consumption may have been because not only are consumption data not a usual component of labor market data sets but there is also a potential endogeneity of the consumption variable.

Our research has provided the first consumption-adjusted estimates of the value of life, which alter both the value of life estimates as well as their age-related distribution. Recognizing the dependency on consumption increases the statistical significance and magnitude of the estimates of the value of life, particularly for estimates including industry controls. More important are the implications of the consumption-adjusted values for the life-cycle distribution of the (average) value of life. The value of life rises then falls over the life cycle, but the eventual declines are reasonably flat. The inverted

U-shape pattern of value of life over the lifetime closely follows the time distribution of consumption shown by the nonparametric estimates of the consumption-age relationship.

The greatest policy interest in the age variation of the value of life stems from the degree to which there should be a senior discount in the value of life used to evaluate the benefits associated with regulatory policies that reduce risks to life and health. Our results show that the implied value of life declines somewhat for the most senior age group in the sample. Even though the *VSL*s for the elderly are lower than the peak value of life in middle-age, they are still higher than the values of life for workers age 36 and below.

How our results could affect policy judgments is exemplified by applying the estimates to the U.S. EPA Clear Skies Initiative, in which the issue of a senior discount achieved prominence. The first column of Table 5 lists the reduced annual fatalities for a base case reflecting current scientific knowledge of the effects of long-term exposures and an alternative case based on risks from short-term exposures.[19] Note that the mortality reduction effects are concentrated among the elderly. The second column indicates the undiscounted annual benefits in year 2010 for each component monetized using the EPA's average value of $6.1 million per life for all lives.[20] The mortality benefits for adults over 65 are $36.6 billion for the base case and $21.9 billion for the alternative estimates. However, using the 37 percent senior discount advocated in the controversial U.S. EPA (2002) report, the mortality benefit figure drops to $23.1 billion for the base case and $14.7 billion for the EPA's alternative estimates.[21] If we use our consumption-adjusted estimates of the relative values of life for the age group 57–65 as

[19] See the U.S. EPA (2003), Table 16, for the total mortality figures.
[20] The $6.1 million per life figure is from the U.S. EPA (2003), p. 26, which is an update of the $6.0 million figure used in U.S. EPA (2002).
[21] The 37 percent discount figure cited in U.S. EPA (2002), p. 35, is derived from the stated preference survey results in the U.K. by Jones-Lee (1989).

the benchmark for assessing values to those 65 and older, the benefit values increase to $37.1 billion for the base case and $22.3 billion for the alternative case.[22] In contrast, the benefit values for children are half as great using the relative benefit values for persons age 18–21 to impute an estimate of their value of life. Although the benefit estimates are only meant to be suggestive, they indicate how using a consumption-adjusted value of life can lead to a significant senior benefit premium rather than a senior discount.

Framing the valuation question in terms of whether there is a decline in the value of life with age mischaracterizes the information needs for policy assessments. Standard policy evaluations use an average value of life for an entire population to assess the benefits. The pertinent question is whether for the senior age groups there should be a discount or premium relative to the population average, not with respect to the peak value of life. Our results in Appendix Table 3 for the age 57–65 group indicate that for every set of estimates the implied value of life for ages 57–65 is somewhat higher than the overall average for workers of all ages. At least for the pre-retirement age groups we study, the benefits assessment issue of whether there is a senior discount is in fact a non-issue.

[22] The relative value of life estimates in the last column of Table 5 use the statistics from Appendix Table 3, without industry controls, with total consumption, IV.

Appendix Table 1. Distribution of Consumption Measures

| Percentile | Food and Housing Expenditures | Total Consumption |
|---|---|---|
| 25th | $8,360 | $19,876 |
| 50th | 12,140 | 35,734 |
| Average | 13,521 | 43,615 |
| 75th | 17,040 | 57,231 |

Appendix Table 2. First Stage Estimates of Consumption-Age Profiles

| | Food and Housing Consumption | | Total Consumption | |
|---|---|---|---|---|
| | Without Industry | With Industry | Without Industry | With Industry |
| Age | 855.47 | 843.14 | 3144.94 | 3046.79 |
| | (101.19) | (100.87) | (582.95) | (598.55) |
| Age Squared | –10.50 | –10.29 | –33.07 | –31.82 |
| | (1.28) | (1.27) | (7.32) | (7.51) |
| Fatality Risk | –6.60 | –51.90 | –152.91 | –229.80 |
| | (24.40) | (42.86) | (90.95) | (99.96) |
| Nonlabor Income | 0.05 | 0.04 | 0.80 | 0.81 |
| | (0.01) | (0.01) | (0.10) | (0.09) |
| R-Squared | 0.28 | 0.29 | 0.31 | 0.32 |
| Observations | 1875 | 1875 | 1596 | 1596 |

NOTE: The sample consists of male heads of household age 18 to 65 in 1997 who are not students, permanently disabled, or institutionalized, who have worked for wages in the past year, whose hourly wage rate is between $2 and $100 per hour, and whose food and housing expenditure is less than $100,000. All regressions control for the head's education, race, marital status, union status, one-digit occupation, region of residence, and the one-digit industry where indicated. The standard errors are adjusted for conditional heteroskedasticity and within fatality-risk cluster autocorrelation.

Appendix Table 3. Group Average Implied Value of Life
(Millions of $1997)

| Age Range | Base Case | With Food and Housing Consumption, OLS | With Food and Housing Consumption, IV | With Total Consumption, OLS | With Total Consumption, IV |
|---|---|---|---|---|---|
| Without Industry Controls | | | | | |
| 18–21 | 10.2 | 11.1 | 11.8 | 12.9 | 11.4 |
| 22–26 | 13.5 | 13.7 | 14.0 | 16.0 | 14.3 |
| 27–31 | 16.4 | 17.0 | 17.7 | 19.7 | 17.3 |
| 32–36 | 20.2 | 21.9 | 24.0 | 24.6 | 21.4 |
| 37–41 | 21.8 | 23.9 | 26.6 | 27.1 | 22.6 |
| 41–46 | 23.5 | 24.3 | 25.6 | 28.1 | 24.3 |
| 47–51 | 25.8 | 27.8 | 30.2 | 30.6 | 26.7 |
| 52–56 | 24.6 | 26.4 | 30.1 | 29.4 | 25.8 |
| 57–65 | 21.6 | 23.6 | 26.1 | 25.9 | 22.0 |
| Overall | 20.9 | 22.3 | 24.1 | 25.1 | 21.7 |
| With Industry Controls | | | | | |
| 18–21 | 4.3 | 7.3 | 9.8 | 8.3 | 6.3 |
| 22–26 | 5.8 | 9.2 | 11.9 | 10.3 | 8.0 |
| 27–31 | 6.9 | 11.3 | 14.9 | 12.6 | 9.6 |
| 32–36 | 8.6 | 14.5 | 20.1 | 15.8 | 11.9 |
| 37–41 | 9.4 | 15.9 | 22.5 | 17.3 | 12.6 |
| 41–46 | 10.0 | 16.2 | 21.6 | 18.1 | 13.6 |
| 47–51 | 11.1 | 18.5 | 25.4 | 19.7 | 14.9 |
| 52–56 | 10.4 | 17.3 | 25.0 | 18.7 | 14.2 |
| 57–65 | 9.2 | 15.5 | 21.8 | 16.5 | 12.2 |
| Overall | 8.9 | 14.8 | 21.8 | 16.1 | 12.1 |

Table 1. Estimates of the Effects of Industry-Occupation Fatality Risk on Fatality-Wage and Age-Wage Profiles, Without Industry Controls

| Variable | Base Case | With Food and Housing Consumption, OLS | With Food and Housing Consumption, IV | With Total Consumption, OLS | With Total Consumption, IV |
|---|---|---|---|---|---|
| Age | 0.0588 | 0.0344 | 0.0157 | 0.0371 | 0.0497 |
| | (0.0073) | (0.0053) | (0.0133) | (0.0075) | (0.0096) |
| Age Squared | –0.0006 | –0.0003 | –0.0001 | –0.0004 | –0.0005 |
| | (0.0001) | (0.0001) | (0.0001) | (0.0001) | (0.0001) |
| Fatality Risk | 0.0061 | 0.0063 | 0.0065 | 0.0071 | 0.0063 |
| | (0.0021) | (0.0018) | (0.0016) | (0.0024) | (0.0030) |
| Consumption | | 0.0286 | 0.0494 | 0.0052 | 0.0016 |
| ($1000s) | | (0.0018) | (0.0151) | (0.0006) | (0.0013) |
| Observations | 1875 | 1875 | 1875 | 1596 | 1596 |

NOTE: The sample consists of male heads of household age 18 to 65 in 1997 who are not students, permanently disabled, or institutionalized, who have worked for wages in the past year, whose hourly wage rate is between $2 and $100 per hour, and whose food and housing expenditure is less than $100,000. All regressions control for the education, race, marital status, union status, one-digit occupation, and region of residence of the head. The standard errors are adjusted for conditional heteroskedasticity and within fatality-risk cluster autocorrelation.

Table 2. Estimates of the Effects of Industry-Occupation Fatality Risk on Fatality-Wage and Age-Wage Profiles, With Industry Controls

| Variable | Base Case | With Food and Housing Consumption, OLS | With Food and Housing Consumption, IV | With Total Consumption, OLS | With Total Consumption, IV |
|---|---|---|---|---|---|
| Age | 0.0568 | 0.0336 | 0.0152 | 0.0358 | 0.0469 |
| | (0.0072) | (0.0063) | (0.0134) | (0.0073) | (0.0088) |
| Age Squared | –0.0006 | –0.0003 | –0.0001 | –0.0003 | –0.0004 |
| | (0.0001) | (0.0001) | (0.0002) | (0.0001) | (0.0001) |
| Fatality Risk | 0.0026 | 0.0042 | 0.0055 | 0.0046 | 0.0035 |
| | (0.0028) | (0.0021) | (0.0021) | (0.0030) | (0.0030) |
| Consumption ($1000s) | | 0.0275 | 0.0494 | 0.0050 | 0.0017 |
| | | (0.0018) | (0.0154) | (0.0005) | (0.0012) |
| Observations | 1875 | 1875 | 1875 | 1596 | 1596 |

NOTE: The sample consists of male heads of household age 18 to 65 in 1997 who are not students, permanently disabled, or institutionalized, who have worked for wages in the past year, whose hourly wage rate is between $2 and $100 per hour, and whose food and housing expenditure is less than $100,000. All regressions control for the education, race, marital status, union status, one-digit industry, one-digit occupation, and region of residence of the head. The standard errors are adjusted for conditional heteroskedasticity and within fatality-risk cluster autocorrelation.

Table 3. Distribution of Implied Value of Life Estimates
($1997 millions)

| Without Industry Controls | | | | | |
|---|---|---|---|---|---|
| Percentile | Base Case | With Food and Housing Consumption, OLS | With Food and Housing Consumption, IV | With Total Consumption, OLS | With Total Consumption, IV |
| 25th | 14.80 | 14.90 | 14.70 | 17.20 | 15.60 |
| 50th | 19.30 | 19.70 | 19.80 | 22.10 | 20.00 |
| Average | 20.90 | 22.30 | 24.10 | 25.10 | 21.70 |
| 75th | 26.80 | 27.20 | 28.00 | 30.00 | 27.40 |
| With Industry Controls | | | | | |
| 25th | 6.31 | 9.95 | 12.40 | 11.00 | 8.62 |
| 50th | 8.26 | 13.10 | 16.50 | 14.30 | 11.10 |
| Average | 8.94 | 14.80 | 20.30 | 16.10 | 12.10 |
| 75th | 11.40 | 18.20 | 23.50 | 19.40 | 15.10 |

Table 4. Age Premium of Implied Value of Life Relative to 18–21 year olds
(Ratio of Group Averages)

| Age Range | Base Case | With Food and Housing Consumption, OLS | With Food and Housing Consumption, IV | With Total Consumption, OLS | With Total Consumption, IV |
|---|---|---|---|---|---|
| Without Industry Controls | | | | | |
| 22–26 | 1.32 | 1.24 | 1.19 | 1.24 | 1.26 |
| 27–31 | 1.60 | 1.56 | 1.50 | 1.52 | 1.53 |
| 32–36 | 1.98 | 1.98 | 2.04 | 1.90 | 1.88 |
| 37–41 | 2.13 | 2.16 | 2.25 | 2.09 | 1.99 |
| 41–46 | 2.30 | 2.20 | 2.18 | 2.17 | 2.14 |
| 47–51 | 2.53 | 2.52 | 2.56 | 2.37 | 2.35 |
| 52–56 | 2.41 | 2.38 | 2.55 | 2.27 | 2.27 |
| 57–65 | 2.12 | 2.13 | 2.21 | 2.00 | 1.93 |
| With Industry Controls | | | | | |
| 22–26 | 1.35 | 1.27 | 1.21 | 1.25 | 1.27 |
| 27–31 | 1.62 | 1.55 | 1.51 | 1.52 | 1.52 |
| 32–36 | 2.01 | 2.00 | 2.05 | 1.90 | 1.88 |
| 37–41 | 2.18 | 2.19 | 2.29 | 2.09 | 2.00 |
| 41–46 | 2.33 | 2.23 | 2.19 | 2.18 | 2.15 |
| 47–51 | 2.57 | 2.55 | 2.59 | 2.37 | 2.36 |
| 52–56 | 2.42 | 2.38 | 2.54 | 2.26 | 2.25 |
| 57–65 | 2.14 | 2.14 | 2.22 | 1.99 | 1.94 |

Table 5. Age Group Effects on Clear Skies Initiative Benefits

| Age Group | Reduced Annual Fatalities in 2010 | Benefits of Reduced Mortality ($ billions undiscounted): Constant Value of Life | Value with Senior Adjusted | Consumption-Adjusted Value of Life |
|---|---|---|---|---|
| Base Estimates – Long-Term Exposure: | | | | |
| Adults, 18-64 | 1,900 | 11.6 | 11.6 | 11.6 |
| Adults, 65 and older | 6,000 | 36.6 | 23.1 | 37.1 |
| Alternative Estimate – Short-Term Exposure: | | | | |
| Children, 0-17 | 30.0 | 0.2 | 0.2 | 0.1 |
| Adults, 18-64 | 1,100 | 6.7 | 6.7 | 6.7 |
| Adults, 65 and older | 3,600 | 21.9 | 14.7 | 22.3 |

Note: The reduced annual fatalities figures are from the U.S. EPA (2003), Table 16. The 37 percent senior discount is from the U.S. EPA (2002), p. 35, and the $6.1 million figure per life is from the U.S. EPA (2003), p. 26. The consumption-adjusted benefit estimates are based on the relative valuations implied by Appendix Table 3, without industry controls, with total consumption, IV, applied to the $6.1 million value of life estimates for the working age population.

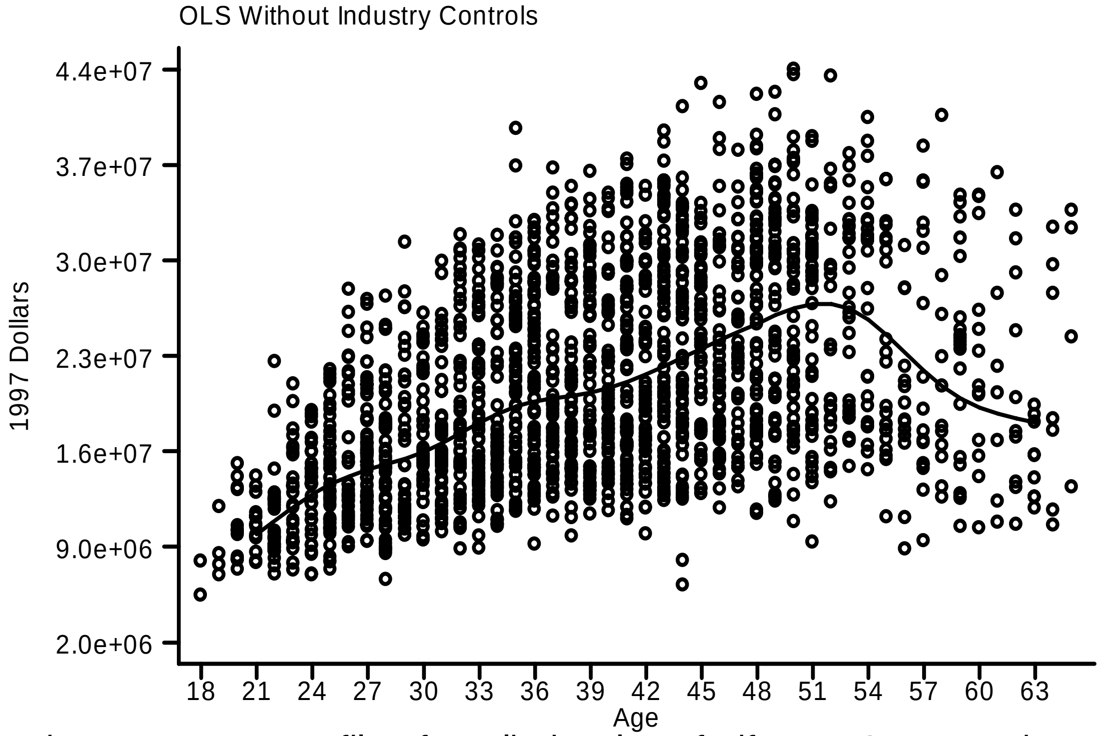


Figure 1a. Age Profile of Implied Value of Life, No Consumption

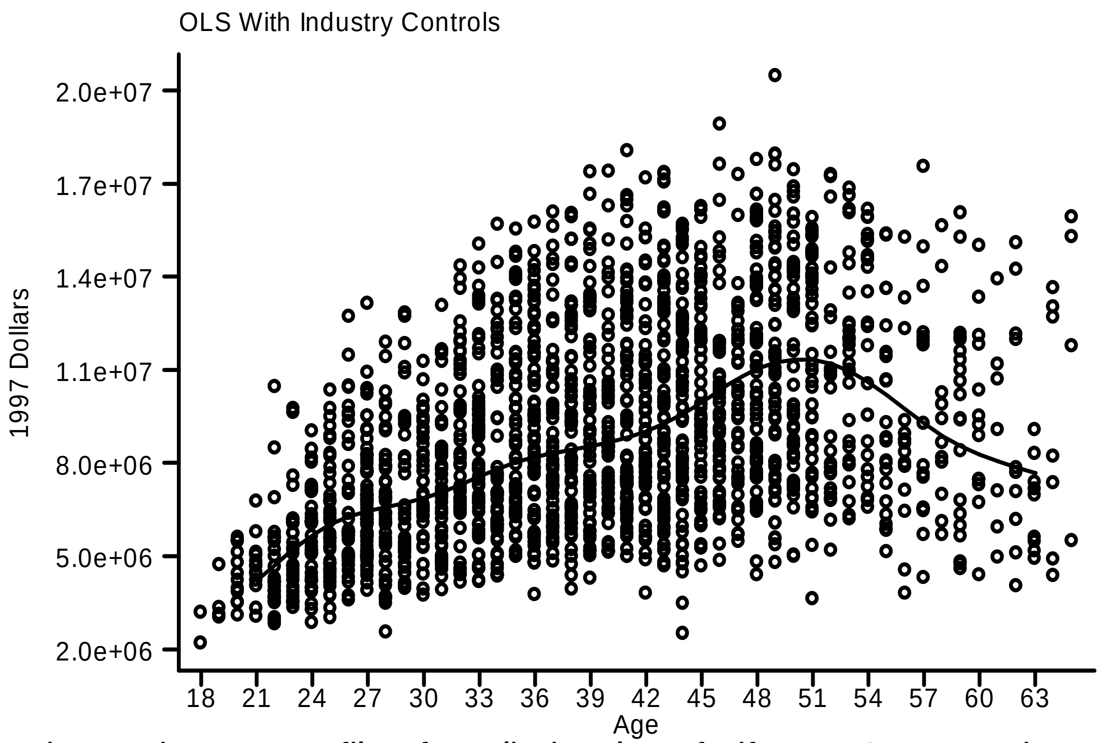


Figure 1b. Age Profile of Implied Value of Life, No Consumption

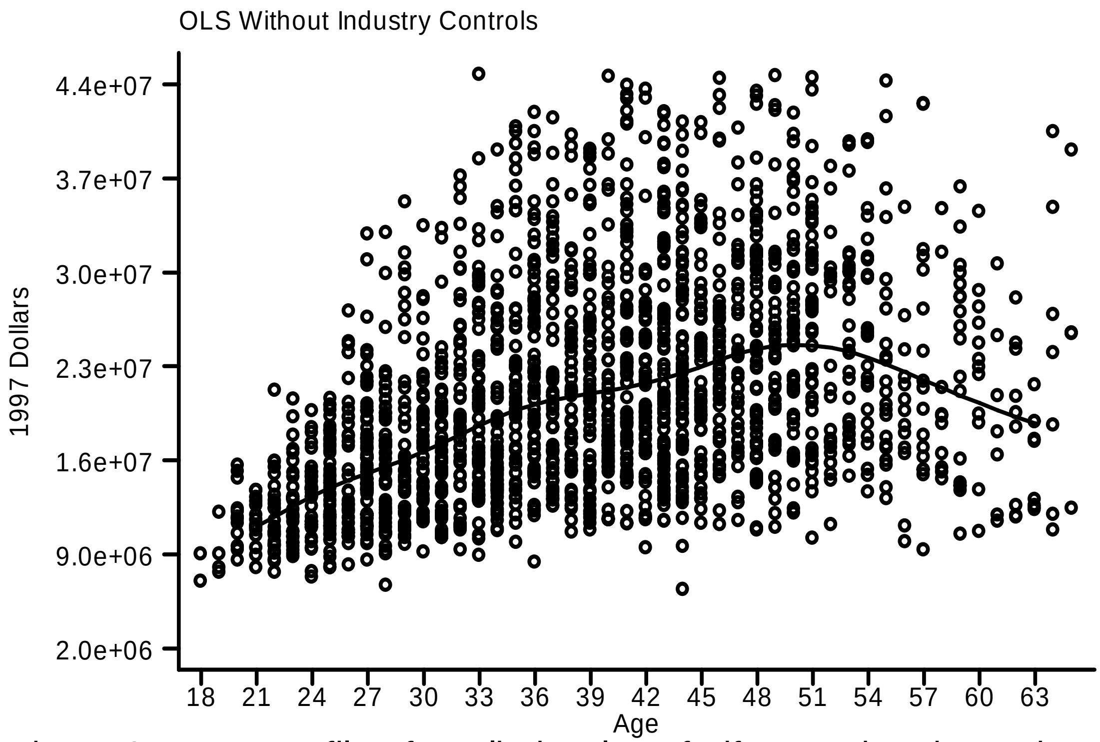

Figure 2a. Age Profile of Implied Value of Life, Food and Housing

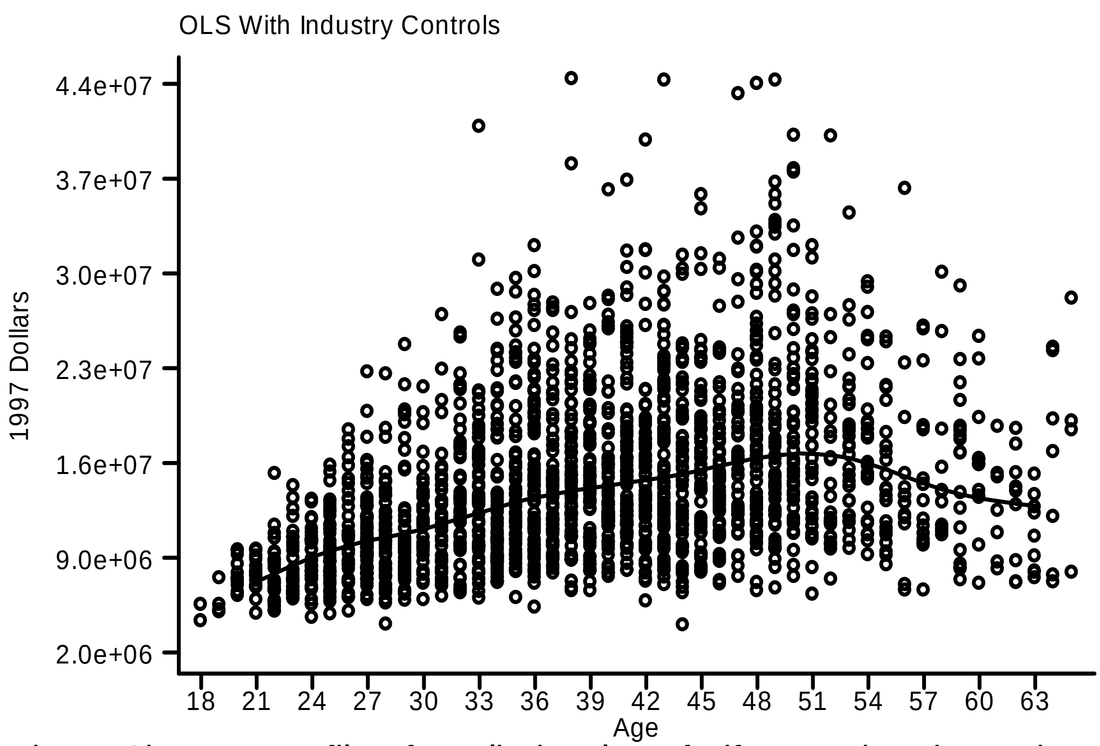

Figure 2b. Age Profile of Implied Value of Life, Food and Housing

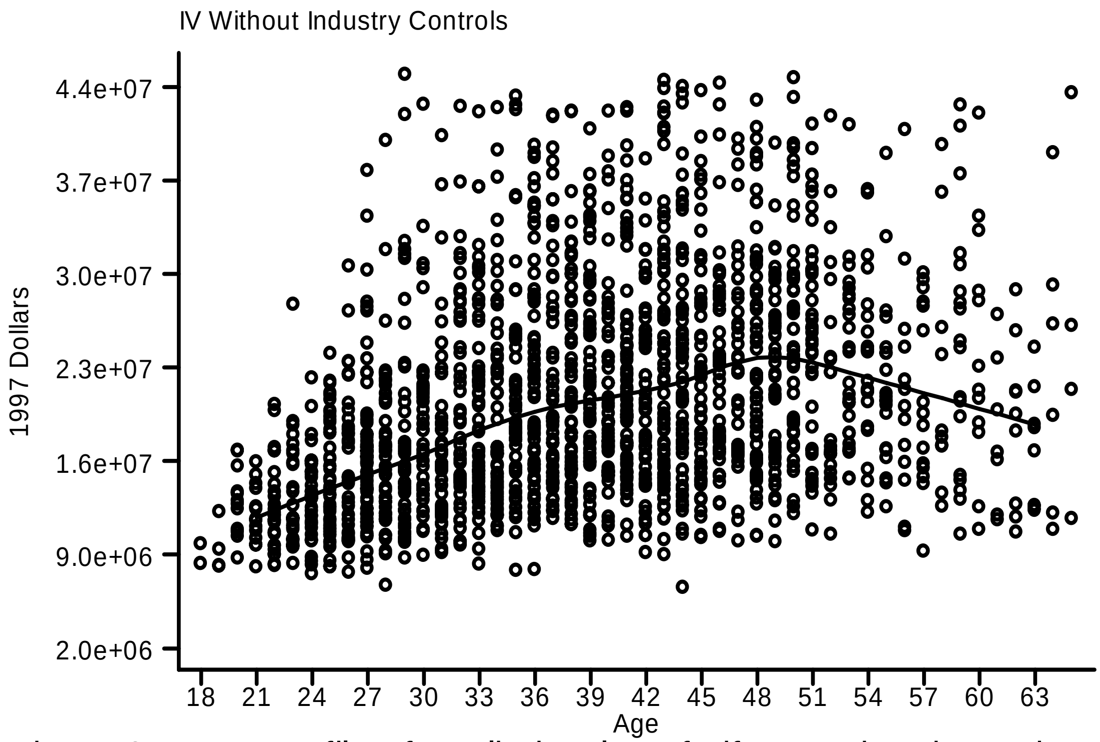


Figure 2c. Age Profile of Implied Value of Life, Food and Housing

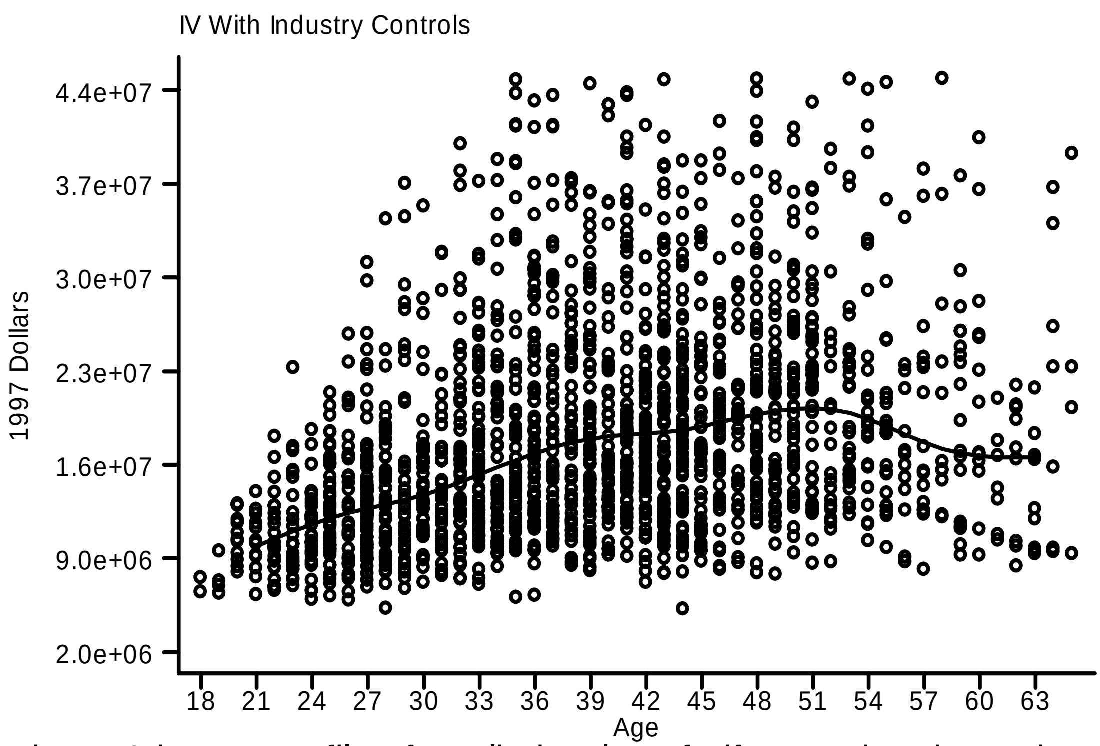


Figure 2d. Age Profile of Implied Value of Life, Food and Housing

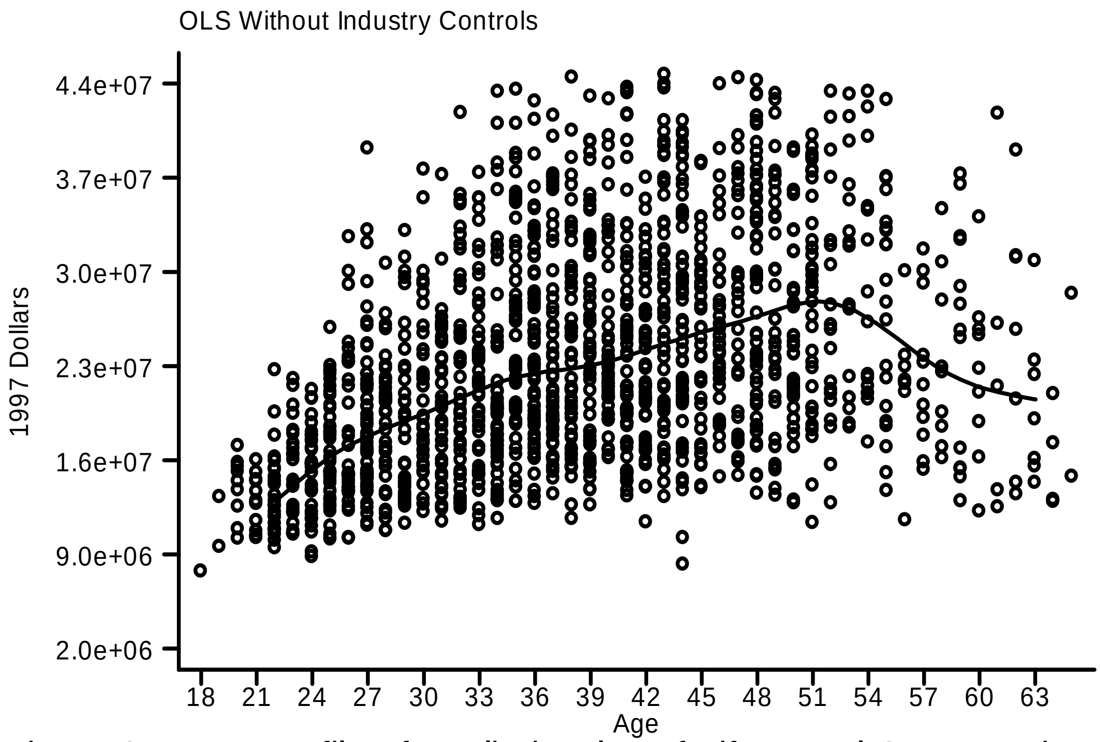

Figure 3a. Age Profile of Implied Value of Life, Total Consumption

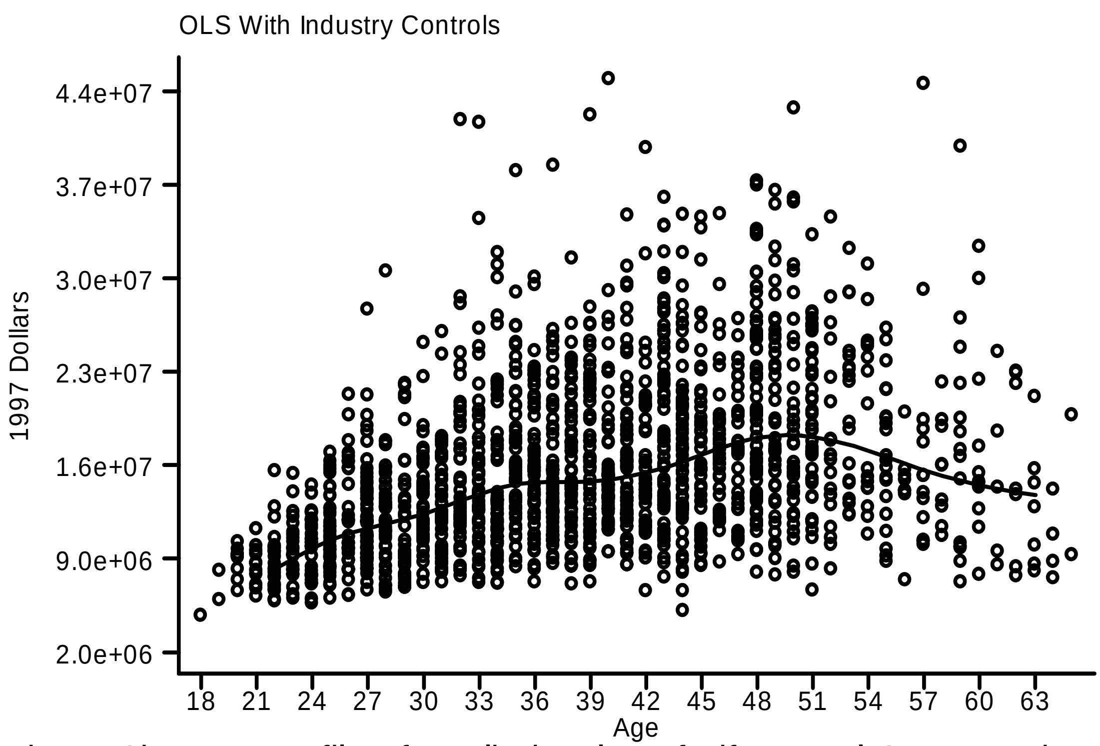

Figure 3b. Age Profile of Implied Value of Life, Total Consumption

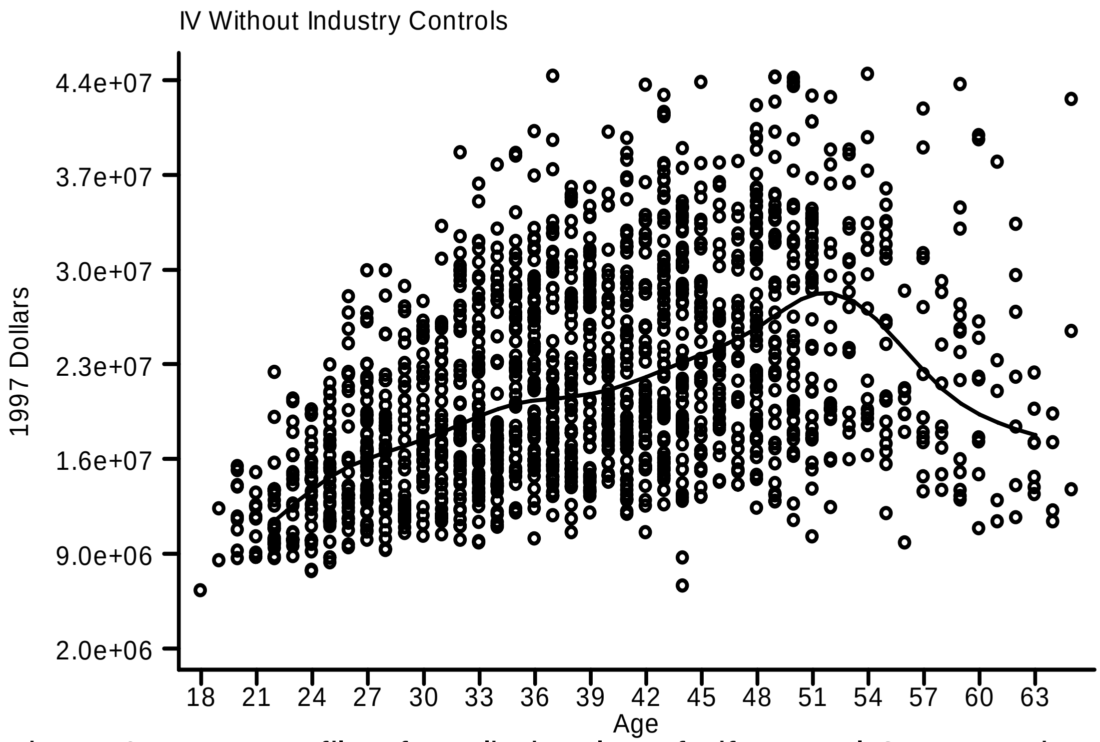


Figure 3c. Age Profile of Implied Value of Life, Total Consumption

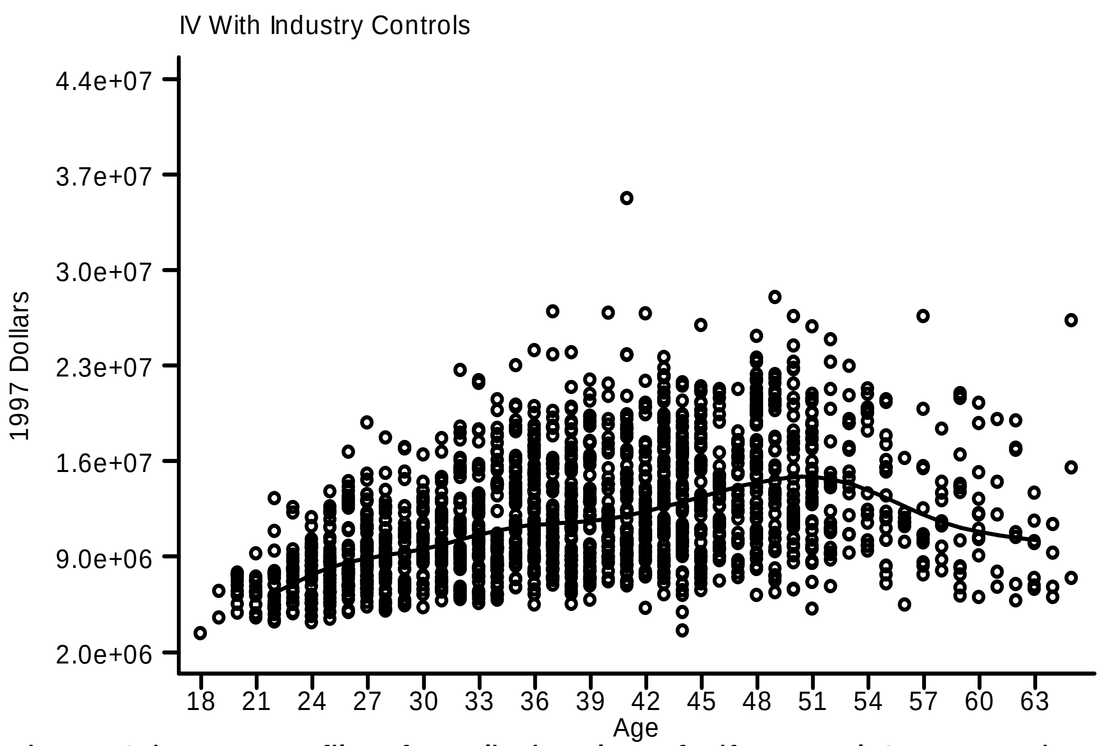


Figure 3d. Age Profile of Implied Value of Life, Total Consumption

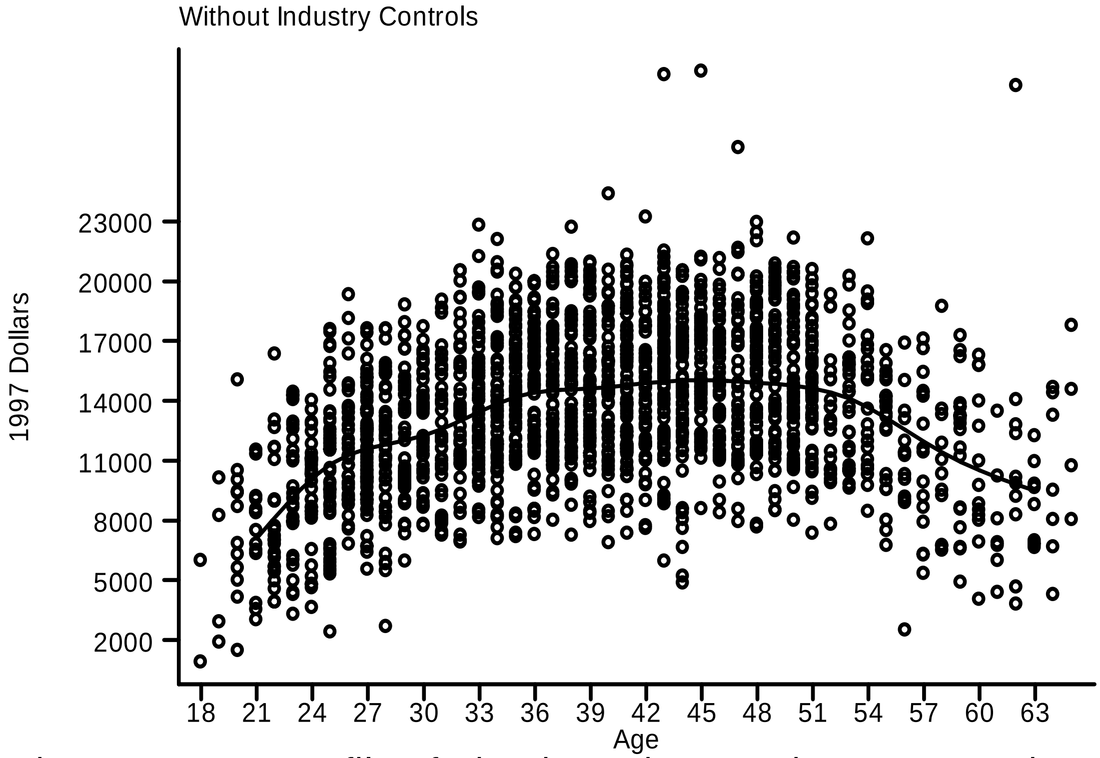


Figure 4a. Age Profile of Fitted Food & Housing Consumption

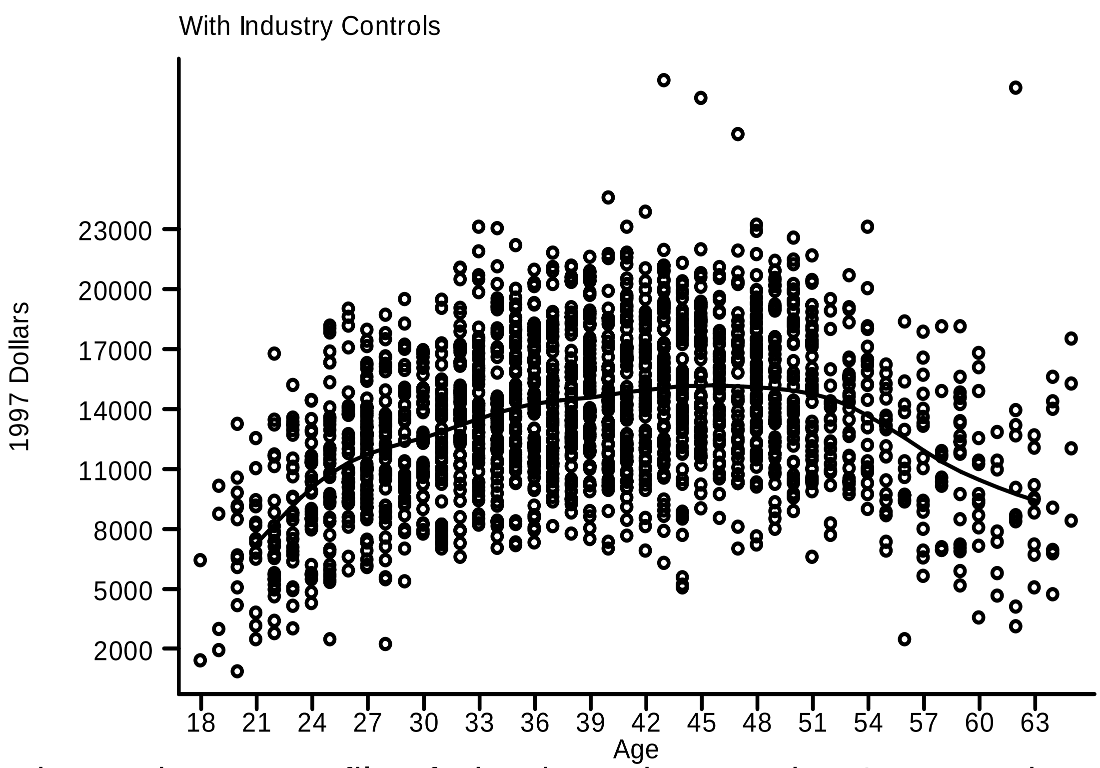


Figure 4b. Age Profile of Fitted Food & Housing Consumption

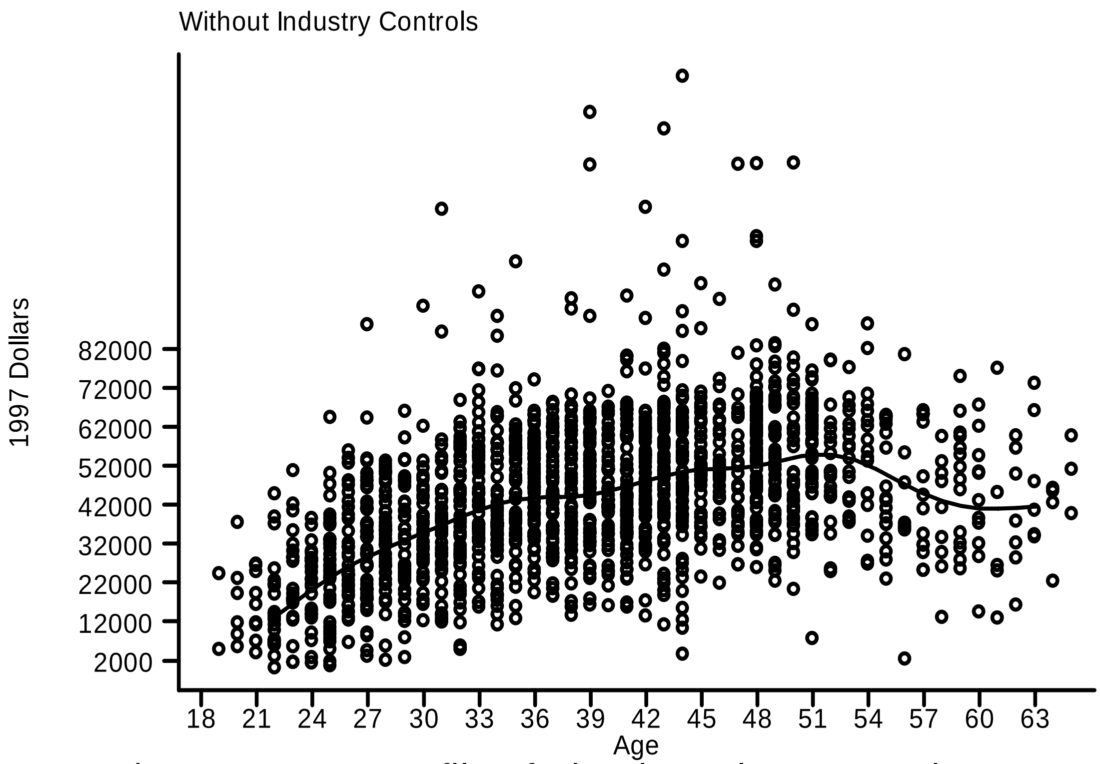


Figure 4c. Age Profile of Fitted Total Consumption

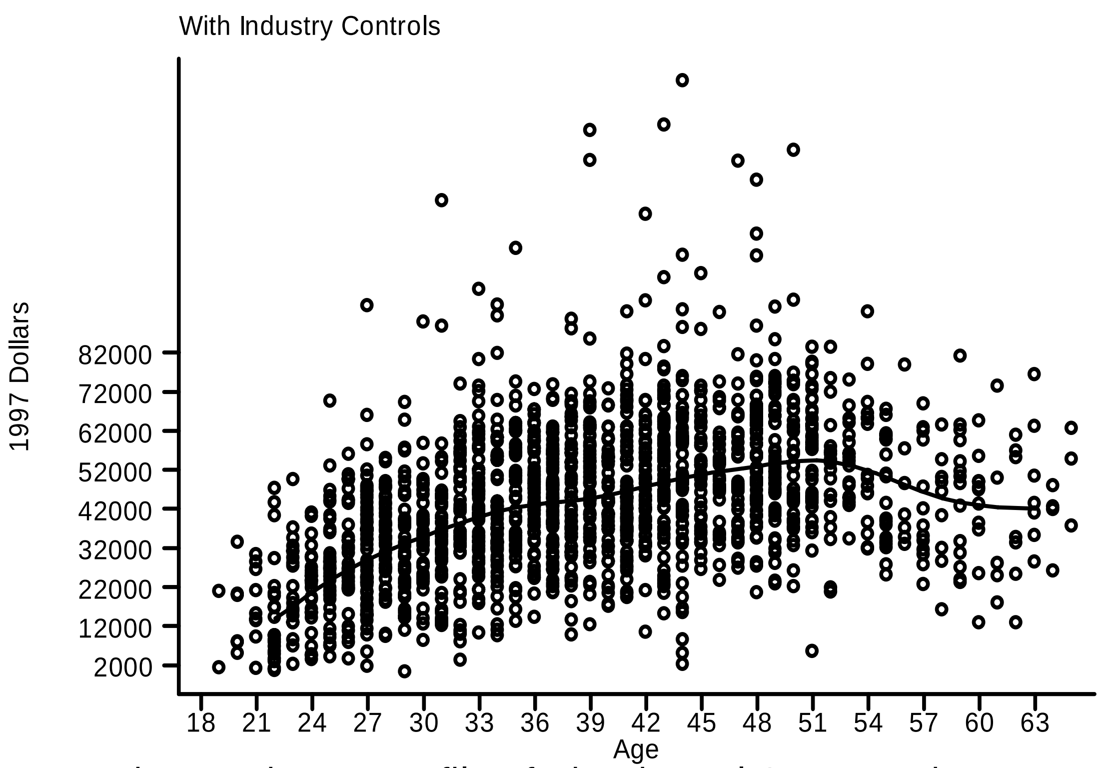


Figure 4d. Age Profile of Fitted Total Consumption

## References


Aldy, J. and W.K. Viscusi. (2004). "Age Variations in Workers' Value of Statistical Life." Working Paper 468. Cambridge, MA: Harvard Law School, Olin Center.

Arthur, W. B. (1981). "The Economics Risks to Life." *American Economic Review* 71(1): 54–64.

Black, D., and T. Kniesner. (2003). "On the Measurement of Job Risk in Hedonic Wage Models." *Journal of Risk and Uncertainty* 27(3): 205–220.

Blomqvist, Å. (2002). "Defining the Value of a Statistical Life: A Comment." *Journal of Health Economics* 21(1): 169–175.

Browning, M., T. Crossley, and G. Weber. (2003). "Asking Consumption Questions in General Purpose Surveys." *The Economic Journal* 113(491): F540–F567.

Browning, M.T. and C. Meghir. (1991). "The Effects of Male and Female Labor Supply on Consumption Demands." *Econometrica* 59 (4): 925–951.

Ehrlich, I. And Y. Yin. (2005. "Explaining Diversities in Age-Specific Life Expectancies and Values of Life Saving: A Numerical Analysis." *Journal of Risk and Uncertainty* 31(2): 129–162.

Garen, J. (1988). "Compensating Differentials and the Endogeneity of Job Riskiness." *Review of Economics and Statistics* 70(1): 9–16.

Heckman, J.J., L.L. Lochner, and P.E. Todd (2005). "Earnings Functions, Rates of Return and Treatment Effects: The Mincer Equation and Beyond." Discussion Paper 1700. Bonn, Germany: Institute for the Study of Labor (IZA). August.

Johansson, P.-O. (2001). "Is There a Meaningful Definition of the Value of a Statistical Life?" *Journal of Health Economics* 20: 131–139.

Johansson P.-O. (2002a). "The Value of a Statistical Life: Theoretical and Empirical Evidence." *Applied Health Economics and Health Policy* 1(1): 33–41.

Johansson, P.-O. (2002b). "On the Definition and Age-Dependency of the Value of a Statistical Life." *Journal of Risk and Uncertainty* 25(3): 251–263.

Johansson, P.-O. (2002c). "Defining the Value of a Statistical Life: Reply." *Journal of Health Economics* 21(1): 177–178.

Johannesson, M., P.-O. Johansson, and K.-G. Lofgren. (1997). "On the Value of Changes in Life Expectancy: Blips Versus Parametric Changes." *Journal of Risk and Uncertainty* 15: 221–239.

Jones-Lee, M. (1989). *The Economics of Safety and Physical Risk*. Oxford: Basil Blackwell.

Lang, K., and S. Majumdar. (2003). “The Pricing of Job Characteristics When Markets Do Not Clear: Theory and Policy Implications.” Working Paper 9911. Cambridge, MA: National Bureau of Economic Research. August.

Mellow, W., and H. Sider. (1983). “Accuracy of Responses in Labor Market Surveys: Evidence and Implication.” *Journal of Labor Economics* 1(4): 331–344.

Meyer, B. and J. Sullivan. (2003). “Measuring the Well-Being of the Poor Using Income and Consumption.” *Journal of Human Resources* 38(Supplement): 1180–1220.

Moore M., and W. K. Viscusi. (1990). *Compensation Mechanisms for Job Risks*. Princeton: Princeton University Press.

Pollak, R. (1969). “Conditional Demand Functions and Consumption Theory.” *Quarterly Journal of Economics* 83(1): 60–78.

Rosen, S. (1988). “The Value of Changes in Life Expectancy.” *Journal of Risk and Uncertainty* 1: 285–304.

Shepard, D.S., and R.J. Zeckhauser. (1984). “Survival Versus Consumption.” *Management Science* 30(4): 423–439.

Smith, V.K., M.F. Evans, H. Kim, and T.H. Taylor. (2004). “Do the Near-Elderly Value Mortality Risks Differently?” *Review of Economics and Statistics* 86(1): 423–429.

Thaler, R., and S. Rosen. (1975). “The Value of Saving a Life: Evidence from the Labor Market.” In N.E. Terleckyj (ed.), *Household Production and Consumption*. New York: Columbia University Press, pp. 265–300.

Viscusi, W.K. (1979). *Employment Hazards: An Investigation of Market Performance*. Cambridge, MA: Harvard University Press.

Viscusi, W.K. (2004). “The Value of Life: Estimates with Risks by Occupation and Industry.” *Economic Inquiry* 42(1): 29–48.

Viscusi, W. K., and J. Aldy. (2003). “The Value of a Statistical Life: A Critical Review of Market Estimates throughout the World.” *Journal of Risk and Uncertainty* 27(1): 5–76.

Ziliak, J. (1998). “Does the Choice of Consumption Measure Matter? An Application to the Permanent-Income Hypothesis.” *Journal of Monetary Economics* 41(1): 201–216.