Value of a Statistical Life: Relative Position vs. Relative Age

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The value of a statistical life (VSL) plays the central role in regulatory decisions affecting risks to life and health. Here we examine empirically the importance of two possible omitted variables that could affect the estimates of VSL based on the typical wage equation: relative position in the wage distribution and relative age within the life-cycle pattern of consumption.

We find that ignoring the worker's relative position in the wage distribution does not affect VSL as conventionally computed, but that ignoring the life-cycle pattern of consumption undervalues VSL by perhaps 20 percent. The modest effect of adding measures of relative economic position to the canonical hedonic wage regression suggests that workers taking risky jobs make their decisions based on their personal wage–risk trade-off rather than their status or relative economic position. In contrast, the worker's relative position within the personal life-cycle pattern of consumption is a driving force that affects the temporal trajectory of VSLs over the life cycle. Appropriate VSL assessments should not downweight the risks to older citizens compared to the young because the effect of age on the level of planned consumption may outweigh or dampen the effect of age in shortening people's remaining future lifetimes.

I. The Canonical Hedonic Wage Regression and Implied VSL

The canonical hedonic wage equation used in the value of statistical-life calculations takes the form

$$\text{(1)}\qquad \ln(w_{ijk}) = \alpha_1 \text{fatal}_{jk} + \mathbf{X}_{ijk}\boldsymbol{\gamma} + u_{ijk}$$

where for worker i in industry j and occupation k, $\ln(w)$ is the natural logarithm of the hourly wage rate, "fatal" is the work-related fatality rate, and **X** is a vector containing both demographic variables (such as education, race, marital status, and union membership) and job characteristic variables (such as the nonfatal injury risk, wage replacement under workers' compensation insurance, and industry, occupation, or geographic location indicators). Finally, u_{ijk} is an error term that may exhibit conditional heteroscedasticity and within-fatality risk autocorrelation, which need be reflected in the coefficients' calculated standard errors.

With a fatality risk measure expressed as deaths per 100,000 workers and a typical work year of 2,000 hours, the value of a statistical life is $\text{VSL} = \alpha \times \exp[\ln(w)] \times 100{,}000 \times 2{,}000$. Although the VSL function depends on the values of the right-hand side in (1), most commonly considered is the mean VSL.

The fatality risk measure we use in our regressions is the fatality rate for the worker's industry-occupation group. Workplace fatality risk is publicly available only by industry. To provide a more precise correspondence between the fatality risk and the worker's job, we constructed the fatality risk using unpublished U.S. Bureau of Labor Statistics (BLS) data from the Census of Fatal Occupational Injuries (CFOI), which is the most comprehensive inventory available of work-related deaths.[1] The number of fatalities in each industry–occupation cell is the numerator of the fatality risk measure, and the number of employees in the industry–occupation group is the denominator of the fatality risk measure.

We considered 720 industry–occupation groups, which are the intersection of 72 two-digit SIC code industries and the 10 one-digit occupation groups. For the 6,238 total

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[1] The fatality data we use are available on CD-ROM from the BLS. In calculating fatality risk we follow the procedures in Viscusi (2004), wherein the fatality risk measure is compared to other death-risk variables and which should be consulted for more details.

work-related deaths in 1997, there were 290 industry–occupation cells with no reported fatalities. Because total fatalities were relatively similar from 1992, which was the first year of the CFOI, up through our regression sample year of 1997, we used the mean fatalities for an industry–occupation cell during 1992–1997 when computing fatality risk. Intertemporally averaging reduces the importance of random changes in fatalities and reduces by two-thirds the number of empty fatality risk cells. In our data the average fatality risk is 4/100,000 with the lowest risk level 0.6/100,000 and the highest about 25/100,000.

In addition to the fatality risk variable just described we estimate the regression in (1) with individual data from the 1997 merged outgoing rotation group of the Current Population Survey (CPS). Sample individuals are nonagricultural full-time workers (usual weekly hours worked at least 35) between the ages of 18 and 65. The VSL from our baseline regression is $4.7–4.8 million, with the upper range from a men-only sample.

II. Relative Position and VSL

Workers' expected utility depends on the job risk and their absolute wage but may also depend on their relative position within the wage distribution (Robert Frank and Cass Sunstein, 2001). Equilibrium market outcomes will then reflect workers' concerns with relative position too. A worker might be willing to accept a lower compensating differential for a given risk than if there were no relative position effects. Standard VSL estimates may be too low because relative position is an omitted variable in the typical hedonic wage equation.

Our amendment of the canonical model to include relative position effects is

$$\text{(2)} \quad \ln(w_{ijk}) = \alpha_2 \text{fatal}_{jk} + \mathbf{X}_{ijk}\boldsymbol{\gamma} + \phi R_i + u_{ijk}$$

where R is the individual's relative position in the wage distribution of some reference group. If Frank and Sunstein are correct, a worker will accept a smaller compensating differential for risk to boost the worker's relevant relative wage, so that $\alpha_2 > \alpha_1 \Rightarrow \text{VSL}(\alpha_2) > \text{VSL}(\alpha_1)$. Ignoring relative position may undervalue safety-enhancing government regulations that do not disturb relative wages, which may be more properly measured by VSL(α_2) compared to regulations that alter relative wages, as measured by VSL(α_1).

Elsewhere we have offered a lengthy conceptual criticism of the importance of relative position (Kniesner and Viscusi, 2003). Even if relative-position effects exist, they seem likely to be small. We find that a worker facing the average fatality risk of 4/100,000 and with the VSL of $4.74 million will receive annual fatality risk compensation of $190, which is unlikely to confer substantial economic status. Moreover, if the relative-position reference group is defined within firms, to the extent that the riskiest jobs are viewed as unattractive low-prestige positions, this may overshadow any income-based status effect. Thus, even if relative status matters, we hypothesize that the key dimensionality of status derives more from the observable physical attributes of the job rather than from wages, which are often unobservable. Such nonpecuniary relative-position concerns will tend to boost the observed wage–risk trade-offs, leading to higher estimated VSLs than if relative position did not matter.

A practical problem with including a relative-position effect based on relative income status is that there is no unique way to infer from the regression what the person's reference group might be (Robert A. Moffitt, 2001). The researcher must start *ex ante* with the reference group when formulating the regression to estimate and then infer the effects of the possibly incorrect reference group's behavior on the individual's behavior. There is also no evidence from micro surveys that establishes the typical worker's economic reference group.

We consider some potential reference groups to see if group effects in a regression framework enlarge the VSL. We consider the relative position (percentile rank) of a person's wage in the state of residence and the relative position of a person's wage among persons of the same gender in the state of residence.[2] We constructed

[2] The larger the reference group, the closer relative position is to a simple ordinal transformation of the dependent variable; and the smaller the reference group, the less informative is the measure of relative position. The state level seems to strike the best balance among possible reference

TABLE 1—THE EFFECTS OF WAGE RANK ON THE HEDONIC WAGE FUNCTION AND VALUE OF STATISTICAL LIFE (VSL)

	Full sample	Ranks by state	
Independent variable	(i)	(ii)	(iii)
Worker fatality risk	0.0017*	0.0012*	0.0013*
	(0.0002)	(0.0002)	(0.0002)
Wage rank	—	−0.0002*	−0.0002*
		(8.3×10^{-7})	(9.1×10^{-7})
Wage rank × worker fatality risk	—	—	-3.1×10^{-8}
			(10.0×10^{-8})
VSL ($ millions)	4.74	3.46	3.57
	Male sample, ranks by state and gender		
Independent variable	(iv)	(v)	(vi)
Worker fatality risk	0.0016*	0.0012*	8.0×10^{-5}
	(0.0002)	(0.0002)	(2.5×10^{-4})
Wage rank	—	−0.0004*	−0.0004*
		(2.1×10^{-6})	(2.4×10^{-6})
Wage rank × worker fatality risk	—	—	1.6×10^{-6}*
			(2.0×10^{-7})
VSL ($ millions)	4.83	3.71	3.95

Notes: $N = 99{,}033$; standard errors are reported in parentheses. All regressions use the 1997 CPS merged outgoing rotation group (MORG) and also include the following variables: a constant, age, age squared, black, Native American, Asian, Hispanic, education, married, union, public employee, residence in SMSA, eight regional dummy variables, nine occupation dummy variables, injury and illness rate, and expected workers' compensation replacement rate.

* Statistically significant at the 5-percent level (two-tailed test).

the relative position variable such that the highest-wage person has the lowest wage-rank variable score, or $R = 1$ = first is best, and R = group size = last is worst.

Our regression results, reported in Table 1, are opposite of Frank and Sunstein's conjecture. VSL is about 25–33-percent smaller when relative position is held constant, compared to when relative position is ignored.

It is well known that the change in the coefficient of a linear regression due to adding a variable depends on the product of two things: (i) the partial effect of the new variable and (ii) the partial relationship between the originally included variable and the newly included variable, holding constant the other regressors (William Greene, 2003 pp. 148–49). Thus, $\alpha_1 > \alpha_2 \Leftrightarrow \phi \times (\partial\text{fatal}/\partial R|X) > 0$. In the estimates of equation (2) $\phi < 0$, which simply reflects that relatively high-wage workers also have high absolute wages ($R = 1$ is the highest wage rank). Many persons with relatively high wages in their state, ceteris paribus, also live in states with higher average fatality rates, so that $(\partial\text{fatal}/\partial R|X) < 0$. Because both terms in the product that determines the change in the coefficient of fatal injury risk are negative, VSL shrinks when relative position is added to the baseline regression.

Including the interaction of the rank variable in the two specifications in Table 1 does not lead to more favorable effects for the relative-position hypothesis. The interaction term is not statistically significant for the ranks by state, and although the interaction term is statistically significant for rankings by state and gender, including the wage-rank × fatality-risk interaction reduces the implied VSL.

III. Consumption and VSL

Elsewhere we consider in detail the fact that VSL should be computed in light of the worker's consumption plans over the life cycle (Kniesner et al., 2004). Someone with a given life expectancy will have a higher VSL if he or she has back-loaded planned consumption than an otherwise identical person whose planned consumption has already occurred (Donald Shepard and Richard Zeckhauser, 1984; Per-Olov Johansson, 2002a, b). Adding consumption plans to a model of the worker's behavior also captures the effects of aging on VSL.

The hedonic model we estimate that adds consumption to the canonical model of wages in (1) is

$$(3) \quad \ln(w_{ijk}) = \alpha_3 \text{fatal}_{jk} + \mathbf{X}_{ijk}\boldsymbol{\gamma} + \delta C_i + u_{ijk}$$

where C is a measure of the individual's consumption. Because persons with higher intended consumption should also have higher-paying jobs, one expects $\delta > 0$ in (3). If persons with more planned consumption are wealthier and choose safer jobs, ceteris paribus, C and the "fatal" variable conditionally covary negatively $(\partial\text{fatal}/\partial C|X < 0)$. It should then be the case that $\alpha_3 > \alpha_1 \Rightarrow \text{VSL}(\alpha_3) > \text{VSL}(\alpha_1)$, and a model

groups. We tried several reference-group alternatives, including age–education as suggested in Isolde Woittiez and Arie Kapteyn (1998), and no other reference group rankings yielded significant regression coefficients in (2).

including consumption effects may have a higher implied value of a statistical life for older workers.

The CPS data we use do not include data on consumption. Examining the change in VSL from adding consumption requires using a second source of data on individual labor-market participants. We use the 1997 wave of the Panel Study of Income Dynamics (PSID), which also provides individual level data on wages, consumption, industry and occupation, and demographics.

Because consumption is a choice variable we allow for $E[u_{ijk}C_i] \neq 0$, which implies the need for an instrumental-variables approach to produce a consistent estimate of α_3, the estimated fatality effect in model (3), to use in calculating VSL. We rely on relatively standard information from economic theory of individual behavior over the life cycle. Based on human-capital theory we take the worker's non-wage income as having no direct effect on the log of the wage, and based on the theory of the consumer we take non-wage income as determining consumption.

Using the PSID, we produce instrumental-variables regression results parallel to regressions from the CPS. Including consumption raises the coefficient on fatality and its *P* value. Adding consumption to the canonical hedonic wage model raises the average VSL by as much as 20 percent (Kniesner et al., 2004).

IV. Discussion

Economists and policymakers continue to search for the most appropriate VSL estimate. One reason why relative position is an interesting variable to Frank and Sunstein (2001) is that it is a simple way to introduce distributional concerns into cost-effectiveness calculations. VSL computed from a hedonic wage regression with relative economic position as a regressor holds constant a measure of the distributional consequences of a regulation that changes fatality risk. Holding relative economic position constant could allow the analyst to avoid having to address issues of distribution more generally, which can prove highly controversial or lead to strategic manipulation of cost-effectiveness calculations (Viscusi, 2000; Sunstein, 2004). However, the level of VSL is the main effect of interest, and we find that introducing relative wage position into the canonical hedonic regression if anything lowers, not raises, VSL.

We agree that there is no unique measure of relative position, such that wage percentile within a state or within a state by gender might not be the typical worker's reference group. However, we have explored alternatives that are less aggregative and found a lack of statistical significance, and our reference-group results for a hedonic wage function are possibly the first attempt to examine the importance of relative position in a hedonic wage function. The main policy implication of our results concerning relative position is that, as typically computed, VSL is not undervalued by ignoring a worker's relative position in the wage distribution.

The conclusion and ultimate policy implication are reversed when we consider that workers' wages are jointly determined with consumption plans. The consequence is that VSL is explicitly a function of the individual's consumption. We have demonstrated that consumption is a significant additional variable in hedonic models used to produce VSL and that incorporating consumption raises VSL by as much as 20 percent, most notably for middle-aged and older workers.

If one wants to net out distributional consequences of policies that affect mortality risk the most transparent way, looking at the effect of policy for workers of a given wealth level could be the best approach. Because consumption changes with age, models that include consumption are a natural way to infer how VSL changes with age, which need not be monotonic if workers have back-loaded their planned consumption (Kniesner et al., 2004).

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