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WHAT'S TO KNOW? PUZZLES IN THE LITERATURE ON THE VALUE OF STATISTICAL LIFE

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Abstract. Notwithstanding the general acceptance of the value of statistical life (VSL) estimates for policy assessment purposes, several important unresolved issues remain. First, the results from revealed preference studies are systematically higher than those from stated preference studies, potentially limiting the usefulness of stated preference studies in generalizing the VSL estimates to different populations and kinds of risks. Second, extrapolating the results of meta-analyses to project the VSL for different population groups requires that such generalization be reflective of the underlying economic content of what average VSL estimates reflect. Third, government agencies within and across countries place differing emphasis on types of VSL studies as well as differing reliance on individual studies versus meta-analyses. Usually, there is no justification provided for the chosen approach.

Keywords. Meta-analysis; Mortality; Risk; Value of statistical life

1. Introduction

The principal economic parameter that governs the attractiveness of efforts to reduce the mortality risks is the value of statistical life (VSL). The VSL measures the trade-off between money and risk for very small risks of death. Studies that ascertain the compensation needed to incur small increases in risk are willingness-to-accept (WTA) studies, while studies that ascertain the amount that people are willing to pay for risk reduction are willingness-to-pay (WTP) studies. For small risks of death, the WTA and WTP values should be approximately equal. As a result, government agencies in the USA generally rely on the implications of the labor market estimates of VSL, which are WTA amounts, even though the basic principle underlying benefit-cost analyses is to utilize WTP as the benefits measure. Mortality benefits valued using VSL often dominate the benefits component of government regulations, as in the case of the Clean Air Act (US Environmental Protection Agency, 2011). The fundamental role of VSL is broader than its impact on benefit-cost analyses, as VSL levels have ramifications for policies such as those dealing with health care and catastrophic risks.

In this paper, I discuss three outstanding puzzles with respect to VSL, all of which involve meta-analyses at least in part. First, is there a systematic difference between the VSL estimates in stated preference studies and revealed preference studies, and what accounts for this difference? Second, to what extent should one exercise caution in extrapolating based on the implications of meta-analyses? Is it appropriate to use the coefficient estimates from meta-analysis regressions to develop the estimates of the VSL for different population subgroups? Third, should government policies to select the VSL be based on the findings of meta-analyses, the best single study, or some other approach?

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2. Revealed Preference versus Stated Preference Studies

Analysis of individuals' risk-money trade-off rates can be based on trade-offs revealed through actual risky decisions or through hypothetical risky decisions. Examples of revealed preference studies based on observed behavior are estimates of the VSL based on the compensation workers receive for fatality risks, price cuts consumers receive for houses in dangerous or polluted neighborhoods, and price premiums commanded by safer used automobiles. Stated preference studies take a different approach in that they present individuals with a hypothetical risky choice and then elicit the VSL based on the expressed preferences toward situations involving risks and monetary rewards, such as their valuation of safer products. A WTP study asks people for their valuation of reducing the risk from x to some lower risk y, while a WTA study asks for the amount that they need to accept an increase in the risk from y to x. Although early stated preference studies that asked people their WTP or WTA amount point blank posed considerable cognitive demands on respondents and often led to unstable results, developments in the stated preference methodology have reduced these difficulties. The main comparative advantage of revealed preference studies is that they pertain to actual decisions that people face and focus on the risks that are of genuine concern to the individual in that these risks pose an actual threat to their well-being.

Notwithstanding the advances that have been made in each of these approaches, there remain disturbing systematic differences in their findings. The VSL estimates implied by stated preference studies tend to be lower than those from revealed preference studies.[1] This is a consistent pattern found for studies in both the USA and UK. The direction of the disparity is surprising in that there are two reasons why one might expect stated preference studies to yield higher VSL estimates. First, stated preference studies can inform subjects of the actual risk level. In contrast, revealed preference studies rely on perceived risk levels for which there is likely to be some measurement error relative to the actual risk level, as in the case of the fatality rate variable in a wage equation. If this measurement error is random, it will bias the revealed preference estimates of the VSL downward. Second, revealed preference studies are based on the decisions of those who have chosen to work on risky jobs or are exposed to other kinds of risks so that this selection bias may lead to underestimates of the VSL relative to the population at large. There is no comparable selection bias for stated preference studies as they can be administered to a nationally representative sample.

The most likely explanations for the disparity between revealed preference studies and stated preference studies appear to stem from the nature of the risk being valued. What is being measured is often quite different. Revealed preference studies pertain to the valuation of risks actually being incurred by the individual. In contrast, stated preference studies address the hypothetical risks that people may not view as a real threat, leading to an understatement of the WTA and WTP amounts. More generally, the respondent may not take the stated risk or the stated risk change in the survey to be a valid reflection of the individual's own personal risk. If the respondent does not take the risk level stated in the survey at face value but instead discounts it to a lower amount, then the implied VSL estimate will understate the VSL. The risk perception effect is probably more influential than the possible hypothetical bias in which money is treated as a free good. Respondents' undervaluation of hypothetical survey money will produce a discrepancy that is the opposite of what is observed.

The survey's risk valuation questions may also not pertain to the valuation of a personal risk reduction but rather to the respondent's WTP for broader societal risk reduction. What is sometimes being valued in a stated preference study is the mortality risk to others and society generally rather than the risk to the respondent. Thus, a mortality risk-money trade-off is being estimated, but it should not be confused with a VSL estimate for which the risk pertains to the individual.

Another manifestation of the disparity between the stated preference and the revealed preference studies pertains to the age-related pattern of VSL. Based on economic theory, in a world with

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imperfect capital markets and imperfect insurance markets, the VSL should rise over the life cycle and then eventually decline. This inverted-U-shaped pattern closely follows the trajectory of income and consumption over the life cycle. The revealed preference studies based on more recent job risk data that make it possible to estimate wage equations using age-specific job fatality measures show a consistent pattern. As indicated in the review by Aldy and Viscusi (2007), the age pattern of VSL in labor market studies does display the predicted inverted-U shape. Moreover, life-cycle changes in consumption levels are strong predictors of the VSL pattern, as economic theory predicts. In contrast, as the results of Krupnick's (2007) survey indicate, the age-related VSL evidence from stated preference studies is more mixed, with no consistent pattern and usually failing to display the kind of trajectory over the life cycle that economic theory predicts. While such studies may be improved over time, the current state of the art for stated preference studies does not provide a robust characterization of the age-related variation.

Notwithstanding these apparent limitations of stated preference studies, they do have a number of advantages. There is, for example, little reliable market evidence that can be used to value mortality risks such as those associated with cancer or terrorism attacks. Revealed preference studies have also fallen short in terms of providing estimates of the VSL for children or people beyond the usual working age in the population. Moreover, in some countries, the revealed preference evidence from labor market studies may not be stable so that the guidance they provide in setting the VSL for policy is unclear. A notable case in point is the situation of the UK. The meta-analysis by Viscusi and Aldy (2003) identified VSL estimates using UK labor market data of $4.2 million, $9.4 million–$11.5 million, $5.2 million–$69.4 million, $19.9 million, and $5.7 million–$74.1 million, where all estimates are in $2000. The source of the instability is unclear and may derive in part from using different samples and econometric models. Improved econometric analyses may be useful. For example, the US VSL estimates based on cross sections using the Panel Study of Income Dynamics generally led to inordinately large VSL estimates, often over $20 million. However, after controlling for individual heterogeneity and similar concerns that can be addressed using the panel aspect of the data, the estimates reported in Kniesner *et al*. (2012) are more in line with those based on other labor market studies. Another potentially fruitful approach as a cross check for the different estimates is to use theoretically related estimates linking VSL to the coefficient of relative risk aversion, as suggested by Evans and Smith (2010). Although similar econometric improvements in the UK may produce more consistent VSL estimates, based on the current situation, there is a strong impetus for UK policymakers to rely on stated preference studies when choosing the appropriate VSL.

3. Extrapolations from Meta-Analysis Results

A typical meta-analysis of VSL includes the variables pertaining to individual personal characteristics as well as aspects of the data used in the study. Thus, for example, the study might estimate that the average VSL from labor market studies increases with income levels, decreases with the average risk level, and increases with unionization. Based on such results, what might the implications be for governments using the VSL estimates in a benefit transfer context in which the VSL is being applied to a different population than that in the labor market studies in the underlying meta-analysis?

Before addressing this issue in the context of labor market studies, it is useful to review what the hedonic labor market studies capture. Any individual study's estimates of the VSL provide the average VSL across the sample. The individual observations of wage-risk combinations in the labor market consist of the points generated by the locus of tangencies of the market offer curves and the constant expected utility loci of the individual. Thus, the estimated trade-off rate at the wage-risk combination for the individual indicates a money-risk trade-off that is simultaneously reflective of

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individual preferences at that point and the marginal costs of providing safety to the employer. These trade-off rate estimates do not imply that nonlocal changes would be similarly valued using the same trade-off rate and, in general, they will not.

Consider first the influence of the level of the risk. To what extent are the local VSL estimates from labor market studies generalizable to large risk changes? One can examine how the VSL varies with the risk level in the sample, as several meta-analyses do. There is a pronounced negative relationship between the estimated VSL and the job risk level as samples consisting of workers in very high-risk jobs have a much lower VSL than do workers in low-risk jobs. This relationship reflects that workers who have much greater WTA for risky jobs gravitate to these high-risk positions. If one were to extrapolate this result to a policy context involving a large increase in risk, as in the situation in which a nuclear waste storage site is going to be sited near an existing neighborhood, then one would use a very low VSL based on the workers in high-risk jobs to value the WTA amount for these risks. Doing so would, however, misestimate the pertinent VSL trade-off amounts.

To identify the WTA amount for the individuals affected by the risk, the shift that should be examined is not along the estimated hedonic wage locus for the population. Rather, the pertinent perspective is that those subject to the increased risk are being moved to a higher risk level along their constant expected utility locus for which the wage rate for the WTA amount at this greater risk level will exceed the required wage rate based on the average market trade-off. Analogously, their WTP amount for very large reductions in risk will be overstated by extrapolating from local VSL estimates, but to a lesser extent than the WTA distortion given the shape of individual utility functions.[2] Appropriate estimation of the effect of large changes in risk levels can be obtained based on the knowledge of individual utility functions, which have been estimated using stated preference data.

A prominent use of meta-analysis results to extrapolate average VSL estimates to different populations is with respect to income levels that differ from those in labor market studies. In particular, what is the pertinent income elasticity of VSL and to what extent can it be inferred based on the analyses of revealed preference data involving cross sections of individuals? The appropriate way to conceptualize this question depends on the nature of the income differences being considered. If the question pertains to an income change for a particular individual, then knowledge of individual utility functions may be needed to pin down the effect. However, the usual policy concern is not with respect to the changes in individual income but with average income differences across different population groups. For example, should risks to passengers on airplanes be accorded a higher VSL than traffic safety risks? Current approaches based on meta-analysis of income elasticities indicate a range from about 0.5 to 0.6 based on a wide range of empirical specifications.[3] However, using quantile regression analysis and a single sample, Kniesner *et al*. (2010) find the income elasticity estimates above 1.0. Meta-analyses may suppress the income variation in VSL across the population by focusing on average VSL estimates for samples. Alternatively, the estimated high income elasticity from a single sample may be an outlier.

4. Criteria for Choosing the VSL

There are several options an agency could use in selecting its VSL for policy purposes, and as of yet, there is no single dominant method. The choices include, among others, the following: (i) the results of a single meta-analysis of labor market studies, (ii) the results of a single meta-analysis of VSL studies including revealed preference and stated preference studies, (iii) the results of multiple meta-analyses that are combined often in some judgmental way, (iv) the results of the "best" labor market study, and (v) the results of the stated preference study most pertinent to the policy context. While these possibilities are not exhaustive, they do capture the menu of the kinds of studies the agencies take into account when setting the VSL level for policy.

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The strength of meta-analyses is that they incorporate the findings from a variety of data sets and make it possible to pool this information across studies. But is such pooling of studies always sensible? Should any meta-analysis rely on previous studies if there have been major advances in the estimation of the VSL? The most significant change for US studies has been the advent of much better job risk data. The current state-of-the-art job risk data utilize job fatality data from the US Bureau of Labor Statistics Census of Fatal Occupational Injuries (CFOI). These data are not a sample, but rather comprise the first comprehensive census of all job-related fatalities that are verified using multiple sources. The level of detail available for each fatality is also greater, making it possible to match risks to workers based on a variety of dimensions. Rather than being restricted to risk levels by broad industry or occupational groups, studies using the CFOI data have examined risks by industry, occupation, age, gender, race, and immigrant status. Often multiple categories are included, such as defining risks by industry–occupation–age. Labor market estimates utilizing the CFOI risk measures clearly are superior in that they reduce the measurement error associated with the job risk variable.[4] The practical question that policymakers face is to what extent improvements in the estimation of the VSL warrant focusing on the studies using state-of-the-art approaches rather than more comprehensive meta-analyses.

5. Conclusion

The set of questions posed here is likely to become more pressing as there is increased refinement in estimates of VSL for different population subgroups and as government agencies seek to tailor their choice of the VSL to better reflect the valuations pertinent to their policies. Even if revealed preference studies are superior for analyzing particular kinds of mortality risks for which there is abundant market data, the desire to establish valuations for mortality risks with different morbidity consequences such as cancer will lead to the continued utilization of stated preference studies as well. Understanding and rectifying the discrepancies of these classes of studies are essential.

This quest for VSL estimates that are pertinent to the affected population subgroup will also increase the pressures for using meta-analysis results to provide the estimates of the VSL for quite different populations with different risk valuations. It is essential to understand when such types of benefit transfer approaches are warranted and what biases may arise from such extrapolations.

Finally, wholly apart from refinements in the VSL, policymakers must continue to confront the more fundamental question of selecting the baseline VSL to be applied to the average population. In particular, what should be the reliance on individual studies or more comprehensive meta-analyses?[5] Fortunately, the current VSL estimates using either of these approaches tend to cluster in a fairly similar range based on most studies in the literature.

Notes

1. See Viscusi (1993) and Kochi *et al*. (2006) for a review and comparison of these studies.
2. A numerical example based on utility function estimates implied by the VSL is presented in Viscusi (2011).
3. See US Department of Transportation (2008), which bases its estimates on Viscusi and Aldy (2003).
4. Viscusi (2004) reports 80 different specifications of wage and log wage equations using the CFOI data, yielding quite robust estimates.
5. This generic question is a long-standing issue in benefit transfer discussions. See Boyle and Bergstrom (1992) and Rosenberger and Loomis (2000).

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