THE VALUE OF A STATISTICAL LIFE: ECONOMICS AND POLITICS

STRATA

March 2017

Primary Investigators:

Ryan C. Bosworth, Ph.D., Associate Professor, Utah State University, Department of Applied Economics

Alecia Hunter, Policy Analyst, Strata

Ahsan Kibria, Ph.D. Student, Utah State University, Department of Applied Economics

STRATA

TABLE OF CONTENTS

STRATA

Executive Summary

The value of a statistical life (VSL) is the marginal rate of substitution between income (or wealth) and mortality risk. The VSL indicates how much individuals are willing to pay (WTP) to reduce the risk of death. Applied properly, the VSL can be used in benefit-cost analysis to evaluate the efficiency of government policies designed to reduce risk.

The VSL can be estimated via revealed preference data by observing individuals choices that influence both income and risk levels. For example, the wage-risk literature examines the premium paid to workers in more risky occupations after controlling for other factors. The VSL is also sometimes estimated via stated preference data by querying individuals about hypothetical choices over income and risk.

All estimation methods for the VSL have weaknesses, however, there is a growing consensus in the academic literature that the population average VSL is in the range of $4 to $10 million (U.S. dollars). This consensus reflects stated VSL estimates used by various government agencies.

There are reasons to suspect that the VSL may be overestimated in the academic literature and misapplied in government policy. In particular, some authors find evidence of substantial levels of publication bias. Behavioral economics also suggests that individuals and policy makers may overreact to small and unknown risks, resulting in over-regulation for small environmental hazards.

Public choice theory indicates that agencies have the incentive to maximize budgets by inflating or misapplying estimates of risk and WTP for risk reductions to increase benefits estimates and improve the likelihood that proposed policy programs are adopted.

We find evidence that the VSL estimates public agencies use can be influenced by political considerations. We also note that under public choice theory agencies have the incentive to avoid analyzing the benefits and costs of inefficient regulations.

Introduction

Many public policies are designed to protect life and health. For example, air quality regulations are designed to protect people from breathing harmful chemicals. Traffic safety regulations attempt to lower the risk of death and injury from automobile accidents.

However, government policies that are designed to protect life and health also come with substantial costs, many of which are not immediately obvious. Moreover, understanding the incentives of researchers, government agencies, and individuals can shed light on the appropriate role for government in mitigating risks to life and health. Because both governments and individuals must make tradeoffs between income and risk, and because understanding these tradeoffs is essential for understanding the value of public policies designed to protect life and health, a large academic literature has developed in this area.

Understanding the proper amount of resources to allocate to government health and safety programs requires an understanding of the value that individuals place on changes in risk levels for threats to life and health. Subsequently, many government policies are directly or indirectly based on the value of these tradeoffs as estimated in the academic literature. This literature is largely focused on measuring a concept known as the Value of a Statistical Life (VSL).

In the popular press, the value of a statistical life is often presented as the value government agencies place on human life. However, rather than place value on individual lives, the concept of the value of a statistical life is based on the notion that reducing risk is costly and it is possible to spend more resources reducing risk than is optimal. For example, a government agency may wish to understand the benefits and cost of a road safety improvement. The improvement may slightly reduce the risk of death for travelers on the road, but the project will be costly. Because it is impossible to identify the specific lives that may be saved by the safety improvement, economists attempt to estimate how much individuals are willing to pay to reduce the risk of dying.

Ideally, an estimate of how much individuals are willing to pay for safety improvements would enable governments to efficiently allocate resources to safety improvements in a wide variety of areas: road safety, environmental pollution regulations, food safety regulations, etc. However, as addressed in this paper, achieving this ideal is problematic for a number of reasons. In this paper we identify and discuss the problems associated with government policy regarding risks to life and health. In particular, we discuss methodological problems associated with estimating the VSL, cognitive biases that may distort risk perceptions, publication bias, and the political economy of the VSL in practice.

Conceptual Foundations

Formally, the value of a statistical life is defined as the marginal rate of substitution between income (or wealth) and mortality risk. Intuitively, this measures the rate at which individuals are willing to trade money for reduced risk of death. In principle, this tradeoff can be measured by observing individual behavior. For example, when individuals choose the speed at which to drive, they reveal information about the relative values of time and risk levels. Likewise, individuals may purchase devices such as smoke detectors that reduce the risk of death.

Mathematically, the value of a statistical life is derived as follows: Assume that individual utility depends on wealth levels and mortality risk. In a commonly used single-period VSL model, it is assumed that individuals maximize their expected indirect utility shown as:

$$V = pu_m(w) + (1 - p)u_s(w)$$

where, v is the indirect utility, p is the probability of mortality risk in the period, $u_m(w)$ is the utility of wealth w if the individuals die within the period, and $u_s(w)$ is the utility of wealth w if the individuals survives within the period. This basic model has been commonly used in the VSL literature. See Hammitt (2000) for a simple introduction.

We adopt the standard assumptions that utility is twice differentiable and that the utility functions are increasing and weakly concave and that at any wealth level, both utility and marginal utility are larger if alive than dead:

(i) $u_s(w) > u_m(w)$

(ii) $u_s'(w) > u_m'(w) \geq 0$

(iii) $u_s''(w) \leq 0$ and $u_m''(w) \leq 0$

By assuming that individuals seek to maximize expected utility under these alternative states of the world, it can be shown that indifference curves over (w,p) are decreasing and strictly convex, as shown in Figure 1. Furthermore, the VSL can be calculated as

$$\frac{dw}{dp} = \frac{u_s(w) - u_m(w)}{(1-p)u_s'(w) + pu_m'(w)}$$

Notice that as per the assumptions i-iii, the VSL is always strictly positive.

Figure 1: Indifference curve over survival probability (p) and wealth (w).
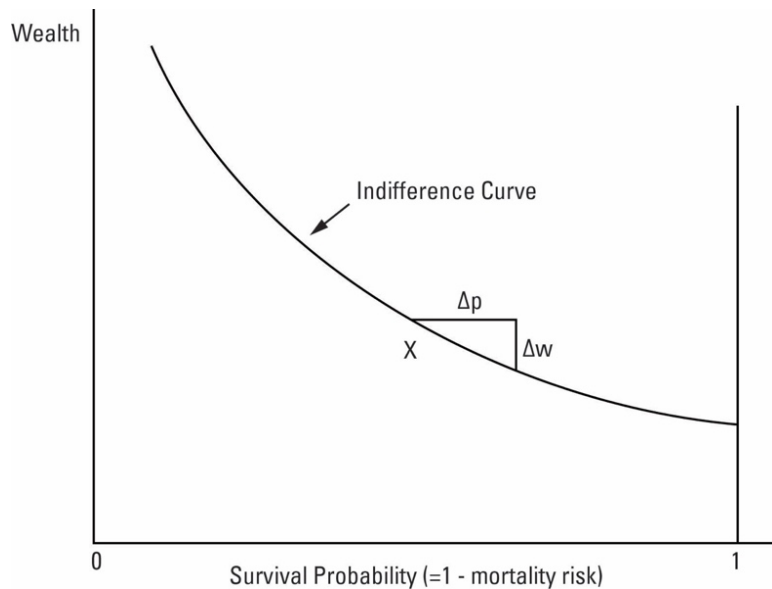
The VSL can be considered as the marginal rate of substitution (MRS) between wealth and survival probability: the slope of the indifference curve at (w, p). The VSL does not estimate the value of life, rather it only measures what an individual is willing to pay to reduce a certain risk level or accept a risk level by not paying for the risk reduction.

Because the calculation of the VSL depends on both income and risk, the reliability of estimates of the VSL depends crucially on individuals' ability to perceive, understand, and place a value on risk reductions. However, research in the areas of risk perception and behavioral economics suggests that individuals' ability to perceive risk levels accurately is subject to a wide variety of psychological biases and conceptual limitations. Moreover, there are substantial methodological, conceptual, and empirical difficulties associated with measuring these trade-offs. As part of this study, we

STRATA

will investigate and identify the possible and probable effects that these biases may have on estimated values for the VSL, as well as the policy implications of these limitations.

History of the VSL

The first use of the term "Value of a Statistical Life" in the academic literature appeared in Thomas Schelling's classic 1968 article "The Life You Save May Be Your Own." In this article, Schelling explained the basic framework for valuing risk reductions. Schelling's fundamental insight was that rather than valuing human life directly, economists could value the risk reductions (or risk increases) resulting from various policy actions. Although people will not typically accept payment in exchange for certain loss of life, individuals will accept payment as compensation for risk increases. For example, an individual may be willing to accept a higher wage as compensation for doing a more dangerous job. Ironically, Schelling's framework was developed specifically to *avoid* placing a value on human life, but the terminology he chose, "value of a statistical life," has created the impression among non-economists that the VSL is in fact the way that economists value human life.

As shown by Banzhaf (2014), the basic framework developed by Schelling has origins in Cold War military strategy and planning. Shortly after the USSR detonated their first atomic bomb, the U.S. Air Force approached the Research And Development (RAND) Corporation with the task of designing a strategy for the first aerial invasion of the Soviet Union. RAND was created in 1946 with the vision of applying systematic scientific thinking to military tactics, strategies, and policy decisions. RAND experts were assigned to the Air Force project, and they created a large model of thousands of different aerial combat scenarios. The specialists reported to the Air Force with the suggestion that they cover the Soviet skies with numerous cheap decoy planes to overwhelm the enemy's air defenses. A few select planes would carry nuclear weapons to inflict major damage. This strategy, while cost-effective in terms of equipment, would likely result in a high number of casualties. Not pleased with RAND's suggestion, the military insisted that RAND account for the value of lives in their calculations. Thus, the challenge of strategizing an attack on the Soviet Union became, at least in part, a challenge of valuing a human life.

After the proposal was declined, the RAND team quickly worked to develop an alternative attack strategy that included the value for a human life. In the 1950s, some of the common methods for attempting to value human life included foregone income, court awards, or the cost of life-saving technology. For example, in wrongful death court cases, the present discounted value of lost income due to premature death is sometimes used to estimate damages. However, this method is clearly unrepresentative of the value of a human life. For example, a homemaker may not earn much or any income, but most would agree that does not have implications for the value of his or her life. The key contribution of Schelling's article was the realization that asking "What is a life worth?" is the wrong question.

Rather than ask what a life is worth, Schelling asked, in effect, "what is it worth to reduce the frequency of death--the statistical probability of death?" He observed that people may be willing to make the trade of life-savings or goods or services to buy a public program to reduce the probability of death. This willingness to pay for the reduction of risk is what is now termed the value of a statistical life.

The VSL is now frequently used by government agencies for cost-benefit analysis when making policy decisions. The VSL estimate allows for public preferences over risk to be represented and it is better supported methodologically and mathematically compared to the life-valuation methods of the 1950s.

VSL Estimation

Intuitively, the VSL captures how much individuals are willing to pay to reduce the risk of death. Because risks to life come from a *multitude* of sources and individuals can undertake many different actions to reduce these risks, it follows that there are multiple ways to estimate the VSL.

For example, consider a mandate that would decrease the risk of premature death by one in a million for each person in a group of one million people. On average, this mandate would be expected to save one life—the regulation would save one *statistical* life. It is important to note that this is not the same as saving the life of an identified person. The regulation may also save seven lives, or two lives or none. The key issue is that the probability of death has been reduced for each person and each person would likely value that reduction. If each person in the population in our example is willing to pay $5 for the decreased risk, then the group is jointly willing to pay $5 million to save, on average, one life--one statistical life--and the VSL is therefore estimated at $5 million. Hence, the VSL reflects the population average marginal rate of substitution between income and risk of death.

Methods to estimate the VSL can be broadly categorized into revealed preference and stated preference approaches. Revealed preference studies are methods where researchers observe individuals' actual behavior and use this behavior to make inferences over values. Stated preference studies use survey techniques to query individuals about their preferences.

We need two key pieces of information for the VSL calculation: a quantifiable risk reduction magnitude and an individual's willingness to pay for a risk reduction of that magnitude. Revealed preference methods work by finding observable situations where individuals make trade-offs between risk and income. For example, a researcher may observe how much people are willing to pay for a safer car or other risk reducing technology, and then combine that information with data on how much the technology actually decreases the risk of death. Combining these pieces of information would enable a researcher to estimate the VSL. These types of "averting behavior" methods use situations where individuals give up something of value (money, time, etc.) to obtain a reduction in risk (Blomquist, 2004).

One major type of VSL methodology uses labor market data to infer the wage premium that must be paid to workers for doing more dangerous jobs. This method is commonly referred to as a wage-risk study, one of the more common revealed preference approaches. Wage-risk studies observe the differences in pay for riskier jobs, controlling for other variables such as education, experience, and industry. Revealed preference methods often tend to be preferred to stated preference studies; people face real consequences, which is a large incentive for people to be well informed and to make decisions that increase their well-being. One of the weaknesses of revealed preference studies is that markets may not exist for the type of risk reduction of interest. For example, it may be of interest to policymakers to understand how much individuals

would be willing to pay to reduce risks from airborne particulates. Unfortunately, individuals cannot simply and directly buy cleaner air for their community.

The other method commonly used to estimate VSL is stated preference studies, which are sometimes used because the value of the mortality risk reduction in question is often difficult to infer from observed behavior and market prices. Stated preference methods provide non-market valuation techniques that are designed to measure how much people would be willing to pay for a good or service that is not actively traded in markets. By using surveys, researchers can simply query individuals about how much they would be willing to pay for various types of risk reductions. Surveys are usually done using choice experiments that allow respondents to make choices between multiple options with different costs, risk reductions, and other attributes. These types of studies are especially useful for valuing broad-based risk changes such as increases or decreases in overall pollution levels.

Meta-analyses are sometimes used as sources of information for estimates of the VSL. A meta-analysis is an analysis of a collection of independent studies on a single topic. This method of analysis can summarize the findings of the academic literature on a particular topic and in some cases provide a better overall estimate than any single study. Meta-analyses are also important because researchers can identify which types of studies lead to different (or similar) conclusions. VSL meta-analyses may be done for all types of VSL studies, or specifically for studies of a certain type: only stated preference VSL studies, for example.

Meta-analyses, however, are still prone to statistical biases and problems. For example, if an estimation problem is present in all or most studies included in a meta-analysis, estimates based on the meta-analysis will still suffer from these problems. Moreover, meta-analyses depend in many ways on the judgment of the researcher conducting the meta-analysis. For example, a researcher must decide which studies to include in the meta-analysis and which types of methods represent best practices.

Problems and Limitations in VSL Estimation

There is an emerging consensus in the academic literature that the VSL in the United States is in the range of $4 to $10 million (See, for example, Kniesner et al. 2012, or Robinson and Hammitt 2015). However, some researchers contend that there are substantial problems with this literature. For example, Doucouliagos et al. (2012) contend that the VSL may be overestimated by as much as 70 to 80 percent.

All techniques for estimating the VSL have weaknesses. In this section, we discuss several of the important limitations to accurately estimating trade-offs between money and risk. Among these weaknesses are: 1) risk perception problems, 2) omitted variables bias and other problems in revealed preference studies, 3) hypothetical bias in stated preference studies, 4) scope test failure in stated preference studies and 5) problems with the VSL resulting from oversimplification.

Risk Perception

In general, individuals have substantial biases and perceptual limitations when estimating the magnitudes of small probabilities (Lichtenstein et al., 1978; Slovic, 1987; Slovic and Peters, 2006). Because the VSL is calculated by observing

what people are willing to give up to reduce risks, if individuals misperceive risks, VSL estimates based on those risk perceptions will be either imprecisely estimated or biased. For example, if an individual perceives the risk of death from a particular cause to be 1 in 100,000 and is willing to spend $5 to eliminate that risk, a researcher who knows the true risk to be 1 in 1,000,000 will calculate the implied VSL as $5/0.000001=$5 million. However, the correct VSL from the individual's perspective would be only $500,000.

Behavioral economists and psychologists have documented several departures from strict rationality in human behavior with respect to risk perception.[1] Several of these behavioral anomalies have implications both for researchers attempting to estimate the VSL and for optimal policy making.

One of the most well-known cognitive biases is the tendency for individuals to overestimate small risks and underestimate large risks (See Lichtenstein et al. 1978 among many others). As noted by Viscusi and Gayer (2015) "because people tend to overestimate small probabilities, when these risks are eliminated they will tend to overestimate the risk reduction that takes place." This propensity to overreact to small risks can cause an overestimate of how many resources should be devoted to reducing threats from, for example, small environmental hazards. However, because individuals tend to overestimate large risk, this can lead to fewer resources than optimal being devoted to reducing these risks.

In addition to overestimating small risks, research has shown that individuals also tend to overestimate risks associated with unusual, spectacular events, or that are associated with a large degree of fear, dread, or uncertainty. Research by Paul Slovic and Ellen Peters (2006) denote this tendency to base risk perception on a "faint whisper of emotion" as *affect*. Because reactions to, and perceptions of, risk can be subject to emotional and psychological factors, VSL calculations based on stated preference studies may be particularly sensitive to risk context as well as the way the risk is framed.

Another cognitive bias that can lead to suboptimal regulation and mis-estimation of the VSL is known as the Ellsberg paradox (Ellsberg, 1961; Segal, 1987). The Ellsberg paradox is also known as "risk ambiguity aversion" and manifests itself as an overreaction to uncertain probabilities. This aversion means that individuals are more averse to risk where the probabilities are unknown. For example, suppose that the actual risk of cancer posed by exposure to a certain chemical is unknown but is either 2/100,000 or 4/100,000. This is equivalent to a situation where the risk is known to be 3/100,000. However, under the Ellsberg paradox, individuals would be more averse to the situation where the true probabilities are unknown. This type of bias can manifest itself in public policy as an overreaction to poorly understood risks. For example, public reactions to genetically modified foods or nanoparticles are often excessive given our best scientific understanding of the actual risks.

Treich (2010) discusses the effect of ambiguity aversion and the VSL in detail and concludes that ambiguity aversion is likely to increase estimates of the VSL. Treich further argues that this ambiguity aversion cannot justify the "ambiguity premium" that appears in environmental policy. Similarly, Sunstein (2002), Viscusi (1998), and Viscusi and Hamilton (1999) show that most Environmental Protection Agency (EPA) regulations have a high (or very high) implicit cost per life saved, sometimes in the range of hundreds of millions or even billions of dollars, as in the Superfund program.

---

[1] For a broad discussion, see Kahneman (2011). For an extended discussion of applications to government policy, see Viscusi and Gayer (2015)

It is important to recognize that these overreactions can manifest themselves in public policy. This may occur because policymakers respond to public demand for policies designed to protect citizens from ambiguous risks. However, it may also occur because policymakers themselves are subject to these cognitive biases (Viscusi and Hamilton 1999).

Revealed Preference

Revealed preference techniques, although generally preferred by economists over stated preference techniques, can suffer from omitted variables bias or a failure to properly account for the endogeneity of the level of risk (Ashenfelter, 2006). For example, it may be tempting to conclude that the relationship between highway speed and death is causal. However, as Ashenfelter explains, while increased speed may cause more fatalities, lower fatality risk increases speeds. Similar endogeneity problems exist in other areas--these problems are particularly important for hedonic studies such as wage-risk studies.

Hedonic studies investigate the correlation between market prices (such as wages) and risk measures. However, it is important to control for all variables that are important for determining the wage of the dependent variable that may also be correlated with the risk measure. Because risk behavior is often based on information known to the person but unknown to the researcher, it is difficult to be sure that all variables have been adequately controlled for. Moreover, individuals can take actions to reduce risk and some individuals may be better at this than others in ways that are not observed by the researcher. Finally, because individuals can often choose whether or not to take a risky action, the observed risk preferences in a particular sample may not reflect the risk preferences of the population. Shogren and Stamland (2002) show, for example, that estimates of the VSL based on wage-risk tradeoffs will tend to be upward biased if the researcher does not account for heterogeneity in workers' unobservable skill to cope with job risk. As explained by the authors: "This upward bias arises because the highest required wage differential among the workers is divided by their average risk across the population."

In 2011, Cropper et al. (2011) collected four hedonic wage meta-analyses, which are listed in Table 1 below. All four studies include VSL studies of non-US populations, however, almost all of the non-US countries are considered high-income countries. Interestingly, even these meta-analyses differ greatly in their best estimate of the value of a statistical life. Mrozek and Taylor (2002) argue that the best estimate of the VSL, from studies that employ "best practices" is around $2.0 to $3.3 million in 2009 dollars.

Much of the variation in the reported VSL estimates can be explained by the choice of studies included, modeling approach, and included covariates. For example, the three meta-regressions contain variables such as mean occupational risk, mean worker earnings, the ratio of unionized workers, and binary variables for interindustry wage differentials or nonfatal job risk. All three studies found that VSL increases with income, however, the rate of increase differs. Mrozek and Taylor (2002) found that the studies that failed to include control variables that account for industry tend to have higher VSL estimates.

Table 1

Meta-Analysis	Publication Dates of Underlying Studies	Highlighted VSL Estimate	
		As Reported (Dollar Year)	Inflated to 2009 USD
Miller (2000)	1974–1990	$3.7 Million (1995 USD)	$5.2 Million
Mrozek & Taylor (2002)	1974–1995	$1.5 Million to $2.5 million (1998 USD)	$2.0 Million to $3.3 million
Viscusi & Aldy (2003)	1974–2000	$5.5 Million to $7.6 million (2000 USD)	$6.9 Million to $9.5 million
Kochi et al. (2006)	1974–2002	$8.9 Million (2000 USD)	$11.1 Million

A review of averting behavior methods of estimating the VSL by Blomquist (2004) shows substantial variation and potential problems among these techniques. Averting behavior methods are methods that use estimates of the costs of reducing risks to estimate the VSL. For example, a person may purchase a helmet to wear while bicycling. If the researcher knows how much the helmet costs and how much the risk of death is reduced by wearing a helmet, an estimate of the VSL can be measured. Averting behavior techniques discussed by Blomquist include traffic behavior and speed limits, bicycle helmet use, seat belt use, child safety seat use, willingness to pay for additional car safety features, and hedonic analysis of housing prices near superfund sites. VSL estimates using averting behavior techniques average around $4 million and range from less than $1 million to around $7 million in year 2000 US dollars.

Stated Preference

With stated preference studies, the key methodological problems are hypothetical bias and scope test failure. Because of the hypothetical nature of stated preference techniques, respondents often provide information that is different from what would be expected if the situation were real. Many studies have established that willingness to pay estimated for hypothetical goods exceeds what is estimated when the same goods are offered with real payment scenarios. This hypothetical bias is unsurprising and occurs in contexts even when participants do not necessarily have the incentive to lie (Murphy et al., 2005; List and Gallet, 2001; Loomis, 2011). "Yea-saying" is used in the literature to describe the tendency for survey respondents to provide answers consistent with what they think the researcher wants to hear. Several strategies have been developed to help combat these forms of bias with varying degrees of success. See Loomis (2014) for a discussion of strategies to mitigate hypothetical bias in stated preference studies.

STRATA

Scope test failure refers to the tendency in many stated preference studies of the value of a statistical life to fail to find a clear relationship between the size of the risk reduction and willingness to pay for the risk reduction (Czajkowski & Hanley, 2009). Economic theory clearly indicates that WTP for a risk reduction should be proportional to the size of the risk reduction: individuals should be willing to pay (roughly) twice as much for a risk reduction that is twice as big. If a study passes a "strong" scope test it means that willingness to pay is (statistically) proportional to the size of the risk. Passing a "weak" scope test means that willingness to pay is at least positively related to the size of the risk reduction, although not proportionally. Unfortunately, many SP studies fail to pass even a weak scope test and few SP studies pass a strong scope test (Czajkowski & Hanley, 2009). These problems appear to be severe enough that one prominent economist declared the contingent valuation technique to be "hopeless" (Hausman, 2012).

VSL studies that are subject to hypothetical bias will overestimate the VSL. Studies that fail a scope test may either under- or over-estimate the VSL, however, the lack of consistency with economic theory suggests that estimates from these studies are not reliable sources of information.

Heterogeneity in the VSL

One of the major complications associated with estimating the value of a statistical life is that the VSL can vary substantially with individual characteristics and risk types. Therefore, appropriate policy responses to threats to life and health may also need to vary with these factors. In reality, risks to life and health vary greatly with the type of risk (e.g. sudden fatal injury vs. prolonged illness), the degree of latency (how far in the future the risk is), and other factors. See, for example, Aldy and Viscusi (2008), Kniesner et al. (2010), or Viscusi (2010) among many others.

Even if the VSL applied by policy makers is accurately estimated as the population average marginal rate of substitution between income and risk, threats to life and health do not affect all sub-populations equally, or at the same time. Moreover, if the preferences of the sub-group affected by the health threat or policy differ from those used to estimate the VSL then benefit-cost calculations based on those estimates may be biased.

Introspection suggests that reducing the probability of death for a very old, very sick individual does not generate the same level of benefits as reducing the probability of death for a child. Research has shown that estimates of the VSL vary substantially with age, income, and other important sociodemographic variables (Aldy and Viscusi, 2008; Krupnick, 2007; Alberini et al., 2004; Hammitt and Robinson, 2011). Additionally, preferences vary over the source of the risk (Hammitt and Liu, 2004), the degree of latency (Van Houtven et al., 2008), and the types of illnesses or injuries the risk source causes (Bosworth, Cameron, and DeShazo, 2009; Cameron and DeShazo, 2013).

Although the VSL is designed to address mortality risk, individuals also have preferences over non-fatal illnesses and injuries. Gentry and Viscusi (2016) show that the VSL varies with morbidity as well as mortality effects. Because many health threats pose both fatal and non-fatal threats Cameron and DeShazo (2013) have developed a framework to account for preference over a wide variety of "illness profiles." These authors show dramatic heterogeneity in preferences for different types of risk. For example, willingness to pay to reduce risks faced in the future is much lower than preferences for reducing risks today. Willingness to pay is also greater when fatal risks are attended by lengthy periods of pain and disability.

Although a one-size-fits-all VSL may be simpler and politically expedient, this practice can lead to inaccurate estimates of the benefits of risk-reduction policies. For example, if senior citizens are willing to pay less for certain types of risk reductions, using the same VSL for this group would overstate the benefits of a risk-reduction policy designed to help seniors. Although some may argue that using different VSL values for different people is "unfair," this line of reasoning fails to recognize that the VSL is an efficiency measure. Using a higher VSL may seem like agencies are placing a higher value on life, but if that value is not supported by preferences, the agency is, in effect, forcing individuals to pay for more risk reduction than they want.

Publication Bias

An important consideration is the possibility of publication bias in the VSL literature. Publication bias in this area can occur because both researchers and publishers may face incentives that result in a higher likelihood of publishing studies that find large or statistically significant VSL estimates. This result can occur even if there is no intentional bias on the part of researchers, editors, or publishers. Doucouliagos et al. (2012) note that publication bias in this context can be considered an example of the fallacy of composition—researchers, editors, reviewers, and publishers may each be attempting to accurately estimate and publish the best possible estimates of the VSL. However, even if this is assumed to be true, there is still substantial evidence of publication bias in the VSL literature (Doucouliagos et al. 2012, Ashenfelter and Greenstone, 2004; Doucouliagos et al., 2014).

Doucouliagos et al. (2012) report that correction for selection bias reduces reported estimates of the VSL by 70-80 percent. The key evidence underlying their conclusion is that, in their sample of studies, VSL estimates are positively correlated with their standard errors—implying that better studies (or studies with lower standard errors) tend to report lower VSL estimates. Viscusi (2015) also finds evidence of publication bias in wage-risk studies, however, his research suggests that the dramatically large publication bias effects reported by Doucouliagos et al. (2012) can be at least partly attributed to the use of older fatality rates data from the Bureau of Labor statistics. Using more recent data, Viscusi finds that publication bias is not statistically significant in studies that use more recent Census of Fatal Occupational Injuries data together with either fixed or random effects and clustered standard errors. Doucouliagos, Stanley, and Viscusi (2014) also find that controlling for publication bias greatly reduces estimates of the income elasticity of the VSL.

Political Economy of the VSL

In principle, using the VSL for cost-benefit analysis is consistent with the goal of pursuing policies that are economically efficient. Ideally, government agencies would be reluctant to impose policies when the costs of the policy exceed the benefits. However, because policy is made in the political arena, policies that influence life and health tend to reflect the incentives and political power of the policy makers. For this reason, the VSL can be thought of as a political variable, subject to influence by those who have political power.

It is also important to recognize that the cognitive biases and limitations of individuals that influence the estimation of the VSL may also influence those who design, implement, and oversee policy. Thus, cognitive biases can appear in

government policy: both as reactions to what the public wants and because of cognitive biases on the part of policy makers themselves.

Public Choice

Public choice theory is a subfield of political economy that analyzes institutions and incentives to explain political behavior (Buchanan and Tollison, 1984). Rather than assume that politicians become self-sacrificing public servants once elected into office, public choice analyzes politicians as rationally self-interested agents. This method of analysis allows the effects of incentives and constraints on political actors to be examined using the same tools that economists use for individual agents such as business owners and consumers. Economists typically assume that self-interested individuals aim to maximize their utility and business owners aim to maximize profits. Similarly, a public choice economist might assume politicians aim to be reelected or that bureaucrats seek to maximize budgets. However, the pursuit of reelection or budget maximization can create problems if the policies that result from these pursuits do not correspond to policies that maximize societal welfare.

It may be useful to think of the estimation, publication, and application of the VSL from a public choice perspective. The incentives of academic researchers are to publish articles in top journals that will be cited. The incentives of editors are to publish articles that will be cited and read. In general, it is not clear that the incentives of those involved in the estimation and publication of VSL estimates are individually distorted. It is possible that statistically insignificant results will not be published—this effect could lead to selection bias and an overestimate of the VSL. Some researchers suggest this effect may be very large (Doucouliagos et al. 2012), others argue that publication bias is not a significant concern when good data and careful econometrics are used (Viscusi 2015).

In the case of those who use the VSL for policy purposes, public choice theory makes clearer predictions, recognizing that just as those who create laws may act according to their own incentives. One common assumption (Niskanen, 1968) is that those in bureaucracies seek to maximize their budgets in order to increase their power and influence. Bureaucracies have the incentive to maximize the estimated value of the benefits of proposed projects. As noted by Hausman (2012) in his critique of contingent valuation: "Numerous branches of the federal government continue to fund contingent valuation research in the hope that it will support their favored policies subject to cost-benefit analysis."

Under the assumption of budget maximizing behavior, agencies who use the VSL to estimate the benefits of agency projects, regulations, or programs will seek to use the largest value for the VSL possible. For example, if the US EPA is performing a benefit-cost analysis on a new pollution control program designed to improve air quality, a larger VSL will increase the estimated benefits of the policy if the avoidance of premature deaths can be attributed to the policy. These increased benefits make it more likely that the policy will pass a benefit-cost test. Evidence suggests areas of inconsistency among VSL measurements used by government agencies in the US. We examine this evidence in the following sections.

The VSL in Practice

US government agencies' VSL estimates and benefit-cost analyses are managed by the Office of Management and Budget (OMB). The OMB is responsible for reviewing agencies' regulatory analyses that are foreseen to have at least a $100 million impact on the economy. Under *Executive Order 12866*, the OMB is intended to administer good regulatory assessment and improve consistency across agencies (Robinson, 2007). The OMB's role is to provide recommendations for estimating the VSL. Because data and resource limitations are a significant factor in the quality of VSL studies, however, there are few unwavering rules. Thus, the OMB guidelines are based on negotiations with each agency. The OMB and agencies discuss and determine the best way to conduct the VSL analysis and estimation. Ultimately, VSL estimates are determined by the judgement of VSL analysts.

VSL estimates differ across agencies. The Office of Management and Budget (OMB) suggests that agencies use VSL estimates ranging from $1 million to $10 million per statistical life (no specified dollar year)[2]. The Environmental Protection Agency (EPA) uses VSL estimates based on meta-analyses of VSL studies and regularly updates and adjusts these estimates for factors such as inflation, income growth, and latency (OMB 2014; Robinson 2007). The EPA estimates are adjusted from a base of $6.3 million (OMB 2014) at a year 2000 price level. The Department of Transportation's (DOT) VSL is estimated at $9.1 million, and the Food and Drug Administration (FDA) currently uses a VSL ranging from $5 to 6.5 million (OMB, 2014; estimates in 2002 dollars).

Each agency has their own procedures for determining the VSL to be used (Robinson, 2007). For example, a large body of data exists for occupational injury-related accidental deaths rather than death from disease. The Department of Transportation's use of injury-related data to calculate its VSL is relatively more similar to the scenarios that the DOT addresses than, for example, the energy or health agencies. The EPA, on the other hand, also uses mostly occupational data and some consumer product data, such as studies on cigarette purchases and smoke detector usage. Much of this data is between 25 and 40 years old, however, making EPA estimates less relevant to the scenarios they are trying to model and thus less accurate.

VSLs also vary between agencies because each agency adjusts their base VSL studies differently. Agencies adjust VSL estimates when data does not reflect the specific regulatory scenarios being assessed. Data may differ from the actual affected population according to characteristics such as age, income, and health status. The OMB asserts, however, that there is only sufficient evidence to adjust for real income and for delays in death after exposure to a harmful scenario (Stavins, 2000). VSLs are typically adjusted to reflect a population's income because greater income is associated with a larger willingness to pay for fatal risk reductions (EPA, 1999). Latency of a fatal scenario can be reflected in the VSL by discounting the benefits of a policy over the years from when the policy is enacted until the population has gained the full

---

[2] Office of Management and Budget. 2014. "2014 Draft Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities." retrieved from:
https://www.whitehouse.gov/sites/default/files/omb/inforeg/2014_cb/draft_2014_cost_benefit_report-updated.pdf

STRATA

policy benefits (EPA, 2005). For example, if a policy reduces environmental pollution in one year, but the entire benefits of the policy take effect five years later, the VSL would be adjusted to reflect the five-year delay of full benefits.

US Environmental Protection Agency

The Environmental Protection Agency (EPA) uses a VSL estimate constructed from 26 studies, five from stated preference studies and the remaining 21 from wage-risk analysis. The studies were published between 1976 and 1991, and the estimates range from $0.9 million to $20.9 million (2002).[3]

There are eight selection criteria for each study that the agency considers using for VSL estimation. Following the SAB's suggestions in 2007 (USEPA, 2007), the EPA organized the following standards in the 2010 White Paper draft:

1. "Minimum sample size of 100

2. Sample frame based on general population

3. Conducted in a high-income country

4. Results based on exclusive dataset

5. Written in English

6. Provides enough information to calculate a willingness to pay estimate if one is not reported in the paper

7. Provides estimates for willingness to pay (willingness to accept estimates were not included)

8. Provide estimates for willingness to pay for risk reductions to adult (estimates for risk reduction to children are not included)"[4]

Using the 2010 selection criteria, the EPA selected 37 studies for a new meta-analysis dataset. Only four of the studies were not published between 1988 and 2009. The average sample size between the studies was 17,741, and the average income was about $45,500 per year (2009 dollars). Of the total data, three datasets came from the National Institute for Occupational Safety and Health (NIOSH), 13 from Bureau of Labor Statistics (BLS) data and nine using Census of Fatal Occupational Injuries (CFOI) data as a measurement for occupational risk. Overall, 24 of the 37 studies were administered in the U.S., and 26 studies included women in their samples. Seven studies were directed to blue collar workers only, and three studies used union members only.[5]

About half of the estimates in the new meta-analysis dataset were treated to a scope test by the authors. The weak form of the scope test examines if the willingness to pay estimate resulted in a statistically significant increase with the size of the risk reduction, but not necessarily equal willingness to pay estimates to the size of the risk reduction. The strong form

---

[3] US Environmental Protection Agency (EPA) . 2010, December 17. "Guidelines for Preparing Economic Analyses.". Retrieved from: https://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf
[4] US Environmental Protection Agency (EPA). 2010, December 10. "Valuing Mortality Risk Reductions for Environmental Policy: A White Paper." Retrieved from: https://yosemite.epa.gov/ee/epa/eerm.nsf/vwan/ee-0563-1.pdf/$file/ee-0563-1.pdf
[5] http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-50.pdf/$file/EE-0568-50.pdf

STRATA

of the scope test would examine similar trends more strictly, testing if the willingness to pay was the same or near proportional to the size of the risk reduction. These scope tests resulted in 90 percent of the estimates passing the weak form test, and only 15 percent passing the strong form scope test.[6]

US Department of Transportation

The Department of Transportation (DOT) last thoroughly revised their VSL in 2013 to $9.1 million or $9.4 (2015) adjusted using the CPI. The DOT's revision of their VSL was motivated by the Environmental Protection Agency's identification of eight hedonic wage studies using the CFOI data. The EPA identified these new studies in attempt to update their VSL dataset in 2010. In addition to the DOT's thorough review in 2013, the DOT stated that they will issue yearly updates to modify the VSL studies for changes in prices and real incomes. The DOT's VSL is now constructed from nine hedonic-wage studies and expected to improve as more evidence and studies are published. The DOT states, "We continue to explore new empirical literature as it appears and to give further consideration to the policy resolutions embodied in this guidance."[7] As for the 2013 update, a more detailed description of the update and the studies is described below.

The DOT's 2013 update was based off of the previous review in 2008 and has since improved. The 2008 studies were based on four meta-analyses, published in 1995 through 2000. The VSL estimates from these studies ranged from $2 to $7 million, or ($3 to $9 million 2015). The quality of the primary studies by 2013 were subpar to the improved data and specifications, which could provide the DOT with more reliable results.[8]

The DOT relies on guidelines for their estimations and depends on an economic expert panel to improve the studies used in their VSL updates. First, the panel of economic experts include Maureen Cropper (University of Maryland), Alan Krupnick (Resources for the Future), Al MCGartland (EPA), Lisa Robinson (independent consultant), and W. Kip Viscusi (Vanderbilt University). The guidelines for "empirical estimates, practical adaptations, and social policies" are described below.[9]

- The DOT's VSL is a one-size-fits-all value and is not adjusted for age, income, or other subpopulation characteristics. If subgroups disproportionately benefit from a Departmental action, no adjustments will be made, but analysts "should call the attention of decision-makers to the special character of the beneficiaries."

- The DOT adjusts the VSL for growth in median real income and monetary inflation.

- The DOT's VSL will be published annually.

- Analysts should forecast VSL values based on expected growth in real income and not based on expected changes in price levels.

- The DOT should prepare a range of benefit estimates.[10]

---

[6] http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0563-1.pdf/$file/EE-0563-1.pdf

[7] US Department of Transportation (DOT). 2015, June 17. "Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in US Department of Transportation Analyses- 2015 Adjustment."Retrieved from:
https://www.transportation.gov/sites/dot.gov/files/docs/VSL2015_0.pdf

[8] Ibid.

[9] Ibid.

[10] US Department of Transportation (DOT). "Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in US Department of

STRATA

The panel of economists concluded that the DOT only use hedonic wage studies completed within the past 10 years that made use of the CFOI database and used "appropriate econometric techniques." With the panel and the guidelines, the DOT underwent a thorough analysis in 2013 to create the base of the DOT's current VSL. The DOT currently uses nine studies, which were chosen out of 15 that were identified by the EPA and the DOT. After gleaning the nine studies, the DOT "adopted the average of the VSLs estimated." The studies averaged out to a VSL estimate of $9.14 million (rounded to $9.1).[11]

Other Agencies

The Office of Management and Budget in 2014 highlighted three agencies' use of VSLs for benefit-cost analyses.[12] The three agencies include the Department of Homeland Security (DHS), the Department of Labor (DOL), and the Department of Health and Human Services (DHHS). It should be noted, the EPA and the DOT are the only two agencies that have created official guidance on VSL study selections or estimation methods.

The DHS does not have any official policy or guidelines for the data or estimation methods of their VSL. In 2008, the DHS suggested that Viscusi's 2004 wage-risk studies were best-fitting for the department contexts.[13] The agency recommends the use of $6.3 million (2008) and has recently used this number for several recent rulemakings through its U.S. Customs and Border Protection. Similar to the EPA, the DHS adjusts their VSL for changes in real income growth.

The DOL and the DHHS also do not have agency-wide VSLs; instead, these two agencies use estimates of the VSL for independent rulemakings. The DOL's Occupational Safety and Health Administration (OSHA) used a VSL of $8.7 million (2010) in their Hazard Communication Final Rule. OSHA bases their estimate off of Viscusi and Aldy's 2003 VSL estimate.[14] The DHHS's Food and Drug Administration (FDA) consistently use VSLs between $5 and $6.5 million (2002) in a considerable number of its rulemakings to monetize fatal risks (OMB 2014). The FDA uses a "hybrid human capital/willingness to pay" to measure micro-risk reductions.[15]

Transportation Analyses- 2015 Adjustment." (2015). Retrieved from: https://www.transportation.gov/sites/dot.gov/files/docs/VSL2015_0.pdf
[11] US Department of Transportation (DOT). 2015, June 17. "Guidance on Treatment of the Economic Value of a Statistical Life (VSL) in US Department of Transportation Analyses - 2015 Adjustment.". Retrieved from:
https://www.transportation.gov/sites/dot.gov/files/docs/VSL2015_0.pdf
[12] US Office of Management and Budget. 2014. "2014 Draft Report to Congress on the Benefits and Costs of Regulations and Unfunded Mandates on State, Local, and Tribal Entities." Retrieved from:
https://www.whitehouse.gov/sites/default/files/omb/inforeg/2014_cb/draft_2014_cost_benefit_report-updated.pdf
[13] Robinson, Lisa A. 2008, June. "Valuing Mortality Risk Reductions in Homeland Security Regulatory Analyses." Retrieved from:
http://www.regulatory-analysis.com/robinson-dhs-mortality-risk-2008.pdf
[14] US Department of Labor, Occupational Safety and Health Administration (OSHA). n.d. "Occupational Exposure to Respirable Crystalline Silica." Retrieved from: https://www.osha.gov/silica/nprm.pdf
[15] Kenkel, D. "Using Estimates of the Value of a Statistical Life in Evaluating Regulatory Effects." Retrieved from:
http://www.ers.usda.gov/media/912790/mp1570d_002.pdf

STRATA

The VSL as a Political Variable

Although most VSL estimates are created by academic researchers and reported in peer-reviewed journals, the value of the VSL that is used in policy is subject to political pressure. This fact is most clearly illustrated by the fallout from the EPA's 2003 proposal to reduce the VSL applied to senior citizens in accordance with research that shows seniors are willing to pay less for mortality risk reductions.[16] The "senior death discount," as many media outlets referred to it, proposed lowering the VSL for those 65 years and older. Although the proposed change was consistent with the EPA's stated general strategy of tailoring VSL estimates to the affected group, a political firestorm broke out.[17]

In response to the EPA's proposal and the subsequent media attention, Senator Boxer of California claimed that the proposed change was "outrageous" and that she would introduce legislation to "reverse this unconscionable decision" and threatened to pass legislation that set a floor to the VSL value (Cameron, 2010). Additionally, Congress prohibited the EPA from underwriting an analysis on age adjustments to the VSL in the fiscal year 2004 Appropriation Bill (H.R. 2673). Later, the OMB advised government agencies against adjusting the VSL for age (Graham, 2003). The process that determined the VSL that is actually applied was directly influenced by political maneuvering rather than only cost-benefit analysis.

Media Misperceptions

As is evident from the political fallout from the "senior discount" episode discussed above, the term "value of a statistical life" is often confused by lay people as putting a price tag on a human life. Some economists believe that the term VSL is so confusing and misleading that researchers should avoid the term entirely. Trudy Cameron (2010) argues that the term "value of a statistical life" is actively harmful to good policymaking and suggests replacing the VSL with an alternative term that communicates the tradeoff implicit in the VSL calculation. Specifically, Cameron suggests changing the term from VSL to WTS, or "willingness-to-swap," adding that WTS ought to also specify what risks specifically will be "swapped." Cameron contests that alternative terminology "will keep in the forefront of people's minds the idea that consumers typically need (or will be asked) to swap wealth for policy-sized reductions in some specific type of risk to their life or health."

Agency Incentives

Even in the case of well-intentioned academic researchers and altruistic regulators, policy applications of the VSL will be subject to political pressures. These pressures can be especially apparent when the actual or proposed policies have either very transparent or very hidden costs (or benefits). These pressures can also be greater when the policies are viewed as political symbols or when they directly impact citizens' lives and well-being.

---

[16] See, for example, Alberini et al., 2004.
[17] It should be noted that although the EPA proposed lowering the VSL for seniors and there is some evidence to support this idea, whether or not seniors are actually willing to pay less for mortality risk reductions is a matter of some dispute in the literature. See Kniesner et al. (2006) and Evans and Smith (2006).

STRATA

Consider the relative transparency of the costs of typical policies proposed or implemented by the EPA and the DOT. The costs of environmental policy are often difficult to discern. For example, suppose the EPA requires a certain industry to install new pollution abatement equipment. The cost of this policy will include lower return to the shareholders of firms in the industry, higher costs for the products the industry produces, and/or lower wages for workers in the industry. Because the costs appear indirectly, they are unlikely to be noticed or attributed to the relevant policy. Thus, the consequence of political support for stricter environmental policy may be hidden from citizens, resulting in increased political demand for the policy. This situation is consistent with the political situation surrounding the "senior discount" policy proposal by the EPA. Using a higher VSL does have real costs, but these costs are not immediately apparent. Thus, the EPA has the incentive to use a higher VSL than what is supported by best evidence.

In contrast, consider the costs of increased safety regulations for traffic policy. The costs of traffic regulations are obvious to individuals who drive: lower speed limits, increased traffic citations and fines, etc. These types of policies typically result in longer travel times and more traffic enforcement. Because these costs are obvious, citizens have direct incentive to oppose policies that they feel impose costs beyond the benefits generated.

If the VSL is not subject to political pressures, we would expect that government agencies would simply use the VSL that would best reflect the benefits of the risk-reducing policies proposed by that agency. These VSL estimates might vary across agencies due to differing risk sources and affected sub-populations but we would not expect to see evidence of political influence on the VSL values used by the agencies.

In contrast, if public choice theories are correct, agencies will use VSL estimates that reflect the political incentives and goals of those in the agency. We have already seen that political pressures induce the EPA to use a VSL that is larger than best evidence would support for senior citizens. Interestingly, there is also indirect evidence that the VSL used by the DOT is subject to political influences, although in a very different way.

Robinson (2007) reports that "the DOT currently recommends the use of a $3.0 million VSL" although the agency notes that this is an imprecise estimate. More recently, OMB (2014) reports that in a 2013 update, the DOT adopted a value of $9.1 million in 2012 dollars. If DOT officials believe that this value accurately reflects the preferences of motorists and pursues policies without regard to political pressure, we would expect VSL estimates implied by motorist behavior to be approximately $9.1 million. However, evidence suggests that the VSL implied by actual speed limit policies is substantially lower. Using traffic fatality data and changes in speed limits to infer tradeoffs between time and mortality risk, Ashenfelter and Greenstone (2004) calculate an implied upper bound estimate of the VSL implied by these policies to be about $1.5 million.

One interpretation of this discrepancy is that the costs of higher speed limits are very obvious to motorists and these policies reflect motorists actual risk preferences. If current speed limit policies reflect actual risk preferences in the population then it is likely that if the DOT tried to set speed limits based on a VSL of over $9 million, motorists and voters would demand change. An alternative interpretation would argue that because people tend to deflate relatively larger risks like transportation and heart disease, raising speed limits while fully informed of the additional risk implies that representatives listen to their constituents and are implementing constituent's psychological biases.

Both the case study of the "senior discount rate" and the DOT case described above support the idea that the VSL is a political variable. These case studies also suggest that government agencies may apply the VSL in benefit-cost calculations in a manner that is consistent with theories of budget maximization and regulatory power.

Conclusions

The academic literature on the value of a statistical life is enormous, as is the number of government policies and regulations that attempt to mitigate threats to life and health. This is understandable, given the importance of the subject. Although there is an emerging consensus of the range of plausible estimates for the population average value of a statistical life, there is still disagreement about the proper application of these values to government policy and on the appropriate role of government in addressing threats to life and health.

There are reasons to suspect that the VSL may be overestimated in the academic literature. In stated preference studies, an upward bias in VSL estimates due to hypothetical bias appears to be pervasive. Widespread failure of scope tests (both weak and strong versions) give additional reason for skepticism of stated preference research. In revealed preference research, the empirical difficulties of dealing with omitted variables bias and endogeneity of risk raise some doubts about the reliability of these estimates. It is possible, especially in the case of wage-risk studies, that these effects contribute to an overestimation of the VSL. Risk perception problems, especially the impact of the Ellsberg paradox, indicate that cognitive biases may also contribute to an overestimation of the VSL in studies of small risks or risks that have especially negative "affect." Finally, there is evidence that publication bias may contribute to an overestimation of the VSL. Some authors suggest that this bias may reduce the average VSL estimate by as much as 70-80 percent (Doucouliagos et al., 2012).

In addition to the possibility of overestimation in the academic literature, there is reason to suspect that the value of the VSL is inflated due to the political incentives of regulatory agencies. Public choice theory indicates that government agencies have incentive to maximize the value of the applied VSL because doing so increases the likelihood of policies or projects passing a benefit-cost test, thus increasing the agency's budget, power, and influence. The results of the "senior discount" episode suggest that the value of the VSL is clearly subject to political pressure and that the EPA may be using a VSL value that is too high.

It is also important to consider that in many instances regulatory agencies either decline to use benefit-cost analysis or ignore the results of benefit-cost analysis. Furthermore, in many cases, agencies are prevented, by statute, from comparing benefits and costs for regulations that affect life and health[18]. In this sense, the VSL is a political variable because the political process decides when it is applied and when it is not.

Finally, it is worth observing that government intervention to regulate threats to life and health, however well-meaning, may carry a heavy implicit cost. Regulations require resources to develop and enforce and these resources will be

---

[18] For an in-depth discussion of these issues, see Hammond et al. (1990)

obtained via taxation with its attendant deadweight loss. Moreover, increased government action raises the risk of government failure, regulatory capture, and rent-seeking in the regulated industry. Regulations may also carry diminished individual freedom for those who once benefited from actions that are now regulated. These costs, implicit in any regulatory action, are usually ignored in benefit-cost analysis.

References

Alberini, Anna, et al. "Does the value of a statistical life vary with age and health status? Evidence from the US and Canada." *Journal of Environmental Economics and Management* 48.1 (2004): 769-792.

Aldy, Joseph E., and W. Kip Viscusi. "Adjusting the value of a statistical life for age and cohort effects." *The Review of Economics and Statistics* 90.3 (2008): 573-581.

Ashenfelter, Orley. "Measuring the Value of a Statistical Life: Problems and Prospects*." *The Economic Journal* 116.510 (2006): C10-C23.

Ashenfelter, Orley, and Michael Greenstone. *Estimating the value of a statistical life: The importance of omitted variables and publication bias.* No. w10401. National Bureau of Economic Research, 2004.

Banzhaf, S. "The Cold War Origins of the Value of a Statistical Life." *Journal of Economic Perspectives* 28 (2014): 213-226.

Blomquist, Glenn C. "Self-protection and averting behavior, values of statistical lives, and benefit cost analysis of environmental policy." *Review of Economics of the Household* 2.1 (2004): 89-110.

Bosworth, Ryan, Trudy Ann Cameron, and J. R. DeShazo. "Demand for environmental policies to improve health: Evaluating community-level policy scenarios." *Journal of Environmental Economics and Management* 57.3 (2009): 293-308.

Buchanan, James M., and Robert D. Tollison. *The Theory of public choice--II.* University of Michigan Press, 1984.

Cameron, Trudy Ann. "Euthanizing the value of a statistical life." *Review of Environmental Economics and Policy* 4.2 (2010): 161-178.

Cameron, Trudy Ann, and J. R. DeShazo. "Demand for health risk reductions." *Journal of Environmental Economics and Management* 65.1 (2013): 87-109.

Cropper, Maureen L., James K. Hammitt, and Lisa A. Robinson. *Valuing mortality risk reductions: progress and challenges.* No. w16971. National Bureau of Economic Research, 2011.

Czajkowski, Mikołaj, and Nick Hanley. "Using labels to investigate scope effects in stated preference methods." *Environmental and Resource Economics* 44.4 (2009): 521-535.

Doucouliagos, Chris, T.D. Stanley, and Margaret Giles. "Are estimates of the value of a statistical life exaggerated?." *Journal of health economics* 31.1 (2012): 197-206.

Doucouliagos, Hristos, T.D. Stanley, and W. Kip Viscusi. "Publication selection and the income elasticity of the value of a statistical life." *Journal of health economics* 33 (2014): 67-75.

Ellsberg, Daniel. "Risk, ambiguity, and the Savage axioms." *The quarterly journal of economics* (1961): 643-669.

Evans, Mary F., and V. Kerry Smith. "Do we really understand the age–VSL relationship?." *Resource and Energy Economics* 28.3 (2006): 242-261.

Gentry, Elissa Philip, and W. Kip Viscusi. "The fatality and morbidity components of the value of statistical life." *Journal of health economics* 46 (2016): 90-99.

Graham, J. D. "Benefit-cost methods and life saving rules". *Memorandum to the President's Management Council. US Office of Management* (2003)

Hammitt, James K. "Valuing mortality risk: theory and practice. "*Environmental Science & Technology* 34.8 (2000): 1396-1400.

Hammitt, James K., and Jin-Tan Liu. "Effects of disease type and latency on the value of mortality risk." *Journal of Risk and Uncertainty* 28.1 (2004): 73-95.

Hammitt, James K., and Lisa A. Robinson. "The income elasticity of the value per statistical life: transferring estimates between high and low income populations." *Journal of Benefit-Cost Analysis* 2.01 (2011): 1-29.

Hammond, P. Brett, and Rob Coppock. "The Politics Of Benefit-Cost Analysis." (1990).

Hausman, Jerry. "Contingent valuation: from dubious to hopeless." *The Journal of Economic Perspectives* 26.4 (2012): 43-56.

Kahneman, Daniel. *Thinking, fast and slow.* Macmillan, 2011.

Kochi, Ikuho, Bryan Hubbell, and Randall Kramer. "An empirical Bayes approach to combining and comparing estimates of the value of a statistical life for environmental policy analysis." *Environmental & Resource Economics* 34.3 (2006): 385-406.

Kniesner, Thomas J., et al. "The value of a statistical life: Evidence from panel data." *Review of Economics and Statistics* 94.1 (2012): 74-87.

Kniesner, Thomas J., W. Kip Viscusi, and James P. Ziliak. "Policy relevant heterogeneity in the value of statistical life: New evidence from panel data quantile regressions." *Journal of Risk and Uncertainty* 40.1 (2010): 15-31.

Kniesner, Thomas J., W. Kip Viscusi, and James P. Ziliak. "Life-cycle consumption and the age-adjusted value of life." *The BE Journal of Economic Analysis & Policy* 5.1 (2006).

Krupnick, Alan. "Mortality-risk valuation and age: stated preference evidence." *Review of Environmental Economics and Policy* 1.2 (2007): 261-282.

Lichtenstein, Sarah, et al. "Judged frequency of lethal events." *Journal of experimental psychology: Human learning and memory* 4.6 (1978): 551.

List, John A., and Craig A. Gallet. "What experimental protocol influence disparities between actual and hypothetical stated values?." *Environmental and Resource Economics* 20.3 (2001): 241-254.

Loomis, John. "What's to know about hypothetical bias in stated preference valuation studies?." *Journal of Economic Surveys* 25.2 (2011): 363-370.

Loomis, John B. "Strategies for overcoming hypothetical bias in stated preference surveys." *Journal of Agricultural and Resource Economics* 39.1 (2014): 34-46.

Miller, Ted R. "Variations between countries in values of statistical life." *Journal of transport economics and policy* (2000): 169-188.

Mrozek, Janusz R., and Laura O. Taylor. "What determines the value of life? A meta-analysis." *Journal of Policy analysis and Management* 21.2 (2002): 253-270.

Murphy, James J., et al. "A meta-analysis of hypothetical bias in stated preference valuation." *Environmental and Resource Economics* 30.3 (2005): 313-325.

Niskanen, William A. "The peculiar economics of bureaucracy." *The American Economic Review* 58.2 (1968): 293-305.

Office of Management and Budget. 2014. "2014 Draft Report to Congress on the Benefits and Costs of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities." retrieved from: https://www.whitehouse.gov/sites/default/files/omb/inforeg/2014_cb/draft_2014_cost_benefit_report-updated.pdf

Robinson, Lisa A. "How US Government Agencies Value Mortality Risk Reductions." *Review of Environmental Economics and Policy* 1.2 (2007): 283-299.

Robinson, Lisa A., and James K. Hammitt. "Valuing reductions in fatal illness risks: Implications of recent research." *Health economics* (2015).

Schelling, Thomas C. "The life you save may be your own." (1968).

Segal, Uzi. "The Ellsberg paradox and risk aversion: An anticipated utility approach." *International Economic Review* (1987): 175-202.

Shogren, Jason F., and Tommy Stamland. "Skill and the Value of Life." *Journal of Political Economy* 110.5 (2002): 1168-1173.

Slovic, Paul. "Perception of risk." *Science* 236.4799 (1987): 280-285.

Slovic, Paul, and Ellen Peters. "Risk perception and affect." *Current directions in psychological science* 15.6 (2006): 322-325.

Stavins, Robert. "An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction." (2000).

Sunstein, Cass R. *Risk and reason: Safety, law, and the environment*. Cambridge University Press, 2002.

Treich, Nicolas. "The value of a statistical life under ambiguity aversion." *Journal of Environmental Economics and Management* 59.1 (2010): 15-26.

US Environmental Protection Agency (EPA). "The benefits and costs of the Clean Air Act, 1990 to 2010." EPA 410-R-99-001 (1999).

US Environmental Protection Agency (EPA). "Economic analysis for the final Stage 2 Disinfectants and Disinfection Byproducts Rule." EPA 815-R-05-010 (2005).

STRATA

Van Houtven, George, Melonie B. Sullivan, and Chris Dockins. "Cancer premiums and latency effects: A risk tradeoff approach for valuing reductions in fatal cancer risks." *Journal of Risk and Uncertainty* 36.2 (2008): 179-199.

Viscusi, W. Kip. *Rational Risk Policy: The 1996 Arne Ryde Memorial Lectures.* Vol. 4. Oxford University Press, (1998).

Viscusi, W. Kip, and James T. Hamilton. "Are risk regulators rational? Evidence from hazardous waste cleanup decisions." *The American Economic Review* 89.4 (1999): 1010-1027.

Viscusi, W. Kip. "The heterogeneity of the value of statistical life: Introduction and overview." *Journal of Risk and Uncertainty* 40.1 (2010): 1-13.

Viscusi, W. Kip. "The role of publication selection bias in estimates of the value of a statistical life." *American Journal of Health Economics* (2015).

Viscusi, W. Kip, and Joseph E. Aldy. "The value of a statistical life: a critical review of market estimates throughout the world." *Journal of risk and uncertainty* 27.1 (2003): 5-76.

Viscusi, W. Kip, and Ted Gayer. "Behavioral Public Choice: The Behavioral Paradox of Government Policy." *Harv. JL & Pub. Pol'y* 38 (2015): 973.

STRATA

At Strata, our mission is to help people make informed decisions about issues that impact the freedom to live their lives. We work to achieve more prosperous and free societies by affecting a change in the climate of ideas. We do this by conducting robust research on energy and environmental issues, informing policy makers, citizens and civic leaders, and by mentoring high-achieving students to become future decision makers. Strata is located in Logan, Utah. We draw from the collective academic strength and ideas from the faculty and students at Utah State University and a strong network of academics and professionals throughout the world.

VISIT STRATA.ORG TO READ MORE

255 S. Main Street
Suite 100, Logan, Utah
84321