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The devaluation of life

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Abstract
The US Environmental Protection Agency (EPA) has been the target of two recent controversies involving the devaluation of life: the 2003 use of a senior discount for the value of statistical life for people over age 65, and the 2008 downward reassessment of the value of statistical life by the EPA Air Office. Even though these new values of statistical life were still among the highest used in the Federal government, there was a strong negative public reaction to each. The public outcry over the EPA policies appears to have stemmed from an irrational response to decreases in the value of statistical life. Proposed Congressional legislation that purportedly seeks to reform the valuations would politicize benefit assessments. A sounder approach is to establish a peer-reviewed scientific advisory panel to advise agencies on the value of statistical life.

Keywords: environmental regulation, regulatory impact analyses, risk regulation, senior discount, value of statistical life.

1. The irrationality of the devaluation controversies

Government agencies have been placing a dollar value on risks to life for more than a quarter of a century. The valuation numbers based on this methodology have been called the "value of life" or the "value of statistical life." Using these values to assess the benefits of government policies has become a routine procedure when evaluating the merits of risk and environmental regulations. Higher value of statistical life (VSL) amounts increase the assessed benefits of government regulations, making more stringent regulations desirable on an economic basis, and lower VSL amounts have the opposite effect. Debate over setting the VSL figures is not a matter simply of academic interest. Rather, the VSL is a key parameter driving the regulatory analyses that set out to determine the stringency of the regulation and whether the regulation passes the test of generating more benefits than costs.

While the practice of attaching dollar values to reduced risks to life and health has not been immune to controversy, particularly among non-economists, two recent devaluations of life have escalated the stridency of the public critiques. In 2003, the US Environmental Protection Agency (EPA) presented an analysis of air pollution regulations in which the reduced risks to lives of people over age 65 received a lower VSL than that placed on reducing risks to younger people (*New York Times* 2003). This devaluation of the VSL for older citizens produced a political firestorm that led the EPA to abandon the

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age adjustment practice. In 2008, the EPA encountered additional opposition when it became known that the EPA Office of Air Quality Planning and Standards (hereafter the EPA Air Office) lowered the VSL figure used in regulatory analyses of air pollution regulations (*The Associated Press* 2008). These policy controversies in turn led to Senator Barbara Boxer's proposed legislation – the "Restoring the Value of Every American in Environmental Decisions Act" – that would ban practices which reduced the value of life over time or decreased the value of statistical life based on demographic factors, including age (110th Congress, 2d Session, 2008).

This article will examine these controversies and the underlying economic issues. Whether and how the EPA should adjust the VSL amount based on demographic characteristics or new studies that emerge over time raises a series of legitimate economic issues, which will be explored below. Section 2 reviews the basics of the VSL approach and Section 3 explores the role of negative age adjustments. Section 4 examines the decision by the EPA Air Office to reduce the VSL amount applied in regulatory impact assessments. While there are legitimate questions that arise with respect to each of these policy actions to reduce the VSL level, the issues that have dominated the debate thus far are off point. Individual age certainly might alter the pertinent VSL, possibly even reducing its value, but what type of age adjustment should be made and to what extent may be quite different than the approach taken by the EPA. Similarly, the possibility that a government agency might alter the VSL number used over time based on new studies in the academic literature may also be quite sensible, although this article will suggest that the particular revision undertaken by the EPA Air Office was not well founded. In contrast, the recently proposed legislative fix to the controversies has no merit as a policy approach. Section 5 provides a detailed critique of that legislation and proposes a scientific basis for establishing VSL policies at the EPA and other agencies.

The fundamental source of the devaluation controversies can be traced not to economic issues but to cognitive failures. The two major recent VSL battles have been over whether the VSL amount can be lowered, either because of differences by demographic characteristics, such as age, or because new studies indicate that a lower value is more appropriate. The critics of the recent EPA decisions to reduce the VSL figure applied in its policy assessments are not disputing the appropriateness of the methodology or the general levels of the VSL figures; rather, they are objecting to the idea of reductions in the values. Thus, the critics are falling prey to a class of well-known behavioral anomalies.

The irrational aversion to decreases in VSL is reflective of several behavioral phenomena. There is considerable evidence that anchoring effects influence decisions, especially when people don't have a strong basis for independent judgment. Thus, suggesting to jurors a target damages value that might be based on a possibly inappropriate reference point may nevertheless influence their chosen award level.[1] In much the same way, the existence of a VSL level previously used by a government agency serves as a reference point for judging the appropriateness of future levels of VSL used in analyses. There is a tendency to anchor on current VSL levels as the frame of reference for what the correct VSL should be. Lower VSL values are departures from the anchored value; they appear on the surface to be inappropriate because they are a decrease from the established value.

Anchoring effects alone do not, however, explain the asymmetry of the response to increases or decreases in VSL. Changes in the established VSL will be viewed quite differently depending on the direction of the change. The prospect theory analysis in the psychology and economics literature documents how people exhibit an asymmetry in

their behavior known as loss aversion: they are much more averse to losses in income than one would expect based on rational economic behavior and their valuation of comparable magnitudes of income gains.[2] The endowment effect, in which people are more reluctant to part with products they already possess than would be suggested by how much they are willing to pay to obtain the same products, is a phenomenon related to loss aversion.[3] These anomalies pertain to the objects of choice, such as income level or products.

A related set of phenomena pertains to the probabilities for different states of the world. With respect to product risk levels, there is evidence of what has been termed a reference risk effect.[4] People are much more averse to increases in risk than one would expect based on their willingness to pay for decreases in risk of similar magnitude. Lowering the VSL used to assess government regulations reduces the estimated benefit value of reductions in mortality risks. Doing so makes stringent regulations less attractive and increases the estimated economically optimal risk level from what would have been desirable had higher VSL levels been used.

These and other related behavioral anomalies are linked to a general family of effects known as status quo biases (see Samuelson and Zeckhauser 1988). People tend to focus on the status quo, whether it involves their income level, their current insurance coverage, or the benefits provided by government policies. Increases from the status quo that are perceived to enhance one's well being are viewed with favor, but there is an irrational bias against diminishing one's welfare through negative disruptions from the status quo. That it was the change in the VSL amount rather than the absolute levels that were influential in creating the controversy will be demonstrated below by comparing the reduced VSL figures used by the EPA with the VSL figures used by other agencies, which often are even lower that the EPA amounts, but nevertheless have not generated a public debate.

Status quo biases were coupled with media coverage that fueled the controversy. Interest groups such as the AARP and environmental organizations joined in the media frenzy. The value of statistical life was equated with the value of certain lives, with no recognition of the small probabilities involved.[5] The general tone of the media coverage was that the current practices were morally questionable in general and that lowering the VSL figure revealed an even greater degree of moral bankruptcy. As the discussion below will indicate, the devaluation of life controversy provides valuable lessons in understanding the fundamental economics of risk regulation policies, but also affords considerable insight into how society fails to think sensibly about risk.

2. What is the value of statistical life?[6]

Before becoming embroiled in controversies concerning what the VSL amount should be, it is useful to review first principles. An individual's VSL amount is a measure of the rate at which he or she is willing to pay for small reductions in mortality risk. Thus, a person who is willing to pay $500 to eliminate a risk of 1/10,000 has a VSL of $500/[1/10,000], or $5 million. Viewed somewhat differently, a group of 10,000 people facing an individual risk of death of 1/10,000 will incur one expected fatality in the group. If each person is willing to pay $500 to eliminate the risk, then there is a collective willingness to pay $5 million to eliminate the one statistical death. Thus, the two key components of interest are the focus on very small reductions in the risk of death, and the linkage of the valuation

measure to the person's own willingness to pay to reduce the risk. The VSL is not an accounting-based measure calculated by an economist or a government official, but instead represents the willingness to pay for risk reduction by the person who is exposed to the risk.

A VSL of $5 million does not imply that a person would be willing to pay $5 million to avoid certain death or that he or she would be willing to accept certain death if paid $5 million. People may lack the financial resources to pay $5 million to eliminate the certainty of death, and similarly they may be quite unwilling to face the risk of certain death even for compensation amounts much greater than $5 million. The VSL tradeoff rate is reflective of the terms of trade involving very small risks and does not generalize to these larger risk situations.

In contrast, measures of compensation for wrongful death are not based on the willingness to pay for small reductions in risk, but generally are tied to appropriate amounts to address the financial losses to the individual's survivors. Thus, a conventional wrongful death award might equal the present value of the lost earnings of the deceased person minus personal consumption expenditures that would have been incurred had the person not died. Such wrongful death awards have a different function than VSL amounts, as they serve as a form of insurance compensation for an individual's family after death rather than as a rate of tradeoff between money and reducing risks of death. Wrongful death awards vary according to a wide range of personal characteristics and are generally bounded from above by the present value of the individual's future income stream. In contrast, it is quite reasonable for a person to express a VSL that exceeds his or her income, as the willingness to pay for very small risk reductions could be substantial, as such amounts may remain well below the person's income constraint. In the example above, people with moderate income levels might be able to afford $500 to eliminate a fatality risk of 1/10,000 even though $5 million may dwarf their current and future financial resources. There is nothing problematic about this result, as one can think of very large changes in risk as a quite different commodity for which a separate willingness-to-pay value should be elicited.

Government policies generally have a very small effect on mortality risks, which is consistent with the small probabilities that typically are involved in labor market studies. Whereas the average job fatality risk was in the order of 1/10,000 a quarter of a century ago, recent studies of compensating differentials for fatality risk have used samples with an average risk of 1/25,000. If, however, one were to extrapolate the results of these studies to deal with larger risk changes, then on a theoretical basis, as the magnitude of the risk change increases, willingness-to-pay amounts increase less than proportionally and willingness-to-accept amounts increase more than proportionally.[7] Thus, a lower VSL figure would be pertinent for large risk changes from a willingness-to-pay perspective, and a higher VSL figure would be appropriate from a willingness-to-accept perspective. The general assumption in policy analysis contexts is that the risk changes are sufficiently small that such non-marginal considerations do not matter.

Because the VSL is tied to a person's subjective willingness to pay, the value will not be the same for everyone. A person might become less willing to bear risk after getting married and having children, thus raising the VSL with age. Increases in a person's income over time likewise might be expected to raise his or her willingness to pay for reductions in risk and consequently raise the VSL. Other changes in one's life, such as becoming unemployed or the stock market collapse of 2008, may reduce one's current

and anticipated future income and consequently may lower the amount one is willing to pay for greater safety. Recognition that the VSL is ultimately based on an individual's personal valuation of risk and that it may vary across people and across time for the same person will clarify many of the controversies examined below.

While asking people hypothetical questions about their willingness to pay to eliminate small risks can be a useful exercise, the dominant approach in the economics literature has been to analyze the payments workers actually receive for fatality risks on the job. While controlling statistically for other aspects of the worker, such as education and occupation, we can ask: how much compensation do workers receive for bearing extra risk? And what do these revealed preferences indicate about their VSL amounts? These questions can be answered based on statistical analyses of large data sets of workers facing fatality risks. The meta-analysis by Viscusi and Aldy (2003) reviewed various labor market studies and found an average VSL of about $7 million (2000 dollars), or an annual wage compensation of $700 for an annual fatality risk of 1/10,000.[8]

Using the VSL estimates based on such reviews of labor market valuations of fatality risk has become the standard best practice throughout the Federal government.[9] The US Office of Management and Budget (OMB) has prepared guidelines for the use of VSL estimates in valuing mortality risks for purposes of regulatory analysis (OMB 2003, appendix D: OMB Circular A-4, Regulatory Analysis). These guidelines do not specify a VSL amount but provide a general framework for approaching the selection of a VSL by an agency. Based on two meta-analyses cited by the OMB, empirical evidence places the VSL between $1 million and $10 million. The OMB does not select a particular VSL estimate from this range. The two meta-analyses the OMB cites, which are Viscusi and Aldy (2003) and Mrozek and Taylor (2002), have been widely used in agencies' selection of the VSL amounts used in their policy assessments (OMB 2003, p. 147: the OMB cites these analyses in footnote 83; at the time of the OMB report, Viscusi and Aldy was listed as "forthcoming," as it was published later in 2003).

The US Department of Transportation (DOT) issued a memorandum in 2008 to provide guidance to the various agencies within the DOT regarding the VSL amount for policies pertaining to highway safety and airplane safety (DOT 2008). Unlike the OMB guidance, this directive is quite specific. As the 2008 memorandum indicates, in its previous 1993 guidance document the agency established $2.5 million as the VSL amount, and this figure could be updated periodically for inflation. The last update was to $3.0 million in 2002. The 2008 memorandum raised the DOT's VSL to $5.8 million. This value was based on the mean value from the following five studies: Miller (2000): $5.2 million; Mrozek and Taylor (2002): $2.6 million; Viscusi and Aldy (2003): $8.5 million; Viscusi (2004): $6.1 million; and Kochi *et al.* (2006): $6.6 million.[10] These figures reflect updates by the DOT to 2007 dollars using the Consumer Price Index for urban consumers (CPI-U) and to reflect changes in income based on the income elasticity of 0.55 estimated by Viscusi and Aldy (2003). The main outlier accounting for the low average value used by the DOT is the low VSL estimate in Mrozek and Taylor (2002). The reasons for this discrepancy will be examined in Section 4.

The VSL level used in regulatory analyses is not standardized across agencies or at any point in time. Table 1 summarizes a series of VSL amounts used in calculations by agencies other than the EPA, which will be examined separately below. Because all figures have been converted to 2008 dollars, the VSL amounts presumably should be fairly

Table 1 Selected values of statistical life used by US regulatory agencies

Year	Agency	Regulation	Value of a Statistical Life (millions, 2008 dollars)
1985	Federal Aviation Administration	Protective Breathing Equipment (50 Federal Register [FR] 41452)	$1.2†
1988	Federal Aviation Administration	Improved Survival Equipment for Inadvertent Water Landings (53 FR 24890)	$1.8†
1990	Federal Aviation Administration	Proposed Establishment of the Harlingen Airport Radar Service Area, TX (55 FR 32064)	$2.5†
1994	Food and Nutrition Service (USDA)	National School Lunch Program and School Breakfast Program (59 FR 30218)	$2.1, $4.3†
1995	Consumer Product Safety Commission (CPSC)	Multiple Tube Mine and Shell Fireworks Devices (60 FR 34922)	$6.9†
1996	Food Safety Inspection Service (USDA)	Pathogen Reduction; Hazard Analysis and Critical Control Point Systems (61 FR 38806)	$2.3
1996	Food and Drug Administration	Regulations Restricting the Sale and Distribution of Cigarettes and Smokeless Tobacco to Protect Children and Adolescents (61 FR 44396)	$3.3†
1996	Federal Aviation Administration	Aircraft Flight Simulator Use in Pilot Training, Testing, and Checking and at Training Centers (61 FR 34508)	$3.7†
1996	Food and Drug Administration	Medical Devices; Current Good Manufacturing Practice Final Rule; Quality System Regulation (61 FR 52602)	$6.8†
2000	Consumer Product Safety Commission	Portable Bed Rails; Advance Notice of Proposed Rulemaking (65 FR 58968)	$6.2
2000	Department of Transportation	NPRM on Tire Pressure Monitoring System (FMVSS No. 138)	$3.9–$6.2
2006	Food and Drug Administration	Recordkeeping Requirements for Human Food and Cosmetics Manufactured From, Processed With, Or Otherwise Containing, Material From Cattle (71 FR 59653)	$5.3–$6.8
2007	Department of Homeland Security	Advance Information on Private Aircraft Arriving and Departing the United States (72 FR 64012)	$3.1–$6.2

†The published summaries of the regulatory impact analyses for these rules do not specify the year in which the reported dollars are denominated. The calculations assume that the dollar year corresponds to the date of rule publication for purposes of converting all values into 2008 dollars using the Consumer Price Index for urban consumers (CPI-U). Note that the CPSC reported a value of statistical life (VSL) of $5 million in both its 1995 and 2000 regulations; the difference in values reflects the conversion to 2008 dollars.

similar, but they are not.[11] As the figures indicate, the VSL amounts have been quite different for the DOT, the Food and Drug Administration, and the different divisions of the US Department of Agriculture. We find that even with downward adjustments for age or for the reassessment of the best estimates from the literature by the EPA Air Office, the 2008 EPA "devaluation" of life yields VSL amounts that are nevertheless higher than many of those that have been widely used throughout the Federal government. The most important reason for the within-agency changes in VSL over time is that new research has come available over time. Substantive causes of the major shifts in the VSL include Viscusi's (1992, 1993) reviews of the VSL literature, the publication of several new meta-analyses of the VSL literature, and the issuance of revised OMB guidance on the VSL. There also might be quite legitimate reasons for using a different VSL for different agencies, which are reducing risks for different populations and with different associated characteristics, such as morbidity effects. The existence of differences in VSL does not provide a rationale for mandating a common VSL across agencies, but it does suggest that one might reasonably inquire as to the basis of the differences.

All of the VSL figures in Table 1 pertain to a single VSL estimate applied to all risks being reduced. It is not, for example, a composite of $5 million applied to older people, $7 million applied to younger people, and $6 million averaged across the entire protected population. Instead, agencies typically use a VSL based on average valuations for samples of workers exposed to risk and they apply that number uniformly to all of their regulations, whether the people being protected are rich or poor, old or young, victims of involuntary risks or people who have chosen to engage in risky pursuits. There appear to be no examples of situations, other than the EPA age adjustments, in which the agency undertook sensitivity analyses using different VSL amounts for various groups protected by a regulation to capture differences in the heterogeneity of the VSL across the population. The OMB guidelines do not indicate that there should be any recognition of heterogeneity other than with respect to valuing the lives of children.

The principal exception to the failure to adjust the VSL based on the heterogeneity of preferences is the unsuccessful attempt by the Federal Aviation Administration (FAA) to use a higher VSL than the rest of the DOT. The FAA's rationale was that airline passengers are more affluent than the average person protected by transportation policies generally, with about one and a half times his or her income level. The FAA commissioned a study, ultimately published in Viscusi (1992, 1993), which reviewed the VSL literature and indicated a possible income adjustment for the VSL based on the greater affluence of airline passengers. Because airline safety regulations would raise company costs and ticket prices, the passengers themselves would largely be paying for the cost of greater safety.[12] Although the FAA advocated an income adjustment for the VSL, there was opposition from other DOT departments and lobbying efforts by the automobile industry, which feared that a higher VSL would lead to more stringent and costly auto safety standards. This internal debate prevented the DOT from permitting the FAA to depart from its very low VSL figures, such as the $1.2 million figure shown in Table 1.

3. The "senior discount" and the complex effects of age

The first policy controversy this article will address is the EPA's use of a lower VSL amount for older people whose lives were being extended by the proposed Clear Skies regulation. This regulation had a differential effect on the survival rates of different age

groups. Mortality rates increase with age generally. Moreover, for the particular individuals likely to benefit from the regulation, there may be additional health impairments that affect mortality risks. People with respiratory conditions are most susceptible to the risks of air pollution, so the benefit values are quite sensitive to the VSL amount used for people over the age of 65, which is the age group for which most of the risk reductions were estimated to occur. The EPA's move to provide a breakdown of some of the age distribution of the effects is commendable in that it provides additional information to policymakers regarding who is being protected and to what extent.[13] In terms of raw demographic statistics, it would also be useful to have detail beyond the age ranges affected. For people over age 65 whose lives are being extended, will they otherwise have normal life expectancy, or do they have advanced respiratory ailments that will limit their remaining lifespan to several months? Such information is useful in assessing both the willingness to pay of the group being protected and the appropriate value that should be attached to their life extension. The value of a statistical life year (VSLY) is particularly attractive when there are potential victims with extremely short life expectancies due, for example, to advanced respiratory diseases.[14]

The summary information based on reductions in long-term exposures to pollution by the Clear Skies initiative provides a general sense of the magnitudes involved.[15] The annual fatalities that the EPA estimates will be prevented are 1,900 for adults aged 18 to 64, and 6,000 for adults aged 65 and over. The estimated benefit from the reduced mortality risk is $11.6 billion for adults aged 18 to 64, based on a VSL of $6.1 million. The main benefit estimate provided by the EPA used this uniform VSL figure. However, the EPA also reported a sensitivity analysis using an age adjustment for people over the age of 65. The benefit derived from adults 65 and older is $36.6 billion using the same VSL of $6.1 million across the population, and $23.1 billion based on the EPA's 37% senior discount adjustment, which would be a VSL of $3.8 million.[16] Thus, the senior discount is not just of symbolic importance: it reduces the estimated benefits from the policy effort by more than $13 billion annually. However, even though the VSL amount is reduced, it is not entirely out of line with what agencies in the Federal government other than the EPA have used. Other countries have also used a senior discount in regulatory analysis.[17] It is the downward adjustment itself – and the idea that age is an acceptable basis for a downward adjustment – rather than the amount that may have been most problematic. The Clear Skies initiative analysis was the first EPA use of a senior discount, but it was not the EPA's first use of the senior discount approach: that occurred during the Clinton administration in an EPA sensitivity analysis of the 2000 highway diesel rule.[18]

The selection of a 37% age adjustment was not an arbitrary choice. It was based on stated preference results reported by Jones-Lee *et al.* (1985) for traffic safety in the UK. The selection of this particular figure does, however, raise some legitimate economic questions. First, the different traffic safety risk questions yielded age-related patterns, some of which indicate a positive age–VSL relation and others which indicate a negative relation; and some of which were statistically significant and others which were not. The age results were simply not robust across different formulations of the safety risk question. Second, VSL levels estimated for the UK have always been quite different from those found in US studies (Viscusi 1993 and Viscusi & Aldy 2003 review the international evidence). Given the quite different income levels and social insurance structures in the two countries, transferring the age-related results across countries surely requires some adjustments or cautionary warnings regarding the exploratory nature of the exercise.

The concept that the VSL might vary by age group is certainly reasonable in that a person's willingness to pay to reduce risk may vary over his or her lifetime, making some kind of adjustment appropriate. Although the EPA effort expanded the age adjustment debate rather than resolved it, the agency should be commended for recognizing that there may be legitimate differences in VSL amounts across the population that should be taken into account in policy assessments.

As a practical matter, however, this sensitivity analysis that explored possible age differences in the VSL was not a success. What generated the controversy was the EPA's seemingly arbitrary devaluation of the lives of people over age 65 by 37% compared to the values for the rest of the population. Elderly citizen groups, such as the AARP, launched a series of public protests against what has come to be known as the "senior discount" or the "senior death discount" (for representative press coverage, see *Wall Street Journal* 2003, *The Washington Post* 2003, and *Washington Times* 2003). EPA regulatory policies also may attract substantial scrutiny because of the large stakes involved, the involuntary nature of many environmental risks, and public perceptions of the importance of environmental quality. After a wave of adverse publicity, the EPA rescinded its age-adjustment approach.

On a conceptual basis, it certainly does not seem entirely unreasonable that the VSL declines steadily with age. Purchasing a risk reduction at age 10 has a much greater effect in increasing life expectancy than purchasing a risk reduction at age 70. And if the risk at age 10 is not reduced, that person may never reach age 70 to have the opportunity to pay for reduced risks at that age. Because the expected amount of life being protected declines steadily with age, there are some simple economic frameworks for which one can show that the VSL peaks at birth and declines steadily with age.[19] Those simple models use very strong assumptions, such as the ability to borrow at birth based on future earnings, and they also abstract from important changes that occur over an individual's life. After being raised by your parents and educated, you in effect become a different person from an economic standpoint, with quite different labor market opportunities and a different willingness to pay for risk reduction. Similarly, other life-cycle changes, including possible marriage, financial responsibilities for children, and wage patterns, will impinge on a person's willingness to pay for risk reduction. Part of this concern may reflect a person's valuation of the importance that others place on his or her survival. Ultimately, whether the VSL increases or decreases over time, and to what extent, is an empirical question that requires that we ascertain how this willingness-to-pay amount to reduce risk varies with age.

At the time of the EPA assessment, the literature on age differences in the VSL was not well developed.[20] As a result, the OMB (2003) guidance with respect to the heterogeneity of the VSL is quite cautious. The OMB indicates that the EPA Science Advisory Board thought that the estimates were not sufficiently refined to provide for different VSL estimates based on the cause of death, such as cancer, or whether the risk was incurred voluntarily or involuntarily. The OMB is quite explicit in opposing age adjustments in the VSL amount.[21] The OMB does, however, permit presenting results based on a single VSL amount for all age groups coupled with a sensitivity analysis that shows the results using VSLYs (OMB 2003, p. 147). Because young people generally have a greater life expectancy than older people, this approach will lead to higher values being placed on mortality risks to the young.[22] However, the OMB would temper such an effect by using a higher VSLY for older people, because "senior citizens face larger

overall health risks from all causes and they may have accumulated savings to spend on their health and safety" (OMB 2003, p. 148, footnote omitted). The OMB does not explain the extent to which there should be an increase in the VSLY with age, but the general thrust of the guidance should serve as a cautionary alert. The early labor market studies of the VSL relied on worker fatality risk data that did not account for differences by age, and the econometric formulations used typically did not allow for substantial flexibility in the relationships between age, fatality risks, and wages. Survey studies likewise did not explore the age variations extensively. The senior discount controversy has stimulated substantial research to examine the age variation in the VSL. Much of my commentary on whether the EPA approach was valid exploits research findings not available at the time of the EPA analysis, thus taking advantage of hindsight.

As more refined labor market fatality risk data by age have become available, economists have been able to estimate how the VSL varies across the population and over the life cycle, which will reflect changes in wealth with age. In much the same way as people's total consumption increases over time, peaks in middle age, and then declines somewhat as a person ages, the VSL likewise displays an inverted U-shaped pattern (see Kniesner *et al.* 2006, Viscusi & Aldy 2007, and Aldy & Viscusi 2007, 2008).[23] But what is interesting is that the upward trajectory when people are young is much steeper than the downward trend after age 60.[24] If we use the age-adjusted VSL estimates in Kniesner *et al.* (2006), the benefit estimates of the Clear Skies initiative for people age 65 and over is $37.1 billion, which actually is somewhat higher than what the EPA estimated when applying no senior discount.[25] Some other recent estimates indicate that there may be little effect of an age adjustment, or there may be some decline in values with age. However, most studies suggest that the VSL for people in their 20s is actually less than that for people age 60, notwithstanding the difference in their future lifespans. Stated preference studies likewise have examined the variation of the VSL with age and offer the advantage of providing evidence for people over age 65, many of whom do not work and whose preferences will not be reflected in hedonic wage study estimates. The results of these studies are reviewed by Krupnick (2007), who finds that the evidence is mixed as to whether the VSL declines with age and to what extent.

It is not entirely surprising that the VSL might not plummet when we age. Individual willingness to pay for risk reduction is linked to one's financial resources, and older people may have more funds with which to purchase reductions in risk. We do not observe people over 65 taking up smoking, stopping the use of seatbelts, buying cars without safety equipment, and engaging in highly risky lifestyles, even though their life expectancy has been reduced. What matters from the standpoint of benefit valuation is whether the personal willingness to pay for risk reduction has declined, irrespective of whether a third party government policymaker thinks that people should be willing to pay less for risk reduction if fewer years of life are being saved.

While there is no consensus regarding the extent of the decline in the VSL with age, such estimates may be refined in future research. Labor market studies have by necessity focused on the working age population, so subsequent declines in the VSL beyond retirement age would not be captured except through extrapolation of age-related trends. It also may be the case that people with extremely short remaining life, such as people with terminal diseases, may have lower VSL figures, so that age-related changes in individual health status may be influential as well.

The prospective policy evaluation question is what use, if any, should be made of recent findings on age-related differences in the VSL. Framing the issue as one of equity is not conclusive. Using the same VSL for all people irrespective of their willingness to pay for safety is symmetric, but the lives being saved by these policies are not. Uniform VSL amounts will place a higher value per expected life year saved for the old than for the young, which can be viewed as an inequity in spending on risk reduction.[26] The EPA's senior discount for the elderly nevertheless placed a higher VSLY for their lives than for those under age 65. Graham (2008) calculates that the VSLY for people under 65 in the Clear Skies analysis was $172,000, whereas the VSLY implied by the senior discount was $434,000 for people over 65. That the VSL and the VSLY remain high as a person ages is mainly a consequence of greater wealth at the end of the life cycle. By failing to decrease the VSL with age, analysts are implicitly according substantial weight to income effects, which is inconsistent with a broader announced policy of ignoring income.[27] Ultimately, the only sound basis for valuing risks is to examine individuals' willingness to pay, irrespective of the differences these values may generate.

The economic efficiency norm is to use the willingness to pay of the protected population as the guide. Thus, if there is a well-established heterogeneity in the VSL, then these differences could be taken into account. Given the present state of research, however, the extent of the discount, if any, which should be applied to reducing risks to older populations is not clear. One possibility is to shift from a VSL benefits measure to a VSLY approach, which assumes that each year of life is equally valued. This approach was specifically not recommended for the EPA policy by the Cropper *et al.* (2007) EPA Science Advisory Board Environmental Economics Advisory Committee memorandum, and is not consistent with recent empirical evidence reported in Aldy and Viscusi (2008). Likewise, a National Academy of Sciences (2008) report did not endorse either the use of the VSLY approach or placing a dollar value on quality-adjusted life years (QALYs).

The overall assessment of the EPA's decision to use a senior discount for the VSL is mixed. Conceptually, the VSL amount may decline with age at some point, and subsequent studies may show that adjustments of this type are warranted. But the evidence we have to date for the working-age population does not indicate a precipitous dropoff in the VSL in one's 60s. Indeed, workers in their 60s reveal a higher VSL in their job choice decisions than do workers in their 20s. Had the EPA documented the more tenuous health status of the particular groups over age 65 whose risk would be reduced by the policy, then it might have been clear that the extension in the life expectancy generated by the policy would be very short. A shortened life expectancy would make a reduced willingness to pay for the policy more plausible, but does not necessarily indicate that a lower VSL is appropriate (for further discussion of this issue, see Hammitt 2007). In the EPA's defense, it should also be noted that the VSL amount after being reduced by the senior discount is still well within the range of values used by other agencies in the Federal government. The EPA analysis fell prey to anchoring biases as people judged the VSL relative to the VSL amounts the EPA applies more generally, which are the highest in the Federal government.

4. The EPA's general devaluation of life

In 2008, the EPA came under attack for lowering the VSL used in assessing air pollution regulations. While many of the studies listed in Table 2 have been discussed in the media,

Table 2 Values of statistical life used by the US Environmental Protection Agency (EPA)†

Year	Regulation or Regulatory Impact Analysis (RIA)	Value of Statistical Life (VSL) (millions, 2008 dollars)
1985	Regulation of Fuels and Fuel Additives; Gasoline Lead Content	$2.1
1988	Protection of Stratospheric Ozone	$5.9
1996	Requirements for Lead-based Paint Activities in Target Housing and Child-occupied Facilities	$7.7
1996	RIA: Proposed Particulate Matter National Ambient Air Quality Standard	$7.8
1996	RIA: Proposed Ozone National Ambient Air Quality Standard	$7.8
1997	Economic Analysis for the National Emission Standards for Hazardous Air Pollutants for Source Category: Pulp and Paper Production; Effluent Limitations Guidelines, Pretreatment Standards, and New Source Performance Standards: Pulp, Paper, and Paperboard Categories-Phase 1	$3.5–$12.5
1997	National Ambient Air Quality Standards for Ozone	$7.7
1998	RIA: NOx SIP call, FIP, and Section 126 Petitions	$7.8
1999	RIA: Final Regional Haze Rule	$7.8
1999	Radon in Drinking Water Health Risk Reduction and Cost Analysis	$7.7
1999	RIA: Final Section 126 Petition Rule	$7.8
1999	RIA: Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements	$7.8
2000	Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements	$7.8
2000	Revised National Primary Drinking Water Standards for Radionuclides	$7.7
2000	Guidelines for Preparing Economic Analysis	$7.8
2000	Arsenic in Drinking Water Rule	$7.8
2004	RIA: Stationary Internal Combustion Engine (RICE) NESHAP	$7.7
2004	RIA: Industrial Boilers and Process Heaters NESHAP	$7.0
2004	Final Regulatory Analysis: Control of Emissions from Nonroad Diesel Engines	$7.7
2005	RIA: Final Clean Air Mercury Rule	$7.0
2005	RIA: Final Clean Air Interstate Rule	$7.0
2005	RIA: Final Clean Air Visibility Rule or the Guidelines for Best Available Retrofit Technology (BART) Determinations Under the Regional Haze Regulations	$7.0
2005	Economic Analysis for the Final State 2 Disinfectants and Disinfection Byproducts Rule	$9.0
2006	RIA: Review of the Particulate Matter National Ambient Air Quality Standards	$7.0
2006	National Primary Drinking Water Regulations: Ground Water Rule; Final Rule	$8.5
2008	RIA: Final Ozone National Ambient Air Quality Standards	$6.9
2008	RIA: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression Ignition Engines Less than 30 Liters Per Cylinder	$6.8

†Statistics were calculated by the author and updated to 2008 dollars using the Consumer Price Index for urban consumers (CPI-U). Some minor differences in VSL levels are due to rounding effects rather than changes in the agency's valuation.

all of the numbers presented here are based on the author's calculations using the original agency documents.[28] Beginning with its analysis of standards for industrial boilers and process heaters in 2004, the EPA Air Office used a VSL in 2008 dollars of $7.0 million rather than the previous values of $7.7–$7.8 million used by the EPA Air Office, which are shown in Table 2. Since 1996, the VSL amount used has always been about $8 million or more, with the only exceptions being the recent VSL figures used by the EPA Air Office. In contrast, other recent EPA analyses were raising the VSL to amounts such as $8.5 and $9.0 million. Because the EPA Air Office's downward shift in the VSL occurred during the Bush Administration, some critics suggested that the devaluation of life might be politically motivated. The devaluation received substantial press attention and media coverage (*The Associated Press* 2008; *The Washington Post* 2008; The Colbert Report, 14 July 2008). The incident also led to proposed legislation intended to prevent such devaluations in the future and to prevent the discounting of the lives of senior citizens.

Setting aside possible political motivations, one might well consider the decision to reduce the VSL to be somewhat perplexing from an economic standpoint. Studies generally indicate that the estimated VSL has been rising over time, not declining. A key reason for this increase is that societal income levels have been increasing steadily. There is a positive income elasticity of the VSL of 0.5 to 0.6, so that a 10% increase in average income levels will boost the estimated VSL by 5 to 6% (Viscusi & Aldy 2003). From the standpoint of long-term temporal economic trends, the VSL that the EPA uses generally should rise, not fall.[29]

A second puzzle is why the downward shift in the VSL was not made agency-wide. The EPA's general guidance for the agency is to use a value of $7.4 million (2006 dollars), which is $7.8 million in 2008 dollars (EPA 2009). This value is based on a series of labor market analyses compiled by the EPA and by Viscusi (1992), which the EPA updated to 2006 dollars. It is also in the range of results found in three meta-analyses cited by the EPA: Mrozek and Taylor (2002), Viscusi and Aldy (2003), and Kochi *et al.* (2006). Branches of the EPA other than the Air Office did not adopt the devaluation of life measure used by the Air Office.

Where then did the EPA Air Office numbers come from? The EPA has consistently relied on labor market estimates of the VSL to establish the figures used in benefit assessments, although recent guidance also draws on stated preference studies.[30] The earlier regulatory impact analyses (RIAs) prepared for the EPA relied on the range of estimates found in a survey of the principal studies in the literature reported in Viscusi (1992, 1993),[31] or on the EPA Guidelines for Preparing Economic Analysis, which in turn cites the same literature.[32] Beginning in 2004, the EPA Air Office began to use the results generated by the meta-analyses by Mrozek and Taylor (2002) and by Viscusi and Aldy (2003).[33] The 2004 boiler standard analysis first articulated the methodology by which the EPA imputed a VSL based on these two meta-analyses.[34] The intellectual underpinnings can be traced to three recent meta-analyses of VSL studies that reviewed the literature and provided estimates of the average VSL across the studies, taking into account the various differences in methodology. Before these meta-analyses existed, the approach had been to use the average VSL amount based on a survey of the labor market literature by Viscusi (1992, 1993), which in turn provided most of the basis for subsequent EPA analyses. The advent of meta-analyses potentially makes available VSL estimates based on a series of formal statistical procedures for pooling the results of the various studies. Following its reliance on these meta-analyses, the EPA has

subsequently examined whether meta-analyses should be used and how the methodology might be improved.[35]

At the time of the EPA analysis, the meta-analyses by Mrozek and Taylor (2002) and by Viscusi and Aldy (2003) had been peer reviewed and published, while a third study by Kochi *et al.* (2006) was not yet peer reviewed, so the EPA relied on it only for corroboration.[36] Given that all three studies set out to be meta-analyses of the labor market literature on the VSL, there are substantial overlaps in the studies.[37] A possibly sound policy evaluation approach would be to select the average VSL estimate based on one of the three studies that the EPA considered to have attributes that made it the most reliable estimate of the VSL. Instead, the EPA Air Office selected as its preferred VSL the midpoint of the 25th percentile of the estimates in Mrozek and Taylor (2002) and the 75th percentile of Viscusi and Aldy (2003). This unusual mathematical formulation creates the illusion of precision but lacks any scientific basis.

A closer examination of these meta-analyses indicates that there are in fact substantial differences in methodology and the resulting estimates that might have been used as a rationale for selecting one of the studies as the reference point. Mrozek and Taylor's (2002) meta-analysis included 203 observations from 33 studies, so studies reporting numerous specifications of a regression equation entered the analysis multiple times. Thus, seven studies with 10 or more observations are included in the sample, including a study in the UK with 21 VSL estimates and an unpublished consulting firm report for Canada with 28 observations. In contrast, Viscusi and Aldy (2003) restricted their study to 49 published, peer-reviewed studies and restricted the sample to what the authors of the studies viewed as the single best estimate from the study so as to avoid giving disproportionate weight to studies that reported multiple equation estimates for the same sample. As striking as these differences in the studies being included in the meta-analyses are, they account for only a small part of the discrepancy in the estimates.

One pivotal difference is that the Mrozek and Taylor (2002) estimates used by the EPA focus on the results obtained after the authors adjusted for what they regarded as the "best practices" for such assessments. The average "best practices" estimate VSL from Mrozek and Taylor (2002) is a range from $1.5 to $2.5 million in 1998 dollars, compared with about $7 million in 2000 dollars from Viscusi and Aldy (2003). The Mrozek and Taylor (2002) study derived this best estimate by adjusting the studies in the VSL literature for important differences in their statistical formulation. Two particularly influential adjustments pertain to the number of industry dummy variables included in the analysis, and the risk data used. The first of these adjustments addresses the question of what the VSL amount would be if all studies had included a detailed set of industry indicator variables. Studies with fewer than five industry indicator variables have a VSL that is more than double their unadjusted counterpart (see table 4 of Mrozek and Taylor 2002). At a risk level of 1/10,000, these adjusted VSL estimates based on estimates using Bureau of Labor Statistics (BLS) fatality risk data have average values of $2 million in 1998 dollars. This amount is considerably lower than that of their unadjusted counterparts, $6 million.[38] This discrepancy alone accounts for the most important difference between Mrozek and Taylor's (2002) and Viscusi and Aldy's (2003) estimates. While taking into account the workers' industry group in estimating a wage equation is potentially relevant, almost all fatality risk measures in the VSL studies are matched to the workers in the sample based on their reported industry. If a wage equation includes variables for each industry used to match the fatality risk to the sample, then there will be no role whatsoever for the fatality

risk variable in the equation. It has been well known in the VSL literature that the inclusion of extensive industry characteristics rather than a parsimonious set of industry variables will pose such estimation problems.[39] The estimates in Mrozek and Taylor (2002) that are based on a parsimonious set of industry dummy variables consequently may be both a more accurate measure of the VSL and much more in line with the estimates in Viscusi and Aldy (2003), who review the merits of detailed industry controls.

A second adjustment factor that accounts for the low VSL estimate from Mrozek and Taylor (2002) pertains to the choice of the fatality risk measure. Mrozek and Taylor (2002) assume that the more meaningful estimates must be based on studies using the BLS fatality risk data rather than the fatality risk data from the National Institute of Occupational Safety and Health (NIOSH).[40] Studies based on the NIOSH fatality risk data yield VSL estimates almost double those based on the BLS estimates. Whereas Moore and Viscusi (1988) suggest that this doubling may be due to the presence of less random measurement error than in the BLS data, Mrozek and Taylor (2002) have the opposite hypothesis and adjust for the possible influence of the higher NIOSH estimates when computing their best-practices range. At a job risk level of 1/10,000, the NIOSH-based estimates yield a VSL of $10.8 million based on models with fewer than five industry dummy variables, and $4 million with more than five industry dummy variables. The comparatively low focal values from the Mrozek and Taylor (2002) study consequently require adjustments for studies based on the NIOSH risk measure as well as adjustments for studies that do not include at least five industry dummy variables.

Wholly apart from this substantive debate over which meta-analyses should serve as the guide, it seems that much of the controversy over the devaluation of life by the EPA Air Office may have stemmed from not presenting the VSL amounts used in current dollars, but instead reporting the values for nominal dollars in a previous year. Thus, the RIA for the 2008 air pollution regulations for emissions and boats used a VSL of $5.5 million in 2000 dollars. But if the $5.5 million figure is converted to 2008 dollars, it becomes a more substantial $6.8 million. Five previous EPA Air Office analyses in Table 2 likewise used a VSL of $5.5 million, but these amounts were reported in 1999 dollars, which equal $7.0 million once converted to 2008 dollars. Magnitudes such as this are at the bottom end of the $7–$9 million zone in which the EPA regulations have been clustered, and are within a million dollars of the $7.8 million general guidance that the EPA has for its regulatory analyses. The numbers are well within the Federal government range for agencies other than the EPA.

Whether government agencies should rely on the results of meta-analyses or should instead focus on the estimates judged to be the most reliable is an issue that has drawn considerable recent attention (see, in particular, EPA 2006, Cropper *et al.* 2007, and Robinson 2008). While there has always been product differentiation in the hedonic wage study literature, there have been advances as well. Chief among these is the availability of more detailed job fatality data from the Bureau of Labor Statistics, called the Census of Fatal Occupational Injuries. These data comprise a complete census of job-related fatalities, providing more comprehensive coverage than earlier sampling and voluntary reporting approaches. It is now possible to construct more refined fatality risk measures, such as the risk by industry and occupation rather than by industry alone. The first of these studies is by Viscusi (2004), which constructed fatality risks by industry and occupation and estimated a series of VSL figures for a wide range of samples and equation specifications. Robinson's (2008) examination of the appropriate VSL for homeland security

policies converted a Viscusi (2004) estimate to 2007 dollars and concludes that the $6.1 million figure implied by his work is the best overall estimate of the VSL.[41] Other studies will continue to lead to additional refinements. A key issue going forward is whether agencies' choice of a VSL should be based on meta-analysis that includes estimates of VSL based on earlier fatality rate measures. Such measurement error in the key risk variable imparts biases of unknown magnitude and direction. Alternatively, agencies might choose to sacrifice some breadth in the studies considered and restrict the focus to those based on state-of-the-art fatality rate data and methodologies.

5. The legislative proposal to set the VSL for the EPA

Following the outcry against the EPA's devaluation of life in 2008, Senator Barbara Boxer proposed a legislative solution, the "Restoring the Value of Every American in Environmental Decisions Act" (proposed in the 110th Congress, 2d Session). This sweeping legislative proposal would politicize the selection of the VSL and would put in place a process that threatens to undermine the integrity of economic policymaking.[42] Whether this legislative initiative is a symbolic shot across the bow or will ultimately be adopted is unclear, but it does provide a useful reference point for exploring the consequences of misunderstanding the VSL approach. Much of the controversy with respect to the VSL policies can be traced to a misunderstanding of what the VSL concept is. The proposed "Restoring the Value of Every American in Environmental Decisions" legislation does not embrace the VSL concept and also includes reasoning that does not interpret the concept correctly. The legislation sometimes equates the VSL approach with characteristics of the procedure used to establish compensation levels for wrongful death. By doing so, the legislation sets out to fix problems that simply don't exist, and it will create a structure that will impede future thoughtful economic analyses.

The proposed legislation begins with a series of purported "Findings" by Congress. The legislation does not allude to the small probability of death aspect of the VSL concept and asserts that "using a dollar value to establish the worth of human life as the basis for making decisions . . . offends many deeply held religious, moral, and ethical beliefs of people in the United States." This framing of the issue mischaracterizes the value at stake. Placing a dollar value on very small risks to life is different than monetizing the value of avoiding the certain death for an identified life, which is a quite distinct and more sensitive moral matter.

The proposed legislation then seeks to blame the use of the VSL for the EPA's failure to use "the latest science" to promote "technology-forcing standards" to foster "right-to-know safeguards." But the use of the VSL is not incompatible with any of these policy approaches. Indeed, it is noteworthy that the first use of the VSL for a government agency led to the landmark right-to-know policy, the Occupational Safety and Health Administration (OSHA) hazard communication regulation.[43] The OMB had turned down OSHA's regulatory proposal because it concluded that the estimated costs exceeded the benefits. The subsequent analysis that introduced the use of the VSL to governmental benefit assessments raised the assessed regulatory benefits by an order of magnitude and led to the ultimate approval of the regulation. Pricing risks to life correctly gives these regulatory effects substantial weight in policy evaluations.

Although a later section in the legislation proposes procedures for setting the VSL, before doing so it voices a series of reservations with respect to the approach. For

example, it claims that "differing economic situations or negotiating positions may falsely skew statistical life methodology estimates downward." It is true that more affluent people have higher willingness to pay for risk reduction and hence higher VSL amounts. If poor people had greater resources, their VSL amounts would be greater. But the appropriate economic reference point is the VSL amounts of those being protected by the policy, not the VSL amounts that this population would have expressed if they were as rich as Bill Gates. To date, government agencies have finessed the role of income differences by using the same VSL for all.

The policies that would be formalized by the legislation, if enacted, include the following:

1 The EPA can never reduce the VSL below the highest value used by the EPA before this Act.
2 The EPA must increase the VSL at least once a year to reflect changes in average income, average bequests, and nonpaid activities.
3 The VSL can never be decreased "based on age, income, race, illness, disability, date of death, or any other personal attribute or relativistic analysis of the value of life."
4 The EPA Administrator must provide a public comment period for any proposed change in the VSL.
5 The EPA must provide an assessment of the validity of the studies upon which the Administrator relies.
6 Any proposed revision must be provided to the Committee on Environment and Public Works of the Senate and the Committee on Energy and Commerce of the House of Representatives.

In all likelihood, the net effect of these proposals will be to ensure that the VSL amount will always increase over time irrespective of the findings in the pertinent economics literature, which may indicate that past VSL amounts used by the agency were too high. It is surprising that the EPA should be singled out for the requirement that the VSL amounts must be on a constant upward trajectory in that the EPA has consistently used the greatest VSL amounts in the Federal government. Notably, other agencies such as the DOT and OSHA would not be bound by this Act, even though they use lower VSL amounts than the EPA does. The proposed Act consequently seeks to place a lower bound on the VSL at the agency whose VSL levels are at the upper bound for the Federal government.

The legislation specifies that adjustments for income and other factors must be asymmetric, as these factors can be taken into account to increase the VSL but not to decrease it. Even though average income levels have been increasing over time, if there were a prolonged economic slump that made society poorer, such as the current economic downturn, or what some doomsayers suggest may be a consequence of climate change, then such negative influences cannot be factored into the analysis even if they are legitimate reflections of decrease in the VSL.

By far the most ominous consequence of the legislation is that it would politicize estimates of the VSL, which are the results of scientific studies in the economics literature. Government agencies such as the EPA are not asked to obtain approval for other economic parameters used in the analysis, such as the rate of inflation or interest rates. The OMB sets guidelines for possible discount rates but permits some leeway. The VSL would be unique in that Congress would be determining the value of a key economic parameter.

The dangers of entrusting such authority to Congress are particularly great given that their incentives involve objectives other than the promotion of sound economic science. Indeed, the wording of the proposed bill makes it clear that the legislation does not imply recognition that the VSL methodology is an appropriate approach.[44] It hardly makes sense to entrust the establishment of VSL amounts to a political entity that is suspicious of the methodology and may seek to use control of the VSL to undermine its economic integrity.

A sounder approach would be to ask that agencies set VSL amounts consistent with the Daubert criteria for scientific evidence applied by the courts, which are reviewed by Berger (2000). The first factor to be applied is that of relevance or "fit." Because the appropriate benefits measure is society's willingness to pay for the risk reduction, the VSL is the magnitude of interest. The present value of lost earnings and other purported economic measures do not satisfy this relevance test as risk-money tradeoff rates are not bounded by present and future income levels.

There need not be general acceptance in the economics field regarding the particular VSL figure. However, the economic evidence that an agency uses to choose its VSL should be based on the scientific method that does meet the standards for intellectual rigor in the economics field. The theory has been peer reviewed, as well as have almost all of the underlying studies and the meta-analyses cited by the EPA. The EPA should also establish a regular peer-review process for its use of the studies to set the VSL amount. In particular, the EPA can seek the advice of its Science Advisory Board Environmental Economics Advisory Committee on its VSL policies, which it has done periodically in the past. But this procedure should be regularized and VSL decisions based on these reviews should be regarded as a "safe harbor," immune from Congressional interference.

Under this article's proposal, the EPA need not consult its advisory VSL panel for periodic updates in the VSL. If the agency is contemplating a major shift in the studies used for setting the VSL or in establishing different VSL amounts across segments of the population or programs within the agency, then seeking appropriate guidance would enhance the credibility of a major change in the valuation procedure. It should be emphasized that there may be quite legitimate reasons for using a different VSL for different agency activities, such as the FAA's attempt to increase the VSL used in policy analyses because of the higher income level of airline passengers compared with victims of traffic accidents. However, the Secretary of Transportation did not approve the adoption of a higher VSL for airline safety regulations.

In assessing the scientific merit of the evidence, the studies on which the agency relies also must meet the usual scientific standards of being reliable, replicable, and having a known degree of error. Given that the VSL literature is based largely on studies using large-scale publicly available data sets, the replicability aspect is easily addressed. The amount of error can be determined by establishing confidence intervals for the estimates, following usual statistical practices. In short, the EPA is on sound scientific ground in turning to the economic literature for guidance, but the process could be bolstered by incorporating a regular peer-review process within the agency.

These proposals for science panels represent an extension of current EPA practices, not a sharp break as the Act permitting Congress to influence the VSL would be. As with respect to other VSL issues, the EPA has been at the forefront in drawing guidance from scientific advisory panels. The Science Advisory Board Environmental Economics Advisory Committee report by Cropper *et al.* (2007) addressed a wide range of

fundamental issues, including the proper use of meta-analyses and the treatment of differences in life expectancy. But the main guidance provided by the committee report pertained to the general research strategies that might be appropriate. The report also identified many fundamental research gaps and urged that the EPA address these. Included among these research issues is the effect of age and health status on the VSL, the income elasticity of the VSL, and the role of measurement error in hedonic wage studies. The committee report largely outlined a structured research agenda for the agency rather than offering specific policy guidance. This SAB Committee report by Cropper *et al.* (2007) consequently should be viewed as an initial effort rather than an endpoint. After addressing the research gaps, the EPA should reconstitute a similar advisory committee to provide more specific numerical guidance on the pertinent levels of the VSL for the different policies evaluated by the agency.

The gaps are much more pronounced elsewhere in the Federal government. Other agencies need to follow the EPA's lead and begin the process of drawing on outside scientific expertise on these issues.

6. The scientific basis for the value of statistical life

A substantial scientific literature in economics has developed estimates of the VSL. Government agencies, most notably the EPA, have made a serious attempt to grapple with the implications of the individual studies, reviews of the literature, and meta-analyses of the literature. These agencies should be encouraged to continue to do so, with the advice of peer review scientific advisory panels having the same stature as those that assist the agency on a variety of other scientific issues, such as the hazards of chemical exposures.

There should be no set template for the best VSL estimate. Contrary to the strictures that would be imposed by the "Restoring the Value of Every American in Environmental Decisions Act," the VSL amount may even decline over time depending on how estimates are refined in the literature. The procedure for picking the VSL estimate may take any of a number of forms. The best estimate from a meta-analysis might be picked, such estimates might be averaged or combined in some fashion, or perhaps a definitive single study could serve as the guide. Regardless of the approach taken, there should be a sound justification for the weight accorded to the particular studies rather than combining the results in a mechanical fashion. Greater weight should also be accorded to studies using state-of-the-art fatality rate data and methodologies, so that a meta-analysis including all studies may not be ideal.

If future research resolves heterogeneity differences more satisfactorily than at present, then recognition of differences in the VSL might be incorporated, depending on the policy context. One situation in which incorporating heterogeneous VSL amounts is compelling is when the beneficiaries of the policy are bearing the cost, so that in effect, they are paying for the greater safety. Airline safety regulations that raise passenger ticket prices and auto safety standards that raise the price of automobiles are notable examples that fit the scenario wherein the beneficiary pays for the policy. Failing to provide safety to those who value it and providing more costly safety policies to those who don't want to pay for such improvements will generate economic efficiency losses in situations in which there are market-like transactions wherein people must pay for the costs of the regulation.

Recognition of heterogeneity across the population does have substantial precedent in other contexts. Wrongful death awards for court cases increase in value with factors such as personal income and remaining work life, so the idea that heterogeneity might be recognized is incorporated in the judicial system's handling of ex post compensation. Such awards have a different purpose in that they are designed to provide compensation for the economic loss of the survivors, which is a quite different matter than reducing the risk of death for people who are still alive. If, however, the policy costs are spread more generally, then not distinguishing different levels of the VSL may be less controversial than making such distinctions.

Although the EPA's analyses that led to the devaluation of life controversies were not entirely sound, on balance the controversies have done a disservice to the agency. The EPA has consistently been a leader in incorporating the results of the academic literature in its analyses, and for years has used VSL levels that have been among the highest in the Federal government. The senior discount procedure and the devaluation of life by the EPA Air Office were well-intentioned attempts by the agency to incorporate age differences in the VSL and to recognize the implications of the more recent meta-analyses in the economics literature. That these efforts received such sharp criticism stemmed not so much from the absolute levels of the VSL that were being used but from the direction of the change. Downward adjustments in values will generate a wide variety of irrational behavioral anomalies, and the criticism of the agency reflected these biases in public reaction. By establishing a scientifically based, peer review process for setting VSL levels, the EPA and other agencies will be able to utilize the best evidence from the economics literature, regardless of whether this evidence increases or decreases the VSL.

Notes

1 Sunstein *et al.* (2002) report on the evidence of anchoring effects in a series of jury experiments.
2 Kahneman and Tversky (1979) developed prospect theory.
3 Kahneman *et al.* (1990) and Plott and Zeiler (2005) provide evidence on the endowment effect.
4 Viscusi *et al.* (1986) analyzed consumer responses to risk increases that they labeled the "reference risk" effect.
5 Cameron (2008) reviews the media controversy and the public's misperception of the VSL concept, and recommends a different terminology based on willingness to pay for small reductions in mortality risk called "micromorts."
6 For an alternative brief introduction see Hammitt (2000). A more extensive treatment appears in Viscusi (1992).
7 For a theoretical model and discussion, see Jones-Lee (2001) and Hammitt (2000). For example, when valuing risk-free cigarettes, the VSL estimated from labor market studies overstates the willingness to pay for a safe cigarette. See Viscusi and Hersch (2008).
8 Equivalently, this VSL amount is $8.6 million in 2008 dollars.
9 For a further discussion of differences in agency practices, see Robinson (2007) and section 2.0 of Robinson (2008).
10 Although the DOT cited preliminary forthcoming versions of these papers, for concreteness the published versions and their dates are referred to here.
11 Some differences arise because of adjustments for changes in income levels and differences in rounding conventions.

12 All costs are shifted to passengers if the supply curve is perfectly elastic.
13 In contrast, for deliberations of the EPA Science Advisory Board Clean Air Science Advisory Committee, the standard EPA analyses presented to the committee for review did not include the critical age-distribution information.
14 The National Academy of Sciences (2008) report discusses the role of impaired health status and the possible use of VSLYs to value risks to those with shorter life expectancies due to adverse health conditions. Viscusi and Hersch (2008) adopt this approach for smokers.
15 The alternative EPA estimates including short-term exposures are similar in that the annual effects of adults 65 and older account for 3,600 reduced fatalities, adults 18 to 64 account for 1,100 reduced fatalities, and children 0 to 17 account for only 30 reduced fatalities. The fatality data are from table 16 in EPA (2003). The 37% discount figure is from EPA (2002, p. 35). The EPA used a VSL of $6.1 million as the base VSL figure, as discussed in EPA (2003, p. 26). The reduced annual fatality estimates are for 2010. The benefit estimates cited are undiscounted.
16 The EPA performed similar sensitivity analyses for other regulations, such as EPA (1999), which discusses other approaches such as the VSLY. The EPA ceased the age adjustment analyses after 2003. The appendix to Sunstein (2004) lists examples of the use of the VSLY approach by agencies in the Department of Health and Human Services, chiefly by the Food and Drug Administration.
17 Aldy and Viscusi (2007) provide the examples of Canada, which used a 25% discount for people over age 65, and the European Commission, which recommends that the VSL decline with age.
18 Graham (2008) describes this analysis, noting that the EPA based the adjustments on two UK surveys, which implied a percentage VSL discount of –10% and –41%.
19 Shepard and Zeckhauser (1984) developed such a model. Hammitt (2007) provides a recent review of the theory.
20 Reviews of the pertinent literature and the timing of the studies appear in Aldy and Viscusi (2007) for the labor market studies and in Krupnick (2007) for the survey studies.
21 "In light of the continuing questions over the effect of age on VSL estimates, you should not use an age-adjustment factor in an analysis using VSL estimates" (OMB 2003, p. 147, footnote omitted).
22 The somewhat inconsistent OMB views and the OMB opposition to age adjustments in the VSL per se may have contributed to the senior discount controversy. The EPA resisted the OMB-approved approach of using a VSLY measure, which would have led to an even greater senior discount than the approach that the agency adopted.
23 One might expect the VSL to rise for the very elderly because money has a low marginal utility after one's death if bequests are not highly valued. Pratt and Zeckhauser (1996) provide a model of the "dead anyway" effect.
24 See Aldy and Viscusi (2008) for age- and cohort-adjusted estimates of the VSL that reflect this pattern. The estimates in Viscusi and Aldy (2007) and Smith *et al.* (2004) show quite substantial VSL levels for the near elderly.
25 Other estimates of the life cycle effects using different data and model structure yield somewhat different estimates. Benefit values based on VSL estimates derived from equations using age-industry fatality risk measures yield findings in line with the EPA's senior discount, whereas benefit values based on VSL estimates derived from equations using industry fatality measures are very similar to the unadjusted EPA benefit values. These estimates are reported in Viscusi and Aldy (2007) and reviewed in Aldy and Viscusi (2007). While the valuation figures differ depending on the study and risk data used, the inverted U-shaped pattern is common to most recent labor market studies. Smith *et al.* (2004) found very high VSL levels for the near elderly.

26 Sunstein (2004) provides a recent discussion of equity issues and advocates a VSLY approach. The appendix to that article lists a series of analyses using the VSLY approach.
27 This observation is often stressed by John Graham, former Administrator, Office of Information and Regulatory Affairs, OMB.
28 The statistics in Table 2 adjust for inflation while some government VSL numbers adjust for changes in income, which will induce some temporal shifts in the VSL.
29 The appropriate VSL may change over time for other reasons as well, including changes in research methodologies, differences in the types of risk considered in the studies, or differences in populations being analyzed.
30 The VSL estimates in stated preference studies tend to be lower, as reviewed in Viscusi (1993), Kochi *et al.* (2006), and Krupnick (2007).
31 Some of the RIAs do not cite specific publications but reference previous EPA studies, which in turn draw on the literature. The analyses that cite Viscusi (1992) include the 1996 proposed particulate matter national ambient air quality standard, the 1998 NOx SIP analysis, the 1999 regional haze rule, the 1999 Tier 2 sulfur control requirements, the 2000 Tier 2 motor vehicle emissions standards, the 2004 stationary internal combustion engine standard, and the 2004 nonroad diesel engine standard.
32 The guidance document cites Viscusi (1992, 1993).
33 Examples of analyses that indicate they are drawing on these studies are the 2004 industrial boilers standards, the 2005 mercury rule, the 2005 final clean air visibility rule, the 2006 review of the particulate matter standards, and the 2008 control of emissions from locomotive engines.
34 "Point estimate is the mean of a normal distribution with a 95 percent confidence interval between $1 and $10 million. Confidence interval is based on two meta-analyses of the wage-risk VSL literature. $1 million represents the lower end of the interquartile range from Mrozek and Taylor (2000) [sic] meta-analysis. $10 million represents the upper end of the interquartile range from the Viscusi and Aldy (2003) meta-analysis. The VSL represents the value of a small change in mortality risk aggregated over the affected population." (EPA 2004, tables 9–7, Unit Values Used for Economic Valuation of Endpoints (2000 dollars)).
35 A recent EPA report (EPA 2006) reviewed the major meta-analyses and made a variety of suggestions regarding improvements that could be made in modeling and econometric analysis. The EPA Science Advisory Board committee report by Cropper *et al.* (2007) developed general criteria for how the results of studies could be combined in a meta-regression. The committee also advocated additional new research on VSL issues.
36 Krupnick (2002) and Hammitt (2002) provide commentaries on Mrozek and Taylor (2002), discussing the strengths and weaknesses of the article as well as the policy implications.
37 Kochi *et al.* (2006) considered 29 contingent valuation studies and 47 hedonic wage studies but reported separate results for the hedonic wage studies.
38 These results are those reported in table 4 of Mrozek and Taylor (2002) for the BLS risk data and their model (3) in table 3.
39 The inappropriateness of including detailed industry controls in an equation in which the job risk variable is matched to workers based on their industry has long been discussed in the literature. This issue was first noted in Viscusi (1979, p. 244, footnote 4). That early study's estimates of the VSL were based on equations including no industry dummy variables.
40 Note that the BLS risk measure in current use is based on the Census of Fatal Occupational Injuries, whereas the earlier BLS fatality risk data were based on a sample of firms and voluntary reporting of deaths.
41 Robinson (2008) also outlines appropriate adjustments for changes in income based on the income elasticity estimates in Viscusi and Aldy (2003), and concludes that $6.3 million is the best VSL estimate for homeland security policies.

42 A similar concern has been voiced by Hahn and Passell (2008/2009).
43 For a description of the role of VSL analysis in the promulgation of this regulation, see Viscusi (1992). For a discussion of Viscusi's role in this debate, see Earley (1985).
44 The "Restoring the Value of Every American in Environmental Decisions" Act contains the following language: "Nothing in this section-(1) expresses on behalf of Congress any endorsement of any-(A) use of value of statistical life analysis as a decision making criterion; (B) cost-benefit analysis; . . . "

References

Aldy JE, Viscusi WK (2007) Age Differences in the Value of Statistical Life: Revealed Preference Evidence. *Review of Environmental Economics and Policy* 1, 241–260.

Aldy JE, Viscusi WK (2008) Adjusting the Value of a Statistical Life for Age and Cohort Effects. *Review of Economics and Statistics* 90, 573–581.

Berger M (2000) The Supreme Court's Trilogy on the Admissibility of Expert Testimony. In: *Federal Judicial Center, Reference Manual on Scientific Evidence*, pp. 9–38. Federal Judicial Center, Washington, DC.

Cameron T (2008) The Value of a Statistical Life: [They] Do Not Think It Means What [We] Think It Means. *AERE Newsletter* 28.

Cropper M *et al.* (2007) SAB Advisory on EPA's Issues in Valuing Mortality-risk Reduction. Memorandum from the Chair, Science Advisory Board, and the Chair, Environmental Economics Advisory Committee, to EPA Administrator Stephen L. Johnson. EPA-SAB-08-001.

DOT (US Department of Transportation) (2008) Office of the Assistant Secretary for Transportation Policy Memorandum: Treatment of the Economic Value of Statistical Life in Departmental Analyses.

Earley P (1985) What's a Life Worth. *The Washington Post Magazine*, 9 Jun.

EPA (US Environmental Protection Agency) (1999) The Benefits and Costs of the Clear Air Act, 1990 to 2010. EPA 410-R-99-001.

EPA (US Environmental Protection Agency) (2002) Technical Addendum: Methodologies for Benefit Analysis of the Clear Skies Initiative.

EPA (US Environmental Protection Agency) (2003) Technical Addendum: Methodologies for the Benefit Analysis of the Clear Skies Initiative.

EPA (US Environmental Protection Agency) (2004) Regulatory Impact Analysis for the Industrial Boilers and Process Heaters NESHAP, Final Report.

EPA (US Environmental Protection Agency) (2006) Report of the EPA Work Group on VSL Meta-analyses.

EPA (US Environmental Protection Agency) (2009) National Center for Environmental Economics, *Frequently Asked Questions on Mortality Risk Valuation*. [Last accessed 9 Feb 2009.] Available fron URL: http://yosemite.epa.gov/ee/epa/eed.nsf/webpages/Mortality%20Risk%20Valuation.html.

Graham JD (2008) Saving Lives through Administrative Law and Economics. *University of Pennsylvania Law Review* 157, 395–540.

Hahn R, Passell P (2008/2009) Legislating Life's Value. *Regulation* 31, 11–12.

Hammitt JK (2000) Valuing Mortality Risk: Theory and Practice. *Environmental Science & Technology* 34, 1396–1400.

Hammitt JK (2002) Understanding Differences in Estimates of the Value of Mortality Risk. *Journal of Policy Analysis and Management* 21, 271–273.

Hammitt JK (2007) Valuing Changes in Mortality Risk: Lives Saved Versus Life Years Saved. *Review of Environmental Economics and Policy* 1, 228–240.

Jones-Lee MW (2001) The Value of Changes in the Probability of Death or Injury. *Journal of Political Economy* 82, 835–849.

Jones-Lee MW, Hammerton M, Phillips PR (1985) The Value of Safety: Results of a National Sample Survey. *The Economic Journal* 95, 49–72.

Kahneman D, Tversky A (1979) Prospect Theory: An Analysis of Decision Under Risk. *Econometrica* 47, 263–291.

Kahneman D, Knetsch J, Thaler R (1990) Experimental Tests of the Endowment Effect and the Coase Theorem. *Journal of Political Economy* 98, 1325–1348.

Kniesner TJ, Viscusi WK, Ziliak JP (2006) Life-cycle Consumption and the Age-adjusted Value of Life. *Contributions to Economic Analysis & Policy* 5, 1–34.

Kochi I, Hubbell B, Kramer R (2006) An Empirical Bayes Approach to Combining and Comparing Estimates of the Value of a Statistical Life for Environmental Policy Analysis. *Environmental and Resource Economics* 34, 385–406.

Krupnick A (2002) The Value of Reducing Risk of Death: A Policy Perspective. *Journal of Policy Analysis and Management* 21, 275–282.

Krupnick A (2007) Mortality-risk Valuation and Age: Stated Preference Evidence. *Review of Environmental Economics and Policy* 1, 261–282.

Miller TR (2000) Variations Between Countries in Values of Statistical Life. *Journal of Transport Economics and Policy* 34(2), 169–188.

Moore MJ, Viscusi WK (1988) Doubling the Estimated Value of Life: Results Using New Occupational Fatality Data. *Journal of Policy Analysis and Management* 7, 476–490.

Mrozek JR, Taylor LO (2002) What Determines the Value of Life? A Meta-analysis. *Journal of Policy Analysis and Management* 21, 253–270.

National Academy of Sciences (2008) *Estimating Mortality Risk Reduction and Economic Benefits from Controlling Ozone Air Pollution*. Committee on Estimating Mortality Risk Reduction Benefits from Decreasing Troposphoric Ozone Exposure. National Academies Press, Washington, DC.

New York Times (2003) EPA Drops Age-based Cost Studies. 8 May.

OMB (US Office of Management and Budget) (2003) Informing Regulatory Decisions: 2003 Report to Congress on the Costs and Benefits of Federal Regulations and Unfunded Mandates on State, Local, and Tribal Entities. Government Printing Office, Washington, DC.

Plott C, Zeiler K (2005) The Willingness to Pay–Willingness to Accept Gap, the "Endowment Effect," Subject Misconceptions and Experimental Procedures for Eliciting Valuation. *American Economic Review* 95, 530–545.

Pratt J, Zeckhauser R (1996) Willingness to Pay and the Distribution of Risk and Wealth. *Journal of Political Economy* 104, 747–763.

Robinson LA (2007) How U.S. Government Agencies Value Mortality Risk Reductions. *Review of Environmental Economics and Policy* 1, 283–299.

Robinson LA (2008) Valuing Mortality Risk Reductions in Homeland Security Regulatory Analyses. Final Report to US Customs and Border Protection, Department of Homeland Security, under contract to Industrial Economics.

Samuelson W, Zeckhauser RJ (1988) Status Quo Bias in Decision Making. *Journal of Risk and Uncertainty* 1, 7–59.

Shepard DS, Zeckhauser RJ (1984) Survival Versus Consumption. *Management Science* 30, 423–439.

Smith VK, Evans MF, Taylor DJ Jr (2004) So the Near-elderly Value Mortality Risks Differently? *Review of Economics and Statistics* 86, 423–429.

Sunstein C, Hastie R, Payne J, Viscusi WK (2002) *Punitive Damages: How Juries Decide*. University of Chicago Press, Chicago.

Sunstein CR (2004) Lives, Life-years, and Willingness to Pay. *Columbia Law Review* 104, 205–252.

The Associated Press (2008) An American Life Worth Less Today. 10 Jul.

The Washington Post (2003) Under Fire, EPA Drops the "Senior Death Discount." 13 May.

The Washington Post (2008) Cosmic Markdown: EPA Says Life is Worth Less. 19 Jul.

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

Viscusi WK (1992) *Fatal Tradeoffs: Public and Private Responsibilities for Risk*. Oxford University Press, New York, NY.

Viscusi WK (1993) The Value of Risks to Life and Health. *Journal of Economic Literature* 31, 1912–1946.

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

Viscusi WK, Aldy JE (2003) The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World. *Journal of Risk and Uncertainty* 27, 5–76.

Viscusi WK, Aldy JE (2007) Labor Market Estimates of the Senior Discount for the Value of Statistical Life. *Journal of Environmental Economics and Management* 53, 377–392.

Viscusi WK, Hersch J (2008) The Mortality Cost to Smokers. *Journal of Health Economics* 27, 943–958.

Viscusi WK, Magat W, Huber J (1986) Informational Regulation of Consumer Health Risks: An Empirical Evaluation of Hazard Warnings. *RAND Journal of Economics* 17, 351–365.

Wall Street Journal (2003) EPA to Stop "Death Discount" to Value New Regulations. 8 May.

Washington Times (2003) What's a Granny Worth? Cost Benefits Must be Based on Good Science and Sound Economics. 7 Jul.

