THE COLD-WAR ORIGINS OF THE VALUE OF STATISTICAL LIFE (VSL)

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Abstract

This paper traces the history of the "Value of Statistical Life" (VSL), which today is used routinely in benefit-cost analysis of life-saving investments. Schelling (1968) made the crucial move of thinking in terms of risk rather than individual lives, with the hope to dodge the moral thicket of valuing "life." But as recent policy debates have illustrated, his move only thickened it. Tellingly, interest in the subject can be traced back another twenty years before Schelling's essay, to a controversy at the RAND Corporation following its earliest application of operation research to defense planning. RAND wanted to avoid valuing pilot's lives, but the Air Force insisted they confront the issue. Thus, the VSL is not only well acquainted with political controversy; it was born from it.

Introduction

The Value of Statistical Life (VSL) is a concept used in benefit-cost analysis by government and intergovernmental agencies around the world to value reductions (or increases) in premature deaths.[1] Common applications include the benefits of highway traffic safety measures and of reductions in air pollution. Typically, these mortality values comprise the lion's share of the estimated benefits of such investments (e.g. US EPA 2011). The VSL also has been used to help augment the national income and product accounts to accommodate non-market goods (e.g. Muller, Mendelsohn, and Nordhaus 2011) and to appraise the costs of war (Bilmes and Stiglitz 2006).

The "VSL" terminology was first introduced by Thomas Schelling (1968). Schelling's crucial contribution in that piece was the notion of *statistical* lives—really, mortality risks—in contrast to lives of specific, identified individuals. His insight was that economists could evade the moral thicket of valuing "life" and instead focus on people's willingness to trade-off money for small risks. Thus, for example, if a reduction in air pollution in a city of one million people reduces the risk of premature death by one in 500,000 for each person, then, ex ante, the policy would be expected to save two lives over the affected population. But from the individuals' perspectives, the policy only reduces their risks of death by 0.0002 percentage points. This distinction is widely recognized as the critical intellectual move supporting the introduction of values for (risks to) life and safety into applied benefit-cost analysis (Ashenfelter 2006, Hammitt and Treich 2007, Viscusi 1993). Despite the importance of this distinction between lives and risks, the VSL maintains an important rhetorical link to the value of life insofar as it divides the average individual's willingness to pay for a given reduction in risk by that risk reduction, to normalize the value on a "per-life" basis.

[1] For introductions to and reviews of the VSL literature, see Ashenfelter (2006), Blomquist (2013), Hammitt (2000), Viscusi (1993, 2011), and Viscusi and Aldy 2003.

Though widely used, the VSL has never been without controversy. One prominent example of a controversy arose in the United States in 2003 with the debate over the "senior death discount," in which the US Environmental Protection Agency (EPA) set a lower value for the VSLs of elderly citizens than for younger citizens, to account for their fewer remaining life-years. Popular outcry against this senior death "discount," given full voice in the US Congress, forced the EPA to retreat. Dismayed, economists in turn criticized Congress for political interference with rational, economic policy-making (see e.g. Viscusi 2009a).

In a comment on that view, Fourcade (2009) has argued that too often economists fail to recognize that they are but one voice in wider political debates about both social values and, materially, the allocation of resources. Indeed, as Porter (1995) has argued, the historical rise of benefit-cost analysis stems from its very appeal as a way to mediate such political conflicts; as such, it is not surprising that benefit-cost analysts sometimes finds themselves caught in the middle of them.[2] In any case, Fourcade argues, the public has a right to enter the political debate, even if it is to reject monetization as demeaning.[3]

Recognizing that economists are operating in a marketplace of ideas in which their paradigm is but one competitor, Cameron (2010) has called for "euthanizing" the term "value of a statistical life" and statistical lives as a unit of account. She argues that this unappealing term is a colossal failure of marketing. It misleads the public, who interpret "value" as intrinsic worth rather than a monetary measure and who understandably interpret "lives" as just that, rather than risks. It is, after all, a lot to ask of the adjective "statistical" to not only modify the noun "life" but to transform it into "risk!" Inevitably, this conflation of the notion of "lives" and "risk" leads to misunderstanding and, in turn, to needless political controversy.[4] Cameron suggests replacing the VSL terminology with "willingness to swap" money for "microrisks."

In this paper, I trace the history of the concept of the VSL and show that such controversies are nothing new. As noted above, the first use of the term "value of statistical life" was by Schelling (1968) in his essay, "The Life You Save May Be your Own." But Schelling's piece did

[2] See also Banzhaf (2009, 2010) for similar themes in the context of measuring non-market valuation of environmental benefits. The point is not limited to benefit-cost analysis by any means. See e.g. Stapleford (2009) for a fascinating account of such issues in the context of social debates over inflation and its measurement via price indices.

[3] Viscusi, in response, argues that to monetize VSLs is not demeaning at all, but rather gives a voice to health and longevity in policy debates (2009b). Thus, for example, Viscusi recounts how he began his career critiquing US benefit-cost analyses of dams and related water projects, which were biased in favor of development in part because they ignored difficult-to-monetize ecological effects. Monetizing them, he argues, gives them an equal seat at the table. Viscusi's view has a long tradition among economists (see, e.g. Schultz's [1961] use of the argument, in turning quoting an argument from von Thünen, in the context of monetizing the value of lives). Of course, this response presupposes the economists' paradigm of benefits, costs, and optimization, which Fourcade would argue is itself open to social debate.

[4] The point has come up in the context of VSLs before. See, e.g., the debate sparked by Broome (1978), much of which is in, or cited in, Jones-Lee (1982). Linnerooth (1982) provides a particularly interesting discussion of the tensions Schelling's VSL approach raises: particular lives will be lost, yet if we value risks instead of lives, and if risks are valued less than their equivalent in whole lives, policy would seem to be biased against health, as if we are "murdering statistical lives." See also Heinzerling (2000).

not rise out of a vacuum. Its origins can be traced back another twenty years, to a controversy at the RAND Corporation following its very earliest applications of operations research (OR) to defense planning. At that time, the US Air Force (USAF) brought the same kind of political interference that was to come again with the debate over the senior discount. But, ironically, it was only this pressure from the USAF that forced RAND to think about the role of lives in its optimization framework, a problem that eventually would attract Schelling's attention.

Thus, the VSL is not only well acquainted with political controversy; it was born from it. Moreover, as we will see, this history suggests a further irony. Arguably, historically it was the very finessing of the twin notions of lives and mortality risk, which as Cameron argues has fed the political fires in recent years, which overcame the political problems in the first place and facilitated the monetization of mortality risks in benefit-cost analysis. To measure the benefits of policies that would save lives would seem to require a value of life, but that raises difficult measurement issues. Values for risk reduction are measurable, but answer a different policy question. The notion of the "value of statistical life" occupies an intellectual middle ground.

RAND's "Criterion Problem"

To understand the origins of the VSL, we must back up some 25 years before Schelling's essay, to the very first years of the RAND Corporation. Officially opening in 1946 as "Project RAND," it began as a small think tank internal to the Douglas Aircraft Company with funding from the USAF. Its primary purpose was to forge an interdisciplinary, integrated study of the engineering of weapons systems and the study of military strategy: the acronym is for "Research ANd Development." Because of the inherent conflict of interest in an aircraft company appraising military hardware and strategy, RAND soon became independent in 1948 with support from the Ford Foundation.[5]

From its early focus on science and engineering, RAND soon showed increasing interest in economics and policy studies. Warren Weaver, a member of RAND's board, established a research section on the "evaluation of military worth," patterned after his Applied Mathematics Panel (AMP), which was viewed as a success in WW II (Leonard 2010, Mirowski 2001). The idea, explained Weaver, was to explore "to what extent it is possible to have useful *quantitative indices* for a gadget, a tactic or a strategy, so that one can compare it with available alternatives and guide decisions by analysis…" (quoted in Kaplan 1983 72, emphasis added). Weaver quickly brought in his protégés from the AMP, John Williams and Edwin Paxson. In previous work for the Naval Ordnance Test Station, Paxson had worked with John von Neumann to model a submarine-destroyer duel, possibly the first application of formal game theory to military problems. In that particular application, the payoffs were tons of shipping saved or lost. In general, though, similar quantitative measures of the costs and benefits were required to subject a choice to RAND's vision of rigorous OR.

[5] Hounshell (1997), Kaplan (1983), and Smith (1966) provide general background on RAND. Leonard (1991, 2010), Mirowski (2002), and Sent (2007) provide additional background on, and develop themes surrounding, RAND's role in shaping modern economics. Finally, Jardini (1996) provides an account that is especially important for my thesis. He focuses on the Pentagon's early disappointments with RAND and RAND's subsequent decision to diversify its research portfolio by branching into social science.

Weaver also brought in a number of economists. Among the first were Allen Wallis and Armen Alchian, who began to work with RAND as early as 1946. By 1948, the economists were constituted as their own division inside the section on evaluation of military worth. The division was headed by Charles Hitch, who in turn brought in Stephen Enke, Jack Hirshleifer, Roland McKean, David Novick, and Albert Wohlstetter (Jardini 1996, Leonard 2010, Mirowski 2001).[6]

Meanwhile, Paxson began a project on strategic bombing, constructing a special Aerial Combat Research Room to simulate aerial maneuvers in a game-theoretic context. By 1947, he and Williams found the computational requirements of their research so demanding that they, along with von Neumann, persuaded RAND to acquire one of the first EDVAC binary computers for their work. Soon, too, George Dantzig was on the scene to apply his simplex algorithm for linear programming (Jardini 1996 86, Mirowski 2001 212). In this way, RAND was reshaping OR and economics in the image of John von Neumann, while using the latest and most powerful technology available. These were heady times.

RAND's first big opportunity to showcase its new analytical capabilities came in 1949, shortly after the Soviet Union detonated its first atomic bomb. The USAF asked RAND to apply systems analysis to design a first strike on the Soviets. The "Strategic Bombing Systems Analysis," led by Edwin Paxson, attempted to use operations research methods to find the optimal mix of atomic bombs and bombers (Jardini 1996, Hounshell 1997). Specifically, it sought to solve a classic OR problem formulated in terms of choosing bombs and bombers to maximizing damage, subject to a fixed dollar budget (to procure, operate, and maintain the force) and fixed budget of fissile material (Jardini 1996 54).[7]

As discussed by Kaplan (1983) and Jardini (1996), Paxson and RAND were initially proud of their optimization model and the computing power that they brought to bear on the problem, which crunched the numbers for over 400,000 configurations of bombs and bombers using hundreds of equations. The massive computations for each configuration involved simulated games at each enemy encounter, each of which had first been modeled in RAND's new aerial combat research room.[8] They also involved numerous variables for fighters, logistics, procurement, land bases, etc. Completed in 1950, the recommended solution to this optimization problem was to fill the skies with numerous inexpensive and vulnerable propeller planes, many of them decoys carrying no nuclear weapons, to overwhelm the Soviet air defenses. Though losses would be high, the bombing objectives would be met.

While RAND was initially proud of this work, pride and a haughty spirit do go before a fall. RAND's patrons in the USAF, some of whom were always skeptical of the idea that pencil-

[6] Note the pragmatic and/or empirical approach of the economists associated with Hitch's group. Game theorists such as Arrow, Shapley, and others, by contrast, were housed in the mathematics section of RAND.

[7] Three alternative models minimized the dollar cost per unit of damage, tons of aircraft lost per unit of damage, or lives lost per unit of damage.

[8] An early, but ignored, warning sign that RAND might have been on the wrong track was the fact that these models of aerial duels predicted kill ratios of 60%, though actual experience in WW II suggested 2% was more realistic (Kaplan p. 88).

necked academics could contribute to military strategy, were apoplectic. RAND had chosen a strategy that would result in high casualties, in part because they had given zero weight to the lives of airplane crews in their objective function, as they seemingly could not be quantified (Hirshleifer 1950, Jardini 1996). In itself, this failure to weigh the lives of crews offended the USAF brass, many of whom were former pilots. But moreover that failure led RAND's program to select cheap propeller bombers rather than the newer turbojets the USAF preferred.[9] For all of RAND's scientific equations, modern computing power, and vain boasting, in the eyes of its USAF patrons its first product was a classic case of garbage in, garbage out.

RAND adapted to this debacle in three ways. First, in the short run, recognizing that its first major study could well prove to be its last, RAND quickly retreated and adopted a more humble posture. To cut its losses, RAND rushed a follow-up study, this one from Paxson's assistant Edward Quade, which incorporated some of the criticism from the Pentagon. In particular, it narrowed the question to the choice of bomber type, adopted the USAF's attack plan, and assumed the possibility of multiple strikes (Jardini 1996 64).

At the same time, RAND quickly altered course for its proposed second major project, this one on air defense systems analysis. Headed by Edward Barlow, the first draft of this project proposal had been a massive 100-page document filled with lots of math, but with dangerously simple assumptions, such as a single strike and a lack of submarines. As RAND began to feel the full force of the USAF's displeasure, the proposal was cut to a slim 16 pages, devoid of offending expressions or arrogant self-confidence in its own scientific method (Jardini 1996 67). Indeed, Barlow explicitly admitted that a weakness with their approach was the potential to ignore non-quantitative factors. "The great dangers inherent in the systems analysis approach," he said, "are that factors which we aren't yet in a position to treat quantitatively tend to be omitted from serious consideration" (1950, cit. Jardini 2006 67). It is a lesson that was to be emphasized by many early advocates of linear programming methods.[10]

Second, as a matter of long-run strategy, RAND reacted to the debacle of the strategic bombing analysis by diversifying its research portfolio outside of military work. Realizing that all its eggs were in one very risky basket, RAND looked for research sponsors outside the Penta-

[9] The problem was compounded by what the USAF perceived as other errors as well. RAND's analysis had unnecessarily (indeed, unrealistically) restricted the bombers to North American bases, even though actual plans called for using America's many forward bases as refueling points (Kaplan 1983). Additionally, it had assumed the US had a window to make only a single strike. Both tilted the analysis in favor of propeller planes, and, because the game was over after the first strike, crews did not have value for additional flights.

[10] For example, Robert Dorfman, a leading advocate of operations research, was visiting RAND around this time (Jardini 1996 92). Perhaps from the lessons he learned from this episode, throughout his career Dorfman always emphasized the importance of being pragmatic about what can be quantified and about the weight that can be placed on policy recommendations that ignore important, but unquantifiable, elements. As he would later put it, "sensible men do not relinquish a project they desire just because an arithmetic requirement is not met, when they are perfectly aware that the arithmetic ignores the considerations that are really motivating them" (cit. Banzhaf 2009). Dorfman would later edit a book volume exploring the problem of non-market valuation, and steered several students into the issue (see Banzhaf 2009, 2010).

gon. Over time, it increasingly diversified into work in health, education, and other areas of social policy. Jardini (1996) explores these moves in some detail, dating the decisive steps as occurring in the mid to late 1960s. In fact however, they occurred earlier. As early as 1952, the Ford Foundation provided RAND with a $1m grant to begin a new program, known as RAND-Sponsored Research, to take up non-military topics "in the public interest" as well as military and geo-political topics. The earliest non-military work seriously occupying RAND staff appears to have been applied work on water resources (De Haven and Hirshleifer 1957, Hirshleifer, De Haven, and Milliman 1960), followed by projects in transportation and education begun around 1960 (Goldstein 1961).[11] Interestingly—and likely not coincidentally—when Hirshleifer and other RAND economists took up water resources they were explicitly entering a research area where the problem of missing prices, or what resource economists call non-market valuation, was one of the main topics motivating contemporary literature (Banzhaf 2009, 2010).[12]

Most importantly for this story, RAND's third response to the debacle was to delve deeper into this question of non-market valuation, that is, to try to put actual weights on airplane crews in its objective functions. Inside RAND this came to be known as the "criterion problem"—essentially the problem of specifying what today are often called "indicators" for imperfectly observed or measured objectives, on both the cost and the benefit side. This was the perfect opening for RAND's economists to exploit (Leonard 1991). Jack Hirshleifer was particularly fast off the mark, expressing his opinions on the debacle in internal memoranda almost immediately (Hirshleifer 1950).

From Hirshleifer's perspective, the bombing study failed because of two issues, both of which economists understood well. The first was the distinction between short-run and long-run analysis. Paxson's bombing study imposed unnecessary constraints on the problem, especially the available quantity of fissile material. In the short-run, such constraints may be reasonable, but for long-run strategic planning, they should be subsumed in the budget constraint. That is, given the monetary resources, and enough time, one could acquire more fissile material. The needless constraint on fissile material, coupled with a large monetary budget, contributed to the use of numerous decoy planes serving little purpose except to be shot down (Hirshleifer 1950).

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[11] The earliest non-military work I can find with any RAND involvement was theoretical research on transportation problems and congestion (Beckmann, McGuire, and Winsten 1956). However, that work was begun and carried out at the Cowles Commission under Tjalling Koopmans, with RAND serving only as a sponsor. Even recognizing that RAND was always noted as a place where scholars came and went, it is hard to view this work as a RAND product. RAND's first work in transportation appears to have focused on land use and development (e.g. Niedercorn and Kain 1963). Later, by the time Schelling was addressing the problem of statistical lives, RAND was sponsoring a great deal of work on traffic safety (e.g. Carlin 1968, Lave 1968, Wohl 1968), a classic application for VSLs.

[12] Interestingly, the Ford Foundation began Resources for the Future (RFF), the first think tank focused on natural resources and the environment, in 1952, the same year it began the RAND-sponsored research program. There would be quite a bit of coming and going between RAND and RFF over the years, including Charles Hitch's eventual move to RFF as its president, as well as moves by Harold Barnett and Sam Schurr. Later, Ford also supported the Harvard Water Program, which engaged RFF in important debates over the role of non-market valuation (Banzhaf 2009). Ford's role behind the development of non-market valuation and benefit-cost analysis generally is a question which has not, to my knowledge, been explored.

The second problem Hirshleifer emphasized was missing prices. The basic idea of linear programming, Hirshleifer reasoned, was to maximize net benefits, which in turn is analogous to maximizing profits. But profits can be maximized in practice because sales and inputs are priced in dollars, so revenues and costs are in common coin. Unfortunately, in military applications like the bombing study, prices were missing from both sides of the ledger. On the benefits side there was the question of quantifying damage to the enemy. But, said Hirshleifer, the main question raised by the bombing study centered on the "cost concept (dollars, crews, or planes) to be used" (Hirshleifer 1950).

Hirshleifer noted that airplane crews can be priced by the cost of training and replacing them, but we may "set a value on human life higher than the mere training cost of a replacement."

> A man may cost $10,000 in terms of a training cost to replace, but we may prefer to lose $15,000 in materials or machines if we can save the man. This sentence points the way to costing loss of men, if the condition described actually holds true. Obviously, there is a limit to the materials or machines we will sacrifice to save the man, and our losses in men should be valued in terms of this limit, cold-blooded as it may sound. In many respects lives and dollars are incommensurable, but unfortunately the planners must compare them. (Hirshleifer 1950 5)

Hirshleifer followed up on this issue along with other economists (including Alchian, Enke, and Hitch) a few months later. "In our society," they wrote,

> personnel lives do have intrinsic value over and above the investment they represent. This value is not directly represented by any dollar figure because, while labor services are bought and sold in our society, human beings are not. Even so, there will be some price range beyond which society will not go to save military lives. In principle, therefore, there is some exchange ratio between human lives and dollars appropriate for the historical context envisioned to any particular systems analysis. Needless to say, we would be on very uncertain ground if we attempted to predict what this exchange ratio should be." (Alchian et al. 1951 20)

In the short term, RAND's best response to this dilemma was to let go of its goal of a general theory of air warfare, and instead focus on smaller subsidiary problems where apples could be compared to apples. Incommensurables—like dollars and human lives—would not need to be compared in the "sub-problem" (Alchian et al. 1951). The basic notion was to isolate a smaller portion of the system to be analyzed, taking one set of variables as given, and maximize the objective over the remaining variables, taking the first set as constraints in the problem. The results of such "sub-optimization" would not be fully optimal, as the tradeoff between the two sets of variables would not be optimized, but it would be efficient. To put it in other terms, the analyst could simply trace out the efficient frontier between dollars and lives. Ultimate decision makers in the Pentagon or the civilian government could eventually make the call

(Alchian et al. 1951, Hitch and McKean 1960 Ch. 10).[13]

This notion of sub-optimization was a major theme in much of Hitch's work and his colleagues' for the next decade, and the example of the lives of bomber crews remained the quintessential example motivating the work (Hitch 1953, 1955, Hitch and McKean 1960, McKean 1963). For example, discussing "incommensurables," Hitch and McKean (1960) considered "the comparison of alternative strategic bombing systems that are to be maintained in a state-of-readiness to deter attack" (185). In this context they further supposed

> that the preferred (that is, minimum-cost) method of achieving the objective is expected to involve the loss of more lives than some alternative method that is more expensive in dollars—even when the costs of recruiting and training the additional personnel required are included…." (183)

Hitch and McKean suggest this is a problem if high casualty rates affect morale but also because "we are interested in lives for their own sake" (183). Although it was no longer on the front burner, clearly the problem raised by Paxson's strategic bombing study was still simmering at RAND ten years later.

That said, the wisdom of seeking "missing prices" so that incommensurables like dollars and human lives could be put into the same equation was not a settled matter at RAND. For their part, Hitch and McKean thought it ought not to be attempted. Precedents for valuing human life based on the values of past decisions, court awards, foregone income, or the cost of life-saving "may be useful in particular problems, but none provides a generally valid and appropriate measure of 'the' value of human life" (1960 184). They recommended several variations on the vector approach of calculating the efficient frontier, identifying the tradeoffs among incommensurables, rather than optimizing by choosing from the frontier.

Others were more hopeful that the seeming incommensurables could be made commensurate by examining the revealed preferences of the USAF. Ten years earlier than Hitch and McKean (1960), Alchian et al. (1951) had made many of the same points (Hitch was one of the six authors), but argued that, once the efficient frontier is identified,

> Presumably it will be the responsibility of the Air Force or the [Joint Chiefs of Staff] to select one of the points as the most sensible one. Of course, any such selection implies a definite exchange ratio between lives and dollars. If this ratio could be revealed to the designers of bombing systems at an early stage they could explicitly determine the most effective system in terms of job done for a combined cost. While probably impossible in this particular case, we ought to avoid whenever possible the presentation of results only in efficient combination form. This yields the weakest possible ordering of the results given minimum rationality assumptions. All effort should be made to utilize whatever information we have about the relative values of the various inputs. (29)

[13] This notion of multi-objective benefit-cost analysis would also be developed in the context of water resources, where it was quite controversial (Banzhaf 2009). Again, the parallel developments between these two fields, RAND's participation in both, and the Ford Foundation's backing of both, is striking.

Note two things in this passage. First, Alchian et al. presumed that it is the responsibility of the USAF to make the tradeoffs between lives and machines. Second, all effort should be made to understand those "exchange ratios" and build them into the design phase, rather than merely to present decision-makers with an efficient frontier to choose from. That effort would soon come from Thomas Schelling and his student Jack Carlson.

Carlson and Schelling

Thomas Schelling (b. 1921) is a Nobel-prize winning economist famous for his work on cold war strategy and conflict.[14] Schelling received his BA from Berkeley in 1944 and his PhD from Harvard in 1951. During the last years of the war he served in the fiscal division at the Bureau of the Budget under Harvard economist Arthur Smithies, an advisor to many second-generation architects of applied welfare economics. Schelling joined RAND as an adjunct fellow in 1956, spent the summer of 1957 there followed by a whole year during 1958-59 with Hitch as his host, a year which he recalled as the most productive in his career (Breit and Hirsch 2007). He also had direct connections to the Pentagon, working with it in the early 1960s to construct war games and advising on the Vietnam conflict (Sent 2007). In other words, Schelling joined RAND a few years after the debacle of the strategic bombing analysis, and visited with Hitch during years when Hitch continued to reflect on the criterion problem and continued to illustrate it with the formative example of valuing the lives of airplane crews.

Jack Carlson (1933 - 1992) was a former Air Force fighter pilot who completed his dissertation, entitled "The Value of Life Saving," in 1963 under Schelling and Smithies. After first beginning his academic career at the Air Force Academy, Carlson went on to a career in government--in the Council for Economic Advisors, the Office of Management and Budget, and as an assistant secretary of the interior--then as head of the National Association of Realtors. Whether the idea to address the question of valuing life saving first came to Carlson and Schelling via RAND or via Carlson's experience in the Air Force is not clear, though to the best of Schelling's recollection the idea for the dissertation topic was Carlson's.[15] What is clear is that the issue had been one of considerable policy relevance to the USAF for some time.

At the time Carlson and Schelling were turning their attention to the problem, seemingly the only approach to valuation of life was the human capital approach, in which a person's life was valued by either his gross earnings or his net earnings after subtracting personal consumption. The approach was used by the courts and some economists (e.g. Weisbrod 1961), but on the whole economists in the 1960s seemed to feel it was inappropriate for valuing a life. Human capital might reflect the material contribution of a person to the market economy, but evidently ignored his non-market contributions, not to mention his own valuation of his life. (Is a retiree of no value to society? Or a homemaker? Do their own feelings count?) How to overcome this problem was not clear however.

Nevertheless, economic elements were recognized. Most importantly, both public and private investments in life-saving have associated opportunity costs. Consequently, there are

[14] For background on Schelling and appraisals of his career, see Sent (2007) and Zeckhauser (1989). For interviews, see Breit and Hirsch (2005) and Carvalho (2007).

[15] Personal correspondence with Thomas Schelling, Nov. 16, 2013.

trade-offs to be made, and therefore economic choices (Fromm 1965, Spengler 1968, Weisbrod 1961).

But if economists were clear on the idea that there were choices to be made, they were less so on what the precise nature of that choice was and who was making it. A number of economists recognized that individuals make tradeoffs between risks and money (e.g. Fromm 1965, Mushkin 1962).[16] Reading back in light of Schelling (1968) and the subsequent literature, it is tempting to view that work as a proto-VSL literature. Until Schelling's essay, however, there was no clear connection between those individual's tradeoffs over *risks* and the apparent policy-relevant question of the value of *lives*. To illustrate the point, consider an applied problem like measuring the benefits of a highway safety improvement. It is entirely natural to approach that problem by asking what the effect would be of the policy, and to proceed by answering that it would save x lives, perhaps with some confidence interval around x. The next logical question would be, what is the value of those lives? How individual values for risks came into it was by no means obvious.

The issue was also tied up with evolving views during the period about the relative roles of consumer sovereignty and political or social sovereignty (Banzhaf 2009, 2011). Though economists could agree that there were tradeoffs to be made, they were not of one mind about who was making those tradeoffs. For private goods, it was clear that it was the individual. For public questions about national defense, public safety, clean air and water, or the distribution of income, that was not so clear. Some economists felt consumers should be sovereign and that their values for these things should be aggregated up to a social value. From this perspective, benefit-cost analysis could be used to judge or *evaluate* public policies.

Others felt these were inherently social questions that only the political process could answer. Consequently, political representatives were sovereign and it was their willingness to trade off among these goods that counted for benefit-cost analysis. From this perspective, benefit-cost analysis could be used to *inform* decision making. First, economists could present the political authorities with an efficient frontier. Once those authorities revealed their willingness to trade off lives for other goods, in later phases those "exchange ratios," as Alchian et al. had put it, could be built into the design.[17] This latter view seemed especially compelling in the case of human lives. No individual would be willing to trade his own life for other social goods. But because that was the relevant policy choice, apparently society had to make the choice as a moral matter. Wrestling with this dilemma, the literature in the 1950s and 60s was quite vague about whose values were at stake (e.g. Fromm 1965, Mushkin 1962, Valavanis 1958, Weisbrod 1961).

All these issues can be seen in Carlson's dissertation (1963). Life saving, he said, is an economic activity because it uses scarce resources. For example, he noted that the construction of certain dams resulted in a net loss of lives (more than ever were expected to be saved from

[16] In the literature pre-dating Schelling (1968), Fromm (1965) came closest to Schelling's idea of the VSL. He suggested that one could think of the willingness to pay for a change in mortality risk, divided by that risk, as the value of life. Importantly, though, he viewed this measure as a value of a human life, not of risk or "statistical life."

[17] See Maass (1966) for a very clear statement of these principles of so-called multi-objective benefit-cost analysis and Banzhaf (2009) for historical discussion.

flood control), but apparently, in proceeding with the projects, the public authorities revealed that they viewed those costs as justified by the benefit of increased hydroelectric power and irrigated land. There are choices to be made, and those choices do not necessarily maximize safety, but a broader objective. In considering how to evaluate those tradeoffs in formal benefit-cost analysis, Carlson considered the human capital approach to be "usable as a first approximation" (86) but as falling short of the full contributions of a person to society. A better approach was to find people making actual choices that revealed their willingness to trade lives for other social goods.

Not surprisingly given his own career and Schelling's RAND connections, Carlson considered choices about life-saving entirely within the context of USAF applications. Taking the approach Hirshleifer had outlined ten years earlier, Carlson considered the USAF's willingness to trade off costs and machines to save men. He considered two specific applications. One was a study of the USAF's recommended emergency procedures when pilots lost control of the artificial "feel" in their flight control systems. The USAF manual provided guidance on when to eject and when to attempt to land the aircraft, procedures which were expected to save the lives of some pilots at the cost of increasing the number of aircraft that would be lost. This approach yielded a lower bound on the value of life of $270k, which Carlson concluded was easily justified by the human capital cost of training pilots. (Note this is an estimate of the lower bound, as the USAF revealed, in making the investment, that lives were worth at least that much.) Similarly, Carlson's other approach was a study of the B-58 capsule ejection system. The USAF had initially estimated that it would cost $80m to design an ejection system for the bomber. Assuming a range of typical cost over-runs and annual costs for maintenance and depreciation, and assuming 1-3 lives would be saved by the system annually, Carlson estimated that in making the investment the USAF revealed its "money valuation of pilots' lives" to be at least $1.17m to $9.0m (92). (Though this was much higher than the other estimate, as two lower bounds they were not inconsistent.)

Why were these values seemingly so high? One reason (among others) was that "valuation placed on a pilot's life must be more closely tied to the decision-makers involved," which here were the commanders of the USAF, "and must include their criteria and preferences" (105). Carlson pointed out that in the USAF important decision makers like General Lemay were often former pilots, who identified with the individuals affected. Additionally, he noted that some of the value might not have been for the lives per se, but for the implicit message the investments sent to air crews that they were highly valued, a message that might boost morale.

Importantly, in both applications just considered, Carlson took the public perspective: it was a matter of either the government generally, or the USAF specifically, to make tradeoffs between lives and equipment.[18] Recall this was the perspective also taken by Hirshleifer and Alchian et al. at RAND a decade earlier. This perspective is particularly natural for military applications. Somebody like General Lemay would certainly factor casualty rates into his decision making, but he would hardly weight those casualties by the preferences of his men. It would be his decision to make based on his own willingness to trade off damage to the enemy for

[18] From a positive perspective, Carlson clearly felt it was the USAF making the tradeoffs. From a normative perspective, he seemed to be somewhat ambivalent on this point. He sometimes wrote as though there might be what we would now call an agency problem, with the USAF overvaluing pilots' lives. In this case, USAF decisions should be reviewed by higher levels of government (119).

lives. Again, I emphasize "lives" here because from the standpoint of the public agency, the outcome is the number of lives saved in the aggregate population, not risks. Consequently, it was perfectly natural for Carlson to call these estimates the value of "life saving" or the "value of human life" (89, 96) and even the "costs and benefits…of preserving a particular life or lives" (1).

Interestingly, however, Carlson had earlier in his dissertation briefly considered the case of hazardous duty pay, in which an individual reveals information about his willingness to accept added on-the-job risk for a compensating increment to income. Here, the decision maker was not a public agency, but an individual choosing a job. Carlson gave examples from the private sector as well as volunteer positions in the military. For example, he figured that a pilot willingly increases his annual risk of dying (during peace time) by 0.00232 to 0.00464 percentage points, for some $2,280 of increased pay.[19] *If* he followed the methodology he had used when considering the public choice applications, he *might* have divided $2,280 by those risks to estimate a per-life value of $491k to $983k. Tellingly, Carlson did not do so in this case: he left it as $2,280 as the willingness to accept for that range of risks. The crucial (albeit implicit) distinction here appears to be the individual perspective versus the social perspective. For the individual as a decision maker it was a matter of evaluating risk—and only risk, so there was no point in aggregating up to per-life values. In contrast, when the public agency was the decision maker, it was a matter of the realizations of the individuals' risks aggregated over the group (expected lives), hence it made sense to convert the values to dollars per life.

Taking up the subject himself five years after his student, Schelling's crucial move was to finesse this distinction. At the outset of his essay, Schelling wanted to make clear that he was by no means tackling the question of the "worth of human life" itself. That question, he suggested, was rightfully tied up in moral questions and was too "awesome" for the economist to even begin to address. Rather, Schelling made clear that his more modest objective was to value the postponement of deaths; and not the death of a particular, known person, but "statistical death." "What is it worth," he asked, to reduce the frequency of death—the statistical probability of death?" (127).

After defining the question in these terms, Schelling next asks, "Worth to whom?" Now, Schelling was clearly addressing the problem of evaluating *public* investments (indeed, his was part of a conference and book volume dedicated to this topic). Although writing solely about public investments, he took the view that those public investments should be evaluated in terms of the *private* worth they had to the *individuals* who would be affected: "Worth to whom? …I shall propose that it is to the people who may die" (127).

Elaborating on this point, Schelling addressed the oft-articulated view that life and death are moral—or at least intangible—matters that cannot be priced:

"For a variety of reasons it is beyond the competence of the economist to assign ob-

[19] Economists remain interested in such decisions. Recently Greenstone, Ryan, and Yankovich (2012) have computed the willingness of soldiers to re-enlist in the US Army based on the hazards and compensation associated with specific duties.

> jective values to the losses suffered under [pain, fear, and suffering]."[20] The same is true of cola and Novocain…. If they were not for sale it would be beyond our competence, as economists, to put an objective value on them, at least until we took the trouble to ask people. Death is indeed different from most consumer events, and its avoidance different from most commodities….. But people have been dying for as long as they have been living; and where life and death are concerned we are all consumers. We nearly all want our lives extended and are probably willing to pay for it. It is worth while to remind ourselves that the people whose lives may be saved should have something to say about the value of the enterprise and that we analysts, however detached, are not immortal ourselves. (128-129)

In other words, consumers' sovereignty must reign when evaluating public investments: it is their preferences which count, not the preferences of public officials.[21] Because it was recognized that individuals do make choices over risk, once consumer sovereignty was embraced it became possible to look to choices over risk as the basis of social values. These exchange ratios can be observed, Schelling suggested, from either the price system itself or through surveys (142-143), both methods that were followed up on in the coming years (e.g. Thaler and Rosen 1976, Jones-Lee 1976). While public policies would still have the effect of costing or saving lives in the population, from the individual's perspective, these effects were measured as risks, and that was what mattered for valuation.

Conclusion

Until Schelling's essay, the implicit perspective in discussions of valuing life for purposes of public investments appeared to be that of a public agency trading off lives for other goods. The question of individual risks to life and limb was restricted to individual decisions. Schelling brought these two together by evaluating the public benefits as the sum of private benefits. In so doing, he essentially merged one perspective that thought in terms of lives with another that thought in terms of risks.[22] Synthesizing the two, Schelling coined the term "statistical lives," as a way to capture both perspectives. This synthesis was critical because valuing lives was, as he put it, too "awesome" a problem, but valuing risks had not, up to that point, seemed relevant to many public investments. Schelling was still talking about lives, but a peculiar kind of lives—"statistical lives." This was a new coinage, but it would have had a familiar ring. It likely resonated with the notion of the "statistical life" of a product—how long a light bulb, for example, could be expected to live.[23] Only in this case, consumers were not evaluating the lives of light bulbs, but of themselves.

Thus, although Cameron (2010) may well be right to suggest that, as a term of art, "VSL"

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[20] The quotation is to D.J. Reynolds, "The Cost of Road Accidents," *Journal of the Royal Statistical Society* 119, 1956, pp. 393-408.

[21] Mishan (1971) would soon make the point even more forcefully.

[22] This point was not necessarily appreciated by people working within these perspectives. Initial comments on Schelling's essay were stunningly dismissive as lacking rigorous analysis of risk, as well as for overlooking the existing literature (Bailey 1968, Fromm 1968).

[23] A JSTOR search uncovers dozens of articles using this term in this way in the decades before Schelling (1968), especially in statistics, economics, and engineering journals.

is unnecessarily confusing to the public today, it made sense in Schelling's historical context. Indeed, it more than made sense. By bridging the gap between the value for *lives*, which was what seemingly was required for social benefit-cost analysis, and the value for *risks*, which was what consumers could reveal either through the market or through surveys, the VSL terminology was an appealing and persuasive way to make the case for introducing those values into benefit cost analysis. In other words, conflating "lives" and "risks" may have been exactly what it took at the time for economists to persuade government officials and the public on the idea of pricing those policy impacts.

As Cameron (2010), Fourcade (2009), Viscusi (2009a,b), and others have discussed, economists' use of the VSL in benefit-cost analysis often becomes tied up in ethical and political debates, with the "senior discount" being but one prominent case in point. But this was always so. Economists did not "discover" the idea of the VSL (or of estimating tradeoffs between money and risks) on their own. They were forced to consider the problem because of political pressure. Going back to 1949, when RAND economists had recommended the use of cheap propeller planes, the USAF objected to their answer and brought political pressure on RAND to change it. Recognizing that one reason they had come to the "wrong" answer was by ignoring the lives of bomber crews, RAND economists turned their attention to this problem of valuation of life, a problem which eventually attracted the attention of Schelling. Schelling's key rhetorical strategy, in turn, was to soothe fears about the awesomeness of valuing life by turning the terms of the debate, ever so subtly, to valuing risk. Judging by today's discussions, economists today may be ready to make that turn a little less subtle, but in doing so they are responding to broader political context in the same way they always have done.

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