Risk Equity: A New Proposal

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INTRODUCTION

How does distributive justice — for short, "equity" — bear on the regulation of health and safety risks? And what are the analytical tools that risk regulators should use to incorporate equity concerns into their decision-making? This Article proposes an answer to these vital questions which is novel, but also firmly grounded in the social-welfare-function tradition in welfare economics. The distributive impacts of risk regulation policies should be evaluated with reference to a social welfare function, with the status quo and each possible policy conceptualized as a probability distribution across population profiles consisting of lifetime income-health-longevity histories for each member of the population.

No clear paradigm for equity analysis has yet emerged in governmental practice. The contrast with risk assessment and cost-benefit analysis is stark. Highly sophisticated procedures for risk assessment and cost-benefit analysis currently exist. These procedures are employed by regulators, carefully

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monitored by oversight bodies, and supported by large bodies of scholarly work.[1] Equity analysis, on the other hand, is inchoate and haphazard. Executive Order 12,866, the chief legal instrument governing agency policy analysis, states that agency regulations should maximize net benefits and then proceeds to explain that benefits include "distributive impacts" and "equity."[2] But the net-benefits-maximization test of traditional cost-benefit analysis is insensitive to distributional considerations. Executive Order 12,866 provides no guidance about the meaning of "distributive impacts" and "equity," nor about how these considerations should be incorporated into cost-benefit analysis. The Office of Management and Budget ("OMB") guidance document regarding compliance with Executive Order 12,866 is lengthy and, on many issues, quite specific. When it comes to distributive analysis, however, the OMB guidance is brief and vague.[3]

Equity considerations are more specifically discussed by a different presidential directive. Executive Order 12,898, the Environmental Justice order, states that: "[t]o the greatest extent practicable and permitted by law, . . . each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States."[4] This order adopts a particular conception of risk equity: namely, a social-gradient conception of equity, which sees an inequitable policy as one whose impacts on socially disadvantaged groups are less favorable than its impacts on socially advantaged groups. Further, Executive Order 12,898 is quite specific in identifying low-income and minority status as the relevant markers of social disadvantage.[5]

However, techniques for implementing an environmental justice/social gradient conception of risk equity in agency decisionmaking remain unsettled. The scholarly literature on environmental justice, which is now quite substantial, has focused on testing factual hypotheses about whether waste dumps, hazardous waste processors, sources of air pollution, or other risk

[1] For citations to the scholarly literature on risk assessment, and to descriptions of the use of risk assessment by governmental bodies, see Matthew D. Adler, *Against "Individual Risk": A Sympathetic Critique of Risk Assessment*, 153 U. PA. L. REV. 1121, 1128-29 nn.28-29 (2005) [hereinafter Adler, *Against "Individual Risk"*]. On cost-benefit scholarship, see, for example, A. MYRICK FREEMAN III, THE MEASUREMENT OF ENVIRONMENTAL AND RESOURCE VALUES (2d ed. 2003). On the use of cost-benefit analysis in the federal government, see generally MATTHEW D. ADLER & ERIC A. POSNER, NEW FOUNDATIONS OF COST-BENEFIT ANALYSIS 1-4, 101-23 (2006), and sources cited therein.

[2] Exec. Order No. 12,866 § 1(a), 58 Fed. Reg. 51,735, 51,735 (Oct. 4, 1993). The recent amendments to Executive Order 12,866, by Executive Order 13,422, do not change the substantive requirements imposed on agency rules by Executive Order 12,866 and, in particular, do not change its content regarding "distributive impacts" and "equity." Exec. Order. No. 13,422, 72 Fed. Reg. 2763 (Jan. 23, 2007).

[3] *See* Circular A-4, Off. Mgmt. & Budget (Sept. 17, 2003), *available at* http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf.

[4] Exec. Order No. 12,898 § 1-101, 59 Fed. Reg. 7629, 7629 (Feb. 11, 1994).

[5] *Id.*

sources tend to be located in minority or low-income areas, and whether such skews are caused by racial or socioeconomic bias.[6] Less work has been done creating tools to measure the degree of inequality between members of advantaged and disadvantaged groups with respect to the effects of health and safety hazards, and for measuring the equity impact of policies that mitigate these hazards.[7] EPA, the largest of the federal agencies that regulate health and safety risks, and generally the most advanced in the development of policy tools, has given some attention to implementing environmental justice. There is an environmental justice office within EPA, and a number of guidance documents and letters have been issued.[8] Yet environmental justice analysis still plays a very small role within EPA decisionmaking — as compared to cost-benefit analysis, let alone risk assessment, which is pervasive.[9] Nor has the agency resolved upon a set of concrete procedures and metrics for structuring the analysis.[10]

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[6] A number of these empirical studies are cited in William Bowen, *An Analytical Review of Environmental Justice Research: What Do We Really Know?*, 29 ENVTL. MGMT. 3, 13-15 (2002) and in Evan J. Ringquist, *Assessing Evidence of Environmental Inequities: A Meta-Analysis*, 24 J. POL'Y ANAL. & MGMT. 223, 245-47 (2005). Other scholarship about environmental justice is cited or excerpted in CLIFFORD RECHTSCHAFFEN & EILEEN GAUNA, ENVIRONMENTAL JUSTICE: LAW, POLICY, AND REGULATION (2002); Sheila R. Foster, *Meeting the Environmental Justice Challenge: Evolving Norms in Environmental Decisionmaking*, 30 ENVTL L. REP. 10992 (2000); and Robert Kuehn, *A Taxonomy of Environmental Justice*, 30 ENVTL. L. REP. 10681 (2000).

[7] On environmental justice tools, see, for example, EPA, SCIENCE ADVISORY BOARD: REVIEW OF DISPROPORTIONATE IMPACT METHODOLOGIES (1998); FENG LIU, ENVIRONMENTAL JUSTICE ANALYSIS: THEORIES, METHODS, AND PRACTICE (2001); TRANSPORTATION RESEARCH BOARD OF THE NAT'L ACADEMIES, EFFECTIVE METHODS FOR ENVIRONMENTAL JUSTICE ASSESSMENT (2004). As discussed below, there are close parallels between the environmental justice and health equity literatures, *see infra* text accompanying notes 15-19; and that latter literature has developed a variety of metrics for quantifying social skews in health. *See, e.g.*, Johan P. Mackenbach & Anton E. Kunst, *Measuring the Magnitude of Socio-economic Inequalities in Health: An Overview of Available Measures Illustrated with Two Examples from Europe*, 44 SOC. SCI. MED. 757 (1997).

[8] For a critical review of environmental justice policy at EPA, see EPA, OFFICE OF THE INSPECTOR GENERAL, EPA NEEDS TO CONSISTENTLY IMPLEMENT THE INTENT OF THE EXECUTIVE ORDER ON ENVIRONMENTAL JUSTICE, REPORT NO. 2004-P-00007 (2004). *See also* Richard J. Lazarus & Stephanie Tai, *Integrating Environmental Justice into EPA Permitting Authority*, 26 ECOLOGY L.Q. 617 (1999); Bradford C. Mank, *The Draft Title VI Recipient and Revised Investigation Guidances: Too Much Discretion for EPA and a More Difficult Standard for Complaints?*, 30 ENVTL. L. REP. 11144 (2000) [hereinafter Mank, *The Draft Title VI Recipient*]; Bradford C. Mank, *Executive Order 12,898*, *in* THE LAW OF ENVIRONMENTAL JUSTICE 107-14, 125-29 (Michael B. Gerrard ed., 1999) [hereinafter Mank, *Executive Order 12,898*]. On environmental justice policy at other federal agencies, see Denis Binder et al., *A Survey of Federal Agency Response to President Clinton's Executive Order No. 12898 on Environmental Justice*, 31 ENVTL. L. REP. 11133 (2001); Mank, *Executive Order 12,898*, *supra*, at 114-23, 129-31.

[9] On risk assessment at EPA, see, e.g., Adler, *Against "Individual Risk," supra* note 1, at 1149-64; *id.* at 1148 n.91 (citing sources). On cost-benefit analysis, see, for example, ECONOMIC ANALYSES AT EPA (Richard D. Morgenstern ed., 1997).

[10] *See* EPA, OFFICE OF THE INSPECTOR GENERAL, *supra* note 8, at 19-26 (discussing differing approaches to identifying disparate impacts on low-income and minority communities employed by EPA regional offices and EPA's failure to establish a single approach). EPA's guidance on incorporating distributional concerns into cost-benefit analysis is lengthier than OMB's in Circular A-4, *see supra* note 3; but it still fails to recommend specific policy metrics

Academic scholarship about risk equity has also failed to advance very far. An important exception, already mentioned, is the literature on environmental justice. The social-gradient model, developed in that literature, does provide a relatively clear conception of distributive justice. However, as I shall argue below, the conception is a problematic one. Relatively little academic work has been done to develop and make workable competing conceptions of risk equity. At least in the United States, neither economists nor the toxicologists and other scholars who write about risk assessment have done so to any substantial degree.

Health economists abroad, particularly in Britain, have discussed the possible use of equity weights in QALY-based policy analysis.[11] This work has had no influence on U.S. governmental bodies, and appears to have had little influence on academic economists in the United States. Economists in this country have done some work quantifying the "incidence" of the costs of environmental policies on different groups, and have also written about the possible use of "distributional weights" within cost-benefit analysis.[12] But the volume of economic writing on these equity matters is fairly small compared to the vast U.S. literature on cost-benefit analysis. Finally, some scholarship within risk assessment does address equity issues, in particular suggesting that regulatory attention to "individual risk" rather than population risk (total deaths) is required by equity.[13] However, scholarship of this sort represents a small fraction of the corpus of work produced by risk assessment scholars, and has not succeeded in producing an influential conception of equity.

The inattention to risk equity by U.S. economists may reflect the old and still lingering view that welfare economics becomes subjective and inappropriately value-laden once it goes beyond endorsing Pareto-efficiency. The risk assessors' inattention may reflect their self-understanding as scientists who make no normative claims whatsoever. Whatever the cause, risk equity as a topic of scholarly discourse remains something of a vacuum.

This Article is intended to help fill that vacuum by advancing a new conception of risk equity. I suggest that health and safety agencies might evaluate the equity impacts of their policies by applying a variety of plausible utility functions and equity-regarding social welfare functions ("SWFs"), with the recognition that health, longevity and income are all important determinants of individual well-being, and the understanding that both the status quo and any given policy have an uncertain effect on individuals' longevity, health, and income. The status quo should be understood as a probability distribution across population profiles, each consisting of a lifetime health and income history for each member of the population. A policy

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for quantifying the degree of distributional skew or balancing distributive concerns with efficiency/overall welfare. *See* EPA, GUIDELINES FOR PREPARING ECONOMIC ANALYSES 139-74 (2000).

[11] *See infra* Part I.C.

[12] *See infra* Parts I.D, I.F.

[13] *See infra* Part I.B.

would perturb this distribution and lead to a different set of probabilities for possible profiles. A utility function assigns a lifetime utility to each individual's longevity-health-income history. With this utility function in hand, the equity analyst can convert each population profile of individual longevity-health-income histories into a population profile of individual lifetime utilities. The status quo, and each policy, become probabilistic packages of population utility profiles. Plausible SWFs are then applied to these packages.

I will call this conception of risk-equity analysis "probabilistic population profile analysis" ("PPPA"). This conception is firmly grounded in the notion of an SWF: a construct that has been developed within a branch of welfare economics which *is* comfortable making normative claims about equity, and that has been mainly applied to questions of optimal tax policy. The contribution of this Article is to explain how the SWF notion might be operationalized in the domain of risk regulation, through PPPA, and to defend that approach as feasible (at least in the foreseeable future) and normatively attractive.

Part I of the Article criticizes existing approaches to risk equity: the environmental-justice or social-gradient paradigm; the notion that equity concerns the distribution of individual risks; QALY-based analysis with equity weights; incidence analysis; "inclusive" equality measurement; and cost-benefit analysis with distributional weights.

Part II defends the PPPA approach. I summarize the notion of an equity-regarding SWF, which grounds the approach. I then describe PPPA in detail and argue that the approach is foreseeably, if not immediately, feasible. Techniques would need to be developed to predict the impact of policies on each individual's lifetime "holdings" of both income and health/longevity. However, such techniques represent an incremental, not radical, extension of existing risk assessment and incidence analysis methodologies. Optimal tax scholarship has already provided a range of plausible SWFs. In particular, PPPA should rely on the so-called Atkinsonian family of SWFs, as well as the rank-weighted SWF, in analyzing risk policies.

Existing scholarly literatures do not contain the information needed to calibrate the utility function that would map individuals' longevity-health-income histories onto utility numbers — the utility numbers that are the arguments for the SWF. This gap can and should be filled through survey research. Until such research takes place, one possibility is to ignore health as a component of utility, and to employ the "constant relative risk aversion" utility function to attach utilities to life histories (now understood as lifetime income sequences). The constant relative risk aversion functional form has been extensively studied by economists, and estimates of the coefficient of relative risk aversion are available. Another possibility is to assume that lifetime utility as a function of health and income is additive across periods and multiplicative within periods, i.e., takes the form of

$$\sum_{t=1}^{T} q(h_{i,t})v(y_{i,t}),$$

where $h_{i,t}$ is individual i's health in period t, $y_{i,t}$ is her income in period t, and $q(h_{i,t})$ and $v(y_{i,t})$ are "subutility" functions measuring the value of health and income, respectively, in each period.[14] It could then be assumed that $v(y_{i,t})$ takes the constant relative risk aversion form. Existing data about individual willingness-to-pay and willingness-to-accept for health could be used to estimate the within-period health function $q(h_{i,t})$.

PPPA represents a social-welfare-function approach to equity analysis that is quite general and can extend beyond risk regulation — for example, to estimate the equity impacts of tax-and-transfer policies, or of spending to fund public goods. But decision-cost and measurement considerations mean that the general approach will be developed differently in different areas. For example, in the case of a policy that funds or defunds national parks, it would be crucial to include individuals' recreational activities as a determinant of their utilities. In the case of risk regulation, where the main effects on individual well-being occur via changes in health, longevity, and income, recreational activities as an input to individual utility, and therewith the SWF, can (plausibly) be ignored. The Article therefore focuses on risk regulation and risk equity, elaborating the application of a social-welfare-function approach to that particular policy domain in the form of PPPA.

I. Existing Approaches to Risk Equity

A. *Environmental Justice*

Executive Order 12,898, as well as much of the scholarly writing under the heading of environmental justice, adopts a social-gradient conception of risk equity.[15] A policy implicates environmental justice insofar as it has a disproportionately negative impact on certain socially disadvantaged groups. The policy (1) imposes costs on at least some group members; and (2) those costs are disproportionately larger than the costs it imposes on non-members.[16]

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[14] For non-economists, what this formula means is that we assign the individual's health state and income state in each period a value. We next multiply these two numbers, arriving at a total value for each period. These period values are then summed to determine lifetime utility.

[15] On this conception within the environmental justice literature, see, e.g., Kuehn, *supra* note 6, at 10683-84. The recent EPA Inspector General report claims that EPA itself is resistant to the social-gradient conception of risk equity. *See* EPA, Office of the Inspector General, *supra* note 8, at 10-11. EPA, however, has officially adopted this conception in various documents. *See, e.g.*, EPA, EPA Guidance for Consideration of Environmental Justice in Clean Air Act Section 309 Reviews (1999); Mank, *The Draft Title VI Recipient*, *supra* note 8, at §1.3.

[16] Scott Farrow has proposed a related approach to equity — namely that a policy not only pass the test of Kaldor-Hicks efficiency, but that actual compensation be provided to members of a "sensitive group," such as low-income or minority groups. Scott Farrow, *Environmental Equity and Sustainability: Rejecting the Kaldor-Hicks Criteria*, 27 Ecological Econ. 183, 185-86 (1998). This proposal, like the disparate-impact tests considered in the text, is vulnera-

In focusing on disadvantaged groups and disparate impact, this social-gradient conception of risk equity is similar to the view that the Equal Protection Clause of the U.S. Constitution proscribes laws that have a disparate impact on racial minorities — a view which the Supreme Court has not incorporated into its justiciable doctrines enforcing that Clause,[17] but is arguably reflected in employment discrimination statutes.[18] The social-gradient conception is also adopted in much of the literature on health equity.[19] Environmental justice scholars typically focus their attention on toxic hazards or environmental disamenities, while the health equity literature typically concerns social skews in health generally or in health care. But these two literatures share, as their basic normative concern, the principle that members of socially disadvantaged groups ought not to fare especially badly with respect to health or longevity.

A fundamental difficulty with the environmental justice/social gradient approach is that it overlooks inequalities among individuals who are not members of the groups counted as socially disadvantaged. Consider the framework of Executive Order 12,898, which enjoins agencies to address disproportionately high health effects on minority populations and low-income populations. Under this framework, the distribution of health and longevity among non-impoverished white individuals — those who fall into neither of the two categories highlighted by the Executive Order — is not seen as an equity concern.

For example, a deregulatory policy that raises air pollutant levels might increase death and morbidity among individuals with respiratory diseases, including some individuals who are neither racial minorities nor have low incomes. Another example: permitting a dangerous product might cause some children to die, including some non-impoverished white children. These look like potential inequities, simply by virtue of the impact of the policies *within the subpopulation of non-impoverished white individuals*, and quite apart from their effect on poor individuals or racial minorities.

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ble to the objection that it ignores inequalities among individuals who do not belong to the "sensitive group."

[17] *See* Washington v. Davis, 426 U.S. 229 (1976).

[18] *See, e.g.*, 42 U.S.C. 2000e-2(k) (2006). I say "arguably" because it is plausible (although certainly not uncontroversial) to take the view that federal prohibitions on practices with a disparate impact are grounded in Congress's power to enforce the Equal Protection Clause, under Section 5 of the Fourteenth Amendment. *See, e.g.*, Richard A. Primus, *Equal Protection and Disparate Impact: Round Three*, 117 HARV. L. REV. 493, 494-95 & n.4 (2003).

[19] *See, e.g.*, Sudhir Anand, *The Concern for Equity in Health*, *in* PUBLIC HEALTH, ETHICS, AND EQUITY 15, 19-20 (Sudhir Anand et al. eds., 2004); Paula Braveman, *Health Disparities and Health Equity: Concepts and Measurement*, 27 ANN. REV. PUB. HEALTH 167, 169-70 (2006); C.J.L. Murray et al., *Health Inequalities and Social Group Differences: What Should We Measure?*, 77 BULL. WORLD HEALTH ORG. 537, 537-38 (1999); Adam Wagstaff & Eddy van Doorslaer, *Overall Versus Socioeconomic Health Inequality: A Measurement Framework and Two Empirical Illustrations*, 13 HEALTH ECON. 297, 297 (2004); WHO Task Force on Research Priorities for Equity in Health & The WHO Equity Team, *Priorities for Research to Take Forward the Health Equity Policy Agenda*, 83 BULL. WORLD HEALTH ORG. 948, 948 (2005).

This is not to say that a policy's impact on poor individuals or racial minorities is not an equity concern. Of course it is. It is rather to say that there is an *additional* equity concern in these examples, which Executive Order 12,898 — framed in terms of disparate impact on minority and low-income groups — does not capture. In the pollution example, some non-impoverished whites have the *further* advantage of good health; others in this group do benefit from being white and having adequate incomes, but have the misfortune to suffer chronic diseases. The gap between their well-being and that of their luckier counterparts is increased by the deregulatory policy. Similarly, in the dangerous product example, some non-impoverished whites have the further advantage of living a full lifespan while others suffer the misfortune of premature death. Permitting the dangerous product has the effect of expanding the size of this unfortunate group.

The objection might be framed as follows. There are various measurable dimensions of well-being, from D_1 to D_K. The benefit of being white in a society with a history of oppression of non-whites is one such "dimension." So is income. So is health. So is longevity. The disparate-impact analysis set forth by Executive Order 12,898 focuses on a *subset* of these dimensions, D_1 to D_J, where $J<K$. That analysis takes a dimension D_i within the subset and asks whether a hazard increases skews in well-being or aspects of well-being between those who are at a high level with respect to D_i and those who are at a low level. What this approach ignores are inequalities among those individuals who are all at a reasonably high level for each D_i with $i \leq J$, but some of whom are at a low level for some D_i with $i > J$.

The environmental justice theorist has two possible responses to this objection. The first is to expand the set of dimensions along which policy skews are measured. We might say that a policy triggers environmental justice concerns if it has a disparate impact on racial minorities, low-income groups, *or* women, disabled individuals, those in poor health, children, or the aged. Indeed, some of the scholarly literature pushes in this direction.[20] The problem here is how to aggregate a policy's equity effects along these multiple dimensions to arrive at an overall equity evaluation of the project. Imagine that we have some measure, S, of disparate impact. (The existing literature on health equity offers a variety of proposals as to what S might be.)[21] A policy might have a high S score with respect to D_1, a low S score with respect to D_2, and so forth. That is to say, it might impose costs on individuals with low D_1 levels that tend to be much greater, in absolute or proportional terms, than its costs for individuals with higher D_1 levels; but also impose costs on individuals with low D_2 levels that tend to be the same or even lower (in absolute or proportional terms) than its costs for individuals with higher D_2 levels. The policy has a highly disparate impact along the

[20] *See* Liu, *supra* note 7, at 95-96; Transportation Research Board, *supra* note 7, at 19.

[21] *See supra* sources cited in note 7.

D_1 axis, but a zero or reverse disparate impact along the D_2 axis — and so forth for axes D_3 through D_K.

If all the measurable dimensions of well-being are included as potential axes for disparate impact, the straightforward answer to this inter-axis aggregation problem is to move away from dimension-specific disparate-impact measures to a single population-wide measure of inequality. Since a skew in well-being or aspects of well-being between those at a low and those at a high level with respect to any one of the D_t raises a distributive concern, why not ask how each individual fares, all things considered, as a consequence of her various attainments along the various dimensions D_1 through D_K; and then apply some metric of inequality to the population distribution of these overall attainments? The environmental-justice approach thereby morphs into the PPPA approach.

But the environmental justice theorist need not be led down this path. Instead, she might insist that the attributes highlighted by Executive Order 12,898 are distinctive. Being a racial minority, or lacking an adequate income, are not merely determinants of well-being. These characteristics are socially salient and have a particular social function that renders them uniquely important as a matter of distributive justice. As Paula Braveman, a leading health-equity scholar, and a co-author explain:

> [e]quity in health . . . [is] the absence of systematic disparities in health . . . between social groups who have different levels of social advantage/disadvantage — that is, different positions in a social hierarchy.
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> . . . .
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> Underlying social advantage or disadvantage refers to wealth, power, and/or prestige — that is, the attributes that define how people are grouped in social hierarchies.[22]

Being black or low-income is *socially* disadvantaging; these characteristics lower social status. And, in Braveman's view, it is health disparities between high-social-status and lower-social-status individuals that health-equity measures should seek to capture.[23]

Perhaps the fullest elaboration and defense of this view is provided by the philosopher Iris Marion Young. She argues that "claims about social justice that invoke equality usually require comparison of groups on measures of well-being or advantage . . . . Assessment of inequality in terms of the comparison of individuals yields little basis for judging injustice."[24] Young's argument rests on two premises about the connection between distributive justice and inequality. The first is that unjust inequalities involve

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[22] Paula Braveman & Sofia Gruskin, *Defining Equity in Health*, 57 J. EPIDEMIOLOGY & CMTY. HEALTH 254, 254 (2003) (emphasis removed). For a similar analysis, see Braveman, *supra* note 19, at 180-82.

[23] *See* Braveman & Gruskin, *supra* note 22, at 256; Braveman, *supra* note 19, at 180-88.

[24] Iris Marion Young, *Equality of Whom? Social Groups and Judgments of Injustice*, 9 J. POL. PHIL. 1, 7 (2001).

an absence of choice and responsibility on the part of the worse-off individuals. "If the causes of an inequality lie in the uncoerced and considered decisions and preferences of the less well-off persons, for example, then the inequality is probably not unjust."[25] The second premise is that inequalities which are not socially caused are also not unjust, or at least not as seriously unjust as socially caused inequalities. "To the extent that injustices are socially caused, . . . [the correct] conception of justice claims that democratic political communities are responsible collectively for remedying such inequalities, perhaps more than they are obliged to remedy the effects of so-called 'brute luck.'"[26] These two premises lead Young to conclude that an inequality must be a "structural inequality" — a difference in well-being or advantage as a result of social hierarchy — to be a central concern of distributive justice. Such differences are, clearly, both socially caused and not the responsibility of the low-status individuals.

> Structural inequality . . . consists in the relative constraints some people encounter in their freedom and material well-being as the cumulative effect of the possibilities of their social positions, as compared with others who in their social positions have more options or easier access to benefits. . . . Unlike the individualized attributes of native ability that often concern equality theorists, . . . structural inequalities are socially caused.[27]

Further, "individuals alone are not responsible for the way they are enabled or constrained by structural relations."[28]

On the issue of individual choice and responsibility, Young's analysis involves a non sequitur. The fact that some individuals are worse off than others by virtue of differing ranks in the social hierarchy is a *sufficient* condition for the worse-off individuals to lack responsibility for the inequality. But it is not a *necessary* condition. Individuals who have a high place in the social hierarchy — they are white, male, and have decent incomes — can surely suffer "brute luck" with respect to other determinants of well-being, for example by ingesting a toxin or being thrown from an automobile, and end up worse off than others through no fault of their own.[29]

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[25] *Id.* at 8.

[26] *Id.* at 16.

[27] *Id.* at 15 (emphasis omitted).

[28] *Id.* at 16.

[29] Much of the recent philosophical literature on equality has tried to articulate a conception of equality that is sensitive to individual responsibility — a concern triggered by Ronald Dworkin's famous work on equality of resources, which distinguishes between "brute luck" and "option luck." *See, e.g.*, Richard J. Arneson, *Welfare Should be the Currency of Justice*, 30 CAN. J. PHIL. 497 (2000) (citing Ronald Dworkin, *What is Equality? Part 1: Equality of Welfare*, 10 PHIL. & PUB. AFF. 189 (1981); Ronald Dworkin, *What is Equality? Part 2: Equality of Resources*, 10 PHIL. & PUB. AFF. 283 (1981); Ronald Dworkin, *What is Equality? Part 3: The Place of Liberty*, 73 IOWA L. REV. 1 (1987)).

The second aspect of Young's argument, one I cannot fully address here, involves the distinction between social and nonsocial causation.[30] If an asteroid containing extraterrestrial carcinogens strikes Missouri without warning, then the inequality between those Missourians who incur cancer as a result of the asteroid, and healthy residents of Missouri or the other forty-nine states, is not (it would seem) socially caused. Does that mean that society has no moral obligation to redress the inequality? Imagine that the bark of a rare tree turns out to be uniquely effective in combating the extraterrestrial toxins, and is also effective for some widespread, nonserious symptom (an annoying rash). Is the choice of how to use the bark *simply* a matter of overall well-being or efficiency?

A plausible answer is no. One might agree that (1) morally significant inequality involves an absence of responsibility on the part of the affected individuals; and that (2) the moral obligation to redress such inequality falls on governmental bodies and other powerful actors, rather than individuals who are powerless to redress it ("ought implies can"); without accepting the further proposition that (3) governmental bodies and other powerful actors lack a moral obligation to redress inequalities that are not socially caused. A different response to Young's argument is to accept this last proposition — to accept the moral importance of social causation — but also insist that social causation is present for most of the health and safety impacts that risk regulators address, even if it is not for the Missouri asteroid. For example, deaths to high-status individuals because of chemical toxins in a waste dump are not caused by the social hierarchy, or by the individuals' position in it, but these deaths are partly caused by a legal regime (a kind of social product) that permitted the establishment of the dump in the first place.

In sum, the environmental justice/social gradient account of risk equity is surely correct to insist that differences in well-being flowing from differences in social position are a major concern of distributive justice. Where the account goes awry is in suggesting that these differences are the *sole* concern of distributive justice. Differences between individuals who have the same social status can also be unfair — for example, differences in health or longevity among equal-status individuals. Environmental justice is therefore an incomplete conception of risk equity.

B. *"Individual Risk" Thresholds and Distributions*

An "individual risk" test measures the risk of fatality, disease, or injury imposed on some specified person by a hazard. Such tests are a key component of the regulation of carcinogens and radiation by U.S. agencies.[31] For example, EPA's criteria for mitigating the risks of abandoned waste sites

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[30] *See, e.g.*, Derek Parfit, *Equality or Priority?*, *in* THE IDEAL OF EQUALITY 81, 95-97 (Matthew Clayton & Andrew Williams eds., 2000) (discussing egalitarian views that do not object to natural inequality).

[31] *See* Adler, *Against "Individual Risk," supra* note 1, at 1149-79.

require that a clean-up occur if the incremental lifetime cancer risk to the person maximally at risk from a site exceeds 1 in 10,000, and that any clean-up bring that risk to within the range of 1 in 10,000 to 1 in 1 million.[32] FDA regulates carcinogens in food additives by refusing to license an additive which imposes an incremental lifetime cancer risk on the person consuming a large amount of the additive (specifically, the 90th percentile consumer) exceeding 1 in 1 million.[33] The Clean Air Act requires that EPA set pollution levels for carcinogenic pollutants by first using a technology-based approach and then considering a lower level if the incremental lifetime cancer risk to the maximally exposed individual exceeds 1 in 1 million.[34] OSHA will not intervene to reduce the levels of a toxin currently present in the workplace unless the incremental lifetime cancer risk to a worker exposed to the toxin for his entire working life exceeds (or at least is not too far below) 1 in 1,000.[35] One of the Nuclear Regulatory Commission's principal safety goals for structuring the licensure and regulation of nuclear plants has been that individuals living close to plants not incur an annual risk of dying in a reactor accident that exceeds 1 in 2 million.[36] Many similar examples could be provided.

Risk assessment scholars sometimes suggest that regulatory attention to "individual risk" levels is justified by equity considerations.[37] The current regime, as just described, typically incorporates "individual risk" *thresholds*. These require or preclude regulation, or require further regulatory deliberation, depending on whether the "individual risk" of some person in the exposure distribution is above or below a numerical cut-off such as 1 in 1,000, 1 in 10,000, or 1 in 1 million. A different sort of regime might attempt to *equalize* "individual risk" levels. We might characterize the distribution of individual fatality risks imposed by a toxic hazard, and apply an inequality metric to that distribution. A large literature in economics seeks to measure the inequality of income, using metrics such as the Gini coefficient, the coefficient of variation, the Theil index, or the Atkinson index.[38] A "distributional" variant of the "individual risk" conception of risk equity

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[32] *See id.* at 1155-58.

[33] More precisely, FDA takes this approach for carcinogens exempt from the Delaney Clause. *See id.* at 1164-69.

[34] *See id.* at 1150-52.

[35] *See id.* at 1169-71.

[36] *See id.* at 1173-78.

[37] *See, e.g.*, Adam M. Finkel, *Comparing Risks Thoughtfully*, 7 RISK: HEALTH, SAFETY & ENV'T 325, 342-44 (1996); John D. Graham, *Making Sense of Risk: An Agenda for Congress*, *in* RISKS, COSTS, AND LIVES SAVED 183, 190-91 (Robert W. Hahn ed., 1996). *See also* Matthew D. Adler, *Risk, Death and Harm: The Normative Foundations of Risk Regulation*, 87 MINN. L. REV. 1293, 1423-31 (2003) (discussing environmental-justice account that attends to skews with respect to "individual risk" levels).

[38] For overviews of the literature on measuring the inequality of income, see HILDE BOJER, DISTRIBUTIONAL JUSTICE: THEORY AND MEASUREMENT 63-134 (2003); PETER LAMBERT, THE DISTRIBUTION AND REDISTRIBUTION OF INCOME 13-132 (3d ed. 2001); AMARTYA SEN, ON ECONOMIC INEQUALITY 24-46 (expanded ed. 1997); F.A. Cowell, *Measurement of Inequality*, *in* 1 HANDBOOK OF INCOME DISTRIBUTION 87 (A.B. Atkinson & F. Bourguignon eds., 2000). As I explain in Part II of the Article, my position is that risk regulation policies should be evaluated

could apply some such inequality metric to the distribution of "individual risk."[39]

There are serious difficulties with the "individual risk" conception of risk equity, whether in the threshold form or in the distributional form. To begin, the "individual risk" levels that currently figure in regulatory decisionmaking are *incremental* fatality risks.[40] EPA, in cleaning up waste dumps, is concerned with the risk to nearby residents of dying *as a result of carcinogens in the dump.* FDA, in licensing toxic food additives, is concerned with the risk to consumers of dying *as a result of carcinogens in their food.* The incremental fatality risk to person *P* from toxins of type *X* during period *T* (a year, a lifetime) is the probability that *X*-type toxins cause *P*'s death during *T* — or some such construct.[41] *X*-type toxins could be all toxins in a particular dump, air pollutants from a particular industrial category, a particular food additive or additives generally, and so forth.

Incremental fatality risks are the wrong currency for risk equity. This is true whether or not the appropriate time-slice for distributive justice is a whole lifetime or a temporal fraction of a lifetime. My own view is a whole-lifetime view, and that view will provide part of the philosophical foundation for PPPA.[42] On the whole-lifetime view, the difficulty with incremental fatality risk tests is that *P*'s incremental risk from *X*-type toxins during any period, even a whole lifetime, may have very little connection to *P*'s total lifetime risk package. For example, the individual maximally exposed to a

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with reference to an Atkinsonian social welfare function, which can in turn be decomposed into an Atkinsonian measure of inequality and overall welfare. *See infra* Part II.C.

[39] Shortly before publication of this Article, I became aware of empirical work by Jonathan Levy and collaborators that does precisely this. See Jonathan I. Levy et al., *Quantifying the Efficiency and Equity Implications of Power Plant Air Pollution Control Strategies in the United States*, 115 ENVTL. HEALTH PERSP. 743 (2007). The approach (which the authors see as applicable to health as well as mortality risks) is also described in Jonathan I. Levy et al., *Incorporating Concepts of Inequality and Inequity into Health Benefits Analysis*, 5 INT'L J. EQUITY IN HEALTH 2 (2006). Although I argue for a different approach here, Levy and his collaborators are to be commended for analyzing the equity implications of air pollution policies in a rigorous and novel way, focusing on population-wide inequality rather than social gradients, and applying inequality metrics developed in the income-inequality literature to risk regulation.

[40] *See* W. Kip Viscusi, *Risk Equity, in* COST-BENEFIT ANALYSIS: LEGAL, ECONOMIC, AND PHILOSOPHICAL PERSPECTIVES 7, 25-31 (Matthew D. Adler & Eric A. Posner eds., 2001) (criticizing conception of risk equity that focuses on incremental risk).

[41] There are different ways to define the incremental fatality risk to person *P* from toxins of type *X* during period *T*: (1) the risk that *X*-type toxins cause *P*'s death during *T*; (2) the difference in the risk that *P* dies during *T*, conditional on his exposure to *X*-type toxins, and the risk that *P* dies during *T*, conditional on non-exposure; and (3) the difference in the risk that *P* dies in the manner characteristic of deaths caused by *X*-type toxins (e.g., dies from cancer), conditional on his exposure to *X*-type toxins, and the risk that *P* dies in that manner conditional on non-exposure. If *T* is less than a full lifetime, all three definitions are possibilities. If *T* is a full lifetime, the first and third are. My critique of an approach to risk equity that focuses on incremental fatality risks does not depend on which precise definition of incremental risk is adopted.

[42] *See* Matthew D. Adler, *Well-Being, Inequality, and Time: The Time-Slice Problem and its Policy Implications* (Univ. of Pa. Inst. for Law & Econ., Research Paper No. 07-17, 2007), *available at* http://ssrn.com/abstract=1006871; *see also infra* text accompanying note 82.

dump, a particular kind of air pollution, a food additive, a radiation source, or a workplace carcinogen may have a low lifetime risk of dying from cancer or a high life expectancy, even though his incremental risk from the dump, air pollution, etc. is above a stipulated threshold or higher than the incremental risks imposed on others in the population.

But even if we shift to a sublifetime account of distributive justice — for example, a view which tries to equalize how individuals fare during each year — there clearly can be slippage between an individual's total risk package during the sublifetime and his incremental sublifetime fatality risk from a particular source. *P*'s risk of dying during a given year could be low even though his risk of dying during the year as a result of exposure to *X*-type toxins is above a stipulated threshold, or high relative to the risk of dying from *X*-type toxins suffered by the rest of the population.

This problematic, incrementalist feature of the "individual risk" conception of equity could be cured by construing the category of *X*-type toxins very expansively, to encompass all carcinogens or all toxins to which individuals might be exposed from any source (rather than toxins in a given dump, air pollution from a particular industrial category, a particular food additive, or a particular workplace toxin). "Individual risk," thus construed, would come closer to focusing on an individual's total sublifetime or lifetime risk package. But two difficulties would remain with the "individual risk" approach.

First, "individual risks" are fatality risks. They ignore other important and measurable components of individual well-being, in particular income and health. Consider a test for risk equity which looks at how a policy intervention changes the distribution of life expectancy or the distribution of the chance of dying within the coming year, within the population generally or in particular age cohorts. These approaches are appropriately holistic rather than incremental with respect to the sources of fatality. Yet they remain problematic in presupposing that an individual's redistributive claim is just a function of his longevity. Individuals with chronic non-fatal diseases, or low but above-subsistence incomes, can have comparatively high life expectancies or low probabilities of dying in the next year, but poor prospects for annual or lifetime well-being, all things considered. An overweight and physically inactive high-income white male in his 50s can have a relatively short life expectancy but relatively high expected lifetime well-being.

Second, a conception of equity that focuses on the "individual risk" of fatality from particular sources, or overall, adopts an *ex ante* rather than *ex post* approach to equity. Chris Sanchirico and I have argued at length elsewhere for an *ex post* conception of egalitarianism under uncertainty.[43] The basic idea is this; given some component *Z* of individual well-being or advantage (which might be income, health, longevity, or utility as a function of all three), plus some measure *M* of equality, plus uncertainty about individ-

[43] *See* Matthew D. Adler & Chris William Sanchirico, *Inequality and Uncertainty: Theory and Legal Applications*, 155 U. PA. L. REV. 279 (2006).

ual attainments with respect to Z, we might (1) apply *M* to individual expectations with respect to Z; or instead (2) determine the expectation of *M*, applied to individuals' actual attainments with respect to Z. Formally, if Z_i is a random variable representing the attainment of individual *i* with respect to Z, and there are *N* individuals, and E(.) is the expected value, we might (1) calculate $M(\mathbf{E}(Z_1), \mathbf{E}(Z_2), \ldots, \mathbf{E}(Z_N))$ or instead (2) calculate $\mathbf{E}(M(Z_1, Z_2, \ldots, Z_N))$. The first approach is the *ex ante* approach, while the second is the *ex post* approach.

To see how the "individual risk" approach to equity involves an *ex ante* conception of equality under uncertainty, and to understand how this difficulty is distinct from the problem of incrementalism versus holism, let us consider an appropriately holistic version of the "individual risk" approach — for example, measuring the distribution of the chance of dying within the coming year within an age cohort.[44] *Z* is then an indicator variable which takes the value 1 if the individual dies within the following year and 0 if she does not. Assume that *M* is the coefficient of variation, i.e., the standard deviation divided by the mean — a very standard measure of inequality. Then the "individual risk" approach determines whether a policy improves equity by comparing the coefficient of variation of $(\mathbf{E}(Z_1), \mathbf{E}(Z_2), \ldots, \mathbf{E}(Z_N))$ in the status quo and given the policy, where $\mathbf{E}(Z_i)$ is individual *i*'s chance of dying in the following year. The problem here is that a policy can reduce the coefficient of variation of $(\mathbf{E}(Z_1), \mathbf{E}(Z_2), \ldots, \mathbf{E}(Z_N))$, but leave unchanged or increase the expected coefficient of variation, that is, $\mathbf{E}(M(Z_1, \ldots, Z_N))$. If, for example, the policy does not change the number of individuals who die in the following year in any given state of the world, but simply shifts around the identity of those individuals, $M(\mathbf{E}(Z_1), \mathbf{E}(Z_2), \ldots, \mathbf{E}(Z_N))$ may decrease, but $\mathbf{E}(M(Z_1, \ldots, Z_N))$ will stay the same. A similar deviation between *ex ante* and *ex post* approaches characterizes other standard inequality metrics, such as the Gini coefficient, the Theil index, or the Atkinson index, and indeed any metric *M* which is not just a linear function of the Z_i.[45]

The argument for the *ex post* approach to the measurement of equality under uncertainty hinges on the "sure thing" principle, which many theorists take to be a compelling principle of both individual and social rationality. The argument also appeals to a principle of dynamically consistent choice. I will not try to summarize the argument for the *ex post* approach here, but refer the reader to my work with Sanchirico.[46] If one accepts the argument, an "individual risk" conception of equity is inexorably flawed — not only

[44] This particular variant of the "individual risk" approach is chosen simply for the sake of illustration. Other holistic variants of the "individual risk" approach also involve an *ex ante* conception of equality under uncertainty — for example, measuring the distribution of the risk of death during some time period other than a year, or measuring the distribution of the lifetime risk of death in a particular manner (e.g., cancer), or measuring the distribution of life expectancy.

[45] *See* Adler & Sanchrico, *supra* note 43, at 304-34.

[46] *See id.* at 334-50.

in its incrementalist versions, but also in more "holistic" versions that consider a wider range of causes of death.

C. *QALY-Based Equity Analysis*

The QALY (quality adjusted life year) approach to health policy decisionmaking employs a single measure of health that incorporates both morbidity and longevity. Surveys are used to rank health states on a zero-to-one scale, with 1 corresponding to perfect health and 0 corresponding to death. The QALY value of an individual's health history during some stretch of time or over a lifetime can then be calculated as

$$\sum_{t=1}^{T} l(h_{i,t}),$$

where $l(h_{i,t})$ is the quality of individual i's health in period t on a zero-to-one scale.[47] Policy-analytic tools that incorporate QALYs are widely used in the literature on health economics and by governments abroad, and have garnered increasing interest in the United States, particularly at the FDA. QALY-based analysis often takes the form of cost-effectiveness analysis, but can also take other forms.[48]

Health economists, particularly in Britain, have discussed at length the possibility of inequality measures, or distributively-sensitive policy-analytic tools, that make use of QALYs.[49] One suggestion is to apply the Gini coefficient, coefficient of variation, Theil index, Atkinson index, or some other inequality metric to the population distribution of expected QALYs.[50] Another is to evaluate policies by using an SWF that takes individuals' QALY levels, rather than income levels, as its arguments.[51] Yet another is to incorporate equity weights into QALY-based cost-effectiveness analysis.[52]

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[47] I use $l(h_{i,t})$ here, rather than $q(h_{i,t})$, as in the additive-across-periods/multiplicative-within-periods representation of lifetime utility as a function of health and income, *see infra* text accompanying notes 105-107, because it is an open question what the connection is between the l function, i.e., the zero-to-one scaling of health states elicited through QALY surveys, and the q function.

[48] *See generally* Matthew D. Adler, *QALYs and Policy Evaluation: A New Perspective*, 6 YALE J. HEALTH POL'Y L. & ETHICS 1, 1-16 (2006) (describing QALY metric, discussing current governmental use, and reviewing and citing scholarship).

[49] *See generally* Franco Sassi et al., *Equity and the Economic Evaluation of Healthcare*, 5 HEALTH TECH. ASSESSMENT 1, 16-28 (2001) (summarizing this literature).

[50] *See* Emmanuela Gakidou et al., *Defining and Measuring Health Inequality: An Approach Based on the Distribution of Health Expectancy*, 78 BULL. WORLD HEALTH ORG. 42 (2000).

[51] *See, e.g.*, Paul Dolan, *The Measurement of Individual Utility and Social Welfare*, 17 J. HEALTH ECON. 39 (1998); Lars Lindholm & Måns Rosén, *On the Measurement of the Nation's Equity Adjusted Health*, 7 HEALTH ECON. 621 (1998); Lars Peter Østerdal, *Axioms for Health Care Resource Allocation*, 24 J. HEALTH ECON. 679 (2005); Adam Wagstaff, *QALYs and the Equity-Efficiency Trade-Off*, 10 J. HEALTH ECON. 21, 35-38 (1991); Alan Williams, *Intergenerational Equity: An Exploration of the 'Fair Innings' Argument*, 6 HEALTH ECON. 117 (1997).

[52] *See* Sassi, *supra* note 49, at 19-21.

QALY-based equity analysis improves upon the deficiencies of the environmental justice and "individual risk" approaches. Unlike the environmental justice approach, it is not committed to a social-gradient conception of equity. Inter-individual differences in QALYs or expected QALYs can be counted as an inequality even if the individuals involved have the same social position. Unlike the "individual risk" approach, QALY-based equity analysis is sensitive to inequalities in health as well as longevity. Furthermore, unlike that approach, QALY-based equity analysis is not committed to an *ex ante* conception of egalitarianism under uncertainty. Many of the health economists who write about QALYs and equity do, in fact, adopt an *ex ante* conception;[53] but the basic construct of a QALY, as an integrated measure of health and longevity, is just as amenable to the *ex post* approach. If M is an inequality metric — for example, the Gini coefficient — and Z_i is a random variable representing an individual's lifetime QALYs, one could calculate $\mathbf{E}(M(Z_1, \ldots Z_N))$: the expected inequality of the distribution of lifetime QALYs, as calculated considering various possible states of the world and the Gini coefficient of the population distribution of QALYs in each state. The same is true, of course, for other inequality metrics.

However, QALY-based equity analysis is problematic because it overlooks inequalities arising from differences in income. It shares this flaw with the "individual risk" approach. Consider, first, the variant of QALY-based analysis just discussed: calculating the value of $\mathbf{E}(M(Z_1, \ldots Z_N))$ for the status quo and for policy alternatives, with M an inequality metric and Z_i a random variable representing individual i's lifetime QALYs. In this format, individuals are solely characterized in terms of their lifetime QALYs, which subsume their health and longevity but not their incomes. A policy might reduce the expected Gini coefficient of lifetime QALYs, but increase the expected Gini coefficient of lifetime income or of lifetime utility (defined as a function of health, longevity *and* income). A parallel critique applies to the proposal to use QALYs as arguments for a social welfare function.[54]

What about the proposal to incorporate equity weights in QALY-based cost-effectiveness analysis? QALY-based cost-effectiveness analysis evaluates policies by measuring health or longevity impacts in QALYs, and by measuring other impacts in dollars. Cutoff ratios are specified (such as $100,000 per QALY), and the decision rule is to implement a policy if its cost/QALY ratio is below the cutoff.[55] Normally, the QALY benefits of a policy are calculated by determining the expected increase in total QALYs.

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[53] *See, e.g.*, Gakidou et al., *supra* note 50, at 43-44; Magnus Johannesson, *Should We Aggregate Relative or Absolute Changes in QALYs?*, 10 HEALTH ECON. 573, 574-75 (2001); Williams, *supra* note 51, at 120-21.

[54] Namely, a policy might reduce the expected value of a given social welfare function taking individual lifetime QALYs as its arguments, but increase the expected value of that same social welfare function now taking individual utility as a function of individual longevity, health, and income as its arguments. This latter approach is just PPPA.

[55] More precisely, the decision rule compares the incremental cost-effectiveness of policies with cutoff ratios. *See* Adler, *supra* note 48, at 8-9, 85-88.

Equity weights would adjust this calculation by giving greater weight to QALY changes affecting those at a lower level of lifetime or sublifetime QALYs.

Income impacts are not completely ignored by this framework. The income-reduction effect of a policy will show up as dollar costs; *ceteris paribus*, a policy that produces a larger reduction in incomes will have a higher cost/QALY ratio. The difficulty, rather, is that the framework ignores inequalities in income. Imagine two policies which have identical health impacts and which also have the same aggregate monetary costs. In one case, those costs are borne by high-income individuals. In the other case, they are borne by low-income individuals. QALY based cost-effectiveness analysis, both in the traditional form and in the equity-weighted form, will not distinguish between the policies. The equity weights are a function of individual QALY levels and come into play in determining the denominator of the cost/QALY ratio for a policy; they are not a function of individual income levels and do not change the numerator of that ratio.

D. *Incidence Analysis*

The framework of "incidence analysis" characterizes taxes as progressive, regressive, or proportional, depending on whether the tax burden as a proportion of income increases, decreases, or remains the same as individual income increases.[56] Some scholarly work employing this framework has been undertaken in the area of risk regulation.[57] It has typically focused on the incidence of environmental taxes; but incidence analysis is also applicable to other sorts of policy measures, and indeed in a few cases has been undertaken for non-tax environmental measures, such as tradeable emissions permits. A non-tax measure that raises or lowers firms' costs of production will affect employee wages, shareholder incomes, and consumer surplus. The income equivalent of these changes can be calculated for representative members of different income groups (defined by annual or lifetime income),[58] and that burden as a fraction of the individual's total income can be calculated.

Incidence analysis in the environmental area has typically ignored health and longevity impacts. The burden of a tax or non-tax measure on a given individual has typically been understood as the income equivalent of the change in her tax payments, wages, consumer surplus, and/or profits received as a firm shareholder, excluding the benefits or costs resulting from a change in her fatality risk or health state. The flaw here is reciprocal to the flaw in QALY-based equity analysis. The equity impact of a risk regulation

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[56] *See* DON FULLERTON & DIANE LIM ROGERS, WHO BEARS THE LIFETIME TAX BURDEN? 1-17 (1993).

[57] *See generally* Ian W.H. Parry et al., *The Incidence of Pollution Control Policies* 10-19 (Resources for the Future, Discussion Paper 05-24, June 2005) (reviewing literature), *available at* http://www.rff.org/rff/Documents/RFF-DP-05-24.pdf.

[58] *See id.* at 5-6, 14.

is a function both of its impact on the distribution of income (which the QALY-based approaches ignore), and of its impact on the distribution of health and longevity (which incidence analysis, as just described, ignores).

This flaw is not an inevitable feature of incidence analysis. The analyst could characterize the total effect of an environmental measure on members of different income groups, including its effect on their health, longevity, wages, shareholder earnings, and any other measurable aspect of well-being. The income equivalent of that effect could then be determined. The measure could be characterized as progressive, regressive, or proportional depending on whether this *inclusive* burden as a proportion of income increases, decreases, or remains the same with increasing income.[59]

However, this inclusive template for incidence analysis remains problematic. One large problem is that the approach provides no guidance in balancing equity against the improvement of overall well-being. A measure may be regressive but still morally justified, all things considered, if the gain to overall welfare is sufficiently large. Second, although it seems feasible to make incidence analysis inclusive in measuring burdens (the "numerator" for determining progressivity/regresssivity), it is much less clear how incidence analysis would be rendered inclusive with respect to the "denominator" for incidence analysis. What if a measure creates burdens that increase as a fraction of incomes as individual incomes increase (thus is progressive using this denominator), but decrease as a fraction of lifetime QALYs as lifetime QALYs increase (thus is regressive using *this* denominator)? In this sort of case, the incidence analyst either uses income as the denominator (in which case the analysis overlooks the possibility that some individuals at a relatively high level of income are at a relatively lower level of well-being, given poor health or short longevity, or vice versa), or she uses something like utility as a function of health, longevity, and income as the denominator (in which case it is unclear why the analyst doesn't simply move beyond the incidence-analysis framework, and use utility numbers as inputs for an inequality metric[60] or PPPA).

E. *Inclusive Equality Measurement*

As already discussed, inequality metrics such as the Gini coefficient, coefficient of variation, Theil index, or Atkinson index might be used in the risk regulation domain.[61] One possibility is to measure the inequality of "individual risks"; another possibility is to measure the inequality of individuals' expected QALYs or (even better) the expected inequality of individuals' QALYs.

We have seen that these particular proposals are problematic because they ignore incomes. But inequality metrics are not necessarily focused on

[59] *See id.* at 25.
[60] *See infra* Part I.E.
[61] *See supra* text accompanying note 50.

health and longevity to the exclusion of incomes, or on incomes to the exclusion of health and longevity. An inclusive inequality-measurement tool sensitive to the distribution of health, longevity, and income could be developed using "utility functions" — a device elaborated below, in connection with PPPA.[62] The status quo and the policy could be seen as probability distributions across population profiles of individual utilities, where each individual's utility is in turn a function of her longevity, health, and income. We could calculate the expected Gini coefficient (for example) of individual utility, for both the status quo and the policy; if the policy has a lower value, it reduces expected inequality.

The inclusive inequality-measurement approach to risk equity, thus structured, would seem to be an improvement on the incidence-analysis approach. Unlike incidence analysis, it readily yields an overall verdict about the equality impact of policies whose fractional burdens move in one direction as individuals are made better off with respect to some dimensions of well-being (e.g., income), but a different direction as individuals are made better off with respect to other dimensions (e.g., health).

However, inclusive inequality measurement shares an important flaw with incidence analysis. Inequality metrics can tell us whether a proposed policy's distribution of individual well-being is more or less equal than the status quo distribution. Inequality metrics cannot tell us whether the policy is better or worse than the status quo, all things considered. They cannot yield a final verdict concerning the policy, given its impacts *both* on the distribution of well-being *and* on overall well-being. A policy analyst might find that cost-benefit analysis (a good proxy for overall well-being) favors the status quo, while the policy reduces the expected degree of inequality as measured by some inequality metric. Inequality metrics provide no guidance in making this sort of choice — in balancing distributive and aggregative concerns.[63]

By contrast, PPPA does provide the requisite guidance. PPPA subsumes both a concern for overall well-being and a concern for the equal distribution of well-being. At the same time, PPPA can provide exactly the sort of information provided by inequality metrics, if we find that information useful: namely how policies compare purely as a matter of equality. These points will be elaborated below.[64]

F. *Cost-Benefit Analysis with Distributive Weights*

Cost-benefit analysis ("CBA") compares a policy to the status quo by summing the monetary amounts that individuals who are benefited by the policy are willing to pay ("WTP") for it, and subtracting the amounts that

[62] *See infra* Part II.B.2.

[63] *See* Louis Kaplow, *Why Measure Inequality?* 5-6 (Harvard Law Sch. Olin Discussion Paper No. 386, 2002).

[64] *See infra* Part II.C.

individuals made worse off by the policy are willing to accept ("WTA") in return for it.[65] Economists have periodically suggested that cost-benefit analysis could be sensitized to equity by multiplying individual WTP/WTA amounts by a weighting factor that decreases with greater individual income.[66] Although this approach has not been adopted by U.S. governmental bodies, it has been adopted in Britain and, in the past, at the World Bank.[67]

At first blush, distributively-weighted CBA seems to provide a very attractive approach to risk equity. It takes a "population" rather than a social gradient approach: individuals with different incomes but identical social positions will receive different weights. It is inclusive with respect to the determinants of well-being: one can calculate individual WTP/WTA amounts, not merely for changes that directly affect income (such as changes in prices, wages, or earnings received as a firm shareholder), but also for changes in health and in longevity risks. Similarly, it is possible in principle to make the weighting factor for a given individual's WTP/WTA amounts a function of her health and longevity as well as her income. Finally, by contrast with incidence analysis and inequality measurement, distributively-weighted CBA provides guidance in balancing equity with overall welfare. The sum of weighted WTP/WTA amounts is meant to indicate whether, on balance, a policy should be pursued, given both distributive and aggregative considerations.

However, the proponents of distributively weighted CBA must confront a number of difficult issues involving the identification and application of weights. To begin, what determines the choice of weights? Consider the simplest sort of case, in which individuals are all healthy and long-lived, and differ only in their incomes. In the status quo, there are equal numbers of rich and poor individuals: the rich with annual incomes of $100,000, the poor with annual incomes of $20,000. A policy benefits the poor but makes the rich worse off. Each poor individual is WTP $250 for the policy, while each rich individual is WTA $300. From the perspective of unweighted CBA, the policy is a net social loss. From the perspective of weighted CBA, it will be a net social gain, if the weighting factor applied to poor individuals' WTP/WTA amounts is more than 6/5 (300/250) the weighting factor applied to rich individuals' WTP/WTA amounts. But should the ratio of the weighting factors be larger or smaller than 6/5?

Second, the straightforward procedure of assigning each individual a weight depending on her level of welfare-relevant characteristics in the status quo (her status quo income, health, longevity, etc.) must be revised for policy choices that involve large changes in some of those characteristics.

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[65] *See* ADLER & POSNER, *supra* note 1, at 1-5.

[66] *See* Olof Johansson-Stenman, *Distributional Weights in Cost-Benefit Analysis—Should We Forget About Them?*, 81 LAND ECON. 337 (2005).

[67] *See* H.M. TREASURY, THE GREEN BOOK: APPRAISAL AND EVALUATION IN CENTRAL GOVERNMENT 24-25, 91-96 (2003), *available at* http://www.hm-treasury.gov.uk/media/3/F/green_book_260907.pdf; Jean Drèze, *Distribution Matters in Cost-Benefit Analysis: Comment on K.A. Brekke*, 70 J. PUB. ECON. 485, 486 (1998).

Again, assume healthy and equally long-lived individuals and imagine that the status quo and the policy each, with certainty, produce a given distribution of annual income. In one case, the policy produces a small change in each individual's annual income; in the second case, it produces a large change in the annual income of some individuals.

"SMALL" POLICY

Individual	*Status Quo Income*	*Income with Policy*	WTP/WTA[68]
1	$100,000	$98,000	–$2,000
2	$100,000	$98,000	–$2,000
3	$ 20,000	$21,000	$1,000
4	$ 20,000	$21,000	$1,000

"LARGE" POLICY

Individual	*Status Quo Income*	*Income with Policy*	WTP/WTA
1	$100,000	$98,000	–$ 2,000
2	$100,000	$50,000	–$50,000
3	$ 20,000	$21,000	$ 1,000
4	$ 20,000	$70,000	$50,000

Assume that we have somehow developed a set of weights for WTP/WTA amounts as a function of annual income. The weight w_{100K} is the weight for an annual income of $100,000. In addition, assume (as seems plausible) that $w_{100K} \approx w_{98K}$, and that $w_{20K} \approx w_{21K}$. It is then straightforward to evaluate the small policy. The $2,000 annual losses of individuals 1 and 2 can be weighted by either w_{100K} or w_{98K} (which are approximately equal), and then subtracted from the $1,000 gains of individuals 3 and 4, weighted by either w_{20K} or w_{21K} (once more, approximately equal). But it is not straightforward to evaluate the large project. Should we weight individual 2's WTP/WTA amount ($50,000) by the weight for his annual income in the status quo, w_{100K}, or by the weight for his annual income in the policy outcome, w_{50K}? Similarly, should we weight individual 4's WTP/WTA amount (also

[68] These are the changes in annual income amounts in the policy outcome that make the individual indifferent between the status quo and the policy. Strictly speaking, these changes are not WTP/WTA amounts — since an individual's WTP/WTA is usually understood as a present, one-time payment sufficient to make her indifferent between the policy and the status quo. To calculate WTP/WTA amounts in this standard sense, we would need to know how long the individuals live and what the discount rate is. For simplicity, then, my example uses WTP/WTA defined as compensating changes to annual income. The point of the example — namely, that large changes in individual incomes pose difficulties for the specification of weights — is unaffected by the choice of annual versus one-time compensation measures.

\$50,000) by the weight for his annual income in the status quo, w_{20K}, or by the weight for his annual income in the policy outcome, w_{70K}?

A third and related problem concerns the application of weights under conditions of uncertainty. It is highly unrealistic to assume that the policymaker knows for sure which outcome would result from each choice available to her. More realistically, each choice leads to a probability distribution across outcomes rather than a particular, certain outcome. But then the problem of identifying a weight for each individual becomes yet thornier. With respect to income, for example, each choice leads to an array of state-dependent incomes for each individual. Even with a function from income levels to weights in hands, how are we to apply this function under conditions of uncertainty, given that neither the status quo nor the policy produces a single income level for any given individual?

In short, the proponent of distributively-weighted CBA needs a normative account of equality, sufficient to provide answers to these sorts of questions about the specification and application of weights. The only plausible such account which has been proposed in the literature on distributive weighting is the SWF account: distributive weights should be attached to WTP/WTA amounts so as to mimic the application of a social welfare function.[69]

Is it true that for any given SWF we can calculate WTP/WTA amounts and assign distributive weights so as to replicate the choices of the SWF? The answer is not obvious. Further, even if a particular SWF can be mimicked through weighted WTP/WTA amounts, it is far from clear why SWFs should be applied indirectly via the mediating device of weighted CBA, rather than directly. One argument for indirect application, that distributively-weighted CBA is a simpler procedure, is undercut by the above examples. For any given individual, her weighted WTP/WTA amount for a policy choice will be a function of the array of state-dependent determinants of well-being (income, health, longevity) that she would face if the policy were chosen, and the array of these state-dependent determinants that she would face if the status quo were chosen. This is just the information that the direct application of an SWF requires. Finally, even if weighted CBA does ultimately prove to be a simpler and more administrable decision procedure for incorporating equity, we should experiment with the direct application of SWFs, to help build the social knowledge base regarding the workings of SWFs that would be needed to develop a functioning system of weighted CBA.

A different difficulty, specifically relevant to distributively weighted CBA as a conception of risk equity, concerns the way in which CBA values longevity. In current practice, CBA translates longevity impacts into WTP/

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[69] *See* Johansson-Stenman, *supra* note 66, at 337-38, 340-42; Parry, *supra* note 57, at 26-29. *See also* Liqun Liu, *Combining Distributional Weights and the Marginal Cost of Funds: The Concept of Person-Specific Marginal Cost of Funds*, 34 PUB. FIN. REV. 60, 63-64 (2006) (discussing use of SWF to set the marginal cost of funds).

WTA amounts using the "value of statistical life" ("VSL") approach, which asks what individuals are willing to pay or accept for changes in their risk of premature death.[70] If social choice under uncertainty should follow the *ex post* rather than *ex ante* approach, then the VSL approach is problematic. There will be cases where CBA using the VSL approach will fail to track the judgments of any social welfare function applied in an *ex post* manner.[71]

The following example illustrates the point. In one case a population of N individuals is exposed to a toxin in the status quo. The individuals are identical, except that only one unknown individual is susceptible to the toxin and will die prematurely for sure if it is not eliminated. In the second case, a small subpopulation of L within this broader population is exposed to the toxin. In this second case, one unknown individual in the subpopulation is susceptible to the toxin and will die prematurely for sure if it is not eliminated. In each case, there is a policy to eliminate the toxin, with costs TC borne by T taxpayers who (for simplicity) are identical and external to the population of N individuals. Imagine that each individual's WTP not to be exposed to a 1-in-N risk of dying from the toxin is V and that each individual's WTP not to be exposed to a 1-in-L risk of dying from the toxin is V^*.

Unweighted CBA using the VSL approach will value the policy in the first case as $NV - TC$. It will value the policy in the second case as $LV^* - TC$. Since WTP is not proportional to the risk reduction for large risk reductions, these need not be the same amount and may indeed differ dramatically. (Imagine that N is 1 million and L is 5.) Weighted CBA, let us imagine, employs weights that are sensitive to individual income and expected longevity, and therefore has different weights for taxpayers (designate the weight for taxpayers as w^T), members of the population who are exposed to a 1-in-N risk of dying from the toxin (w^N), and members of the population who are exposed to a 1-in-L risk of dying from the toxin (w^L), with $w^L \geq w^N$.[72] So weighted CBA will value the first policy as $N \times w^N \times V - T \times w^T \times C$. Weighted CBA will value the second policy as $L \times w^L \times V^* - T \times w^T \times C$. Again, the two valuations can differ.

Because both unweighted and weighted CBA can give different valuations to the two policies, it is possible that both unweighted and weighted CBA will yield different choices in the two cases: favoring the policy in one case but the status quo in the other. But any social welfare function which is sensitive to distribution and is applied in an *ex post* manner will treat the two

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[70] *See* Adler, *Against "Individual Risk,"* *supra* note 1, at 1197-98, 1198 n.300.

[71] *See also* James K. Hammitt & Nicolas Treich, *Statistical Versus Identified Lives in Benefit-Cost Analysis*, 35 J. RISK & UNCERTAINTY 45 (2005) (showing that CBA, using the VSL method, may deviate from a utilitarian SWF that maximizes the sum of expected utilities because that method is sensitive to information about the distribution of individual fatality risks that the utilitarian SWF would ignore).

[72] I say that $w^L \geq w^N$ to accommodate both the possibility that the weights for the exposed individuals are determined by their attributes in the status quo (in which case $w^L > w^N$) and the possibility that those weights are determined by their attributes with the policy (in which case $w^L = w^N$). However these weights are set, weighted CBA can deviate from an SWF applied in an *ex post* manner.

cases as identical.[73] The *ex post* account of social choice under uncertainty views equity as a matter of the distribution of realized, not expected, well-being. Each status quo involves the same distribution of realized well-being: taxpayers reach a certain level, members of the population reach a different level, and the unfortunate individual who dies from the toxin yet a different level.[74] Each policy also produces the same distribution of realized well-being: now everyone in the population reaches the same level of well-being, and the taxpayers reach a different level.

In short, CBA using the VSL approach — even CBA incorporating distributive weights — is a less than fully accurate proxy for any distributively sensitive SWF applied in an *ex post* manner under uncertainty.

II. A New Approach: Probabilistic Population Profile Analysis

This Part describes in detail how equity considerations could be brought to bear on risk policy choices via a technique I call "probabilistic population profile analysis" ("PPPA").

PPPA represents one particular format for analyzing policy choices through the application of a social welfare function. Section A summarizes the philosophical basis for PPPA. Section B describes PPPA itself, and discusses its feasibility. Section C clarifies the connection between PPPA, equality measurement, and cost-benefit analysis.

A. *Social Welfare Functions and the Philosophical Basis for PPPA*

The SWF approach to distributive issues has been developed within theoretical welfare economics[75] and has been used in the optimal tax literature to study tax policies.[76] SWFs have also been used, in a few academic works, to evaluate environmental regulation.[77]

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[73] For that matter, a utilitarian SWF which is applied in an *ex post* or *ex ante* manner will treat the two cases as identical. From the *ex post* perspective, the two cases are identical; and a utilitarian SWF always reaches the same verdicts whether applied *ex post* or *ex ante*. *See* Adler and Sanchirico, *supra* note 43, at 307. Only a distributively-sensitive SWF applied in an *ex ante* manner might treat the two cases as different.

[74] To be sure, this is only true if the amount and distribution of *fear* in the two cases are the same. *See generally* Matthew D. Adler, *Fear Assessment: Cost-Benefit Analysis and the Pricing of Fear and Anxiety*, 79 Chi-Kent L. Rev. 977 (2004). The hypothetical should therefore be structured so that no individual experiences a different fear state in the status quo in the first case than in the second case, and so that no individual experiences a different fear state with the policy in the first case than in the second case. In particular, it might be assumed that the exposed populations in the two cases are unaware of their exposures.

[75] *See* Robin Boadway & Neil Bruce, Welfare Economics 137-69 (1984).

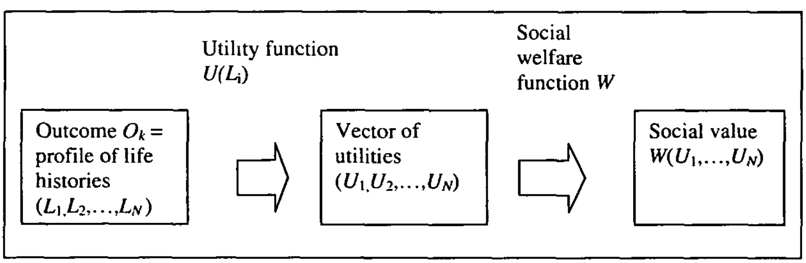
[76] *See* Matti Tuomala, Optimal Income Tax and Redistribution 1-14 (1990); Nicholas Stern, *The Theory of Optimal Commodity and Income Taxation: An Introduction*, *in* The Theory of Taxation for Developing Countries 22 (David Newberry & Nicholas Stern eds., 1987).

[77] *See* Parry et al., *supra* note 57, at 26-28. A recent article by Marc Fleurbaey addresses issues of health equity using the SWF framework. *See* Marc Fleurbaey, *Health Equity and Social Welfare*, 83/84 Annales d'Économie et de Statistique 21 (2006). Unfortunately, I

The approach is welfarist. It assumes that individual well-being is the sole morally relevant information about outcomes, and that principles of equality govern the distribution of well-being. This might be seen as a limitation of the approach. But "welfare" can be construed broadly, to encompass anything that improves the quality of an individual's life. More precisely, the welfare-enhancing or welfare-reducing features of a life might plausibly be understood as those features that individuals with full information and good deliberative conditions would converge in preferring or dispreferring. Individual well-being, on this ideal-preference account, arguably encompasses the quality of an individual's experiences, health states, intellectual life, practical accomplishments, relationships with friends and family, and standing and participation in the broader community.[78] To be sure, measuring all these items is a big challenge. But the crucial point to understand here is that the SWF framework is potentially inclusive with respect to the constituents of welfare.

The SWF approach employs a characteristic mathematical formalism to represent welfarist moral judgment. Each outcome[79] is mapped onto a vector of "utility numbers," representing each individual's well-being in that outcome. A given SWF is, in turn, a particular mathematical function that takes the utility vector for each outcome and assigns it a single number. That social welfare number represents how good or bad the outcome is, morally speaking, as compared to other outcomes.

THE SWF FRAMEWORK



In what way is the SWF framework sensitive to distributive concerns? A crucial point is that the set of possible social welfare functions includes not merely the utilitarian SWF, which simply adds up individual utilities, but

became aware of Fleurbaey's article as this Article was going to press and was not able to revise the Article to discuss how it bears on my analysis.

[78] *See* ADLER & POSNER, *supra* note 1, at 25-39; Matthew D. Adler, *Welfare Polls: A Synthesis*, 81 N.Y.U. L. REV. 1875, 1904-05, 1959-68 (2006).

[79] By "outcome," I mean a set of possible worlds that is homogenous with respect to each individual's well-being. A possible world is a completely specified possible history of the universe. A different definition of outcome is also conceivable: one might just define an outcome as a single possible world and conceptualize SWFs as operating on utility vectors corresponding to each possible world. But this definition unnecessarily inflates the number of outcomes, since every possible world within each set of possible worlds homogeneous with respect to each individual's well-being would have the same utility vector.

also a wide array of distributively sensitive or "equity regarding" SWFs. The formal expression of distributive sensitivity is the so-called "Pigou-Dalton" principle. This principle stipulates that shifting utility from someone at a higher utility level to someone at a lower level, without changing total utility, must increase the value of the SWF.[80]

THE PIGOU-DALTON PRINCIPLE

(1, 5, 10, 15) = utility vector for outcome O_k

Transfer of two units of utility from the third to the second individual, keeping total utility constant

(1, 7, 8, 15) = utility vector for outcome O_h

The Pigou-Dalton principle requires that the SWF, W, prefer O_h to O_k. Note that the utilitarian SWF ranks the two outcomes as equally good.

Anyone proposing to employ the SWF framework for policy choice must confront a number of basic philosophical issues. First, which distributively-sensitive SWF should drive the analysis? While there is only one utilitarian SWF, an infinite number of SWFs satisfy the Pigou-Dalton principle. The optimal-tax literature has focused on a particular family of distributively-sensitive SWFs, the "Atkinsonian" family. As I will elaborate below, this family of distributively sensitive SWFs indeed has attractive properties, and PPPA should principally draw on SWFs within this family. The rank-weighted SWF, a different sort of distributively sensitive SWF, might also be used.[81]

A second basic question involves the time slice. Is equality a matter of equalizing individuals' lifetime well-being, or rather of equalizing well-being during some temporal fraction of their lives, such as annual or momentary well-being? Formally, do the individual utility numbers upon which SWFs operate represent lifetime utilities or "sublifetime" utilities? I have argued at length elsewhere for the lifetime view and will not repeat those arguments here.[82]

A third question involves the application of SWFs under conditions of uncertainty. Absent uncertainty, each policy choice available to a decisionmaker corresponds to a particular vector of lifetime utilities: the particu-

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[80] *See* Adler & Sanchirico, *supra* note 43, at 296-304.
[81] *See infra* Part II.B.3.
[82] *See* Adler, *supra* note 42.

lar outcome that the choice would produce. Given uncertainty, each policy choice corresponds to a set of vectors of lifetime utilities: the set of possible outcomes that the choice might produce, each assigned a probability. Formally, each individual's lifetime utility is a random variable U_i, and an outcome is a realization of random variables U_1 through U_N, with N individuals in the population. The question then arises whether the social welfare function should be applied to a given choice in an *ex post* or *ex ante* manner. As mentioned, Chris Sanchirico and I have elsewhere defended the *ex post* approach.[83] If W is the social welfare function, and $\mathbb{E}$ is the expectation operator, the *ex post* approach is to calculate $\mathbb{E}(W(U_1, \ldots, U_N))$ for each choice, while the *ex ante* approach is to apply the social welfare function to the vector of expected utilities associated with each choice, i.e., to calculate $W(\mathbb{E}(U_1), \mathbb{E}(U_2), \ldots, \mathbb{E}(U_N))$ for each choice.

Ex Ante Versus _Ex Post_ Application of an SWF: An Example

W = the sum of the square root of individual utilities. There are 2 individuals in the population, Jim and June. A policymaker is choosing between the status quo (which has two equiprobable outcomes, A and B), and a policy (which also has two equiprobable outcomes, C and D). The numbers in the tables are the individuals' utilities in each possible outcome.

	STATUS QUO			POLICY		
	Outcome			Outcome		
	A	B		C	D	
	p=.5	p=.5		p=.5	p=.5	
Jim	4	9	Jim's expected utility = 6.5	3.5	3.5	Jim's exp. utility = 3.5
June	0	4	June's expected utility = 2	3.5	3.5	June's exp. utility = 3.5
	W(A)=2	W(B)=5		W(C)=W(D)=3.74		
	($\sqrt{4}+\sqrt{0}$)	($\sqrt{9}+\sqrt{4}$)		($\sqrt{3.5}+\sqrt{3.5}$)		

W applied *ex ante* to the status quo: $\sqrt{6.5}+\sqrt{2}=3.96$

W applied *ex post* to the status quo: $2\times.5+5\times.5=3.5$

W applied *ex ante* to the policy: $\sqrt{3.5}+\sqrt{3.5}=3.74$

W applied *ex post* to the policy: $3.74\times.5+3.74\times.5=3.74$

Note that if W is applied in an *ex ante* manner, the status quo is favored over the policy: $3.96 > 3.74$. However, if W is applied in an *ex post* manner, the policy is favored over the status quo: $3.5 < 3.74$.

B. PPPA, Step by Step

PPPA represents a concrete attempt to operationalize the SWF framework described in Section A: namely, one that employs an equity-regarding SWF which is applied to lifetime utilities, and which is applied in an *ex post* rather than *ex ante* manner.

PPPA begins by specifying a population of interest. This might be limited to U.S. citizens who are currently alive, or it might include other individuals, such as foreign citizens or future or past generations. For simplicity, I will focus on the case in which the population of interest comprises current

[83] *See* Adler & Sanchirico, *supra* note 43.

U.S. citizens. In that case, there are $N \approx 300$ million individuals in the population, and the same N exist in all possible outcomes.[84]

Each individual i has different possible life histories. Each possible outcome O_k is a possible combination or "population profile" of life histories, one for each of the N individuals. If there are K such possible combinations, then there are K possible outcomes $\{O_1, \ldots, O_K\}$. Each outcome has the form $(L_1, L_2, \ldots, L_N)$, where L_1 is a possible life history for individual 1, L_2 a possible life history for individual 2, and so forth. Let us say that $L_{i,k}$ is the particular life history that individual i lives in outcome O_k.

Each possible life history $L_{i,k}$ is a description of certain welfare-relevant facts about individual i's life. What facts exactly? I propose that each $L_{i,k}$ include those facts about individual i that are readily measurable given current available metrics. In particular, at least for purposes of analyzing the equity implications of risk policy, $L_{i,k}$ should include all the various facts highlighted by the different literatures on risk equity described in Part I: health, longevity, income, and perhaps readily measurable markers of social position (paradigmatically, race and gender). The QALY and "individual risk" literatures underscore the measurability of impacts on health and longevity, and the importance of health and longevity for individual well-being. The incidence-analysis literature underscores the measurability of income impacts, and the importance of income for individual well-being. Finally, as regards the literature on environmental justice, one can reject the social-gradient approach but preserve the insight that social position can impair individual flourishing.

In short, $L_{i,k}$ consists of the following sorts of facts.

— The life-span of individual i in outcome O_k

— The income of individual i during each period she is alive in outcome O_k

— The health state of individual i during each period she is alive in outcome O_k

— Measurable markers of individual i's social position (such as race and gender)

This template for $L_{i,k}$ is not meant to be rigid. To begin, there are important constituents of well-being, such as the individual's experiential states (happiness), relationships with friends and family, or accomplishments at work or in the community, that are not included on the list because they are more difficult to measure with current metrics.[85] Reciprocally, income is not

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[84] Variable-population issues pose a difficult set of problems for social choice theory which I will not attempt to engage here. *See generally* CHARLES BLACKORBY ET AL., POPULATION ISSUES IN SOCIAL CHOICE THEORY, WELFARE ECONOMICS, AND ETHICS (2005). Extending PPPA to the variable-population case is a topic for further research.

[85] To be sure, there is a burgeoning literature on the measurement of happiness, but I take it that data on the current population distribution of happiness, and on how policies perturb that, is still thinner than data on health and income. In any event, as mentioned immediately below, PPPA certainly could be modified to incorporate happiness data and have lifetime utilities be partly determined by happiness. Crucially, however, happiness is not the sole component of well-being. For citations to the happiness literature and a discussion of the connection

a direct constituent of well-being but is on the list. Income is a "resource" or "primary good" that allows individuals to advance their well-being in various ways, and income measurement techniques are very well developed. Different variants of PPPA might replace income with consumption or omit both income and consumption and conceptualize each life history as a set of facts concerning the individual's longevity, health, experiential life, social position, friendships and family relationships, and the other attributes of human lives that are directly constitutive of well-being. However, the longevity-health-income-social position characterization seems more tractable for now.

The construct of a population profile is one of the key building blocks of PPPA. Another is a utility function, U, that maps each individual $L_{i,k}$ onto a lifetime utility number $U(L_{i,k})$. The final one is a social welfare function W that maps a vector of N lifetime utilities onto a single "social welfare" number.

Using these building blocks, PPPA proceeds as follows. (1) A policy choice situation, consisting of the status quo choice of inaction plus at least one alternative, is given exogenously.[86] (2) Each available policy choice corresponds to a probabilistic population profile, that is, to a probability distribution across population profiles. In other words, if $\{O_1, \ldots, O_K\}$ is the set of all possible outcomes, i.e., all possible population profiles, then each choice corresponds to a probability distribution across these outcomes. Risk assessment techniques and techniques for estimating the income impact of policy choices are used to determine which probabilistic population profile corresponds to a given choice. (3) The utility function U is used to transform each possible population profile O_k of individual longevity-health-income-social position histories, $O_k = (L_{1,k}, L_{2,k}, \ldots, L_{N,k})$, into an N-entry vector of lifetime utilities, one for each individual in the population. Each choice therefore becomes a probability distribution across lifetime utility vectors. (4) The social welfare function W is applied to each choice — characterized as a probability distribution across lifetime utility vectors — in an *ex post* manner. The choice with the greatest expected W-value is that choice which is best, on balance, given both equity concerns and concerns about overall well-being.

Even if this approach is philosophically well-grounded, is it truly feasible? I will discuss the various steps of the approach in turn.

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between happiness and well-being, see Matthew D. Adler & Eric A. Posner, *Happiness Research and Cost-Benefit Analysis* (Univ. of Pa. Inst. for Law & Econ., Research Paper No. 07-15, 2007), *available at* http://ssrn.com/abstract=999928.

[86] Our best-developed policy-analytic tools, such as CBA, provide rigorous guidance in choosing among a given set of options, not in identifying the initial choice set. *See* Matthew D. Adler, *Rational Choice, Rational Agenda-Setting, and Constitutional Law: Does the Constitution Require Basic or Strengthened Public Rationality?*, *in* LINKING POLITICS AND LAW 109, 113-14 (Christoph Engel & Adrienne Héritier eds., 2003). PPPA is similar to CBA in this regard.

1. *The Predictive Step: Mapping Choices onto Probabilistic Population Profiles*

PPPA characterizes each choice as a probability distribution or lottery across population profiles, where each profile or outcome has the form $O_k = (L_{1,k}, L_{2,k}, \ldots, L_{N,k})$ and each $L_{i,k}$ includes information about individual *i*'s lifespan, her health states in all the periods in which she is alive, her income in all the periods in which she is alive, and her measurable social position. For simplicity, I will assume that the relevant periods are years.

One aspect of this task is characterizing the effect of policy choices on each individual's possible income sequences over her lifetime. That task would presumably involve general equilibrium modeling. We have a model of the economy in the status quo, with some random elements, producing a probability distribution across population profiles. Each profile has information about each of the *N* individuals' wages, capital income, and perhaps other sources of earnings, in each period. A policy intervention perturbs this model in some way, leading to a different distribution of incomes.

General-equilibrium modeling is an established technique,[87] and a substantial number of studies have been undertaken that employ such models in the environmental context: to characterize the incidence of policies' burdens on different groups; to determine whether policies have net costs or benefits; and, in a few cases, to evaluate environmental policies with reference to an SWF.[88] Most relevant for my purposes, here, is the fact that general equilibrium models have been used to estimate the effect of policies on the distribution of lifetime incomes. A particularly thorough and impressive example is work by Fullerton and Rogers, who engage in modeling to characterize the progressivity of various taxes with respect to lifetime income. As they summarize their approach:

> [W]e build a general equilibrium simulation that encompasses all major U.S. taxes, many industries, both corporate and noncorporate sectors within each industry, and consumers identified by both age and lifetime income. It is not a model of annual decisionmaking, but a life-cycle model in which each individual receives a particular inheritance, a set of tax rules, a wage profile, and a transfer profile. Each then plans an entire lifetime of labor supply, savings, goods demands, and bequests. We also look at each industry's use of labor, capital, and intermediate inputs. We can then simulate the effects of a tax change on each economic decision through time. We calculate new labor supplies, savings, capital stocks, outputs, and prices. . . .

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[87] *See* EPA, GUIDELINES FOR PREPARING ECONOMIC ANALYSES 126-30 (2000).

[88] *See id.*; Parry, *supra* note 57; Klaus Conrad, *Computable General Equilibrium Models in Environmental and Resource Economics*, *in* THE INTERNATIONAL YEARBOOK OF ENVIRONMENTAL AND RESOURCE ECONOMICS 2002/2003 66, 66 (Tom Tietenberg & Henk Folmer eds., 2002).

> . . . [W]e evaluate the effects of each U.S. tax by comparing its estimated burdens with those of a proportional tax . . . . In our lifetime framework, a progressive tax is one in which the lifetime tax burden as a fraction of lifetime income rises as lifetime income rises, and a regressive tax is one in which the lifetime tax burden as a fraction of lifetime income falls as lifetime income [rises].[89]

Fullerton and Rogers are engaged in lifetime-income incidence analysis, while I am advocating a different approach to equity analysis, namely PPPA. What their work demonstrates, for my purposes, is that the kinds of models and techniques that would be required to estimate population profiles of individual income sequences, and changes in such profiles caused by policies, are already in use.[90]

What about the health and longevity characteristics of individual life histories? Describing the health and longevity characteristics of a given population, such as the U.S. citizenry, is already the focus of a large amount of work by public health scholars and organizations.[91] Describing the change in status quo morbidity and premature mortality that would result from policies falls under the rubric of risk assessment — also a large area of existing work.[92]

Of course, neither population health characterization, nor risk assessment, currently focuses on the particular sort of information required by PPPA — namely, a probability distribution across population profiles. Ignoring lifetime-income information for the moment, PPPA would presumably work along something like the following lines. Existing population data would be used to calibrate a lifetime health-and-longevity model for the N individuals in the population. The model would assign an annual probability of both death and morbidity (perhaps summarized in a QALY value) to each individual. These probabilities could be a function not only of the individual's age but also of other characteristics. Running the N models once would produce a particular population health-and-longevity profile. Doing this repeatedly would produce a probability distribution across population health-and-longevity profiles for the status quo. A policy's effect consists in *changing* mortality and/or morbidity probabilities for some individuals in some years. Running the altered N models repeatedly would produce a probabilistic population health-and-longevity profile associated with the policy.

The approach to generating probabilistic population health-and-longevity profiles just described, although certainly not a standard format for public

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[89] FULLERTON & ROGERS, *supra* note 56, at 4-5.

[90] Another example of the use of simulation models to estimate policy effects on lifetime incomes is Jan H.M. Nelissen, *Annual Versus Lifetime Income Redistribution by Social Security*, 68 J. PUB. ECON. 223 (1998). Further examples are discussed *id.* at 224-25.

[91] *See generally* SUMMARY MEASURES OF POPULATION HEALTH (Christopher J.L. Murray et al. eds., 2002).

[92] *See generally* sources cited *supra* note 1.

health work, is surely feasible with existing tools.[93] Microsimulation models that model lifetime histories of an entire population are already in use, particularly in evaluating the impacts of tobacco and cancer policy.[94] For example, Tammy Tengs and co-authors estimated the total change in QALYs that would result over 50 years from federal policy requiring safer cigarettes, by using the Tobacco Policy Model.

> The Tobacco Policy Model is a flexible system dynamics computer simulation model . . . [that is] designed to calculate the public health gains or losses from any change in the hazards or patterns of cigarette use.
>
> To start the present simulation, we initialized the model with the number of people in the U.S. population in the year 2003. We divided the population into cohorts according to gender, initial age . . . and smoking status (current, former, or never smoker). . . . The model then simulates annual transitions such as birth, death, aging, net migration, and changes in smoking behavior in the U.S. population over 50 years with transition probabilities varying by age, gender, smoking status, and year.
>
> . . . .
>
> In our model, gains or losses in an individual's health are measured with quality-adjusted-life-years (QALYs). . . . Quality of life data for current, former, and never smokers of various ages and genders were obtained from [survey data]. We estimated mortality hazard functions using mortality data for each gender . . . and smoking status . . . .[95]

A bigger challenge for PPPA is integrating the income and health-and-longevity elements. Imagine that, using a general equilibrium model, we have generated a baseline probability distribution across population profiles each consisting of an income history for each of the *N* individuals in the population and a perturbation in that distribution occasioned by the policy. Similarly, using risk assessment techniques and information about population health, we have generated a baseline probability distribution across population profiles each consisting of a health-and-longevity history for each of the *N* individuals in the population and a perturbation in that distribution

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[93] *See* Michael Wolfson & Geoff Rowe, *On Measuring Inequalities in Health*, 79 BULL. WORLD HEALTH ORG. 553, 557-58 (2001) (describing use of microsimulation modeling to estimate population health inequality and stating that existing modeling methods are "more than adequate").

[94] On tobacco policy, see, for example, Sajjad Ahmad & John Billimek, *Estimating the Health Impacts of Tobacco Harm Reduction Policies: A Simulation Modeling Approach*, 25 RISK ANAL. 801 (2005); Tammy O. Tengs et al., *Federal Policy Mandating Safer Cigarettes: A Hypothetical Simulation of the Anticipated Population Health Gains or Losses*, 23 J. POL'Y ANAL. & MGMT. 857 (2004) and sources cited therein. On cancer policy, see David Fone et al., *Systematic Review of the Use and Value of Computer Simulation Modelling in Population Health and Health Care Delivery*, 25 J. PUB. HEALTH MED. 325, 332 (2003).

[95] Tengs et al., *supra* note 94, at 860.

occasioned by the policy. How do we synthesize this information to produce the requisite characterization of the status quo and the policy as probability distributions over profiles that contain information both about each individual's health/longevity and about her income?

The simplest approach would be to assume that the income and the health/longevity components of population profiles occur independently. In other words, the probability of a given combined profile, with information both about each individual's income and about each individual's health and longevity, is simply the product of the probabilities of the constituent income profile and health/longevity profile. This approach is very crude, of course, because morbidity (and mortality!) will change an individual's income. The practice of PPPA might commence using this approach; but certainly techniques should be developed to incorporate interactions between morbidity/mortality and income in predicting individual longevity-health-income histories and population profiles of these histories. Existing work on health equity in the "social gradient" tradition may be helpful here. Much of this work documents correlations between income and health/longevity[96] and could well be helpful in calibrating sophisticated composite life-cycle models that include both characteristics.

I have discussed techniques for characterizing population profiles with respect to individual health, longevity and income. Adding information about measurable social position, such as race and gender, should not pose a large challenge. Sophisticated models that estimate individual longevity-health-income histories might already include race and gender as one predictor of these attributes.[97] In any event, there is much existing information about the correlation of race and gender with income, health and longevity.[98]

2. *The Well-Being Step: Identifying a Utility Function*

PPPA requires a utility function U that maps each possible individual life history $L_{i,k}$ onto a lifetime utility number, thereby converting a population profile of life histories $O_k = (L_{1,k}, L_{2,k},...,L_{N,k})$ into a vector of lifetime utilities $(U(L_{1,k}),U(L_{2,k}),...,U(L_{N,k})) = (U_{1,k}, U_{2,k},...,U_{N,k})$. Where does this utility function come from? Let us place to one side, for the moment, the difficult and controversial problem of incorporating measurable social position in

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[96] *See, e.g.*, Tony Blakely & Nick Wilson, *Shifting Dollars, Saving Lives: What Might Happen to Mortality Rates, and Socio-Economic Inequalities in Mortality Rates, if Income Was Redistibuted?*, 62 Soc. Sci. Med. 2024, 2024-25 (2006); Braveman, *supra* note 19, at 169-70, 172; Ulf-G. Gerdtham & Magnus Johannesson, *Income-Related Inequality in Life-Years and Quality-Adjusted Life-Years*, 19 J. Health Econ. 1007, 1007-08 (2000). *See also* Angus Deaton, *Health, Inequality, and Economic Development*, 41 J. Econ. Lit. 113, 113-14 (2003) (discussing literature concerning connection between income inequality and health).

[97] For example, the Tobacco Policy Model described above uses gender as one predictor of annual transitions. *See* Tengs et al., *supra* note 94, at 860.

[98] *See, e.g.*, Braveman, *supra* note 19, at 170-72; Peter Franks et al., *The Burden of Disease Associated with Being African-American in the United States and the Contribution of Socio-Economic Status*, 62 Soc. Sci. & Med. 2469, 2469-70 (2006).

the determination of utility. Consider the problem of specifying a utility function that assigns a lifetime utility number to each $L_{i,k}$ as a function of its income, health, and longevity attributes.

The best approach to specifying that function would involve surveys, where randomly selected members of the general public are placed in a favorable informational and deliberative state and are asked to rank different hypothetical longevity-health-income histories, and perhaps lotteries over these histories, with respect to well-being. Utility numbers, in turn, would be the numbers (unique up to some transformation) that represent respondents' well-informed preferences over the histories and lotteries. In previous work, I have discussed the use of utility surveys as a way to generate utility numbers that could improve the practice of CBA.[99] Here, I propose utility surveys as a way to generate the numbers that equity analysis would require.

Estimating utilities based on surveys inquiring about lifetime health-and-income histories is a less utopian enterprise than it may seem. Surveys are already widely employed to elicit information about individual well-being that is useful for policy analysis.[100] The three chief examples are "contingent valuation" surveys, which ask individuals about their WTP/WTA amounts for different policies; happiness surveys, which ask individuals to quantify their happiness or their satisfaction with their lives; and QALY surveys, which ask individuals to measure the quality of health states on a zero-to-one scale. The lifetime-health-and-income survey contemplated here is roughly analogous to a QALY survey, with two crucial differences. First, individuals should be asked to rank temporally extended histories rather than particular health states (which is what the QALY method focuses on). Second, individuals should be asked to rank histories that encompass both income and longevity/health.

Neither of these innovations represents a huge step beyond existing survey formats. As for the first, some survey work has already been done by public health researchers that departs from the standard QALY format and inquires about preferences over temporally extended health histories.[101] As

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[99] *See* Adler, *supra* note 78, at 1965-68; Adler, *supra* note 48, at 53-57, 55 n.184.

[100] *See generally* Adler, *supra* note 78.

[101] *See* Adler, *supra* note 48, at 19-20, 47; Aki Tsuchiya & Paul Dolan, *The QALY Model and Individual Preferences for Health States and Health Profiles over Time: A Systematic Review of the Literature*, 25 MED. DECISION MAKING 460 (2005). To be sure, surveys to elicit respondents' preferences regarding longevity-health-income histories must be designed to be feasible, given respondents' cognitive limitations. Respondents cannot be asked to evaluate every possible history. On this score, it should be noted that the proposal of some health scholars to use a survey format which *would* value health histories — the "healthy year equivalent" or "HYE" format — has been criticized as infeasible. *See id.* at 465-67. However, it is not clear why using surveys to assign values to temporally extended histories is qualitatively less feasible than using surveys to value momentary states, which is what the QALY format does. Just as it is impossible for a cognitively limited respondent to consider all possible histories, so it is impossible for her to consider all possible momentary states. QALY survey designers circumvent this difficulty in various ways. For example, they may use standardized "health state classification systems" to describe health states as a combination of locations on a discrete number of dimensions, and ask each respondent to value a sample of the total set of possible states, so as to estimate a function that maps each combination of

for the second, contingent-valuation surveys that ask about WTP/WTA for health effects or mortality risks are routinely conducted,[102] and these surveys do require respondents to make tradeoffs between income and health or longevity. Indeed, the theoretical literature on contingent-valuation surveys often assumes that respondents answer with reference to a utility function. In the case of a survey asking about WTP/WTA for health effects, this means a utility function that takes both health and income as its arguments. In the case of a survey asking about WTP/WTA for mortality risks, this means a utility function that is sensitive to the length of time for which a respondent is alive and can enjoy her income.

What particular survey format should be used to determine the utility value of longevity-health-income histories? This is a matter for experimentation. One possibility builds on the "standard gamble" format, widely employed in eliciting QALY valuations. The QALY standard gamble asks the respondent to identify the indifference probability q, such that she is indifferent between living some given period of time in a health state h, and a lottery with probability q of living for that period of time in perfect health and $1\text{-}q$ of dying instantly. Similarly, one might use a lifetime standard gamble to determine lifetime utilities. Specify a nearly perfect longevity-health-income history (one hundred years in full health and a high income) and a perfectly awful one (one hundred years in a health state no better than death and a subsistence income). For a given life-history $L_{i,k}$, ask the respondent for the probability u that makes her indifferent between getting the life-history for sure and a lottery with probability u of the nearly perfect life history and probability $1\text{-}u$ of the perfectly awful one. Set $U(L_{i,k}) = u$.

The lifetime standard gamble format is theoretically appealing because a strong case can be made that the utility numbers emerging from this format would be the correct numbers to use as inputs into the social welfare function.[103] However, the format might prove cognitively overwhelming, and other formats should be experimented with. Along with the standard gamble, so-called "time tradeoff" questions are routinely employed in QALY surveys. Ann Holmes has experimented with the use of time tradeoff questions to elicit respondent preferences with respect to both health and non-health characteristics.[104]

Another possibility is to constrain the form of the utility function. Health economists often assume that the utility of health and consumption or

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locations along the dimensions to a QALY value. *See, e.g.*, Adler, *supra* note 48, at 48-50. It is not clear why similar devices could not be used to elicit valuations of temporally extended histories.

[102] *See, e.g.*, Adler, *supra* note 48, at 40-41 n.133 (citing surveys of health-related contingent valuation studies).

[103] In particular, Harsanyi's account of interpersonal comparisons, which reduces judgments of overall well-being to preferences over lotteries of possible life histories, provides a theoretical basis for the lifetime standard gamble. *See* Adler, *supra* note 48, at 17-24 (presenting Harsanyi's account).

[104] *See* Ann M. Holmes, *A Method to Elicit Utilities for Interpersonal Comparisons*, 17 MED. DECISION MAKING 10 (1997).

income is additive across periods and multiplicative within periods.[105] In other words,

$$U(L_{i,k}) = \sum_{t=1}^{T} q(h_{i,t})v(y_{i,t}),$$

where individual i lives for T periods in outcome O_k; $h_{i,t}$ is her health state in period t; $y_{i,t}$ is her income or consumption in period t; and $q(h_{i,t})$ and $v(y_{i,t})$ are "subutility" functions measuring the value of health and income/consumption, respectively, in each period.[106] Bleichrodt and Quiggin have shown that this functional form follows from a set of preference axioms.[107] I have argued that $U(L_{i,k})$ might take a different form. If different axioms are satisfied, $U(L_{i,k}) = Q(H_{i,k}) \times V(Y_{i,k})$, where $H_{i,k}$ is individual i's lifetime health history in outcome O_k and $Y_{i,k}$ is her lifetime income history.[108] Surveys might be conducted to test whether the preferences of well-informed individuals regarding longevity-health-income histories tend to satisfy either set of axioms.[109] If one axiom set is more or less satisfied, surveys designed to establish the parameters of the particular functional form $U(L_{i,k})$ grounded on that set can then be undertaken. Surveys of this sort would presumably be less cognitively demanding than lifetime standard gambles. For example, if

$$U(L_{i,k}) = \sum_{t=1}^{T} q(h_{i,t})v(y_{i,t}),$$

then surveys regarding preferences for hypothetical health-and-income combinations during a period (not whole lifetime histories) would be needed to estimate the $q(h_{i,t})$ and $v(y_{i,t})$ functions.

The utility function U should, ideally, represent the convergent preferences of well-informed respondents contemplating hypothetical longevity-health-income histories. But what if survey respondents diverge in their an-

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[105] *See* James K. Hammitt, How Much is a QALY Worth? Admissible Utility Functions for Health and Wealth 2 (May 2002) (unpublished manuscript, on file with the Harvard Environmental Law Review).

[106] Strictly, $h_{i,t}$ should be $h_{i,t,k}$ and $y_{i,t}$ should be $y_{i,t,k}$, but to avoid unwieldy symbols I have omitted the "k" subscript.

[107] *See* Han Bleichrodt & John Quiggin, *Life-Cycle Preferences over Consumption and Health: When Is Cost-Effectiveness Analysis Equivalent to Cost-Benefit Analysis?*, 18 J. Health Econ. 681, 683-90 (1999).

[108] *See* Adler, *supra* note 48, at 25-30. More precisely, $U(L_{i,k}) = Q(H_{i,k}) \times V(B_{i,k})$, where $B_{i,k}$ is the "background" or non-health characteristics of individual i in outcome O_k (such as income, social position, family relationships, or professional accomplishment). If PPPA ignores background characteristics other than income, then $Q(H_{i,k}) \times V(B_{i,k})$ becomes $Q(H_{i,k}) \times V(Y_{i,k})$.

[109] *Cf.* William N. Evans & W. Kip Viscusi, *Estimation of State-Dependent Utility Functions using Survey Data*, 73 Rev. Econ. & Stat. 94 (1991) (using contingent-valuation surveys to estimate the structure of utility as a function of health and income); W. Kip Viscusi & William N. Evans, *Utility Functions that Depend on Health Status: Estimates and Economic Implications*, 80 Am. Econ. Rev. 353 (1990) (same); Beatrice Rey & Jean-Charles Rochet, *Health and Wealth: How Do They Affect Individual Preferences?*, 29 Geneva Papers on Risk & Ins. Theory 43 (2004) (discussing possible test to discriminate between different health-and-wealth utility functions).

swers? After all, interrater convergence in the case of existing QALY surveys is often not very high.[110] This important question raises large issues about interpersonal comparisons, incommensurability, and the meaning of utility numbers, which I have grappled with elsewhere and cannot address at length here.[111] A first-cut response is to stress that well conducted surveys should attempt to debias respondents and provide them with information. If divergence persists, median or average values should be used, as a reasonable estimate of what respondents under yet more ideal conditions would converge in preferring.

I have suggested that surveys asking respondents about their preferences over hypothetical longevity-health-income histories would be very helpful in calibrating the utility function U. But survey data of this sort does not yet exist. How should PPPA be undertaken in the interim? An initial possibility is to ignore health in the analysis. The appropriate form of the utility function in the case where it is conceptualized as a function of income (or consumption) alone has been discussed at length in various subfields of economics. A standard assumption is that the utility function has the "constant relative risk aversion" form $U(y) = y^{1-e}/(1-e)$, or log (y) where $e = 1$.[112] The British government, which now recommends distributive weighting in CBA, adopted this assumption in deriving recommended weights.[113] The parameter e can be estimated based on individual behavior as well as surveys, and substantial work of this sort has been undertaken.[114] One review of this literature concludes that policymakers should use a range of 0.7 to 1.5 for the value of e;[115] another suggests a broader range, namely 0.5 to 4.0.[116]

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[110] *See, e.g.*, Paul Dolan et al., *The Time Trade-Off Method: Results from a General Population Survey*, 5 HEALTH ECON. 141, 150 (1996).

[111] *See, e.g.*, Adler, *supra* note 48, at 21-22; ADLER & POSNER, *supra* note 1, at 49-50, 161-62, 161 n.28; Matthew D. Adler, *Incommensurability and Cost-Benefit Analysis*, 146 U. PA. L. REV. 1371, 1401-08 (1998).

[112] *See, e.g.*, TUOMALA, *supra* note 76, at 47; Olof Johansson-Stenman, *On the Value of Life in Rich and Poor Countries and Distributional Weights Beyond Utilitarianism*, 17 ENVTL. & RESOURCE ECON. 299, 302-03 (2000); CHRISTIAN GOLLIER, THE ECONOMICS OF RISK AND TIME 27 (2001).

[113] *See* David J. Evans, *The Elasticity of Marginal Utility of Consumption: Estimates for 20 OECD Countries*, 26 FISCAL STUDIES 197, 200 (2005).

[114] *See* Frank A. Cowell & Karen Gardiner, *Welfare Weights* 25-29 (STICERD, London School of Economics, 1999); Evans, *supra* note 113; David Pearce & David Ulph, *A Social Discount Rate for the United Kingdom* 9-15 (CSERGE Working Paper GEC 95-01, 1995). *See also* Louis Kaplow, *The Value of a Statistical Life and the Coefficient of Relative Risk Aversion*, 31 J. RISK & UNCERTAINTY 23 (2005) (discussing high values of e estimated in literature on "equity premium," and the inconsistency between those values and existing estimates of the income elasticity of the value of statistical life); Louis R. Eeckhoudt & James K. Hammitt, *Background Risks and the Value of a Statistical Life*, 23 J. RISK AND UNCERTAINTY 261, 276-77 (2001) (discussing relation between income elasticity of VSL and coefficient of relative risk aversion). For an interesting recent study that uses a Harsanyi-style veil of ignorance format to estimate e, see Olof Johansson-Stenman et al., *Measuring Future Grandparents' Preferences for Equality and Relative Standing*, 112 ECON. J. 362 (2002).

[115] Pearce & Ulph, *supra* note 114, at 14-16. These authors focus on the range of e appropriate for policymaking in the United Kingdom.

Using this constant-relative-risk-aversion function, utility would be assigned to a life-history as

$$\sum_{t=1}^{T} U(y_{i,t}) = \sum_{t=1}^{T} y_{i,t}^{1-e}/(1-e),$$

that is, by adding up the individual's income utility in all periods until she dies.

It should also be possible to employ existing data from health contingent-valuation surveys to estimate the shape of U, particularly if

$$U(L_{i,k}) = \sum_{t=1}^{T} q(h_{i,t})v(y_{i,t}),$$

in accordance with the Bleichrodt and Quiggin axioms. The amount of money that an individual is willing to accept to move from one health state to a worse state (her WTA for that move), or the amount of money that she is willing to pay to move from one health state to a better state (her WTP amount), depends on the marginal utility of income in the two states. From WTP/WTA data, then, we can estimate the marginal utility of income in different health states, and thus the shape of the function $q(h_{i,t})$. By assuming further that the function $v(y_{i,t})$ is the constant relative risk aversion form with risk aversion parameter e, we have concrete specifications for both the q and v functions and can apply these to a given $L_{i,k}$ to calculate $U(L_{i,k})$. Viscusi and Evans have undertaken pioneering work that employs WTP/WTA data to estimate the marginal utility of income in different health states,[117] and more work of this kind would be very useful in estimating U for purposes of PPPA.

Finally, what about social position? Socioeconomic status automatically enters into PPPA, even without separate attention to social position, since an individual's life-history includes information about her income. Insofar as PPPA employs an SWF that is equity-regarding rather than utilitarian, or a utility function with diminishing marginal income utility, PPPA will automatically be sensitive to the distribution of income. It is not, however, automatically sensitive to the racial or gender characteristics of those who benefit or are harmed by policies. Should it be?

Incorporating social position as a determinant of individual lifetime utility — as a separate element of an individual's life-history — is a double-edged sword. On the one hand, this adjustment means that low-status individuals have stronger redistributive claims. Redistributing a unit of lifetime utility from a high- to a low-status individual with identical income, longevity, and health characteristics increases the value of an equity-regarding

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[116] Cowell & Gardiner, *supra* note 114, at 33. *See also* Johansson-Stenman et al., *supra* note 114, at 363 (noting that "values in the interval 0.5-2 [for relative risk aversion] are often referred to").

[117] *See* Viscusi & Evans, *supra* note 109, at 363-67. *See also* Frank A. Sloan et al., *Alternative Approaches to Valuing Intangible Health Losses: The Evidence for Multiple Sclerosis*, 17 J. HEALTH ECON. 475, 478, 489-90 (1998).

SWF, but would not do so if social position were ignored. On the other hand, incorporating social position may mean that income, longevity, and health have greater marginal utility when possessed by high-status rather than low-status individuals. Imagine that lifetime utility is of the form

$$s_i \sum_{t=1}^{T} q(h_{i,t})v(y_{i,t}),$$

where s_i is a positive number that measures status, increasing as status increases. Then a given increment in health or income in some period has a greater effect on lifetime utility for a high-status individual, as does a given extension of longevity. A utilitarian SWF would, therefore, end up shifting health, longevity, and income to higher-status individuals. An equity-regarding SWF could also do so, depending on how it balanced distributive considerations with overall well-being. Further, the degree to which race and gender currently correspond to lower-status social positions is a complicated and controversial question.

For these reasons, incorporating social position as a separate determinant of individual lifetime utility will be politically controversial, and agencies (and even academics) undertaking PPPA may hesitate to do so. Bracketing political constraints, social position should be incorporated in life histories as a separate determinant of individual lifetime utility. The double-edged impact of social position on welfarist analysis, described in the preceding paragraph, does not — to my mind — show the contrary.[118] But the best is the enemy of the good, and it is certainly possible to structure PPPA so that race and gender information is (1) wholly ignored, or (2) employed only at the predictive stage, to improve estimates of the probability of different population profiles, which are described as combinations of individual longevity-health-income histories rather than individual longevity-health-income-social position histories.

3. *The Social Welfare Step: Identifying an SWF*

The final step of PPPA is applying an equity-regarding SWF, or family of SWFs, to the probabilistic population profile in the status quo and resulting from each policy. This may seem like a hopeless task. There are countless functions from utility vectors to social welfare numbers that satisfy the Pigou-Dalton principle and therefore count as equity-regarding. How does the PPPA analyst know which one(s) to use?

This problem is more tractable than it may seem at first glance. The academic scholarship that has actually employed SWFs to study concrete

[118] As already mentioned, Ann Holmes has conducted surveys where respondents are asked to value hypothetical lives described both in terms of health and in terms of other characteristics. The additional characteristics include gender. *See* Holmes, *supra* note 104.

policy questions often uses the so-called Atkinsonian family of SWFs.[119] This family has the form

$$W(U_1,U_2,...,U_N) = \sum_{i=1}^{N} U_i^{1-\gamma}/(1-\gamma),$$

where γ is the so-called inequality-aversion parameter and $\gamma \geq 0$, $\gamma \neq 1$.

$$(\text{Where } \gamma = 1,\ W(U_1,U_2,...,U_N) = \sum_{i=1}^{N} \log(U_i)).^{120}$$

The set of SWFs comprised of SWFs within the Atkinsonian family and increasing transforms thereof[121] are the only SWFs that satisfy two plausible axioms in addition to the basic Pigou-Dalton axiom: separability and ratio-rescaling-invariance.[122] Separability means that the particular utility level of

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[119] *See* TUOMALA, *supra* note 76, at 28-29; Johansson-Stenman, *supra* note 112, at 302-03; Samuel Fankhauser et al., *The Aggregation of Climate Change Damages: A Welfare Theoretic Approach*, 10 EVNTL. & RESOURCE ECON. 249, 257 (1997). In some of this literature, the social welfare function is an Atkinsonian function that takes individual incomes rather than utilities as its arguments. *See* Parry et al., *supra* note 57, at 26-28; Louis Kaplow, *Concavity of Utility, Concavity of Welfare, and Redistribution of Income* 2 (Harvard L. Sch. Discussion Paper No. 437, 2003). Atkinsonian SWFs are also used in the health economics literature that discusses applying SWFs to QALYs. *See* sources cited *supra* note 51.

[120] *See, e.g.*, BOJER, *supra* note 38, at 110. The formula for the Atkinsonian SWF is sometimes multiplied by $1/N$, where N is the population size. Where N is the same in all outcomes — as assumed throughout this Article, *see supra* text accompanying note 84 — that formula is equivalent to the one given in the text, both in its ranking of utility vectors and in its ranking of policies. In the case where $\gamma = 1$, the formula for the Atkinsonian SWF is sometimes given as the product of individuals' utilities rather than the sum of the logarithms of utilities. These formulations are increasing transformations of each other (*see, e.g.*, Fankhauser, *supra* note 119, at 257-58) and therefore order utility vectors (but not necessarily policies) the same way. *See infra* note 121.

[121] Take an Atkinsonian SWF

$$W(U_1, U_2,...,U_N) = \sum_{i=1}^{N} U_i^{1-\gamma}/(1-\gamma),$$

with γ specified. Consider W^*, which is an increasing transformation of W. (In other words, $W^*(U_1,U_2,...,U_N) = g(W(U_1,U_2,...,U_N))$, where g is what's known as an "increasing" or "monotonically increasing" function, which means that the graph of g always slopes up). Because W^* is an increasing transformation of W, W^* and W order utility vectors the same way. However, W^* and W applied in an *ex post* fashion to policies (probability distributions over utility vectors) may not order these policies the same way. This raises the difficult question, which I cannot address here, about how one identifies the appropriate transformation to use in PPPA, once one has specified γ. That identification involves determining the degree to which policymakers should be risk averse in social welfare. As an initial matter, I suggest, PPPA should assume risk-neutrality in social welfare, i.e., simply use the Atkinsonian SWF itself rather than some nonlinear transformation. But the issue certainly deserves more exploration.

[122] *See* LAMBERT, *supra* note 38, at 94-102; Anthony Atkinson, *On the Measurement of Inequality*, 2 J. ECON. THEORY 244, 244-45, 249-52 (1970). It is important to note that the Atkinsonian family of SWFs is *not* attractive if individuals' lifetime utilities can be negative. With negative utilities, the function $U_i^{1-\gamma}/(1-\gamma)$ is either undefined or, if defined, is either decreasing or strictly convex. Therefore, the SWF will not satisfy both the Pareto principle and the Pigou-Dalton principle. Identifying an appropriate SWF that can allow for negative utilities is a difficult task that I will not attempt to resolve here. *See* Campbell Brown, Matters of Priority 192-197 (Mar. 2005) (unpublished Ph.D. thesis, The Australian National University) (on file with the Harvard Environmental Law Review) (proving that no SWF has the pri-

an individual who has the same utility in two outcomes being compared is irrelevant to the SWF's rankings of those outcomes. This axiom is a formal expression of the philosophical position known as "prioritarianism," which many philosophers of equality now adopt.[123] Ratio-rescaling-invariance means that the ranking of utility vectors should not change if we multiply all utilities by a common positive constant. In other words, if W assigns a greater value to $(U_1, U_2, \ldots, U_N)$ than to $(U_1^*, U_2^*, \ldots, U_N^*)$, then it must assign a greater value to $(kU_1, kU_2, \ldots, kU_N)$ than to $(kU_1^*, kU_2^*, \ldots, kU_N^*)$. Ratio-rescaling-invariance is very plausible, since welfarist theory currently provides no basis for thinking that there are genuine, measurable, and morally significant aspects of individual well-being which are captured by some vector of utility numbers representing a given outcome but lost if we multiply everyone's utility by a common positive constant.[124]

To be sure, the Atkinsonian SWFs are an entire family of SWFs, parameterized by the inequality-aversion parameter γ. At one extreme, with $\gamma = 0$, the Atkinsonian SWF becomes the utilitarian SWF. At the other extreme, with $\gamma = \infty$, the Atkinsonian SWF becomes the "leximin" social ordering, which gives absolute priority to improving the well-being of worse-off individuals.[125] So which value of γ should be used?

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oritarian form of summing an increasing, strictly concave function of individual utilities *and* has an unrestricted domain and is invariant to a ratio transformation); Amartya Sen, *Social Choice Theory*, *in* 3 HANDBOOK OF MATHEMATICAL ECONOMICS 1073, 1127 & n.74 (Kenneth J. Arrow & Michael D. Intriligator eds., 1986). As for utility vectors that include zeros, the Atkinsonian SWF will be defined only for $\gamma < 1$.

[123] *See* Adler & Sanchirico, *supra* note 43, at 300-02.

[124] Harsanyi-style utility numbers, the expectations of which represent well-informed individuals' convergent preferences over lotteries of life histories, will be unique up to an affine transformation. It is a well-known feature of such "von-Neumann/Morgenstern" utilities, meant to represent decisions under risk or uncertainty, that they are unique up to an affine transformation. In other words, given a utility function U which maps life histories onto utilities, such that the expected utility numbers calculated using these utilities accurately represent a well-informed individual's preferences over lotteries of those histories, we can multiply U by a positive constant c and add a constant d. Expectations with respect to these new utilities will produce the very same ordering of lotteries as expectations with respect to the original utilities.

By taking a morally significant zero point — for example, a life no better than nonexistence — and giving it a utility of zero, we can narrow down the set of admissible utility functions. Consider a function U^* that represents the well-informed individual's ordering of lotteries and assigns a value of zero to the zero point. Any admissible function will have to be produced by taking U^* and multiplying it by a positive constant. However, that transformation remains admissible. Any new function produced by multiplying U^* by a positive constant will still assign zero to the zero point, and expectations formed with respect to this new function will still order lotteries of life histories correctly.

To preclude multiplying utilities assigned to life histories by a positive constant, we would need to have morally significant information beyond (1) well-informed individuals' (convergent) ordering of life histories and lotteries of life histories, and (2) their (convergent) identification of the zero point. It is hard to see what that information would be.

[125] *See, e.g.*, LAMBERT, *supra* note 38, at 99-102; Kristof Bosmans, *Extreme Inequality Aversion Without Separability*, 32 ECON. THEORY 589, 592 (2007).

A first cut at this problem is to use the entire range of values of γ.[126] This might be illuminating. Larger values of γ translate into a stronger social preference for equality.[127] If PPPA using the Atkinsonian family prefers one policy to another for all values of γ, or for all values below a high value of γ, or for all values above a low value of γ, then the first policy is probably the best policy, all things considered. Conversely, if PPPA's ranking of the two policies is sensitive to the choice of γ, then the case for one or the other policy is unclear.

A second cut at this problem is to isolate some range of values of γ as particularly plausible through normative analysis, surveys, or reverse engineering. A given value of γ has policy implications. Normative analysis, in the standard reflective equilibrium mode, means making these policy implications explicit and deciding whether the analyst finds them intuitively acceptable or unacceptable. Atkinson long ago suggested a "leaky bucket" thought experiment for specifying a social welfare function,[128] and a number of other authors have since seconded his suggestion.[129] Leaky-bucket thought experiments have different variants,[130] the simplest being as follows. Imagine that one individual h is at well-being level U_h, and a second, less well-off individual l is at well-being level U_l. A policy reduces the first individual's well-being by a small amount, u, and improves the second's by du, with d less than or equal to 1. If d is equal to 1, then anyone but the utilitarian will count the policy as an improvement. Imagine decreasing the value of d from 1. At what value of d do you think that the policy and the status quo are equally good? Your answer fixes a value of γ.

A different sort of thought experiment asks about sacrifices to overall well-being for the sake of equalizing well-being.[131] Specify an unequal population distribution of well-being, $(U_1, \ldots, U_N)$, and identify the level of

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[126] *See* Fankhauser et al., *supra* note 119, at 257-59. Many studies use a smaller range of values of γ, often in the context of an SWF that takes incomes rather than utilities as its arguments. *See* LAMBERT, *supra* note 38, at 129; Parry, *supra* note 57, at 28.

[127] For any unequal distribution of utilities, there is an amount U^+ of utility which, if equally distributed, has the same social welfare value as the unequal distribution. That amount, U^+, is lower the greater the value of γ. Also, for a given pair of individuals at utility levels High and Low, the ratio between the marginal social value of Low's utility and High's utility increases with γ.

[128] *See* Yoram Amiel et al., *Measuring Attitudes Towards Inequality*, 101 SCANDINAVIAN J. ECON. 83, 86-88 (1999) (discussing Atkinson's proposal).

[129] *See, e.g.*, Cowell & Gardiner, *supra* note 114, at 15-16; Pearce & Ulph, *supra* note 114, at 14-15; Stern, *supra* note 76, at 47-48. A closely related kind of question asks about the choice between benefiting some individual by a certain amount and a better-off individual by a greater amount. *See* Dolan, *supra* note 51, at 51-52.

[130] Other variants could specify the two individuals' health, income and longevity positions and ask about leaky transfers of health, income or longevity. Given a utility function from longevity-health-income histories to utility, answers to these sorts of question will also fix or help fix a γ.

[131] *See, e.g.*, Lindholm & Rosén, *supra* note 51; Williams, *supra* note 51.

well-being U^+ such that the initial distribution and the distribution (U^+, U^+, . . . , U^+) are equally good. The level U^+ fixes a value for γ.[132]

Normative analysis to specify a value of γ is no more "indeterminate" or "subjective" than normative philosophical scholarship generally, and should be undertaken by scholars, whether philosophers or welfare economists. A different tack is to conduct a "policy survey" — in effect, to invite the public to engage in normative analysis. "Policy surveys" invite respondents to evaluate policies, not from the stand-point of their own well-being, but from a more disinterested perspective.[133] Much survey work of this sort has been undertaken, including surveys about health and risk policy.[134] Some economists have in fact used policy surveys to estimate the degree of inequality-aversion of an Atkinsonian SWF: Amiel asks a leaky-bucket question, Lindholm an equalization question.[135]

Finally, "reverse engineering" the value of γ means establishing that value implied by existing policies — for example, existing tax-and-transfer policies.[136]

Although the case for limiting PPPA analysis to Atkinsonian SWFs should be very persuasive to those who hold a "prioritarian" understanding of equality — who accept the separability axiom — it will be less persuasive to non-prioritarians. The debate between prioritarians and nonprioritarians continues apace in the philosophical literature, with no clear winner.[137] Ideally, then, SWF analysis should test policies using both Atkinsonian SWFs and a plausible nonprioritarian SWF. One appealing possibility is to use the rank-weighted SWF. Take a utility vector (U_1, . . ,U_N). Set W equal to a sum consisting of N times the smallest utility in this vector, plus (N-1) times the next-smallest utility, plus (N-2) times the third-smallest utility, and so forth, up to 1 times the largest utility. This rank-weighted SWF satisfies the Pigou-Dalton principle, is ratio-rescaling-invariant, and (as it happens) gen-

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[132] It should be stressed that leaky-bucket and equalization thought experiments are only two particularly straightforward forms of normative reflection about the value of γ. Any analysis of the implications of a given γ for some principle that the analyst endorses, or some scenario about which the analyst has intuitions, could be helpful in specifying γ. *See, e.g.*, Fankhauser et al., *supra* note 119, at 259-62 (identifying values of γ consistent with use of uniform per-unit global warming damages).

[133] On the distinction between policy surveys and welfare polls, see Adler, *supra* note 78.

[134] *See, e.g.*, Paul Dolan et al., *QALY Maximisation and People's Preferences: A Methodological Review of the Literature*, 14 HEALTH ECON. 197 (2005).

[135] *See* Amiel et al., *supra* note 128, at 86; Lindholm & Rosén, *supra* note 51. For related survey work, see Ignacio Abasolo & Aki Tsuchiya, *Exploring Social Welfare Functions and Violation of Monotonicity: An Example from Inequalities in Health*, 23 J. HEALTH ECON. 313 (2004); Louis Gevers et al., *Professed Inequality Aversion and its Error Component*, 81 SCANDINAVIAN J. ECON. 238 (1979); Herbert Glejser et al., *An Econometric Study of the Variables Determining Inequality Aversion Among Students*, 10 EUR. ECON. REV. 173 (1977); Magnus Johannesson & Ulf-G. Gerdtham, *A Note on the Estimation of the Equity-Efficiency Trade-off for QALYs*, 15 J. HEALTH ECON. 359 (1996); Magnus Johannesson & Ulf-G. Gerdtham, *A Pilot Test of Using the Veil of Ignorance Approach to Estimate a Social Welfare Function for Income*, 2 APPLIED ECON. LETT. 400 (1995).

[136] *See* LAMBERT, *supra* note 38, at 129; Cowell & Gardiner, *supra* note 114, at 24-25.

[137] *See* Adler & Sanchirco, *supra* note 43, at 296-302.

erates the Gini coefficient as the corresponding measure of inequality,[138] but it does not satisfy the separability principle. A utility transfer from a high-utility to a low-utility individual increases social value (thus the Pigou-Dalton principle is satisfied); but the size of the increase depends on the ranks of the two individuals in the whole population distribution, not their utility levels taken alone.

C. *PPPA, Cost-Benefit Analysis, and Equality Measurement*

PPPA produces an integrated assessment of policies, sensitive to both overall well-being and equity. Equity-regarding SWFs such as the Atkinsonian SWFs or the rank-weighted SWF are sensitive to equity because they satisfy the Pigou-Dalton axiom.[139] At the same time, they are sensitive to overall well-being in that (1) Pareto superior outcomes are always preferred[140] and more generally (2) holding constant the degree of inequality, an equity-regarding SWF will prefer the outcome with greater total utility.[141]

These observations raise the question of how PPPA relates to cost-benefit analysis (CBA), on the one hand, and inequality measurement, on the other. Eric Posner and I have defended CBA as a proxy for overall well-being.[142] PPPA is more flexible than CBA. PPPA *can* yield a verdict about overall well-being, by inserting a utilitarian SWF into the format. Yet, as just explained, PPPA (unlike CBA) can yield a judgment about whether the policy is better than the status quo on balance, given both overall-well-being and equity concerns. This occurs automatically when PPPA employs an equity-regarding rather than utilitarian SWF.

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[138] *See* Adler & Sanchirico, *supra* note 43, at 302. Actually, there are many different variations on the simple rank-weighted SWF described in the text. Consider any SWF which ranks utilities from lowest to highest, multiplies each by a positive weight which is a decreasing function of rank, and sums the weighted utilities. Any such SWF will be ratio-rescaling-invariant, satisfy the Pareto principle, and satisfy the Pigou-Dalton principle. So an equity analyst who is conducting a particularly full PPPA analysis might want to consider evaluating policies using different rank-weighted SWFs within this general family. *See generally* BLACKORBY ET AL., *supra* note 84, at 75-82, 99-100 (discussing rank-weighted family of SWFs).

[139] *See supra* text accompanying notes 80-81.

[140] Although it is possible to have "non-Paretian" SWFs — SWFs that sometimes fail to prefer a Pareto-superior outcome — the case for the Pareto principle is powerful, and it is certainly possible for SWFs to both satisfy the Pigou-Dalton principle and be Paretian. In particular, Atkinsonian SWFs and the rank-weighted SWF have both characteristics *See* Adler & Sanchirico, *supra* note 43, at 291-304; BLACKORBY ET AL., *supra* note 84, at 69-82.

[141] The ordering of outcomes produced by a given equity-regarding SWF W is the same as that produced by assigning each utility vector a number equaling

$$(\sum_{i=1}^{N} U_i)(1-M^W(U_1,U_2,\ldots,U_N)), \text{ where } \sum_{i=1}^{N} U_i$$

is total utility and M^W is an inequality measure generated by the SWF. *See* Marc Fleurbaey, *Equality versus Priority: How Relevant is the Distinction?*, *in* FAIRNESS AND GOODNESS IN HEALTH (Daniel Wikler et al. eds., World Health Organization) (forthcoming). Holding constant the degree of inequality, i.e., the value of M^W, outcomes with greater total utility are preferred.

[142] *See* ADLER & POSNER, *supra* note 1.

At some point PPPA might displace CBA. But that is not the proposal here. CBA is widely employed by agencies, and its techniques are now highly developed. PPPA is novel and untested. My proposal, therefore, is that agencies and policy analysts employ PPPA in conjunction with CBA. If both CBA and PPPA favor one policy over a second, then the case for the first policy is strong. If CBA favors the first policy but PPPA favors the second, then it would appear that overall well-being favors the first policy but that the overall balance of moral considerations — overall well-being plus equity — favors the second. The case for the first policy is weaker; the case for the second policy is stronger, although not yet necessarily clear, because PPPA itself is an experimental procedure. In this event, it may be appropriate for the agency to undertake a more intensive CBA or PPPA, or perhaps to elicit guidance from Congress or the President.

What about the connection between PPPA and inequality measurement? PPPA yields an integrated assessment of policies, but agencies may find it useful to ascertain how policies compare purely as a matter of equality. PPPA readily yields that sort of evaluation. Economists of inequality have developed the important insight that any equity-regarding SWF generates a corresponding inequality metric. For a given social welfare function W, there is a corresponding inequality metric M^W, which ranges from zero (no inequality) to 1 (maximal inequality), defined as follows. For any utility vector $(U_1, U_2, \ldots, U_N)$, identify U^+ such that $W(U_1, U_2, \ldots, U_N) = W(U^+, U^+, \ldots, U^+)$. In other words, a perfectly equal outcome in which every individual receives the same amount of utility, U^+, has the same W-value as the initial vector. Then

$$M^W(U_1, U_2, \ldots, U_N) = 1 - NU^+ / \sum_{i=1}^{N} U_i.$$

The denominator of the

$$NU^+ / \sum_{i=1}^{N} U_i$$

fraction is the total well-being associated with the initial vector; the numerator is the amount of total well-being which, if equally distributed, would have the same W-value as the initial vector. The smaller this fraction is, the larger the fraction of the total well-being associated with the initial vector that could be lost in an equalizing redistribution while still holding social welfare constant, and thus the larger the degree of inequality.[143]

With this insight, PPPA can be straightforwardly adapted to provide a judgment about the change in expected inequality produced by a policy. The status quo is a probability distribution across lifetime utility vectors; the policy is a different distribution. For each possible status quo vector, we determine its inequality as measured by M^W. The expected status quo inequality

[143] *See, e.g.*, LAMBERT, *supra* note 38, at 94-102; SEN, *supra* note 38, at 38-39; BOJER, *supra* note 38, at 108-11; Cowell, *supra* note 38, at 113-15.

is simply the sum of each vector's inequality, discounted by its probability. The same series of calculations yields the expected degree of inequality for the policy.

CONCLUSION

This Article presents a novel approach to considering the equity impacts of risk regulation policies. This approach, "probabilistic population profile analysis" (PPPA), is rooted in the SWF view of social choice — specifically, in a particular version of the SWF approach for which I have provided a full philosophical defense elsewhere, one that focuses on lifetime well-being and that adopts an *ex post* rather than *ex ante* view of choice under uncertainty. From this perspective, PPPA is a large improvement on existing approaches to risk equity, described in Part I. PPPA adopts a population-wide approach to equity, unlike the social gradient view adopted by environmental justice scholars. It attends to the impact of both income and health/longevity on individuals' (lifetime) well-being. (By contrast, "individual risk" tests focus solely on longevity; QALY analysis handles income impacts imperfectly; and incidence analysis handles health/longevity impacts imperfectly.) PPPA addresses uncertainty in an *ex post* manner, unlike "individual risk" tests or CBA using the VSL method. And PPPA is sensitive to both overall well-being and the distribution of well-being, unlike inequality metrics or incidence analysis (or, for that matter, "individual risk" tests or the disparate-impact tests employed in the environmental justice literature).

Nor is PPPA a utopian project. The SWF approach has already been employed to study tax policies and, in a few cases, environmental policies. Part II describes in detail how PPPA would be implemented. It discusses both the information that would be needed to bring the approach to full fruition (such as surveys to calibrate utility functions, and more survey work to calibrate the SWF), as well as the steps that policymakers can take in the interim.

Only utilitarians believe that policy choice should be solely a function of overall well-being. Only utilitarians, then, should be comfortable with the current state of policy analysis, as practiced by governmental agencies and supported by the existing scholarly literature. Cost-benefit analysis, which is a workable measure of overall well-being,[144] is now very highly developed and widely employed by agencies. Equity analysis garners much less scholarly attention and is rarely used in government. We need to develop implementable and philosophically well-grounded tools for evaluating the equity impacts of policies. PPPA is one such tool and, I believe, a particularly promising one.

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[144] *See* ADLER & POSNER, *supra* note 1.