The Life Satisfaction Approach to Environmental Valuation

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Abstract

In many countries, environmental policies and regulations are implemented to improve environmental quality and thus individuals' well-being. However, how do individuals value the environment? In this paper, we review the life satisfaction approach (LSA), which represents a new nonmarket valuation technique. The LSA builds on the recent development of subjective well-being research in economics and takes measures of reported life satisfaction as an empirical approximation to individual welfare. Microeconometric life satisfaction functions are estimated, taking into account environmental conditions along with income and other covariates. The estimated coefficients for the environmental good and income can then be used to calculate the implicit willingness to pay for the environmental good.

1. INTRODUCTION

Environmental quality is an important determinant of individuals' well-being and an important policy issue. Many countries are implementing environmental policies and regulations to improve poor environmental conditions. However, how do individuals value the effects on the environment?

In this paper, we review the life satisfaction approach (LSA), which represents a new nonmarket valuation technique. The LSA builds on the recent development of subjective well-being research in economics. A common understanding in this field is that subjective well-being can serve as an empirical approximation to individual welfare. If this interpretation of subjective well-being measures is accepted, it becomes straightforward to value environmental goods: Environmental conditions, along with income and other covariates, can be taken into account in microeconometric life satisfaction functions. The estimated coefficient for the environmental good offers, first, a direct valuation in terms of subjective well-being. Second, the estimated coefficients for the environmental good and income can be used to calculate the implicit willingness to pay (WTP) for the environmental good or constant trade-off ratios between the environmental good and income. In other words, the increase in income that would be necessary to compensate an individual for a given decrement in environmental conditions can be calculated.

This newly emerged approach stands in a long tradition and debate of research trying to measure individual welfare. Classical economists such as Bentham and Edgeworth believed that measurement of utility not only is possible but also could be used to improve the rationality of policy decisions. In contrast, today's mainstream economics completely abandoned this idea. Preferences are inferred from behavior, above all from market behavior. This poses obvious problems for environmental goods and other public goods for which no markets exist and for which individuals have limited incentive to disclose their true demand. Therefore, for a long time, economists have been very pessimistic as to whether it is possible to assess people's preferences for public goods: "[T]he very essence of the public goods problem is that there is no way these preferences can be determined" (Due & Friedlaender 1973, p. 53).

In defiance of this negative view, economists developed ingenious ways to value environmental and other public goods. Essentially, two avenues have been pursued: Either people are asked to state their preferences in hypothetical contingent markets, or the preferences are inferred from behavior as they are revealed in markets for private goods that are complements to or substitutes of the environmental good. Stated preference methods such as the contingent valuation method (CVM) and revealed preference methods such as the hedonic method (HM) have been widely used in practice, both in the regulatory process and in litigation (Palmquist & Smith 2002, Carson et al. 2003). However, these methods suffer from well-known problems. The hypothetical nature of CVM surveys may entail superficial answers and strategic behavior. The HM, in contrast, yields biased results if housing markets are not in equilibrium because, for example, people are not fully informed or mobility is not costless.

The LSA aims at obviating several of these problems inherent in the standard methods or at least at offering a complementary approach. Importantly, the approach does not rely on an equilibrium assumption. Furthermore, individuals are not asked to value the environmental good directly but to evaluate their general life satisfaction. This is presumably a cognitively less demanding task, and there is no reason to expect strategic behavior.

Although the LSA avoids some of the difficulties of previous valuation approaches, it depends on its own preconditions for a successful application. In particular, the validity of measures of subjective well-being, their inclusiveness, and their reference to the present situation are important. Moreover, reports of life satisfaction should have small measurement errors, should be interpersonally comparable, and should be available at a sufficiently large scale (at a sufficiently low cost).

The remainder of this review is organized in four sections. Section 2 introduces the basics of the LSA. Section 3 compares the LSA to the most prominent standard nonmarket valuation methods, the CVM and the HM. Section 4 provides a review of applications of the LSA. The focus is on studies valuing air quality. Section 5 offers concluding remarks.

2. THE BASIC CONCEPT

The measurement of individual welfare, using data on reported subjective well-being, has made great progress and has led to a new field of subjective well-being research in economics.[1] The LSA rests upon this new field of research and has begun to build an important pillar of its fruitful policy-relevant application.[2]

First, we discuss measures of subjective well-being as an approximation of individual welfare. Second, the valuation procedure as proposed by the LSA is outlined. Third, the prerequisites for a successful application of the approach are explained.

2.1. Measuring Individual Welfare

In received economics, utility is what is maximized in consistent choice, a representation of preferences that are simply choice-connected rankings of outcomes. According to the axiomatic approach, individuals' choices provide all the information required to infer the utility of outcomes. Subjectivist experience captured by surveys is rejected as being not objectively observable and unscientific. However, this position restricts the questions that can be addressed. Most importantly, conceptions about individuals' preferences or utility functions remain vague, and the valuation of public goods is hampered. Revealed preference methods cannot be applied in all cases of interest, and nonuse values leave no behavioral trace. It is, therefore, no coincidence that nonmarket valuation is a field in economics in which surveys have been widely used.

In recent economic research, new ways have been proven to approach individual welfare. Utility is again related to the original, Benthamite meaning of utility as the hedonic quality of experience, broadly construed to include satisfaction as well as pleasure. In many situations, the choice-based concept and the experience-based concept of utility coincide, but evidence also indicates that they may systematically diverge in some situations (Kahneman et al. 1997). Empirically, utility based on judgments of satisfaction and pleasure can be captured by measures of subjective well-being.[3]

[1]For surveys on the study of subjective well-being in economics, see Frey & Stutzer (2002a,b), Layard (2005), Di Tella & MacCulloch (2006), Clark et al. (2008), and van Praag & Ferrer-i-Carbonell (2008).

[2]For a general discussion on the use of research on subjective well-being in public policy, see Adler & Posner (2008) and Frey & Stutzer (2010).

[3]The empirical study of subjective well-being used to be the province of hedonic psychology (for reviews, see Diener et al. 1999, Kahneman et al. 1999a).

Subjective well-being is the umbrella term for different measures that can be distinguished along two dimensions. Regarding the first dimension, a common distinction is between cognition—the cognitive, evaluative, or judgmental component of well-being (usually assessed with life satisfaction)—and affect, the pleasure-pain component of well-being (Diener 1984). With regard to affect, two independent components of positive and negative affect are differentiated. The discriminant validity of the three components is analyzed in Arthaud-Day et al. (2005). The second dimension distinguishes between measures that capture a person's level of subjective well-being and the duration in one rather than another mental state. Because life satisfaction is a relatively stable construct, duration measures usually refer to affect. A primary example of a duration measure is the U-index, which measures the proportion of time an individual spends in an unpleasant state. Thus, the combination of the dimensions entails four typical measures: the level of life satisfaction, the level of positive affect, the level of negative affect (or the difference between the two affective levels), and the duration in one affective state.

The measures are elicited with global self-reports in surveys, with the Experience Sampling Method (ESM), which collects information on individuals' actual experiences in real time in their natural environments, and the Day Reconstruction Method (DRM), which asks people to reflect on how satisfied they felt at various times during the day (on the latter two techniques, see Stone et al. 1999 and Kahneman et al. 2004). Measures and measurement techniques are not independent of each other. For example, measures with an inherent time component are best captured by the ESM or DRM. Furthermore, neurophysiological correlates of subjective well-being have been found with electroencephalography (EEG) and neuroimaging techniques (Urry et al. 2004). On the one hand, these correlates validate survey measures; on the other hand, they can be used as independent measures of subjective well-being.

The various measures capture different aspects of individual well-being and thus different concepts of individual welfare. For a measure of reported subjective well-being to serve as a proxy for individual welfare, an important assumption is necessary: The standards underlying a person's judgments are those the individual would like to pursue in realizing his or her ideal of the good life. People's judgments about their life can then serve as a proxy for their individual welfare. People are assumed to pursue individual welfare on the basis of some stable evaluation standards. Moreover, the extent to which individual welfare is identified depends on whether the evaluation metric fits people's judgments about their life.

The normative basis of this approach goes beyond assuming the pursuit of happiness and also involves choosing the concrete evaluation metric to elicit people's judgments.[4] Thus, ambiguities remain when selecting the empirical concept to measure individual welfare.

Some people may favor a distant, ex post perspective, reflecting on one's life after the fact, whereas others favor reasoned ex ante evaluations as their standards. Still others may give priority to how they felt when experiencing the course of life.

Imagine those people who see high individual welfare as something like the "positive, persistent attitude towards both particular experiences and life experience more generally that a person feels upon repeated reflection" (Kelman 2005, pp. 408–9). For them, general evaluations of their satisfaction with life as a whole may be an appropriate metric to capture judgments about individual welfare. For those people who equate individual welfare with

[4]Kelman (2005) provides an excellent account of the ambiguities of welfare in the context of economics and hedonic psychology.

moment-to-moment affect, individual welfare may be best measured by approaches such as the ESM or the DRM. When one is looking for an empirical tool to collect information about people's judgments, it is thus important to reveal the concrete metric.

Most of the empirical work undertaken so far on subjective well-being research in economics has been based on representative, large-scale sampling of individual global evaluations of life satisfaction. Given the state of research, we favor these measures of life satisfaction to value people's living conditions (and this also explains the name of the approach), as they offer a blend of cognitive judgment and affective state. Moreover, this kind of affect-contaminated cognition corresponds to what has been considered the best theory on the nature of welfare in philosophy (Sumner 1996, pp. 140–56).

2.2. The Valuation Procedure

Granted that reported subjective well-being can serve as an empirically adequate and valid approximation for individual welfare, it is an obvious and straightforward strategy to directly evaluate public goods in welfare terms. Moreover, by measuring the marginal utility of a public good or the marginal disutility of a public bad, as well as the marginal utility of income, one can calculate the trade-off ratio between income and the public good.

The respective relationship can be stated in a simple, subjective well-being function:

$$SWB = f(x, y, \theta' z). \tag{1}$$

Individual welfare in terms of subjective well-being depends on some good x, i.e., the environmental condition to be valued, income y, and a set $\theta' z$ of other individual-level and macro-level determinants of subjective well-being.

Roughly speaking, a change in the nonmarket good of Δx is valued by Δy (corresponding to an implicit WTP) if this holds individual well-being constant. For a marginal change of x, the marginal WTP (MWTP) can be derived from totally differentiating Equation 1 and setting $dSWB = 0$:

$$\text{MWTP} = -dy/dx = (\delta f/\delta x)/(\delta f/\delta y). \tag{2}$$

MWTP is invariant to any monotonic transformation of the subjective well-being function, i.e., no cardinal utility function is required.

For the valuation of inframarginal changes of a nonmarket good x, two measures exist: First, the compensating variation is the amount of income necessary to keep the individual at the original or ex ante level of subjective well-being when a change in environmental conditions occurs. Second, the equivalent variation is the change in income necessary to attain the level of subjective well-being as if a change in environmental conditions occurred, i.e., the ex post level for a hypothetical change in environmental quality.

To calculate the relevant welfare measures, a subjective well-being function such as Equation 1 can be estimated as an ordered discrete-choice model applying ordered logit or ordered probit regressions. Although the estimated coefficients from these models have no meaningful interpretation (as they refer to an underlying latent variable), ratios between any two coefficients can be interpreted. Therefore, the coefficients for the nonmarket good x and income y can be employed to calculate the marginal rate of substitution or the MWTP and welfare measures for inframarginal changes. Thus, it is not necessary to assume cardinality.

For applications with individual panel data, ordinary least squares (OLS) estimations that allow one to control for individual-fixed effects are attractive. There is some evidence that assuming cardinality and using OLS make little difference for estimating ratios between coefficients (whereas taking into account individual heterogeneity makes a large difference) (Ferrer-i-Carbonell & Frijters 2004).

A common specification of an empirical subjective well-being function is the following:

$$LS_{i,j,t} = \beta_0 + \beta_1 x_{j,t} + \beta_2 \log(y_{i,t}) + \beta' z_{i,j,t} + \rho_j + \tau_t + \iota_i + \varepsilon_{i,j,t}. \quad (3)$$

In this specification, $LS_{i,j,t}$ stands for reported life satisfaction as a specific measure of subjective well-being of individual i in location j in time t. Equation 3 is a linearized version of Equation 1 up to the log of income term $\ln(y_{i,t})$. A log of income specification presumes that the monetary value of change in environmental conditions is measured as a fraction of an individual's income. This implies that people with a higher income are prepared to give up more income in absolute terms for some improvement in environmental quality. This is equivalent to imposing a decreasing marginal utility of income. Vector z again captures other individual-level and macro-level determinants. Finally, ρ_i is a set of region or location-fixed effects taking into account unobserved time-invariant factors, τ_t is a set of time-fixed effects capturing unobserved location-invariant factors, ι_i are individual-fixed effects, and $\varepsilon_{i,j,t}$ is an error term.

So far, the LSA is presented without any interaction between the quality of the environment and other determinants of subjective well-being that are taken into account in the empirical analysis. In particular, market forces are expected to lead to upward wage pressure and a downward pressure on rents for housing in locations where the environmental quality is bad. These are the two most fundamental channels through which people are compensated for adverse environmental conditions. Accordingly, Equation 1 would need to be extended to include income as a function of x, i.e., $y(x)$, and rents as one of many other factors in z to depend on x, i.e., $z(x)$. Obviously the aspect of (partial) compensation is relevant for the interpretation of measured partial correlations between environmental conditions and subjective well-being. We discuss this aspect in Section 3.4 after an exposition of HM that values nonmarket goods under the presumption of compensation of amenities and disamenities on the market. We emphasize the links between LSA and HM and outline under what conditions they can serve as complementary approaches.

There are, of course, the standard identification issues in empirical analyses that also apply to the LSA. We do not discuss them here in abstract but in relation to specific applications in Section 4.

2.3. Premises for the Application of the Life Satisfaction Approach

The different measurement techniques and their corresponding measures all have their strengths and weaknesses. Which measure and measurement technique are to be preferred depends ultimately on their intended use. In the following, we list six premises that are relevant for the evaluation of public goods. The measures of subjective well-being should (*a*) be valid measures of individual welfare, (*b*) be broad and inclusive, (*c*) refer to the respondents' present situation, (*d*) have small measurement errors and no systematic ones, (*e*) be interpersonally comparable, and (*f*) be available at a sufficiently large scale (at a sufficiently low cost).

2.3.1. Validity. Although we claimed the validity of subjective well-being measures at the outset of this review, we present here some specific evidence for reported satisfaction with life. Respondents who are satisfied with their lives are also rated as satisfied by family members, friends, and experts (Sandvik et al. 1993). Life satisfaction scores correlate with other variables that can be plausibly claimed to be associated with true individual well-being (Di Tella & MacCulloch 2006). In two 20-year follow-up studies, low levels of reported life satisfaction predicted all-cause, disease, and injury mortality, especially for male respondents (Koivumaa-Honkanen et al. 2000), and suicide (Koivumaa-Honkanen et al. 2001). Satisfied individuals are less likely to suffer from hypertension, a relationship that even translates into a correlation between hypertension and satisfaction at the national level (Blanchflower & Oswald 2007). Finally, life satisfaction predicts both future marriage (Stutzer & Frey 2006) and future marital breakup (Gardner & Oswald 2006).

2.3.2. Inclusiveness. Essentially, this criterion approaches the validity issue from a second angle. Subjective well-being is an appropriate empirical approximation of individual welfare if it is broad and all-inclusive. We think that the current evidence supports this position. However, critics claim that subjective well-being is extremely narrow and constitutes only one of many components of individual welfare (Adler & Posner 2006, p. 77), one subutility function among others (Kimball & Willis 2006). This debate parallels the normative question of the nature of welfare, with the objectivist ascribing various goods intrinsic importance and subjectivists conceding other goods only instrumental importance insofar as they contribute to well-being. The positive question asks whether other higher-order goods are subutility functions of equal standing with subjective well-being or whether these goods are arguments in the subjective well-being function with no independent effect on individual utility. Data on subjective well-being can be used to evaluate policies only if subjective well-being is a broad and (all-)inclusive concept.

The strategy of the critics is to equate subjective well-being with pleasure and pain and to declare the ESM or DRM as the gold standard of measurement techniques. They then reject the view that subjective well-being thus understood is a meaningful measure of overall utility and extend the conclusions beyond the narrower measures to subjective well-being research in general. This victory over measures of subjective well-being is cheap and hollow. As we mention above, there is a wide array of measures and measurement techniques.

2.3.3. Reference to presence. Measures of subjective well-being should refer to the respondents' present lives and represent their period utility or flow utility. If scores of subjective well-being reflected discounted expected future utility, it would become difficult to relate changes in objective circumstances to changes in subjective well-being. In measures of global self-reports, the focus on the present situation is often indicated by means of the wording of the question. Often the questions have extensions such as "these days," "now," "nowadays," or "at present."

2.3.4. Measurement errors. The major concern in the discussion on the degree of inclusiveness is that measures of subjective well-being may exclude important aspects of utility. The converse concern is that measures of subjective well-being include a lot of noise and are contaminated by confounding factors. Most research on this problem has focused on global self-reports.

Normally, the global judgments are construed only when asked. Answering the question involves cognitive (memory and aggregation) and communicative processes. At the level of the cognitive processes, concerns may arise that respondents may make little mental effort and instead rely on easily accessible information. Experimental research shows that self-reports can be influenced by the immediate context as well as by artificially induced intra- and interpersonal comparisons and temporal mood states (Schwarz & Strack 1991). At the level of the communicative process, issues of communicative norms, self-representation, and social desirability become important (Larsen & Frederickson 1999, Schwarz & Strack 1999).

To assess the importance of these findings for the LSA, it is useful to integrate them into a measurement error framework. This allows us to distinguish two types of errors: white-noise errors that are unrelated to right-hand-side variables, on the one hand, and systematic errors that are correlated with the explanatory variables, on the other hand. Mood variability and most context effects fall into the first category. Conceptually, errors of this sort pose no problem. They entail no systematic bias, as the idiosyncratic effects cancel each other out. However, the random variation reduces the statistical fit. Therefore, the ratio of error variance to true variance has to be sufficiently low to make statistical work productive.

Measurement errors that fall into the second category pose a more serious problem. Two findings of the experimental research are of potential relevance for the LSA. First, other questions in the questionnaire and the order of the question can influence the reported subjective well-being. If the questionnaire includes questions referring to the public good to be evaluated and to income, these questions may systematically bias the results, especially if the questions precede the subjective well-being question. On the one hand, the questions increase the accessibility of information on the public good and income and heighten their awareness, thereby increasing the weight of these aspects in the global judgment. On the other hand, conversational norms of nonredundancy may decrease the weight of these aspects. The latter effect is to be expected if questions of satisfaction with the public good or satisfaction with income immediately precede the subjective well-being question. Both effects have been documented (Strack et al. 1988). Second, answers deemed to be socially desirable or serving self-representation purposes can also systematically influence the results. Thus, problems of the second category have important implications for the questionnaire design and survey mode as well as for the choice of existing data.

2.3.5. Interpersonal comparability. It is in principle not possible to observe the level of an individual's utility or, therefore, to compare utility levels of different persons (Robbins 1938). Individuals with identical preferences (as revealed through behavior) and with identical expressive reactions to any situation may nevertheless attach different utilities to identical situations. In the present context, the practical questions thus are whether identical (verbal and physiological) expressions reflect similar mental states and what the consequences for empirical research are if they do not.

Kahneman (2000) suggests that there is evidence of considerable interpersonal convergence in ranking of pleasure and pain. In painful medical procedures, for example, the relationship between expressed pain and physiological reactions is similar across persons. Similarly, the correlations between self-reports and other reports discussed above show that self-reports are not just artifacts of individual specific response behavior but are related to shared standards of evaluation. More importantly, for most empirical research

(including research using the LSA), comparisons at the individual level are not necessary. Instead, empirical analysis focuses on groups and compares the subjective well-being of individuals under different circumstances, e.g., the subjective well-being of groups of individuals exposed to different levels of a public good. By a focus on groups, personal peculiarities of individuals counterbalance one another.

In sum, Robbins's (1938) statement that utility cannot be interpersonally compared with standard scientific rigor still holds and pertains to all measures of subjective well-being. However, it is important to remember that without the assumption of interpersonal comparability of utility, cost-benefit analyses and many other analyses in applied welfare economics are impossible.

2.3.6. Availability and costs. Most public goods can be expected to have relatively small effects on subjective well-being, in particular smaller effects than personal characteristics. To statistically detect the effects, large sample sizes are required. Therefore, the cost component is another criterion for evaluating measures and measurement techniques. Beyond doubt, the least expensive measurement technique is surveys including global self-reports. The most expensive measurement techniques are probably the ESM and physiological techniques; the DRM falls between these two extremes.

3. COMPARISON WITH STANDARD METHODS

In economics, environmental valuation is typically based on preferences stated in hypothetical contingent markets or on preferences revealed in the demand for marketed goods (e.g., Freeman 2003). In this section, we discuss the two most prominent methods—the CVM and the HM—and their inherent problems, in particular those that the life satisfaction approach obviates.[5]

3.1. Stated Preference Methods: The Contingent Valuation Method

The CVM is a survey-based technique of nonmarket valuation. Respondents are asked directly what they would be willing to pay for a change in an environmental amenity. This is often an unfamiliar situation and gives rise to problems of strategic responses. Therefore, the credibility, validity, and reliability of results based on the CVM are the subject of heated controversy in economics. Skepticism is based largely on the empirically observed embedding effect (Kahneman & Knetsch 1992), which refers to several interrelated regularities in CVM surveys, i.e., the insensitivity of expressed WTP to the scale and scope of the public good, as well as sequencing and subadditivity effects. Critics see the embedding effect as evidence for the nonexistence of individual preferences for the public good; individuals receive positive feelings from expressing support for good causes, and accordingly the survey process creates the values it seeks to reveal (Diamond & Hausman 1994). However, meta-analyses find significant sensitivity to scale and scope (Smith & Osborne 1996), and according to proponents, the sequencing and the subadditivity effects can be explained in terms of substitution effects and diminishing marginal rates of substitution (Hanemann 1994, Carson et al. 2001). Furthermore, a number of guidelines have been developed to

[5]Comparisons of the LSA with the standard approaches can also be found in van Praag & Frijters (1999), Frey et al. (2009), Luechinger (2009), Luechinger & Raschky (2009), and van Praag & Ferrer-i-Carbonell (2010).

assure credibility, validity, and reliability. Most important among these guidelines are the presentation of adequate information, the choice of a credible (hypothetical) method of public good provision and payment mechanism, and the use of the referendum format (or alternative discrete-choice methods) (Hanemann 1984, Arrow et al. 1993, Portney 1994).

Nevertheless, the two basic problems of the CVM are difficult to overcome. The hypothetical nature of the questions asked and the unfamiliarity of the task often entail superficial answers and symbolic valuation in the form of attitude expression (Kahneman et al. 1999b). Similarly, the problem of strategic behavior can be addressed only to a limited extent. The LSA is not affected by either of these problems. It does not rely on respondents' ability to consider all relevant consequences of a change in the provision of a public good. In fact, people may not even consciously notice a relationship between environmental conditions like fine particulate matter in an urban region and their subjective well-being. It suffices if they state their own life satisfaction with some degree of precision. This considerably reduces subjects' cognitive burden and costs of information processing. Moreover, there is no reason to expect strategic behavior because the researcher makes an ex post connection between life satisfaction and the environmental good. One might argue that a respondent exposed to a negative externality, anticipating that his or her reported life satisfaction is used to value the externality, strategically reports an overly low life satisfaction. Although theoretically possible, this problem is most likely to be of minor importance in practice. Life satisfaction data are usually collected for a multitude of purposes, and the same data can be used to value a wide array of (environmental) goods. This multiplicity of purposes effectively prevents strategic biases.

3.2. Revealed Preference Methods: The Hedonic Method

The HM invokes the assumption of weak complementarity between an environmental good and a private good such as housing and can be used if the former is a qualitative characteristic of the latter. In such a situation, the housing market functions as a market for the environmental good, and information on environmental-good demand is embedded in the prices and consumption level of housing. House price differentials between locations with different environmental conditions serve as implicit prices for the environmental good. In equilibrium, they correspond to the individuals' MWTP for the environmental good (Rosen 1974, Roback 1982).

The main problems of the HM arise from its dependence on the equilibrium assumption. This assumption is met only if there is a sufficiently wide variety of houses, if prices adjust rapidly, if households have full information, and if transaction and moving costs are zero.

These conditions are often violated, and consequently WTP estimates are biased. For example, if mobility is costly, the true value of a change in an environmental amenity is greater than the house price effects imply. Consider the case of an exogenous improvement in air quality in a particular region. The cleaner air attracts new residents, and as a consequence, costs of housing rise until a new equilibrium is reached. Without mobility costs, the change in the costs of housing fully reflects the value of cleaner air. However, if migration is costly, a person will move to the region with improved air quality only if the cleaner air compensates him or her for both the higher rents and the cost of moving. To estimate the full WTP in the presence of migration costs, Bayer et al. (2009) developed an alternative discrete-choice approach that models household decisions directly and does not

rely on the equilibrium condition. They used their approach to value air quality [total suspended particulate (TSP)] in U.S. metropolitan areas in 1990 and 2000. The estimated annual MWTP for the median household income amounts to between $309 and $384 (in 2007 U.S. dollars).[6] By comparison, the MWTP estimated with the conventional hedonic model is only $114. Their results thus suggest that conventional hedonic models underestimate the WTP for clean air by a factor of approximately three. In contrast to the HM, the LSA explicitly captures individual welfare in the absence of market equilibria. In the case of public goods, for which it is useful to distinguish between expected benefits and materialized benefits and for which the effects on life satisfaction are identified on the basis of the latter, the LSA can recover the full utility consequences independently of the degree of capitalization in the housing and labor market. For all other public goods, compensating variation in the private markets has to be accounted for. If they are not, the LSA captures only the residual effect. These issues are discussed in more detail below. Anticipating one of the main conclusions, the discussion suggests that, if anything, the LSA works best if there is no market equilibrium.

As with mobility costs, incomplete information of households is likely to bias the hedonic estimates downward. To correctly anticipate the effect of an environmental disamenity such as air pollution at a particular location, a prospective house buyer or renter requires adequate knowledge of pollution risks and adequate information about prevailing pollution levels. Distorted risk perceptions may bias hedonic estimates in either direction because people may underestimate or exaggerate the risk of pollution.[7] In contrast, incomplete information about prevailing pollution levels invariably attenuates price gradients toward zero (Pope 2008b). Several studies suggest that individuals' information void on location-specific amenity levels and the resulting downward bias in hedonic estimates may be large. Brookshire et al. (1985) and Troy & Romm (2004) find no price discounts for properties in areas with elevated risks of earthquakes and flooding before laws that require sellers of property to disclose information on earthquake and flood risks have been passed. However, these researchers find large and significant price discounts after the passage of such laws. Similarly, Pope (2008a) finds the introduction of mandatory disclosure requirements to increase the marginal valuation of airport noise by 37%.[8]

Distorted perceptions are of particular importance for the capitalization of health effects. Smith & Huang (1995) provide evidence consistent with the notion of incomplete capitalization of health effects. Benefit estimates for improvements in air quality in selected U.S. cities based on dose-response functions and value-of-statistical-life estimates are at least four times higher than benefit estimates based on hedonic studies. Smith & Huang (1995, p. 223) conclude that "hedonic models are more likely to reflect aesthetics, materials and soiling effects, and, to some degree, perceived health effects, but the latter may well be incomplete."[9] Moreover, reduced mortality risk is only one benefit of clean air.

[6]Bayer et al. (2009) report their results in 1982–1984 U.S. dollars. The figures have been transformed to 2007 U.S. dollars, using the CPI for all urban consumers (CPI-U) of the Bureau of Labor Statistics.

[7]For example, McCluskey & Rausser (2001) show that newspaper coverage significantly influences risk perceptions and consequently hedonic price gradients.

[8]Of course, in the case of highly salient risks or changes in the environmental conditions, it is more likely that people are accurately informed. For example, Hallstrom & Smith (2005) find large effects of the information that Hurricane Andrew in 1992 conveyed to homeowners on property prices.

[9]The primary objective of Smith & Huang (1995) was to assess if systematic factors are associated with different estimates across markets. Thus, their primary objective was not to measure losses to health effects.

Reduced risk of morbidity, reduced chronic diseases and minor symptomatic discomforts, reduced material damages, and improved visibility are other benefits.

A conceptual problem of revealed preference methods is that individuals' behavior in private markets always reflects expected future risks (even if expectations are based on current or past risks). In contrast, in most applications of the LSA, the welfare consequences of risks are identified primarily on the basis of actual events, i.e., when the risk materializes. The LSA is, therefore, less affected by distorted risk perceptions. As mentioned above, the LSA can also capture effects of externalities that affect individuals' life satisfaction through a process unnoticed by the individuals themselves. For example, it can capture the welfare consequences of health effects, even if individuals are ignorant about the causes. Moreover, most survey respondents are long-term residents in a particular location, and they are arguably better informed about prevailing pollution levels than are prospective house buyers and renters who consider moving to that location. This is not to say that perceptions are irrelevant for the LSA. To the extent that perceptions of local pollution levels enter into individual welfare judgments, distorted risk perceptions affect life satisfaction estimates as well. However, the above discussion suggests that distorted perceptions are more important for the HM than for the LSA.

3.3. Utility Misprediction and Valuation

The systematic divergence of two basic concepts of utility also challenges the standard methods. The traditional axiomatic approach in economics holds that the choices made by individuals provide all the information required to infer the utility of outcomes. People, on average, correctly predict how they value some outcome. This first concept of utility is the basis for the revealed preference methods for valuing the environment. The same presumption with regard to the accurate prediction of utility also underlies stated preference methods. There is now more evidence in both hypothetical and real markets that individuals mispredict their future feelings (Kahneman & Thaler 2006, Frey & Stutzer 2008). This finding undermines a tenet of the revealed preference approach. Utility misprediction is due to a combination of incorrect intuitive theories about the determinants of happiness, incorrect beliefs regarding the speed and degree of adaptation, a difference in saliency of various aspects between the moment of prediction and the moment of experience, and a focusing illusion (for a discussion of these effects in the specific context of the CVM, see Loewenstein & Schkade 1999, Kahneman & Sugden 2005, and Dolan & Kahneman 2008). Moreover, these deviations and discrepancies are most likely in complex decisions with long-term trade-offs (Camerer et al. 2005), i.e., nearly all decisions of policy relevance. Therefore, the second utility concept underlying the LSA emphasizes individuals' judgments of experiences ex post, for example, as reflected in measures of reported life satisfaction. With this concept, systematic prediction errors are expected to bias valuations of alternatives less.

3.4. Relationship Between the Hedonic Method and the Life Satisfaction Approach

There is some disagreement in the literature about the relationship between the HM and the LSA and about what effects of environmental quality can be identified with the LSA. Whereas some economists compare estimates based on the HM with estimates based on

the LSA and, thus, implicitly or explicitly see the two methods as substitutes that measure the same thing (e.g., Dolan & Metcalfe 2008), others argue that the methods are complementary and that the estimates from the two methods have to be combined (van Praag & Baarsma 2005, Luechinger 2009). The intuitive explanation underlying the second position is that—according to the premise of the HM—people exposed to negative externalities are compensated in the housing market. The markets compensate people for the costs of self-protection measures, for the costs of locally financed public measures as well as for any direct utility costs associated with these measures, for higher-risk premiums for insuring themselves against damages, and for all noninsurable and nonavertable losses. Therefore, this compensating variation has a countervailing effect on individual welfare. In the market equilibrium, rents must adjust to equalize utility across locations. Otherwise, some individuals would have an incentive to move (Roback 1982). If the equilibrium assumption held and people were fully compensated, we would find no effect of an environmental disamenity on life satisfaction in a life satisfaction regression with the environmental disamenity as an explanatory variable. However, as discussed above, migration costs and informational asymmetries may prevent full capitalization, in particular in the short run. The LSA captures these residual shadow costs of environmental conditions.

So far, the discussion refers to cross-section analyses, but the same argument can be made for panel analyses.[10] Utility is equalized across regions at every point in time but not necessarily across time. However, changes over time are usually captured by time-specific effects. Thus, panel data capture only the residual effect. Of course, in a panel setting, the focus is on changes in environmental conditions. Compensation of these changes is likely to be less pronounced, and the residual effect may capture a great part of the overall effect. Nevertheless, conceptually, it is still a residual effect, and the two methods remain complements.

An exception is environmental conditions for which it is useful to distinguish between expected benefits or costs and materialized benefits or costs, i.e., environmental risks such as the risk of flooding. In the case of risks, compensating variation in the housing market is based on expected risks. If the underlying probabilities are stable, the compensating variation is captured by region-specific effects. By the same token, the fixed effects reflect all utility costs of insurance, protection measures, and self-protection measures. In applications of the LSA with panel data, the effect of risks is accordingly identified on the basis of actual events, i.e., if the risk materializes. Therefore, the full utility losses or, more precisely, the full noninsurable and nonavertable losses, can be recovered. In this situation, the HM and the LSA are substitutes.

4. APPLICATIONS

The LSA can be used to value a wide range of different public goods and bads and negative and positive externalities. For example, the LSA has been used to value climatic conditions (Frijters & van Praag 1998, Rehdanz & Maddison 2005, Becchetti et al. 2007, Brereton et al. 2008), airport noise nuisance (van Praag & Baarsma 2005), proximity to infrastruc-

[10]Recent papers assessing the extent of error in conventional cross-section experiments and in quasi-experiments and, thus, the relative performance of conventional cross-section versus quasi-experimental methods are Klaiber & Smith (2009), Kuminoff & Pope (2009), and Kuminoff et al. (2009).

ture (Brereton et al. 2008), urban regeneration schemes (Dolan & Metcalfe 2008), droughts (Carroll et al. 2009), floods (Luechinger & Raschky 2009), crime (Cohen 2008), and terrorism (Frey et al. 2009). However, as with the HM, the most widely studied environmental disamenity is air pollution.

Air pollution was the object of interest in the first application of the HM to the valuation of a public good (Ridker & Henning 1967). By the mid-1990s, the number of studies allowed for a meta-analysis: Smith & Huang (1995) identified 86 MWTP estimates for a reduction in TSP in 37 different studies (the median MWTP was $46, and the mean was $228, in 2007 U.S. dollars).[11] Still, today many methodological innovations are exemplified by the case of air pollution (Chay & Greenstone 2005, Bayer et al. 2009). This interest in air pollution is shared by the growing number of LSA studies. As of spring 2010, there were at least seven studies focusing on air pollution. This interest may be explained by the fact that air pollution is a long-standing environmental concern and was the focus of the earliest and most significant environmental regulations. Whereas for some countries and air pollutants the situation improved, the situation in other countries, especially developing countries, and for other air pollutants is deteriorating.

Table 1 summarizes the aforementioned seven LSA studies on air pollution. The table reports the source and structure of the survey data used, the spatial resolution, the time period, the included pollutants, and the main control variables, along with MWTP estimates (all estimates are in 2007 U.S. dollars). Most studies report the results for several specifications. The table summarizes the results from the baseline regression. If several specifications are presented as baseline regressions, the table presents the results of the most complete or comprehensive model. Similarly, if studies contained baseline regressions with the pollutants included individually and baseline regressions with the pollutants included jointly, the reported estimates are based on the latter regressions. Furthermore, only statistically significant estimates are shown. Despite these studies' shared focus on air pollution, the diversity in terms of considered pollutants, countries or regions, and time periods as well as methodology renders futile any attempt to synthesize their results into summary statistics. The review of the studies rather serves to exemplify methodological aspects that pertain to the LSA literature more generally.

The structure of the survey data is a first difference between the seven studies. Although most of these studies use repeated cross-section data, two studies use cross-section data (Welsch 2002, MacKerron & Mourato 2009). The inability to control for unobserved spatial heterogeneity that is correlated with air pollution makes cross-section estimates more prone to omitted variable bias and, most likely, more sensitive to changes in the specification. For example, in Welsch (2002), the effect of nitrogen dioxide (NO_2) falls below conventional levels of significance if the number of scientists is excluded from the set of controls. Only one study uses individual panel data (Luechinger 2009). Although controlling for individual heterogeneity may be less important to correctly estimate the effect of pollution, it has substantial effects on the estimates of the effect of personal characteristics such as income (Ferrer-i-Carbonell & Frijters 2004). This is important because the coefficient for income feeds into the calculation of the benefit estimates in monetary terms.

[11]Smith & Huang (1995) report their results in 1982–1984 U.S. dollars. The figures have been transformed to 2007 U.S. dollars, using the CPI for all urban consumers (CPI-U) of the Bureau of Labor Statistics.

Table 1 Summary of LSA studies valuing air quality[a,b]

Study	Data, structure, spatial resolution, and period	Air pollution indicators	Controls	MWTP[c,d]
Welsch (2002)	Various sources, cross section, 54 countries (dependent variable is country average of happiness): early and mid-1990s	TSP, SO_2, and NO_2	Water pollution and other economic and societal variables	NO_2: \$113
Welsch (2006)	Eurobarometer, repeated cross section, 10 European countries (dependent variable is country-year average of life satisfaction): 1990–1997	TSP, NO_2, and Pb	GNP per capita as well as country and year effects	Pb: \$184
Di Tella & MacCulloch (2007)	Eurobarometer and GSS, repeated cross section, 12 OECD countries: 1975–1997	SO_x emissions per capita	Personal characteristics, life expectancy, crime rate, and other economic and societal variables as well as country and year effects	SO_x: \$171
Levinson (2008)	GSS, repeated cross section, approximately 300 U.S. counties: 1973–1996 (with gaps)	PM10; in separate regressions, also SO_2 and CO	Personal characteristics, temperature and precipitation, region, and year and month effects	PM10: \$896
Luechinger (2009)	GSOEP, individual-level panel, approximately 450 German counties: 1985–2003	SO_2, conventional and IV estimates	Personal characteristics, county characteristics, state-specific time trends as well as time and individual effects	SO_2: \$200; $SO_{2,\,IV}$: \$340
Luechinger (2010)	Eurobarometer, repeated cross section, 13 European countries: 1979–1994	SO_2, conventional and IV estimates	Personal characteristics, macroeconomic variables, and country and time effects	SO_2: \$157; $SO_{2,\,IV}$: \$324
MacKerron & Mourato (2009)	Own Web survey for London, cross section, zip codes of 400 respondents: 2007	NO_2	Personal characteristics, attitudes and perceptions, distance from major road and city center	NO_2: \$8296

[a]Most studies present the results of different specifications. The table summarizes the results from the baseline regression. If several specifications are presented as baseline regressions, the table presents results of the most complete or comprehensive model.

[b]Abbreviations used: GSOEP, German Socio-Economic Panel; GSS, U.S. General Social Survey; MWTP, marginal willingness to pay; PM10, particulates of <10 μm; TSP, total suspended particulate.

[c]The results reported in the studies have been transformed to 2007 U.S. dollars with the CPI for all urban consumers (CPI-U) of the Bureau of Labor Statistics and annual exchange rates where necessary.

[d]MWTP estimates refer to a reduction of 1 μg m^{-3} of the respective pollutant. Exceptions are the MWTP estimates for lead (Pb) and sulfur oxide (SO_x) emissions. For Pb, the MWTP refers to a reduction of 0.01 μg m^{-3} because Pb concentrations are approximately 100 times lower compared with the concentrations of other pollutants. For SO_x emissions, MWTP refers to a reduction of 1 kg per capita.

Another difference across these studies is the spatial resolution at which the survey data and the pollution data are merged. Most of the studies use country or country-year averages of pollution levels (Welsch 2002, 2006; Di Tella & MacCulloch 2007; Luechinger 2010). To the extent that the country averages do not well represent respondents' experienced degree of exposure to pollution where they live, the estimated effect of pollution on life satisfaction is attenuated toward zero.[12] This problem can be addressed by using pollution data with a higher spatial resolution such as the county or zip code level (Levinson 2008, Luechinger 2009, MacKerron & Mourato 2009). The relevance of the attenuation bias is ultimately an empirical issue and will differ across settings. Whereas for some pollutants and time periods the large cross-country and temporal variation may dwarf within-country differences, for other settings the bias is likely to be more severe.

Levinson (2008) extends the logic of the argument above to the issue of temporal resolution. A higher resolution is generally desirable in the spatial case but not necessarily in the temporal case. The appropriate degree of temporal resolution depends on the channels through which pollution is likely to affect life satisfaction. On the one hand, if air pollution affects subjective well-being mainly through adverse health consequences, material damages, and the like, measures capturing longer-term exposure are relevant, and thus longer-term measures such as annual mean concentrations are more appropriate than short-term measures. On the other hand, if aesthetics effects such as reduced visibility are the most important channel, short-term measures may be more relevant. Empirically, however, high peak concentrations and high annual mean concentrations will often go together, and hence the choice of temporal resolution will be of minor importance.

Even if repeated cross-section and panel data allow researchers to control for time-invariant spatial heterogeneity, estimates of pollution benefits are still prone to severe omitted variable biases: Local air pollution is likely to be highly correlated with unobserved local economic activity. In their HM analysis on the costs of TSP pollution, Chay & Greenstone (2005) provide evidence that supports this conjecture. Conventional MWTP estimates often have a perverse positive sign or are at best economically small and statistically insignificant. In contrast, MWTP estimates based on IV regressions range between $176 and $315 (in 2007 U.S. dollars).[13] To address this simultaneity problem, two of the studies in **Table 1** use exogenous changes in air pollution to identify the effect of air pollution on life satisfaction. Luechinger (2009) exploits the natural experiment created by the mandated scrubber installation at German power plants together with wind directions dividing counties into treatment and control groups. Luechinger (2010) instruments a country's air pollution with the long-range transboundary air pollution caused by emissions in foreign countries. As can be seen from **Table 1**, MWTP estimates based on IV regressions are higher than the conventional estimates in both studies.

With the LSA, it is straightforward to go beyond estimating average effects. Several studies report differentiated effects for different subgroups of the population such as predicted risk groups, the elderly, or environmentalists (Levinson 2008; Luechinger 2009, 2010).

[12]In the Di Tella & MacCulloch (2007) study, this problem is aggravated by the fact that the authors use sulfur oxide (SO_x) emissions instead of sulfur dioxide (SO_2) concentration as measure of air pollution. Because a large part of SO_x pollution is transboundary, emission and pollution levels can differ greatly.

[13]Chay & Greenstone (2005) report their results in 1982–1984 U.S. dollars. The figures have been transformed to 2007 U.S. dollars, using the CPI for all urban consumers (CPI-U) of the Bureau of Labor Statistics.

On the one hand, these differentiated effects can serve as a robustness and plausibility check. On the other hand, differentiated effects can provide valuable information for policy makers and can help them understand the intensity of support for public good provision in the political process.

5. CONCLUDING REMARKS

On the basis of our review of the LSA, concluding remarks in three directions are drawn. First, we derive some implications for research on subjective well-being and nonmarket valuation in economics. Second, we raise the issue of whether the effects of public goods on life satisfaction should be monetized. Finally, some proposals for future research are raised.

5.1. Implications for Research on Subjective Well-Being and Nonmarket Valuation

The LSA emphasizes public goods and externalities as determinants of individual welfare and thus complements our understanding of people's preferences as derived from research on subjective well-being in economics. For a further successful application, we discuss above six requirements that subjective well-being measures should meet: (*a*) validity, (*b*) inclusiveness, (*c*) reference to presence, (*d*) sufficiently high signal-to-noise ratio, (*e*) interpersonal (or intergroup) comparability, and (*f*) availability. These requirements are important for empirical happiness research in general.

It was the aim of this review to convince the reader that subjective well-being data can be used to value public goods and hence that the LSA expands economists' toolbox in the area of nonmarket valuation. This same approach also allows researchers to test the underlying assumptions of the standard nonmarket valuation techniques. For example, the negative relationship between life satisfaction and air pollution indicates that air pollution is incompletely capitalized. Thus, the HM understates the value of clean air. However, the problem of undercapitalization is likely to be more severe for externalities that are rapidly changing and that have important indirect effects than for stable and salient risks.

5.2. Monetization?

Does the LSA overshoot when monetizing the value of environmental conditions? The standard argument for monetization of externalities and public goods is that money is a convenient measuring rod that allows decision makers to compare various benefits and costs. However, it has long been recognized that WTP for a change in public good provision imperfectly approximates the effects of the change of overall welfare because of the wealth effects and the variable marginal utility of income or, in other words, because of the diminishing marginal utility of income. Suppose, for example, that a public project benefits the poor but hurts the rich. Such a project may increase aggregate welfare, even though the sum of individual WTP is negative. Moreover, if public goods are monetized with the LSA, estimates on the effect of income on life satisfaction play a crucial role. Unfortunately, estimating this effect is associated with serious problems, most importantly endogeneity and omitted variable problems (Clark et al. 2008). This may well speak in favor of subjective well-being scores as an alternative nonmonetary scale.

However, several counterarguments speak in favor of monetization. First, many costs naturally accrue in monetary form, e.g., if compliance costs decrease firms' profits and increase consumer prices. Converting monetary figures into life satisfaction scores is associated with exactly the same potential problems as the reverse operation. Second, in many situations, the LSA is complementary to the standard techniques and captures only the residual shadow benefits. In these situations, WTP estimates based on different methods must be summed up to calculate the total shadow benefits of a public good. Third, for some potential uses of the LSA, welfare effects ultimately have to be expressed in monetary terms. An example is tort cases. Fourth, a large body of literature contains a wealth of information on people's WTP for public goods. For academic curiosity and for practical purposes, one may want to compare estimates based on the LSA to these WTP estimates.

We recommend that studies using the LSA offer effect sizes both in terms of subjective well-being scores (together with exact information on the subjective well-being question, the mean response, and the standard deviation in the sample) and in monetary terms. Effects in terms of subjective well-being can later be combined with state-of-the-art findings for the effects of monetary transfers on individual welfare.

5.3. Future Research

We see two areas that warrant further research in the future. First, important insights will be gained by additional comparisons of the LSA with the standard methods. For example, subjective well-being data would allow us to test the crucial assumption of the travel cost approach that traveling to a recreational site provides no direct utility or disutility. One potential avenue to test would be an analysis along the lines of the DRM study of Kahneman et al. (2004). Interestingly, they report commuting to be (one of) the least pleasant activities. Alternatively, subjective well-being data could be used to quantify the nonpecuniary costs of defense and prevention behavior that is relevant for the defense expenditure approach. The second area for future research relates to improvements of the LSA. One major issue in this respect is a need for better estimates of the effect of income on life satisfaction. So far, estimates based on exogenous changes in income are rare. Many correlates in subjective well-being are actually choice variables, and choices involve trade-offs. Thus, it should be no surprise if—at least at the margin—the raw effect of the choice variable on life satisfaction is small. Another issue concerns the subjective well-being measures. We argued that existing measures of subjective well-being, particularly global self-reports of life satisfaction, are well suited for the purpose of valuing public goods. Yet there is still the concern that these measures and the estimates based thereupon are systematically biased because of conceptual problems and contextual factors such as question order effects and the lack of intergroup comparability. The LSA would greatly benefit if these problems were taken seriously in the development of the next generation of subjective well-being measures.

In sum, there is still room for improvement, and many of the questions raised in this review remain unanswered. However, if we convinced the reader that the LSA can be used to value public goods and that it is worthwhile to address the open issues, we have achieved our aim.

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LITERATURE CITED

Adler MD, Posner EA. 2006. *New Foundations of Cost-Benefit Analysis*. Cambridge, MA: Harvard Univ. Press

Adler MD, Posner EA. 2008. Happiness research and cost-benefit analysis. *J. Legal Stud.* 37:S253–92

Arrow KJ, Solow RS, Portney PR, Leamer EE, Radner R, Schuman H. 1993. Report of the NOAA-panel on contingent valuation. *Fed. Regist.* 58:4601–14

Arthaud-Day ML, Rode JC, Mooney CH, Near JP. 2005. The subjective well-being construct: a test of its convergent, discriminant, and factorial validity. *Soc. Indic. Res.* 74:445–76

Bayer P, Keohane NO, Timmins C. 2009. Migration and hedonic valuation: the case of air quality. *J. Environ. Econ. Manag.* 58:1–14

Becchetti L, Castriota S, Londoño Bedoya DA. 2007. *Climate, happiness and the Kyoto Protocol: Someone does not like it hot*. Work. Pap. 247, Tor Vergata Univ.

Blanchflower DG, Oswald AJ. 2007. Hypertension and happiness across nations. *J. Health Econ.* 27:218–33

Brereton F, Clinch JP, Ferreira S. 2008. Happiness, geography and the environment. *Ecol. Econ.* 65:386–96

Brookshire DS, Thayer MA, Tschirhart J, Schulze WD. 1985. A test of the expected utility model: evidence from earthquake risks. *J. Polit. Econ.* 93:369–89

Camerer CF, Loewenstein G, Prelec D. 2005. Neuroeconomics: how neuroscience can inform economics. *J. Econ. Lit.* 43:9–64

Carroll N, Frijters P, Shields MA. 2009. Quantifying the costs of drought: new evidence from life satisfaction data. *J. Popul. Econ.* 22:445–61

Carson RT, Flores NE, Meade NF. 2001. Contingent valuation: controversies and evidence. *Environ. Resour. Econ.* 19:173–210

Carson RT, Mitchell RC, Hanemann WM, Kopp RJ, Presser S, et al. 2003. Contingent valuation and lost passive use: damages from the Exxon Valdez oil spill. *Environ. Resour. Econ.* 25:257–86

Chay KY, Greenstone M. 2005. Does air quality matter? Evidence from the housing market. *J. Polit. Econ.* 113:376–424

Clark AE, Frijters P, Shields MA. 2008. Relative income, happiness and utility: an explanation for the Easterlin paradox and other puzzles. *J. Econ. Lit.* 46:95–144

Cohen MA. 2008. The effect of crime on life satisfaction. *J. Legal Stud.* 37:S325–52

Diamond PA, Hausman JA. 1994. Contingent valuation: Is some number better than no number? *J. Econ. Perspect.* 8:45–64

Diener E. 1984. Subjective well-being. *Psychol. Bull.* 95:542–75

Diener E, Suh EM, Lucas RE, Smith HL. 1999. Subjective well-being: three decades of progress. *Psychol. Bull.* 125:276–302

Di Tella R, MacCulloch RJ. 2006. Some uses of happiness data in economics. *J. Econ. Perspect.* 20:25–46

Di Tella R, MacCulloch RJ. 2007. Gross national happiness as an answer to the Easterlin paradox? *J. Dev. Econ.* 86:22–42

Dolan P, Kahneman D. 2008. Interpretations of utility and their implications for the valuation of health. *Econ. J.* 118:215–34

Dolan P, Metcalfe R. 2008. *Comparing Willingness-to-Pay and Subjective Well-Being in the Context of Non-Market Goods*. CEP Discuss. Pap. 890, London Sch. Econ.

Due JF, Friedlaender AF. 1973. *Government Finance: Economics of the Public Sector*. Homewood, IL: Irwin. 5th ed.

Ferrer-i-Carbonell A, Frijters P. 2004. How important is methodology for the estimates of the determinants of happiness? *Econ. J.* 114:641–59

Freeman AM III. 2003. *The Measurement of Environmental and Resource Values: Theory and Methods*. Washington, DC: Resourc. Future

Frey BS, Luechinger S, Stutzer A. 2009. The life satisfaction approach to the value of public goods: the case of terrorism. *Public Choice* 138:317–45
Frey BS, Stutzer A. 2002a. *Happiness and Economics: How the Economy and Institutions Affect Well-Being*. Princeton, NJ: Princeton Univ. Press
Frey BS, Stutzer A. 2002b. What can economists learn from happiness research? *J. Econ. Lit.* 40:402–35
Frey BS, Stutzer A. 2008. Stress that doesn't pay: the commuting paradox. *Scand. J. Econ.* 110:339–66
Frey BS, Stutzer A. 2010. Happiness and public choice. *Public Choice*. In press
Frijters P, van Praag BMS. 1998. The effects of climate on welfare and well-being in Russia. *Clim. Change* 39:61–81
Gardner J, Oswald AJ. 2006. Do divorcing couples become happier by breaking up? *J. R. Stat. Soc. Ser. A* 169:319–36
Hallstrom DG, Smith VK. 2005. Market responses to hurricanes. *J. Environ. Econ. Manag.* 50:541–61
Hanemann WM. 1984. Welfare evaluations in contingent valuation experiments with discrete responses. *Am. J. Agric. Econ.* 66:332–41
Hanemann WM. 1994. Valuing the environment through contingent valuation. *J. Econ. Perspect.* 8:19–43
Kahneman D. 2000. Experienced utility and objective happiness: a moment based approach. In *Choices, Values, and Frames*, ed. D Kahneman, A Tversky, pp. 673–92. New York: Cambridge Univ. Press
Kahneman D, Diener E, Schwarz N, eds. 1999a. *Well-Being: The Foundations of Hedonic Psychology*. New York: Russell Sage Found.
Kahneman D, Knetsch JL. 1992. Valuing public goods: the purchase of moral satisfaction. *J. Environ. Econ. Manag.* 22:57–70
Kahneman D, Krueger AB, Schkade DA, Schwarz N, Stone AA. 2004. A survey method for characterizing daily life experience: the day reconstruction method. *Science* 306:1776–80
Kahneman D, Ritov I, Schkade DA. 1999b. Economic preferences or attitude expressions? An analysis of dollar responses to public issues. *J. Risk Uncertain.* 19:203–35
Kahneman D, Sugden R. 2005. Experienced utility as a standard of policy evaluation. *Environ. Resour. Econ.* 32:161–81
Kahneman D, Thaler RH. 2006. Anomalies: utility maximization and experienced utility. *J. Econ. Perspect.* 20:221–34
Kahneman D, Wakker PP, Sarin R. 1997. Back to Bentham? Explorations of experienced utility. *Q. J. Econ.* 112:375–405
Kelman M. 2005. Hedonic psychology and the ambiguities of "welfare". *Philos. Public Aff.* 33:392–412
Kimball M, Willis R. 2006. *Utility and Happiness*. Univ. Mich., (Mimeo)
Klaiber HA, Smith VK. 2009. *Evaluating Rubin's causal model for measuring the capitalization of environmental amenities*. NBER Work. Pap. 14957, Cambridge, MA
Koivumaa-Honkanen H, Honkanen R, Viinamäki H, Heikkilä K, Kaprio J, et al. 2000. Self-reported life satisfaction and 20-year mortality in healthy Finnish adults. *Am. J. Epidemiol.* 152:983–91
Koivumaa-Honkanen H, Honkanen R, Viinamäki H, Heikkilä K, Kaprio J, et al. 2001. Life satisfaction and suicide: a 20-year follow-up study. *Am. J. Psychiatry* 158:433–39
Kuminoff NV, Parmeter CF, Pope JC. 2009. *Specification of hedonic price functions: guidance for cross-sectional and panel data applications*. Work. Pap. 2009-02, Dept. Agric. Appl. Econ., Va. Polytech. Inst. State Univ.
Kuminoff NV, Pope JC. 2009. *Capitalization and welfare measurement in the hedonic model*. Work. Pap. 2009-01, Dept. Agric. Appl. Econ., Va. Polytech. Inst. State Univ.
Larsen RJ, Frederickson BL. 1999. Measurement issues in emotion research. See Kahneman et al. 1999a, pp. 61–84
Layard R. 2005. *Happiness: Lessons from a New Science*. New York: Penguin
Levinson A. 2008. *Valuing air quality using happiness data: the case of air quality*. Work. Pap., Dept. Econ., Georgetown Univ.

Loewenstein G, Schkade DA. 1999. Wouldn't it be nice? Predicting future feelings. See Kahneman et al. 1999a, pp. 85–105
Luechinger S. 2009. Valuing air quality using the life satisfaction approach. *Econ. J.* 119:482–515
Luechinger S. 2010. Life satisfaction and transboundary air pollution. *Econ. Lett.* 107:4–6
Luechinger S, Raschky P. 2009. Valuing flood disasters using the life satisfaction approach. *J. Public Econ.* 93:620–33
MacKerron G, Mourato S. 2009. Life satisfaction and air quality in London. *Ecol. Econ.* 68:1441–53
McCluskey JJ, Rausser GC. 2001. Estimation of perceived risk and its effect on property values. *Land Econ.* 77:42–55
Palmquist RB, Smith VK. 2002. The use of hedonic property value techniques for policy and litigation. In *The International Yearbook of Environmental and Resource Economics 2002/2003*, ed. T Tietenberg, H Folmer, pp. 115–64. Cheltenham, UK: Edward Elgar
Pope JC. 2008a. Buyer information and the hedonic: the impact of a seller disclosure on the implicit price for airport noise. *J. Urban Econ.* 63:498–516
Pope JC. 2008b. Do seller disclosures affect property values? Buyer information and the hedonic model. *Land Econ.* 84:551–72
Portney PR. 1994. The contingent valuation debate: why economists should care. *J. Econ. Perspect.* 8:3–17
Rehdanz K, Maddison D. 2005. Climate and happiness. *Ecol. Econ.* 52:111–25
Ridker RG, Henning JA. 1967. The determinants of residential property values with special reference to air pollution. *Rev. Econ. Stat.* 49:246–57
Roback J. 1982. Wages, rents, and the quality of life. *J. Polit. Econ.* 90:1257–78
Robbins LC. 1938. Interpersonal comparisons of utility: a comment. *Econ. J.* 48:635–41
Rosen S. 1974. Hedonic prices and implicit markets: product differentiation in pure competition. *J. Polit. Econ.* 82:34–55
Sandvik E, Diener E, Seidlitz L. 1993. Subjective well-being: the convergence and stability of self-report and non-self-report measures. *J. Personal.* 61:317–42
Schwarz N, Strack F. 1991. Evaluating one's life: a judgment model of subjective well-being. In *Subjective Well-Being: An Interdisciplinary Perspective*, ed. F Strack, M Argyle, N Schwarz, pp. 27–47. Oxford, UK: Pergamon
Schwarz N, Strack F. 1999. Reports of subjective well-being: judgmental processes and their methodological implications. See Kahneman et al. 1999, pp. 61–84
Smith VK, Huang J-C. 1995. Can markets value air quality? A meta-analysis of hedonic property value models. *J. Polit. Econ.* 103:209–27
Smith VK, Osborne LL. 1996. Do contingent valuation estimates pass a "scope" test? A meta-analysis. *J. Environ. Econ. Manag.* 31:287–301
Stone AA, Shiffman SS, DeVries MW. 1999. Ecological momentary assessment. See Kahneman et al. 1999, pp. 26–39
Strack F, Martin LL, Schwarz N. 1988. Priming and communication: social determinants of information use in judgments of life satisfaction. *Eur. J. Soc. Psychol.* 18:429–42
Stutzer A, Frey BS. 2006. Does marriage make people happy, or do happy people get married? *J. Socio-Econ.* 35(2):326–47
Sumner LW. 1996. *Welfare, Happiness, and Ethics*. Oxford, UK: Oxford Univ. Press
Troy A, Romm J. 2004. Assessing the price effects of flood hazard disclosure under the California Natural Hazard Disclosure Law (AB 1195). *J. Environ. Plan. Manag.* 47:137–62
Urry HL, Nitschke JB, Dolski I, Jackson DC, Dalton KM, et al. 2004. Making a life worth living: neural correlates of well-being. *Psychol. Sci.* 15:367–72
van Praag BMS, Baarsma BE. 2005. Using happiness surveys to value intangibles: the case of airport noise. *Econ. J.* 115:224–46
van Praag BMS, Ferrer-i-Carbonell A. 2008. *Happiness Quantified: A Satisfaction Calculus Approach*. Oxford, UK: Oxford Univ. Press

van Praag BMS, Ferrer-i-Carbonell A. 2010. Happiness, economics and hedonic equations. In *Monitoring the Urban Quality of Life in Latin America*, ed. E Lora, A Powell, B van Praag, P Sanguinetti. Washington, DC: World Bank. Forthcoming

van Praag BMS, Frijters P. 1999. Different data sources for studying behaviour. In *Economics, Welfare Policy and the History of Economic Thought: Essays in Honour of Arnold Heertje*, ed. MMG Fase, W Kanning, DA Walker, pp. 290–309. Cheltenham, UK: Edward Elgar

Welsch H. 2002. Preferences over prosperity and pollution: environmental valuation based on happiness surveys. *Kyklos* 55:473–94

Welsch H. 2006. Environment and happiness: valuation of air pollution using life satisfaction data. *Ecol. Econ.* 58:801–13

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