

On Using Standard Values of Time in Project Appraisal: Income Equity vs. Preference Equity

Luis Ignacio Rizzi ^a

Seiji S.C. Steimetz ^{b,*}

^a Department of Engineering and Transport Logistics
Pontificia Universidad Católica de Chile
Casilla 306, Código 105, Santiago 22, Chile
Email: lrizzi@ing.puc.cl
Phone: 56-2-2354-4270

^b California State University, Long Beach
1250 Bellflower Boulevard
Long Beach, CA 90840, United States of America
Email: seiji.steimetz@csulb.edu
Phone: 1-562-985-5078

* Corresponding author

Abstract

We examine the practice of using “standard” or “equity” values of time to evaluate the benefits of transportation improvements, and we make explicit the social weighting schemes that are consistent with that practice. We demonstrate that if travel-time preferences vary, then standard values of time typically imply social weighting schemes that favor those who gain the least utility from travel-time savings. We further show how this finding persists when improvements are financed by user payments such as road tolls and taxes. We then describe a remedial weighting scheme that generalizes several valuation approaches developed in the literature.

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I. Introduction

The benefits of transportation improvements are typically dominated by the travel-time savings that they offer. And so the “subjective value of travel-time savings”, or simply the “value of time”, is arguably the most important transportation policy parameter (Small and Verhoef, 2007). Intuitively, the economic benefits of a time-saving improvement would be calculated by multiplying each user’s value of time by the amount of time saved. But doing so can result in a valuation scheme that favors projects benefiting higher income groups (Galvez and Jara-Diaz, 1998; Mackie et al., 2001; Mackie et al., 2003). Specifically, using the value of time for cost-benefit analysis, in the context of a social welfare function, implies welfare weights that are inversely proportional to the marginal utility of income. If the marginal utility of income falls as income rises, then those with higher incomes are assigned a higher welfare weight.

To address that equity concern, some national project appraisers (mainly in the U.K. and European Union) have adopted “standard” values of time, i.e. a single value applied to all users (Mackie et al., 2001; Odgaard et al., 2005; Fowkes, 2010; MIDEPLAN, 2011). In the U.K., for example, it is the value of time evaluated at the average income level — sometimes referred to as an “equity value”. The use of standard values can also be justified as a pragmatic approach, given the difficulty in mapping heterogeneity in the value of time to corresponding members in the population. In the United States, for example, the value of “personal” travel time is evaluated at the national median of household income (U.S. Department of Transportation, 2014). Whether standard values are adopted on the grounds of equity or parsimony, it is important to understand their implications for welfare analysis.

The purpose of this paper is to clarify the welfare implications of using standard values of time in transportation project appraisal, and to demonstrate implications that have been overlooked in the literature. We show that there is more than one way to derive a standard value of time from a social welfare function. And, more importantly, we show that using those standard values typically results in appraisal schemes that give more weight to those with the lowest marginal utility of travel time. In other words, standard values of time favor those who gain the least from travel-time improvements.

Our discussion proceeds as follows. From the relevant literature in transportation economics, Section II outlines an analytical framework for using the value of time in project appraisal in the context of a social welfare function. Within that framework, Section III makes explicit the social weighting schemes implied by the practice of using standard values for project appraisal, and demonstrates how that practice can require a tradeoff between income equity and travel-time preference equity. Section IV proposes a simple and remedial social weighting scheme, which generalizes other schemes developed in the literature. Section V offers concluding remarks.

II. The Value of Time in Project Appraisal

Our analysis builds upon the seminal work of Galvez and Jara-Diaz (1998), and important discussions and extensions offered by Mackie et al. (2001), Mackie et al. (2003), and Fowkes (2010). We focus on the value of “non-work” (or “personal”) travel time, i.e. we do not consider commercial values of time. We begin with a social welfare function, W , defined as

$$W = W[U_1(T_1, P_1, Y_1) \dots U_n(T_n, P_n, Y_n)] \quad (1)$$

comprising N transportation system users indexed by $i = 1, \dots, n$, each with an indirect utility function, U_i , which depends on travel time, T_i , prices, P_i , and income, Y_i . A time-saving transportation project generates a welfare gain of

$$dW = \sum_i \frac{\partial W}{\partial U_i} \frac{\partial U_i}{\partial T_i} dT_i \quad (2)$$

For ease of expression we define

$$\begin{aligned} s_i &\equiv \frac{\partial W}{\partial U_i} \\ \theta_i &\equiv -\frac{\partial U_i}{\partial T_i} \\ \lambda_i &\equiv \frac{\partial U_i}{\partial Y_i} \end{aligned} \quad (3)$$

where s_i is the social weight applied to each individual welfare gain, θ_i is the marginal utility (i.e. negative marginal disutility) of travel time, and λ_i is the marginal utility of income. Those definitions imply that each user's (subjective) value of time, V_i , is

$$V_i \equiv \left. \frac{dY_i}{dT_i} \right|_{dU_i=0} = -\frac{\partial U_i / T_i}{\partial U_i / Y_i} = \frac{\theta_i}{\lambda_i} \quad (4)$$

and that the total welfare gain is

$$dW = \sum_i s_i \theta_i dT_i = \sum_i s_i \lambda_i V_i dT_i \quad (5)$$

which is the socially-weighted sum of individual utility gains.

Expressing this welfare gain as a monetary benefit for project appraisal requires a conversion factor that transforms social utility to social money (analogous to how λ_i transforms θ_i to an individual's monetary valuation). Let λ_W denote that conversion factor, and let dB denote the monetary benefit of the project, such that $dB \equiv \frac{dW}{\lambda_W}$.¹

An intuitive measure of that benefit, along the lines of Small and Rosen (1981), would be the summation of individuals' travel-time savings multiplied by their values of time, i.e.

$$dB = \sum_i V_i dT_i \quad (6)$$

¹ We discuss specific forms of λ_W below.

This valuation approach follows that prescribed by Harberger (1971), where the benefits accruing to each user are “added without regard to the individuals to whom they accrue”.² In the context of the social welfare function in (1), the approach is consistent with applying a social weight of $s_i = \frac{\lambda_i W}{\lambda_i}$ to each individual gain. Henceforth we shall refer to $h_i \equiv \frac{\lambda_i W}{\lambda_i}$ as “Harberger weights” and the appraisal scheme in (6) as the “Harberger approach” (with $s_i = h_i$).

As expertly illustrated by Galvez and Jara-Diaz (1998), this approach raises income-equity concerns. Because the Harberger weights are inversely proportional to the marginal utility of income, those with higher incomes receive more weight in the appraisal process (to the extent that there is diminishing marginal utility of income). An analogous interpretation is that those with higher values of time receive greater weight, as illustrated by (6).

This presents economic appraisers with a quandary. On one hand, the Harberger approach is consistent with how choices in markets are actually made, and it may not be the concern of transport policy to repair income inequality (Mackie et al., 2003). On the other hand, equity concerns are legitimate policy concerns, and it may be desirable to make equity adjustments given the opportunity (Fowkes, 2010). In practice, particularly in the U.K. and E.U., equity adjustments have been applied to the value of time, giving rise to “standard” values for use in project appraisal. A prominent example of such an adjustment is to average the value of time over income and apply it uniformly to all travel-time savings.

III. “Standard” Values of Time

Consider an average value of time (typically by income) defined as V for use as a standard value. The implied monetary benefit of a time-saving improvement is

$$dB_S = V \sum_i dT_i \quad (7)$$

where the “S” subscript denotes that a standard (or “equity”) value of time is employed, as is often the case in Chile, the E.U., the U.K., and the U.S. (Mackie et al., 2003; Odgaard et al., 2005; Fowkes, 2010; MIDEPLAN, 2011; U.S. Department of Transportation, 2014). Our objective here is to reconcile the Harberger approach with the standard-value approach so we can make explicit the social weighting scheme that converts (6) to (7).

We interpret the standard-value approach as a reweighting of the Harberger approach on the basis of equity (or, in some cases, for simplicity). Let e_i represent an “equity weight” making that adjustment. When applied to the Harberger approach, the social weight, s_i , applied to each user’s welfare gain becomes

$$s_i = h_i e_i \quad (8)$$

Because the purpose of this equity weight is to “undo” the income-regressivity of giving more weight to those with higher values of time (and less weight to those with lower values), a natural

² This is Harberger’s “Postulate C” — see Harberger (1971), p. 785.

choice is one that gives less weight to above-average values (and more weight to below-average values). In that spirit, consider

$$e_i \equiv \frac{V}{V_i} \tag{9}$$

implying that $dB_S = V \sum_i dT_i$ as in (7). Equations (7)–(9) thus demonstrate that the standard-value approach is consistent with a social weighting scheme that applies an equity adjustment given by (9) to the Harberger weighting scheme.

We are now ready to state a key finding of this paper: if a standard value of time is used to correct the income-regressivity of the Harberger approach, then it will also favor those with the least aversion to travel delays. In other words, attempting to correct an inequity in the income distribution comes at the expense of introducing an inequity in the distribution of travel-time preferences. To see this, note that the social weighting scheme implied by the standard-value approach is

$$s_i = h_i e_i = \frac{V \lambda_W}{\theta_i} \tag{10}$$

which shows how those with the lowest marginal utility of travel time receive the highest weight. The intuition behind this result is simple: because the value of time is the ratio of marginal utilities between time and money, giving more weight to those with higher income utility implies giving less weight to those with higher travel-time utility. Put differently, (10) can be expressed as $s_i = \frac{V}{V_i^{SPT}}$, where $V_i^{SPT} \equiv \frac{\theta_i}{\lambda_W}$ is an individual’s “social price of time” as discussed in Mackie et al. (2001), showing that individuals with higher social opportunity costs of time receive less weight. It follows that using standard values of time for project appraisal may not be as “equitable” as desired.

A corresponding finding is that if standard values are required, either for equity or simplicity, they can be obtained without relying on the (possibly unrealistic) assumption that the marginal utility of travel time is equal for all users.³ For example, Mackie et al. (2003) show that (7) can be derived by imposing a single marginal utility of travel time with the normalization $\theta_i = 1 \forall_i$ and then rescaling the implied welfare gain by V . Galvez and Jara-Diaz (1998) and Mackie et al. (2001) show that the assumption of $\theta_i = \theta \forall_i$ yields a standard value of $\frac{\theta}{\lambda_W}$. The two approaches are consistent if $\lambda_i = \lambda_W \forall_i$ or $\lambda_i = \lambda \forall_i$, where λ represents an average of marginal utilities. In contrast, our analysis demonstrates that if heterogeneity in travel-time preferences exists, then standard values of time can be obtained, but only in a manner that favors those with the lowest travel-time marginal utility.⁴ Our more general finding is that employing standard values of time is consistent with a social weighting scheme in which $s_i \propto \frac{1}{\theta_i}$.

³ The value-of-time derivation in DeSerpa (1971), for example, theoretically motivates heterogeneity in the marginal utility of time. Moreover, modern travel-demand estimation methods frequently specify random coefficients for travel time, necessarily implying heterogeneity in travel-time utility.

⁴ An exception is when standard values are calculated in a manner that explicitly compensates for that effect, such as the equity value proposed by Fowkes (2010). We discuss this further in Section IV.

Thus far we have not considered any specific form of λ_W . We now extend our analysis to consider the form derived by Galvez and Jara-Diaz (1998) for when a project is funded by user payments such as tax contributions.⁵ Suppose that each user contributes dM_i toward a project that requires a total funding of $\sum_i dM_i$. The total welfare gain from the project is still given by (5) and converted to a monetary benefit when divided by λ_W . Galvez and Jara-Diaz (1998) refer to λ_W as the “social [marginal] utility of money” and define it as

$$\lambda_W = \sum_i s_i \lambda_i \pi_i \quad (11)$$

where $\pi_i \equiv \frac{dM_i}{\sum_i dM_i}$ is each user’s share of the total payments.⁶ The monetary value of the welfare gain is thus

$$dB = \frac{dW}{\lambda_W} = \frac{\sum_i s_i \theta_i dT_i}{\sum_i s_i \lambda_i \pi_i} \quad (12)$$

Under the Harberger approach with $s_i = h_i = \frac{\lambda_W}{\lambda_i}$, the value of the improvement is again $dB = \sum_i V_i dT_i$.⁷ Under the standard-value approach, with $e_i = \frac{V}{V_i}$, that benefit is measured as

$$dB_S = \left[\sum_i \frac{\pi_i}{V_i} \right]^{-1} \sum_i dT_i = V_{HM} \sum_i dT_i \quad (13)$$

where $V_{HM} \equiv \left[\sum_i \frac{\pi_i}{V_i} \right]^{-1}$ is the weighted harmonic mean of individual values of time, with payment shares serving weights. Note that (13) holds for any initial standard value of time chosen for the equity adjustment, e_i .⁸ The consequences are striking: if the welfare gains of time savings and the welfare costs of financing are to be equally weighted, and if the marginal utility of time is allowed to vary, then the only standard value of time available for project appraisal is the weighted harmonic mean value of time.⁹ And we see that this standard value requires a social weighting scheme such that $s_i \propto \frac{1}{\theta_i}$.

⁵ For ease of expression and comparison with previous studies, and following Galvez and Jara-Diaz (1998), we implicitly assume that the marginal cost of public funds equals one.

⁶ See Galvez and Jara-Diaz (1998), p. 210, equations (13)–(16).

⁷ An alternative treatment of user payments is given by Mackie et al. (2003), where $dW = \sum_i s_i [\theta_i dT_i + \lambda_i dM_i]$. The Harberger approach implies $dB = V_i dT_i + dM_i$, whereas the standard-value approach, with equity adjustment $e_i = \frac{V}{V_i}$, implies $dB_S = V \sum_i dT_i + \sum_i \frac{V}{V_i} dM_i$. Mackie et al. (2003) derive this latter expression by assuming that the marginal utility of travel time is the same for all users. Our analysis shows that it can be obtained while allowing for heterogeneity in travel-time utility.

⁸ This is due to the fact that if a constant is included in the social weight, s_i , it appears in both the numerator and denominator of (12) and thus cancels.

⁹ If the marginal utility of time is assumed to be equal for all users, i.e. $\theta_i = \theta \forall_i$, then the standard value of time is $V_\theta = \frac{\theta}{\lambda_W}$, as shown by Galvez and Jara-Diaz (1998) and Mackie et al. (2001).

In practice, however, the weighted harmonic mean is not employed (nor do we advocate it). It only arises as a standard value when the social weights on time savings and user payments are constrained to be equal. Instead, benefits are typically measured as in equation (7). We now demonstrate that the standard-value approach in (7) can arise from applying different social weights to time savings and user payments.¹⁰ Define s_T as the time-savings social weight and s_M as the social weight on money contributions. The corresponding benefits measure is then

$$dB = \frac{\sum_i s_T \theta_i dT_i}{\sum_i s_M \lambda_i \pi_i} \quad (14)$$

Now consider $s_T = h_i e_i = \frac{v \lambda_W}{\theta_i}$, which includes a value-of-time equity adjustment, and $s_M = h_i = \frac{\lambda_W}{\lambda_i}$, which is an unadjusted Harberger weighting scheme on money. What results is the standard-value approach where benefits are measured as in (7).

Again, whether equal or disparate social weights are applied to time savings and user payments, we see that the standard-value approach is consistent with social weighting schemes that correct for income regressivity at the cost of introducing travel-time-preference regressivity. This may result in a misallocation of resources, as discussed by Pearce and Nash (1981), Sugden (1999), and Mackie et al. (2003). For example, consider a project that primarily affects low-income users who (at least for the sake of argument) also have low marginal utilities of travel-time savings. That project could be selected among competing projects based on the standard-value approach, even if those users would prefer longer commutes over a larger tax burden.

IV. An Alternative Social Weighting Scheme

The cause of the tradeoff between income inequity and time-preference inequity is in attempting to make corrections through willingness-to-pay values instead of focusing on the culprit: the diminishing marginal utility of income. If a social weighting scheme with equity adjustments is desired, we propose the following:

$$e'_i \equiv \frac{\lambda_i}{\lambda} \quad (15)$$

where λ is an average value of marginal utility. For example, in a discrete-choice model where travel cost is interacted with income, λ could be the marginal utility of income evaluated at the average level of income.¹¹ Or in the absence of income information, perhaps λ would be the estimated mean value of λ_i when specified as a random parameter (to accommodate unobserved income heterogeneity, *inter alia*). The role of e'_i is to lend more weight to above-average

¹⁰ Mackie et al. (2003) implicitly refer to this requirement in their discussion of the “mixture” of appraisal practices in the U.K. that leads to a standard value of time.

¹¹ Consider the conditional indirect utility specification $U_i = X\beta + \gamma C_i + \delta C_i Y_i + \varepsilon_i$ such that the marginal utility of income is measured by $\lambda_i = -\frac{\partial U_i}{\partial C_i} = \gamma + \delta Y_i$. The average marginal utility of income is then $\lambda = \gamma + \delta Y$, where Y is the average level of income. If income categories are used in place income levels, then λ would be the average of marginal utilities weighted by the proportion of users in each income group.

marginal utilities of income (and less to below-average utilities). The resulting social weighting scheme is then

$$s_i = h_i e_i' = \frac{\lambda_W}{\lambda} \quad (16)$$

which adjusts for income inequity without introducing time-preference inequity. In general, the corresponding benefits measure becomes

$$dB = \frac{\sum_i \theta_i dT_i}{\lambda} \quad (17)$$

where $\frac{\theta_i}{\lambda}$ can be interpreted as an income-adjusted value of time that accommodates heterogeneity in travel-time preferences. While this expression is not as parsimonious as one comprising a single value of time, all of its ingredients are readily obtained from ordinary travel-demand analysis.

When λ_W is specified as in Galvez and Jara-Diaz (1998) and Mackie et al. (2001), the benefits measure becomes $dB = \frac{\sum_i \theta_i dT_i}{\sum_i \lambda_i \pi_i}$, which is equivalent to the “neutral approach” to appraisal proposed in their analyses.¹² If λ_i and π_i are uncorrelated, then $dB = \frac{\sum_i \theta_i dT_i}{\lambda}$ as in (17).¹³ Alternatively, using (14), if $s_T = h_i e_i' = \frac{\lambda_W}{\lambda}$ and $s_M = h_i = \frac{\lambda_W}{\lambda_i}$, then benefits are also measured as in (17). This latter interpretation may be pragmatic when π_i is difficult to calculate but is believed to be correlated with λ_i .

The benefits measure in (17) is also equivalent to the equity-value approach proposed by Fowkes (2010). That approach uses a distance-weighted, average value of time of the form

$$V_K \equiv \sum_i \frac{\lambda_i}{\lambda} \frac{V_i K_i}{\sum_i K_i} \quad (18)$$

where K_i is each user’s travel distance, and where $dB_K \equiv V_K \sum_i dT_i$.¹⁴ The first summand of (18) shows how the equity adjustment proposed in (15) is applied to that weighted average. In Fowkes’s analysis it is assumed that each user’s travel-time savings is proportional to distance such that $dT_i = \rho K_i$, and summation implies $\rho = \frac{\sum_i dT_i}{\sum_i K_i}$. It follows that

$$dB_K = \sum_i \frac{\lambda_i}{\lambda} \frac{V_i K_i}{\sum_i K_i} \sum_i dT_i = \sum_i \frac{\theta_i}{\lambda} K_i \frac{\sum_i dT_i}{\sum_i K_i} = \sum_i \frac{\theta_i}{\lambda} \rho K_i = \sum_i \frac{\theta_i}{\lambda} dT_i = dB \quad (19)$$

¹² It is a “neutral approach” in the sense that it is equivalent to a social weighting scheme where $s_i = 1 \forall_i$.

¹³ If the covariance between λ_i and π_i is zero, then $\sum_i \lambda_i \pi_i = \lambda$.

¹⁴ Using our notation, λ in (18) is actually expressed as λ_W in Fowkes (2010). In deriving that expression, however, a social weighting scheme is imposed such that $\lambda_W = \frac{1}{N} \sum_i \lambda_i = \lambda$.

Hence the equity adjustment proposed in (15) yields the distance-weighted, equity value of time derived by Fowkes (2010). However, we see that there is no need to tabulate trip distances or formulate a standard (equity) value because (17) provides an equivalent benefits measure.

V. Conclusions

Our preceding analysis is designed to clarify the roles of social weights in economic appraisals of transportation improvements, and to demonstrate the consequences of implicitly making equity adjustments to those weights by employing “standard” or “equity” values of time. In particular, we show that this standard-value approach typically favors those who derive the smallest utility gain from a time-saving improvement, which could lead to a misallocation of resources. A corresponding finding is that standard values of time can be obtained without relying on the assumption that everyone derives the same utility gain from such improvements.

The implications of our analysis extend beyond the valuation of transportation projects. Consider, for example, an improvement in air quality that is valued by the marginal rate of substitution between pollution and income, or any other marginal valuation along the lines of Small and Rosen (1981). Those with higher incomes may have a greater willingness to pay for clean air, in which case a Harberger valuation approach would favor pollution-abatement projects in higher-income regions. Although it may be socially desirable to correct for that inequity, applying a “standard” marginal value of air quality to all projects could favor those who derive the least utility from cleaner air.

In response, we propose a simple equity adjustment that targets the culprit of the income inequity: the diminishing marginal utility of income. This adjustment is feasible with ordinary travel-demand analysis, is applicable beyond transportation projects, and generalizes several appraisal schemes discussed in the literature.

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