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Reverse-engineering of the rule-of-half in order to retrofit an assessment procedure based on resource consumption

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1. Introduction

Policy measures are usually an attempt to improve the existing system while taking into account current limiting conditions, and to assure a sustainable development in a changing environment. In the transport sector, the necessary planning and decision process is supported by economic appraisal methods (e.g. Pearce and Nash, 1981; Short and Kopp, 2005), an approach which is widely accepted due to the substantial investment costs of transport infrastructure.

These appraisal methods vary substantially between countries mainly because of cultural, historical, and economic differences (Grant-Muller et al., 2001). Several authors reviewed and compared the appraisal methods from different countries (among others, e.g. Nakamura, 2000; Hayashi and Morisugi, 2000; Bristow and Nellthorp, 2000; Rothengatter, 2000). In this context, Hayashi and Morisugi (2000) pointed out the importance of sharing the methods that are applied in transport project appraisals with scientists and practitioners from other countries. Olsson et al. (2012) take this recommendation one step further and implement different countries' appraisal methods for a specific rail project in Norway. However, what they call the "German" method is in fact the result of the EU HEATCO project, which resides in fact on a German server (Bickel et al., 2006), but has otherwise little to do with the assessment procedure of the German Federal Ministry of Transport. Daly et al. (2013) confirm that internationally available information on the German procedure is scarce.

With the present paper, we aim at mitigating some of these issues by comparing the cost benefit analysis (CBA) procedure of the German Federal Transport Infrastructure Plan ('Bundesverkehrswegeplan' or BVWP) to an analysis based on basic consumer theory. The BVWP is performed every 10 to 15 years by the German federal government, and forms the decision basis for all major federal investments into long-distance (> ∼50km) surface transport infrastructure.

2. The German Federal Transport Infrastructure Plan

Historically, the German BVWP assessment procedure is based on the concept of resource consumption. This concept means that new transport infrastructure causes changes in the consumption of time, money, safety, environment, etc. Monetized changes of those attributes are related to the construction and maintenance cost borne by the federal government, and the resulting benefit-cost ratios provide indicators which help to prioritize investment decisions (Rothengatter, 2000; BVU et al., 2003).

This assessment approach works well as long as all mode-specific demand remains fixed, and the remaining question thus is to serve that demand as efficiently as possible. As soon as demand is assumed to be elastic for the facility under consideration (e.g. when considering inter-modal interdependences or induced travel), this leads to inconsistencies between the behavioral model and the evaluation method. The archetypical example is an acceleration of a rail connection, while still remaining slower than the competing road connection. Any logit model or similar would, in that situation, predict that some users switch from road to rail. In terms of resource consumption, those travelers would afterwards consume more time than before; in the absence of additional effects, for those travelers the project would have a negative benefit according to the resource consumption approach. This is intuitively not in line with basic consumer theory since in the choice model, there needs to be a reason for these travelers to change mode. The conceptual shortcoming here is that the trip by rail causes additional benefits which are not included in the (observed) variables used for monetization. This shortcoming was, in the German context, pointed out by Helms (2000), together with a recommendation to use the concept of consumer surplus/rule-of-half in order to remove those inconsistencies.

There were, in fact, efforts by the Ministry of Transport to improve the assessment of mode choice and latent demand (induced traffic):

- The ministry commissioned a study (STASA et al., 2000, and references therein) concerning the evaluation of so-called induced traffic (realized latent demand) based on an advanced system-analytical traffic model (cf. the SILUS model in NTUA and others, 2000). The parameterization approach developed in that study was subsequently used in the BVWP 2003. This ignored a suggestion made by Planco (1999, pp. 210) at the same time. It also ignored the recommendations made by Helms (2000).
- A reassessment of the BVWP 2003 projects, performed in 2010 as part of a regular reassessment procedure (BMVBS, 2010), uses a version of the rule-of-half, but only for travel time savings of rail passengers (BVU and ITP, 2010). A similar procedure is used in the so-called Standardized Assessment (ITP and VWI, 2006), used for the evaluation of urban public transit projects.

These modifications made the procedure more complex and in consequence more difficult to handle. In some cases, they were applied to some parts of the procedure but not to others; for example, the rule-of-half was used for travel times only but not for user prices (see Sec. 5), and it was used for rail passenger traffic but for nothing else.

Winkler (2011, 2012) once more pointed out the shortcomings and once more suggested a switch to the consumer surplus/rule-of-half. According to this rule, new users of an improved infrastructure gain on the average half of the benefits of existing users (e.g. UK Department for Transport, 2011; Worldbank, 2005; Bickel et al., 2006, p. 17). The first new user gains almost as much as the average existing user, while the last new user is almost indifferent between both alternatives. Assuming linear demand functions, the average new user gains half of the benefits of existing users. The rule-of-half greatly simplifies the estimation of user benefits, as one only needs the initial and final quantities and the changes in generalized costs, instead of all demand functions and cross-demand relations (Small and

Verhoef, 2007, p. 183). Even though the rule-of-half is an approximation, it has proved to be a very powerful tool in project appraisal (Button, 2001, p. 73). Newer research suggests the use of the logsum term directly derived from the logit model as evaluation measure (e.g. de Jong et al., 2005; Winkler, 2011).

However, given the nature of the problem here, the issue is not to discuss the limitations of, or the alternatives to the rule-of-half (for some proposals see e.g. Nellthorp and Hyman, 2001), but rather the question if, and how, the established German assessment procedure can be made consistent with basic consumer theory. The present paper will propose an easily applicable procedure to include the logic of the rule-of-half into the existing evaluation approach. We show that the resulting calculation yields the same result as the rule-of-half while maintaining the rest of the former evaluation method. Additionally, we also give a behavioral interpretation of the newly introduced correction term that we call "implicit utility". Finally, we discuss how the Standardized Assessment for urban public transit projects (ITP and VWI, 2006) fits into the proposed procedure.

3. Going into the details

3.1 Comparing options *a* and *b*

We start by comparing options *a* and *b*. In transport, *a* might be car and *b* might be train. If we plot generalized costs vertically, one obtains a diagram like Fig. 1. Here, t^a and t^b are the travel times and p^a and p^b are the user prices (out-of-pocket costs) of options *a* and *b*, respectively. The user price, *p*, can be decomposed into the resource cost, *rc*, and the producer surplus, *ps*, where the resource cost is the variable part of the cost of providing the transport service. In competitive markets, one would have $p = rc$ and thus $ps = 0$. Since the competitive market assumption may not hold, we do all our following calculations with the assumption that the resource cost *rc* may be different from the user price *p*.

In the following, we assume that travel times, as well as all other contributions to the generalized travel costs, are given in monetary units.

3.2 Switching from *a* to *b*

Now let us assume that there is an improvement of the travel time of t^b, from t^b_0 to t^b_1, and as a result some demand shifts from option *a* to option *b*. The diagram would look as in Fig. 2. We make the assumption that there is no change in generalized cost at the option *a*, so the only reaction is a horizontal shift of the demand curve to the left. We also assume that there are only switchers on option *b*, i.e. there was nobody on option *b* before. This is just for illustration. Note that one needs, to make Fig. 2 possible, a mode choice model that allows for users to select option *a* in the first place – i.e. a mode choice model where some users select an option that does not have the least generalized cost. Logit mode choice models, for example, display this type of behavior.

3.3 Change in welfare

The standard welfare effects of this infrastructure measure are given by the three dark gray areas of Fig. 3:

- Gain in consumer surplus: $\Delta CS = \frac{1}{2} \times (t_0^b - t_1^b) \times |\Delta x|$ – the usual rule-of-half, with $\Delta x = x_1^b - x_0^b = x_0^a - x_1^a$.[1]
- Gain in producer surplus on option b: $\Delta PS^b = ps^b \times |\Delta x|$
- Loss in producer surplus on option a: $\Delta PS^a = -ps^a \times |\Delta x|$

For this to be valid, it is assumed that the rule-of-half is an applicable approximation, and that there are no complications such as income effects (Jara-Díaz and Videla, 1989; Herriges and Kling, 1999) or income-dependent values-of-time.

3.4 Change in resource consumption

The German national assessment exercise typically computes the change in "resource consumption" rather than the change in welfare. The changes in resource consumption of this infrastructure measure are the four light gray areas of Fig. 4:

- Reduction in time consumption $\Delta T^a = -t_a \times |\Delta x|$
- Reduction in resource costs $\Delta RC^a = -rc^a \times |\Delta x|$.
- Increase in time consumption $\Delta T^b = t_1^b \times |\Delta x|$.
- Increase in resource costs $\Delta RC^b = rc^b \times |\Delta x|$.

3.5 Comparison

Fig. 5 shows the different areas together in one figure. It is difficult to draw immediate visual conclusions since the economic benefit is

- according to the welfare computation: the dark gray areas on the right minus the dark gray area on the left
- according to the resource consumption computation: the light gray areas on the left minus the light gray areas on the right.

It is, however, immediately clear that the two computations will, in general, not lead to the same result: One could, for example, assume a different ta while everything else remains the same. In consequence, the related light gray area would change while all dark gray areas remain the same. Hence, the result of the calculation according to resource consumption would change while the result of the calculation according to welfare computation would remain unchanged. Thus, in general they cannot yield the same result.

[1] We use $|\Delta x|$ instead of Δx throughout this paper to indicate that, for this paper, we always have a positive number here.

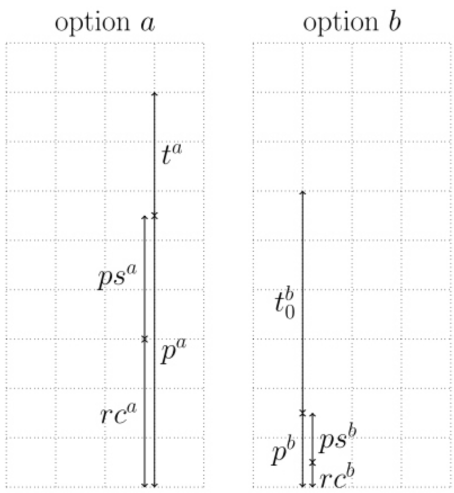

Figure 1: Resource costs (*rc*), user prices (*p*), producer surplus (*ps*), and travel times (*t*) of two options *a* and *b*.

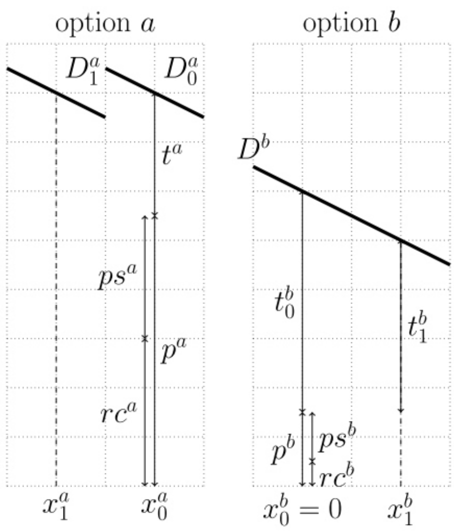

Figure 2: Including demand curves, an improvement (reduction in travel time) for *b*, and switching travelers.

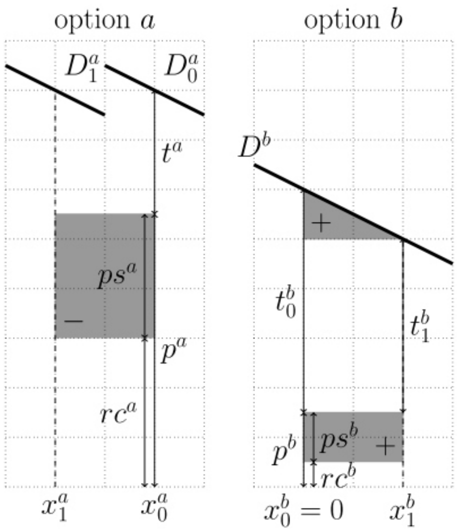

Figure 3: The dark gray areas depict changes in welfare, i.e. the sum of consumer and producer surplus. A "+" in the shape means that a larger shape increases the benefit; a "–" in the shape means that a larger shape reduces the benefit.

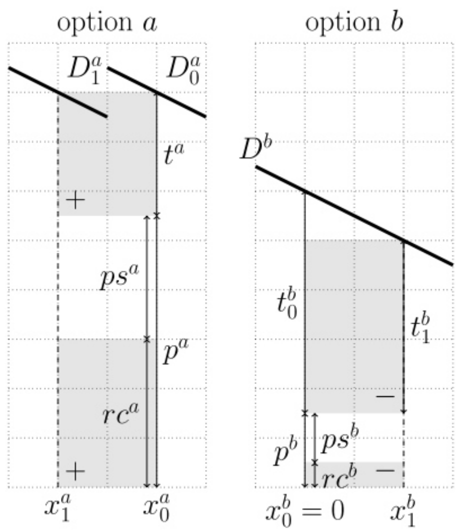

Figure 4: The light gray areas depict changes in resource consumption. A "+" in the shape means that a larger shape increases the benefit; a "–" in the shape means that a larger shape reduces the benefit.

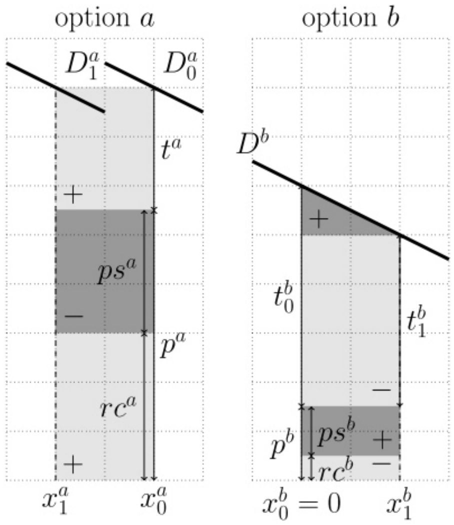

Figure 5: Visual comparison of the calculations according to welfare (dark gray) and resource consumption (light gray). A "+" in the shape means that a larger shape increases the benefit; a "–" in the shape means that a larger shape reduces the benefit.

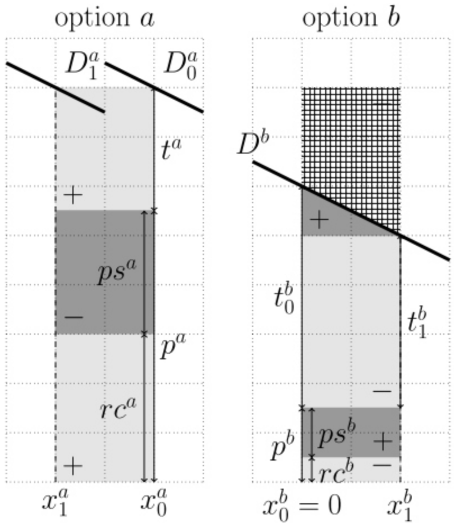

Figure 6: Adding the "implicit utility" (gridded). A "+" in the shape means that a larger shape increases the benefit; a "–" in the shape means that a larger shape reduces the benefit.

3.6 Implicit utility

When looking at Fig. 5, it seems that the dark gray and light gray areas complement each other, with the exception of the area above the D^b demand curve. This can be corrected by including that area into the computation, see Fig. 6. We then have

$$(rc^a + ps^a + t^a) \times |\Delta x| = (rc^b + ps^b + t_1^b) \times |\Delta x| + CS + Grid \,, \tag{1}$$

where *CS* is the consumer surplus according to the rule-of-half as defined earlier, and *Grid* is the gridded area above D^b. From this, we get

$$CS + (ps^b - ps^a) \times |\Delta x| = [(rc^a - rc^b) + (t^a - t_1^b)] \times |\Delta x| - Grid$$

or

$$\Delta Welfare = RCC - Grid \,, \tag{2}$$

where *RCC* means "resource consumption calculation". That is, when the gridded area is deducted from the result of the resource consumption calculation, the two computations are equivalent.

An alternative way to express Eq. 1 – better to see directly from Fig. 6 – is

$$(rc^a + ps^a + t^a) \times |\Delta x| = \left(rc^b + ps^b + \overline{t^b}\right) \times |\Delta x| + Grid,$$

where $\overline{t^b} = (t_0^b + t_1^b)/2$is the average travel time before and after the change. This averaging approach can indeed be extended to all variables, leading to

$$(\overline{rc^a} + \overline{ps^a} + \overline{t^a}) \times |\Delta x| = \left(\overline{rc^b} + \overline{ps^b} + \overline{t^b}\right) \times |\Delta x| + Grid$$

or

$$\begin{aligned} Grid &= \left[(\overline{rc^a} + \overline{ps^a} + \overline{t^a}) - \left(\overline{rc^b} + \overline{ps^b} + \overline{t^b}\right)\right] \times |\Delta x| \\ &= \left[(\overline{p^a} + \overline{t^a}) - \left(\overline{p^b} + \overline{t^b}\right)\right] \times |\Delta x|. \end{aligned} \tag{3}$$

The final equality stems from the observation that $p = rc + ps.$

3.7 Behavioral interpretation of the gridded area: implicit utility

The behavioral interpretation of the gridded area is that there needs to be a reason why users did not switch from *a* to *b* in the first place in spite of the fact that $t^b + p^b$ is much smaller than $t^a + p^a$. It is plausible to assume that this is caused by some difference in generalized cost or utility which is not included when considering only travel time and price.

More precisely, the leftmost height of the gridded area is what is missing to make the first switching user indifferent between the options. Since, in basic consumer theory, that user is assumed to be indifferent, that height needs to be due to one or more unobserved attributes. The effect is rather similar to an alternative-specific constant in discrete choice models – which absorbs all remaining differences in base utility between two options. One could therefore also speculate that the gridded area should become smaller with the addition of further explanatory attributes.

4. Adding the implicit utility to the resource consumption calculation

4.1 Approach

The above insights can be used to add a term to the established resource consumption calculation in order to make it consistent with basic consumer theory. From Eqs. (2) and (3), the correction term is

$$-Grid = \left[-(\overline{p^a} + \overline{t^a}) + \left(\overline{p^b} + \overline{t^b}\right)\right] \times |\Delta x| =: \Delta U_{implicit} \qquad (4)$$

This is also what is recommended by Planco et al. (2015), except that in that recommendation it is assumed that option a is not affected by the measure, and thus the averaging is not needed for option a, i.e. $p_0^a = p_1^a = \overline{p^a}$, and the same for t^a.

Note that the correction term, Eq. 4, is much easier to construct—but not necessarily easier to justify—by recognizing that the first bracket denotes the loss of gross consumer surplus by leaving the option *a*, and the second bracked denotes the gain of gross consumer surplus by going to option *b*.

A resource consumption table would now look as Tab. 1. There, for completeness, the conversion rate of travel time into monetary terms, β_t, also called “Value of Time” or “Value of Travel Time Savings”, and the number of switchers, $|\Delta x|$, have been included, and it is assumed that the attributes of option *a* are not affected by the measure.

Adding these terms up and rearranging leads to a change in welfare of

$$\Delta Welfare = \left[\beta_t \times \left(\overline{t^b} - t_1^b\right) + \left(\overline{p^b} - rc_1^b\right) - (p^a - rc^a)\right] \times |\Delta x|$$

$$= \left[\beta_t \times \left(\overline{t^b} - t_1^b\right) + \left(\overline{p^b} - p_1^b\right) - (p_1^b - rc_1^b) - (p^a - rc^a)\right] \times |\Delta x| \,.$$

Table 1: resource consumption table

	base case	policy case	resource difference	gain in monetary terms
prod cost a	$rc^a \times x_0^a$	$rc^a \times x_1^a$	$-rc^a \times \lvert\Delta x\rvert$	$+rc^a \times \lvert\Delta x\rvert$
travel time a	$t^a \times x_0^a$	$t^a \times x_1^a$	$-t^a \times \lvert\Delta x\rvert$	$+\beta_t t^a \times \lvert\Delta x\rvert$
prod cost b	0	$rc_1^b \times x_1^b$	$+rc_1^b \times \lvert\Delta x\rvert$	$-rc_1^b \times \lvert\Delta x\rvert$
travel time b	0	$t_1^b \times x_1^b$	$+t_1^b \times \lvert\Delta x\rvert$	$-\beta_t t_1^b \times \lvert\Delta x\rvert$
impl. utl. diff.				$\big[-(p^a+\beta_t t^a)$ $+ \big(\overline{p^b} + \beta_t \overline{t^b}\big)\big]$ $\times \lvert\Delta x\rvert$

This is, however, exactly the calculation of the rule-of-half:

- $\left[\beta_t \times \left(\overline{t^b} - t_1^b\right) + \left(\overline{p^b} - p_1^b\right)\right] \times |\Delta x| = \beta_t * (t_0^b - t_1^b)/2 + (p_0^b - p_1^b)/2] \times |\Delta x|$ is the change in consumer surplus,
- $[p_1^b - rc_1^b] \times |\Delta x|$ is the change in producer surplus on option b,
- $[-(p^a - rc^a)] \times |\Delta x|$ is the change in producer surplus on option a.

That is, after including an implicit utility difference according to Eq. 4 into the resource consumption calculation, it yields the same result as the welfare calculation using consumer and producer surplus. Or, in other words, the insights provided by the welfare computation including the rule-of-half were used to retrofit the calculation according to resource consumption in such a way that the result is in line with basic consumer theory.

4.2 Consequences of including the implicit utility into the resource consumption calculation

The implicit utility difference of switching, and therefore its contribution to the economic benefit, is

- positive if $p^b + t^b > p^a + t^a$,
- negative if $p^b + t^b < p^a + t^a$.

As a tendency,

- a further improvement of an already fast and cheap (train or car) connection will generate less benefits than with the existing approach, and

- an improvement of a slow and expensive (train or car) connection will generate more benefits than with the existing approach.

That is, including the implicit utility into the German national assessment exercise will, as a tendency, *increase the benefit-cost-ratio for measures that improve below average elements* of the infrastructure to the average. And similarly, it will, as a tendency, *decrease the benefit-cost-ratio for measures that improve already above average infrastructure elements*. Improvements here refer to improvements in travel time and travel cost, but Eq. 5 implies that the analysis would hold for improvements in all considered attributes.

4.3 Advantages and disadvantages

The welfare computation is much simplified if one assumes that a and b are competitive markets. In that situation, $p^a - rc^a$ and $p^b - rc^b$ can both be approximated by zero, which simplifies the computation significantly. The computation according to resource consumption, however, remains at the same level of complexity. This may justify the application of the welfare computation in situations where the competitive market assumption is assumed to hold.

If, however, the competitive markets assumption is not applicable, then both computation paths have a similar level of complexity. In consequence, when there is a tradition of using the resource consumption approach, the only argument for a move to the standard welfare approach seems to be international consistency. On the other hand, when staying with the resource consumption approach, then the existing computational modules, including intuition for most of their numbers, can be kept, and just a term is added. Also, the term has a plausible interpretation: It is the utility difference of switching to the improved infrastructure. This becomes, in fact, particularly clear when considering completely new ("induced") traffic, i.e. not just a switch from another mode. Here, the utility difference is exactly the implicit benefit from doing an activity at another location (see Sec. 4.4).

Another advantage of the resource consumption approach, after the correction, is that one does not need the producer surplus, ps. Clearly, computationally this is just the same as $p - rc$, i.e. the difference between the charged price and the resource cost. However, in the German tradition, there exist already models for p and rc, since p is the out-of-pocket price that is already used in the mode choice models, and rc is the old resource cost. For ps, in contrast, there is, e.g., debate of how to include taxes, that is, if "gains to private firms" are to be accounted in the same way as "gains to government", or not.

4.4 "Induced" traffic

A welcome consequence of the above retrofitting of the resource consumption approach is that it also works for so-called induced traffic, i.e. activated traffic demand that was latent before the infrastructure improvement (more trips, longer trips, completely new trips). On the one hand, this is to be expected, since the rule-of-half approximates the utility effects of changes from *any* alternative, including the alternative of not having made a trip before. On the other hand, it is instructive to go through the calculation. According to Eq. 4,

$$\Delta U_{implicit} = \left[\overline{p^b} + \overline{t^b}\right] \times |\Delta x|,$$

since t^a and p^a are zero since no trip takes place for that option.

That is, the implicit utility difference for the average new user is exactly as large as the generalized cost of the travel for the average new user. In other words, the equation yields an estimate for the implicit utility of additional mobility. As stated, from the perspective of the rule-of-half this is not a surprise. From the perspective of the German national assessment exercise, it provides a straightforward solution to a situation that is difficult to resolve otherwise, because in (the basic version of) the resource consumption calculation, *any* additional travel just leads to increased resource consumption and thus a negative benefit.

4.5 Additional attributes besides price and travel time

Eq. 4 only includes price and travel time. When looking at the derivation, however, it should be clear that additional attributes, for example unreliability, can be easily added. One could also use different monetization approaches for options *a* vs. *b*, if the measurement for unreliability underneath is different. The equation then becomes

$$\Delta U_{implicit} = \left[-\left(\overline{p^a} + \sum_i \beta_i^a * \overline{z_i^a}\right) + \left(\overline{p^b} + \sum_i \beta_i^b * \overline{z_i^b}\right)\right] \times |\Delta x|, \qquad (5)$$

where the z_i are the various attributes, and the β_i are their monetization factors.

5. Partial inclusion of the consumer surplus — The German standardized assessment for public transit investments

Practitioners have been aware of the problem for a long time. In particular, it was considered counter-intuitive that persons switching to an improved train connection might *reduce* the benefits of a measure (cf. example in Sec. 2). In order to improve upon this, a version of the rule-of-half was introduced into the process (ITP and VWI, 2006; BVU and ITP, 2010). What was done is equivalent to using the rule-of-half for the travel times but staying with resource consumption for the production costs. The result is discussed in Sec. A.

The "story" for this is quite plausible: One the one hand, there is the consumer, and she reaps the consumer surplus. On the other hand, there is the "producing economy", and it needs to spend resources to produce the service. However, the result is not the same as from the standard welfare computation.

6. Discussion

Different switchers are treated differently in the 2003/2010 BVWP procedure (BVU et al., 2003; BVU and ITP, 2010).

- **Passengers** switching **from road to rail** are treated according to the rule-of-half with respect to travel time (BVU and ITP, 2010). All other attributes are treated according to resource consumption.
- Similarly, **induced rail traffic** is treated according to the rule-of-half with respect to the time component (BVU and ITP, 2010).
- **Passengers** switching **from rail to road** are treated according to resource consumption. It seems that this would imply that the average travel time gain from rail to road should be counted as a benefit, but this is effectively not included since the corresponding benefits component (denoted "NE" = Nutzen der Erreichbarkeit) is computed for existing car users only.
- Passengers switching to road are not included into the traffic assignment.
- **Induced road traffic** is treated according to a parameterized approach without explicitly computing its volumes (STASA et al., 2000).
- **Freight** mode switches in both directions are computed according to resource consumption. Travel time improvements induce mode switches for freight, but the value of time of freight is set to zero in the benefits calculation.
- Freight switching to road is not included into the traffic assignment.
- It is assumed that there is **no induced freight traffic**.

Overall, these different treatments make it difficult to keep track of all the different cases, and thus to keep the approach consistent. Furthermore, they are a hindrance with respect to future developments. For example, induced traffic cannot be included into the road assignment, since the additional congestion effects are already contained in the parameterization. This, however, would make any detailed emissions calculations for those users impossible. – The approach presented in this paper makes it possible to treat mode switchers and induced traffic explicitly: They would switch according to the mode choice or induced demand model, they would be included into the respective modal assignments, and their effect would be computed in a plausible way by including the implicit utility difference into the resource consumption computation. Extra parameterizations and special rules would no longer be necessary, simplifying the conceptual approach and thus making it more transparent.

A concern might be that more emphasis should be put on strategic or system aspects (Rothengatter, 2000; Wissenschaftlicher Beirat, 2010). The present paper is not meant as a counter-argument to this. Nevertheless, we believe that the cost-benefit-analysis part of the assessment should be comprehensible and transparent, and an understanding in how far a procedure is similar or different to other procedures contributes to that. This is what the present paper concentrates on.

7. Conclusion

The objective of this paper was to propose a way to adapt the current German national CBA approach for infrastructure projects, which is based on resource consumption, to the international evaluation standard of welfare computations, in particular to the approximation based on the rule-of-half. As shown in our calculations, adding an implicit benefit component to the resource consumption leads to the equivalence of both approaches. We also analysed the practical consequences of including these implicit user benefits for the assessment results. With the inclusion of that benefit component, the current evaluation procedure could largely be kept, while illogical and counterintuitive effects in conjunction with mode switchers or induced traffic would be avoided.

Acknowledgments

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A. German standardized assessment (Standardisierte Bewertung)

Figs. 7 and 8 show an example where the "German standardized assessment" is not consistent with the welfare approach:

- Assume $ps^a = ps^b = 0$, i.e. prices are competitive and thus there is no producer surplus.
- In consequence, the surplus calculation would only yield the consumer surplus.
- Yet there may still be a difference in the resource consumption, yielding a (positive or negative) contribution in the resource consumption calculation.

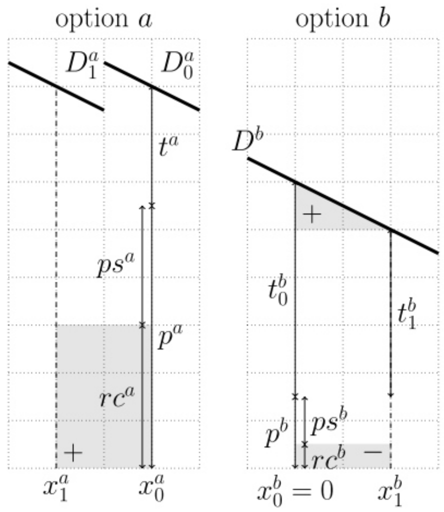

Figure 7: Areas that are considered for the benefits calculation in the German standardized assessment for public transit investments ("standardisierte Bewertung"; see ITP and VWI, 2006) and in the intermediate revision of the CBA numbers of the German national assessment exercise ("Bedarfsplanüberprüfung", see BVU and ITP, 2010). Again, a "+" in the shape means that a larger shape increases the benefit; a "–" in the shape means that a larger shape reduces the benefit.

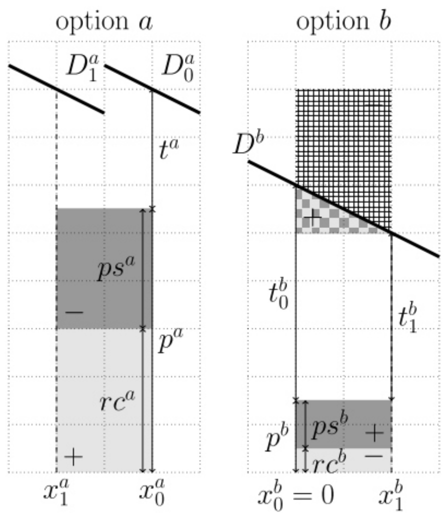

Figure 8: "Standardized assessment", full comparison

What is the explanation for this difference? It might be easiest to understand this from a comparison with a standard welfare computation, similar to Sec. 3.6. Adding up the areas in Fig. 8 leads to

$$[rc^a + ps^a + t^a] \times |\Delta x| = [rc^b + ps^b + t_1^b] \times |\Delta x| + CS + Grid$$

or

$$CS + [ps^b - ps^a] \times |\Delta x|$$

$$= \left[\left(rc^a - rc^b + \frac{t_0^b - t_1^b}{2}\right) - \frac{t_0^b - t_1^b}{2} + (t^a - t_1^b) - \left[(p^a + t^a) - \left(p^b + \overline{t^b}\right)\right]\right] \times |\Delta x|$$

or

$$\Delta Welfare = GSAC + (p^b - p^a) \times |\Delta x|,$$

where $\overline{t^b} = (t_0^b + t_1^b)/2$ was used, and *GSAC* means "German standardized assessment computation".

That is, while the resource consumption calculation needs to be corrected by $\left[-(\overline{p^a} + \overline{t^a}) + \left(\overline{p^b} + \overline{t^b}\right)\right] \times |\Delta x|$ (Eq. 4), the "standardized assessment" only needs to be corrected by $(-p^a + p^b) \times |\Delta x|$ in order to be consistent with the standard welfare computation[2].

The consequences of moving the German standardized assessment to the welfare computation approach would be the following:

- Projects where $p^b > p^a$ would improve their benefits-cost-ratio.
- Projects where $p^b < p^a$ would decrease their benefits-cost-ratio.

That is, changing the German standardized assessment computation to the welfare computation approach would, as a tendency, *increase the benefit-cost-ratio for improvements of infrastructure elements that charge above average user prices*. And similarly it would, as a tendency, *decrease the benefit-cost-ratio for improvements of infrastructure elements that charge below average user prices*.

A bigger problem may be that the German "standardized assessment" approach still produces implausible results for induced traffic. Consumer surplus with respect to travel time is calculated correctly. However, the additional resource cost is *deducted* from the benefit. The welfare calculation, in contrast, would include the difference between the additional resource cost and a (higher) price as *positive* benefit.

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[2] or by $-\left(\overline{p^a} + \overline{p^b}\right) \times \Delta x$ if one assumes that prices change

8. Abstract

The German evaluation procedure for the Federal Transport Infrastructure Plan ('Bundesverkehrswegeplan') is a large-scale and comprehensive modeling, simulation, and evaluation effort. An important component of the evaluation procedure is a cost-benefit analysis, based on the concept of resource consumption. This concept means that new transport infrastructure causes changes in the consumption of time, money, safety, environment, etc. In this paper, we show that — assuming elastic demand for the facility under consideration — the current approach is not in line with basic consumer theory. This stems from inconsistencies between the behavioral model and the evaluation method: ignoring unobserved attributes of the different transport modes in the evaluation can lead to quite different economic gains than when these attributes are considered. Current practice in other EU countries avoids this problem typically by applying the so-called rule-of-half, or by directly deriving the logsum term from the underlying logit model. However, a change in the German assessment procedure towards one of these best-practice approaches for the upcoming Federal Transport Infrastructure Plan in 2015 seems politically not feasible. We therefore propose an easily applicable procedure to include the logic of the rule-of-half into the existing evaluation approach. We show that the resulting calculation yields the same result as the rule-of-half while maintaining the rest of the former evaluation method. Finally, we discuss how another German assessment scheme for urban public transit projects, which is currently under revision, fits into the proposed procedure.

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