DO COST-BENEFIT ANALYSES INFLUENCE TRANSPORT INVESTMENT DECISIONS? EXPERIENCES FROM THE SWEDISH TRANSPORT INVESTMENT PLAN, 2010-2021.

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Abstract

Cost-benefit analysis (CBA) for transport investments is particularly useful for situations where a large number of investments have to be ranked against each other. This study draws on experiences in developing the Swedish National Transport Investment Plan 2010-2021. We study how CBA results were used in the process of shaping the investment plan and what influence they had on investment decisions. We show that there is a fairly strong correlation between the benefit-cost ratio of an investment and its probability of being included in the plan by the planning authorities. The correlation is strongest for low and moderate benefit-cost ratios. For investments decided directly by politicians, however, there is no such correlation. By interviewing planners and decision-makers about how CBA was used in the process, we clarify what role CBA actually played in the planning process. We find that not only did the CBAs play a role for the selections; they also helped developing more cost-efficient investments. Further, we explore whether planners' implicit valuations, as revealed by their investment selections, differ from official CBA valuations. We find that freight benefits were valued higher and traffic safety lower than the official recommendations. Finally, we identify the most important areas for improvement of the CBA state-of-practice methodology.

1. INTRODUCTION

Cost-benefit analysis (CBA) has been an important tool for transport planners for several decades, in particular for evaluating and ranking transport investments. While CBA is also an important and useful tool for evaluating transport policy measures (and indeed should probably be used even more for this than currently), it is for transport investments that CBA is routinely and widely used and where the methodology is most developed. While CBA is useful and enlightening for evaluating a single investment, CBA really comes into its own when it becomes necessary to compare the relative merits of many alternative investments against each other. An extreme example is the construction of a national transport investment plan. During such a process, planners need to quickly sift through several hundreds of proposed investments, evaluating and ranking them relative to each other. The sheer number of investments makes standardized and semi-automatic evaluation tools such as CBA virtually indispensable.

Despite the considerable efforts to develop better CBA methodology – a research field which includes large subfields such as transport modelling, transport economics and valuation of non-market goods – there has not been very much research on the practical CBA process itself, and what impact CBA actually has on transport investment decisions. In this paper, the aim is to investigate the following issues:

1. To what extent do CBA results affect the choices of which transport investments to build?
2. How do planners use CBA results in their professional practice?
3. Do planners' implicit valuations of different benefit types, as revealed by the selection of investments, coincide with official CBA relative valutations?
4. What are the most important areas for improvement of CBAs?

The study builds on data and experiences from the construction of the Swedish multi-modal National Transport Investment plan[1] for the period 2010-2021. The focus of the study is limited to transport investments, and hence we exclude questions about CBA for policy measures and maintenance.

CBA as a principle is generally supported by economists, since it, at least in principle, is a way to identify which investments give the most benefits to society for a given budget. Further, as Arnott (1997) points out, "most public transport projects entail cost sharing between several jurisdictions […]. To avoid unnecessary conflicts and confusion, it would seem sensible to have different jurisdictions employing the same appraisal method." The literature on CBA methodology is enormous: good general overviews of transport CBA methodological practice can be found in Bristow and Nellthorp (2000), Grant-Muller et al. (2001), Odgaard et al. (2005) and HEATCO (2006). It is well known that in practice, CBA has

[1] The analysis is restricted to rail and road investments, which comprise the bulk of the plan; a few investments for sea transport are excluded, as are funds for unspecified small measures.

many shortcomings, such as excluding certain environmental effects (e.g. Willis et al., 1998) and certain external effects from motor traffic (Saelensminde, 2004). Mackie and Preston (1998) provide an excellent list and discussion of common flaws in transport modeling and CBA practice. There are also many critics of the CBA concept as such. Hansson (2007) gives an overview of philosophical problems and sorts them into ten classes, such as the assumption of interpersonal compensability or the bias in the delimitation of consequences. Another example is Damart and Roy (2009), who examine how the use of CBA interacts with the use of public debate and stakeholder participation in France. They question the value of CBA as a guide for decision makers, concluding that CBA is "not compatible with relevant and constructive debate".

Research on the relation between CBA and actual decision making is rather scarce. An early example is Nilsson (1991), who examined the 10-year investment plan of the Swedish Road Administration, finding that the connection between CBA results and actual decisions was limited at best – despite the fact that the Road Administration claimed to use CBA as a method for ranking and evaluating investments. A similar conclusion was found by Fridström and Elvik (1997), who examined Norwegian road investments, finding that "cost and benefit appear to be of only marginal importance for the priorities". Odeck (1996) also concluded that the benefit-cost ratio only had a marginal impact on the choice of road investments – in 11 out of 15 regions in Norway it was not even a significant explanatory variable. In the latter study, the Road Administration argued that the reason for the discrepancy between CBA results and investment decisions was that too many costs and benefits were not captured by the CBA, but Odeck concludes, based on a survey material, that it was doubtful whether Regional Road Agencies actually understood the principles of CBA. Nyborg (1998) interviewed Norwegian parliament members, concluding that although CBA was seen as a useful screening tool, few would use it for ranking investments. In another interview study on politicians, Sager and Ravlum (2005) found that "political decision makers gather information and do not use it; ask for more information and ignore it; make decisions first and look for relevant information afterwards; and collect and process a great deal of information that has little or no direct relevance to decisions." It should be noted that the two latter studies are examples of politicians as decision-makers, whereas the present study is mainly concerned with professional planners. As we shall see, these seem to make more "rational" decisions from a welfare-maximizing point of view. As to the related question of estimating decision-makers implicit preferences, an early reference is McFadden (1975, 1976), who estimate the influence of benefits, costs and other variables on freeway route selection.

The paper is organized as follows. Section 2 describes the process of constructing the proposal for the National Transport Investment plan, and also gives a brief account of Swedish transport modelling and CBA methodology. Section 3 explores to what extent CBA results affect which investments are included in the investment plan. This is done by carrying out a quantitative analysis of the relationship between the benefit-cost ratio of an investment and its probability of inclusion in the plan. Section 4 is devoted to interviews with planners about how they actually used CBA results in the plan construction process. Section 5 estimates planners' implicit valuations, as revealed by the investment selection, and compare

these to recommended relative CBA weights. In section 6 the most important CBA improvements from a state-of-practice perspective are identified. Section 7 concludes.

2. CONSTRUCTING THE TRANSPORT INVESTMENT PLAN

Selection process

The Swedish Transport Investment Plans are typically revised every five years and cover a period of around ten years. The plan analysed in the present study covers the period 2010-2021, and was prepared jointly by the Road and Rail Administrations during 2008-2009. The plan comprises one part with national road and rail investments and one part with 21 regional plans, one for each county region[2].

CBA has been used as a tool for Swedish transport planning in general and investment planning in particular for decades, but for this investment plan, even more focus was to be placed on CBA. The Government had declared that CBA results should carry more weight than for earlier plans, and that CBA results would also affect the allocation of funds between road and rail investments. Earlier, each mode of transport had had pre-specified total budgets, so CBA results could in principle only affect the ranking of investments within each mode. This made the Road and Rail Administrations, who were responsible for delivering the investment plan proposal to the Government[3], devote considerable effort to ensuring that the CBA process and methodology were developed further and, above all, were comparable between modes. This was not limited to parameters such as values of time or emissions, but also scenario assumptions (future population, fuel prices etc.), methods for calculating investment costs, presentation of results etc[4]. The authors of the present paper chaired the committee responsible for developing and harmonizing CBA methodology and subsequently for making sure that CBAs were completed for all suggested investments.

The CBAs together with related material were handed over to another committee responsible for putting together the National Transport Investment Plan proposal. This committe organized consultations with a large number of stakeholders , ranging from counties and regions to different interest groups. The Rail and Road Administrations made the final decision of which investments were included in the national part of the plan, while the county organizations decided about the respective regional parts of the plan. The entire plan proposal was then eventually handed over to the Government for decision (after possible further amendments). The emphasis of the analyses in this paper will be on the national part

[2] The plans also contain investments for other purposes as well as funding for maintenance, but the focus in this paper is limited to investments.
[3] Previously, the Road Administration and the Rail Administration had carried out their planning more or less independently. This time, however, they carried out the entire planning process jointly. The Road and Rail Administrations was merged into a Transport Administration in April 2010.
[4] The Rail and Road Administrations were already using the same transport models (SAMPERS for person traffic and SAMGODS for freight traffic, described below).

of the plan, since the material is scarcer for the regional plans, and also since the selection process is different in the regional organizations.

Out of a total of almost 700 suggested investments, 479 made it as far as having complete CBAs carried out. Out of those, the Government had at an initial stage selected 90 that had to be included in the plan. These 90 projects, comprising the *Initial Plan*, were hence taken as given at the outset[5] of the planning process. The total cost[6] of the Initial Plan was around 115 billion SEK. Most of the investments in the Initial Plan were remaining from the preceding investment plan (2004-2015), and were now in the building stage or in the final planning stages.

The Road and Rail Administrations and the regional organizations then selected another 149 investments, with a combined cost of 41 billion SEK. Together with the investments in the Initial Plan, these investments comprise the *Base Plan*. The national part of the Base Plan proposal is considerably larger than all regional plans put together: it comprises 134 billion SEK compared to the sum of regional plans of 21 billion SEK (in the Base Plan). The numbers of investments, however, are comparable (108 in the national plan and 134 in the regional plans).

The Government also asked for a proposal for an *Extended Plan*, with around 15% larger budget than the Base Plan. A further 71 investments were included in the Extended Plan. Out of all investments that had reached the stage where complete CBAs were made, 169 investments were left outside the Extended Plan.

Table 1: Suggested investments, for which CBAs were carried out in the Swedish investment planning for 2010–2021. Costs in 2009 present values, consumer prices.[7]

	Number of investments			Investment costs (billion SEK)		
	Rail	Road	**Total**	Rail	Road	**Total**
Initial Plan (decided by the Gov.)	23	67	**90**	44	70	**115**
Additions in Base Plan (excl. investments in Initial Plan)	17	132	**149**	16	25	**41**
Additions in Extended Plan (excl. investments in Base Plan)	15	56	**71**	7	12	**20**
Excluded	7	162	**169**	28	21	**49**
Total	*62*	*417*	***479***	*96*	*128*	***224***

[5] In fact, the list of investments in the Initial Plan was changed somewhat by the Government during the course of the planning process. The story of these changes is irrelevant for the purposes of this paper, however.
[6] All investment costs in this paper are given as 2009 present values and expressed in consumer prices, to be consistent with the costs used in the CBAs (Swedish CBA are carried out in consumer prices). Hence, numbers differ somewhat from the numbers in the state budget, due to discounting effects and the conversion from producer to consumer prices.
[7] The share of total costs for rail and road differs from the share in the plans since more rail investments miss CBAs.

Swedish transport modelling and CBA methodology

SAMPERS is the national transport model for person trips, covering all types of domestic person trips. First developed around 2000, SAMPERS is the official Swedish transport model used by most public authorities. This has the benefit that virtually all analyses of transport investments or transport policy measures are comparable with each other, even if the analyses are carried out by different authorities or interest groups. SAMPERS consists of five different regional sub-models for short-distance trips and one national sub-model for long-distance trips. The demand models are nested logit models, while the assignment to the road and transit networks is carried out with EMME/2.

The national freight model is called SAMGODS. It operates on a much coarser geographical scale than SAMPERS (288 Swedish zones and ca 160 zones abroad), and has a rather simplistic model structure. Freight volumes per origin-destination (O-D) pair are calculated by adjusting a prior O-D matrix with the change per economic sector using an external multiregional input-output model. The resulting freight volumes per O-D pair are hence not sensitive to changes in transport costs. O-D volumes are then assigned to transport chains (combinations of modes and routes) with a deterministic assignment model (STAN).

The CBA parameters – benefit valuations, discount rate etc. – are decided by representatives from a number of public authorities, using advice and research reviews from commissioned researchers. The CBA guidelines are summarized in the so-called “ASEK report”, and are supposed to be used for all transport-related CBA in Sweden. For the latest ASEK report (2008), efforts were made to harmonize Swedish values and practices with the corresponding European recommendations in the HEATCO report (HEATCO, 2006). Below is a table presenting some of the more important parameters.

Table 2: Some of the parameters used in Swedish transport-related CBAs. Source: SIKA (2008)

Value of time	Private trips <10 km	51 SEK/h
	Private trips >10 km	102 SEK/h
	Business trips	275 SEK/h
Value of lives and injuries	Life	22.3 MSEK
	Severe injury	4.15 MSEK
	Light injury	0.2 MSEK
Emissions[8]	Carbon dioxide	1.50 SEK/kg
	Particles	11 494 SEK/kg
	VOC	68 SEK/kg
	SO2	333 SEK/kg
	NOx	36 SEK/kg
General parameters	Discount rate	4%
	Producer/consumer price conversion factor	1.21
	Appraisal period	40 years

3. DO CBA RESULTS INFLUENCE THE SELECTION OF INVESTMENTS?

During the plan preparation process, considerable efforts were spent on developing and harmonizing CBA methodology, and subsequently carrying out CBAs for all proposed investments. This section explores to what extent CBA results actually affected which investments were included in the final plan proposal.

CBA results can be summarized in several different ways. Throughout the paper, we will use the standard measure used in Swedish CBA, namely the *net benefit/investment cost ratio* (NBIR). This is defined as the net present value of all benefits and costs (including investment costs), divided by the investment cost. This measure gives an optimal ranking of projects if decision makers are faced with the problem to select a welfare-maximizing portfolio of investments given a fixed investment budget. Although primarily a ranking criterion, its absolute value is also interpretable: if NBIR>0, then the investment increases welfare. The NBIR differs from the *benefit-cost ratio* (BCR) in that the BCR includes maintenance costs in the denominator, and (less important) in that an investment increases welfare if BCR>1. The BCR is the correct ranking criterion if the budget constraint also includes the net present value of future maintenance costs, and not only investment costs. This is not the case in Swedish planning, however: the budget constraint is in fact only formulated as a constraint on investment costs. A closely related measure to the NBIR is the *ratio of net present value to public sector support* (RNPSS). The difference is that the RNPSS includes only the fraction of investment cost covered by public funds in the

[8] Values depend on geographical area (except for carbon dioxide). The values relate to the inner city of Stockholm.

denominator. If the budget constraint applies to public funding, and not to total investment costs independent of source, then the RNPSS is the correct ranking criterion.

Plan inclusion probability

As mentioned above, the National Transport Investment plan consists of three parts: the *Initial Plan*, consisting of investments pointed out directly by the Government at the outset, the *Base Plan*, where investments selected by the Road and Rail Administrations and the regions were added, and the *Extended Plan*, where additional investments were selected by the Road and Rail Administrations subject to an approximately 15% higher budget constraint.

The diagram below shows the NBIRs for the four different groups of investments, sorted by decreasing NBIR.

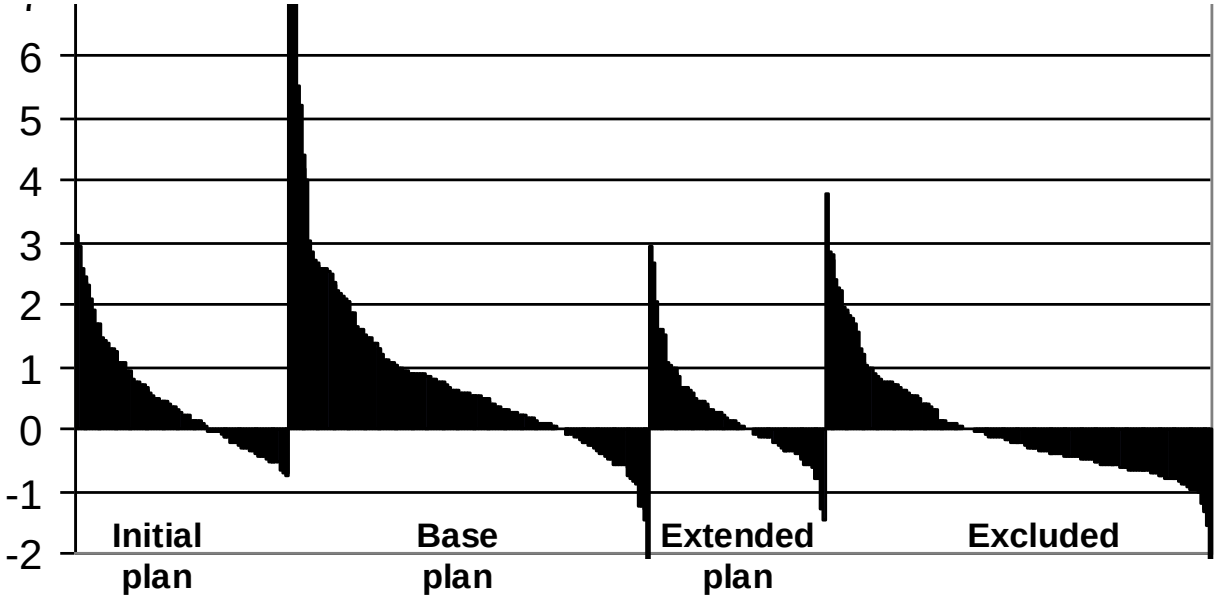

Figure 1: NBIRs for four groups of investments, sorted by decreasing NBIR.

It is evident from the diagram that CBA results alone do not explain what investments are selected for inclusion in the plan. There are investments with conspicuously low NBIRs included in all three parts of the plan, and there are investments with conspicuously high NBIRs excluded from the plan. There are even investments in the Base Plan with NBIR< -1, meaning that these investments generate *negative* benefits, even disregarding the investment cost.

The table below shows how the investments are distributed across different intervals of NBIR.

Table 3: Distribution of investments across intervals of NBIR for groups of investments.

NBIR	Number	Average*	Total**	<-0.5	-0.5 – 0	0 – 1	1 – 2	>2
All suggestions	479	0.41		18%	25%	38%	11%	9%
Initial Plan	90	0.45	0.0	11%	28%	38%	16%	8%
Base Plan, additions	152	0.91	0.7	10%	14%	45%	13%	17%
Extended Plan, additions	74	0.21	0.1	12%	31%	45%	8%	4%
Excluded	163	0.01	-0.2	33%	29%	27%	7%	4%

**across all investments in the category, not weighted with cost*
*** investments are weighted with their cost*

Some interesting conclusions can be drawn from the table. First, note that the average NBIR of all proposed investments is 0.41. The NBIRs are rather evenly spread around 0 with surprisingly little skewness (the distribution is bound to be somewhat skewed, since few investments have NBIR<-1). The Initial Plan has only a trifle better average NBIR (0.45) than the average of all analyzed investments. Put differently, the investments selected by the Government have just a trifle better NBIRs, on average, than what a random sample from the list of all proposed investments would have had. The slight improvement is only because some of the very worst investments (in NBIR terms) have been avoided[9], namely those with NBIR<-1 (i.e. those which should not be built even for free, according to the NBIR calculation).

The investments in the Base Plan additions, however, are significantly better on average than what a random sample from all possible investments would have been. However, a considerable number of investments with very low NBIRs have been included in the Base plan additions as well. The additional investments in the Extended Plan are worse in NBIR terms than the investments in the Base Plan additions. To some extent this should be expected, since the best investments should already have been included in the Base Plan. But this cannot be the only explanation, which is apparent from the last row with excluded investments; there are still a large number of investments with very high net benefits left outside the Extended Plan.

The diagram below shows how the probability that an investment is included in each part of the plan depends on the NBIR. The probabilities refer to inclusion probability in each successive step in the construction of the Plan. In other words, the “Initial Plan” inclusion probability is the probability that an investment is selected from the total of all suggested investments; the “Base Plan” inclusion probability is the probability that an investment is selected out of the remaining ones, excluding those that are already included in the Initial Plan; and similarly for the “Extended Plan” inclusion probability.

The relationships between NBIR and plan inclusion probabilities are non-parametric estimates using a normal kernel estimator. Parametric estimates are given further below.

[9] The average NBIR of all possible investments with NBIR>-1 is 0.46, and no investments with NBIR<-1 are included in the Initial Plan. In other words, the Initial Plan is slightly worse (in NBIR terms) than a random sample of all investments with NBIR>-1 had been.

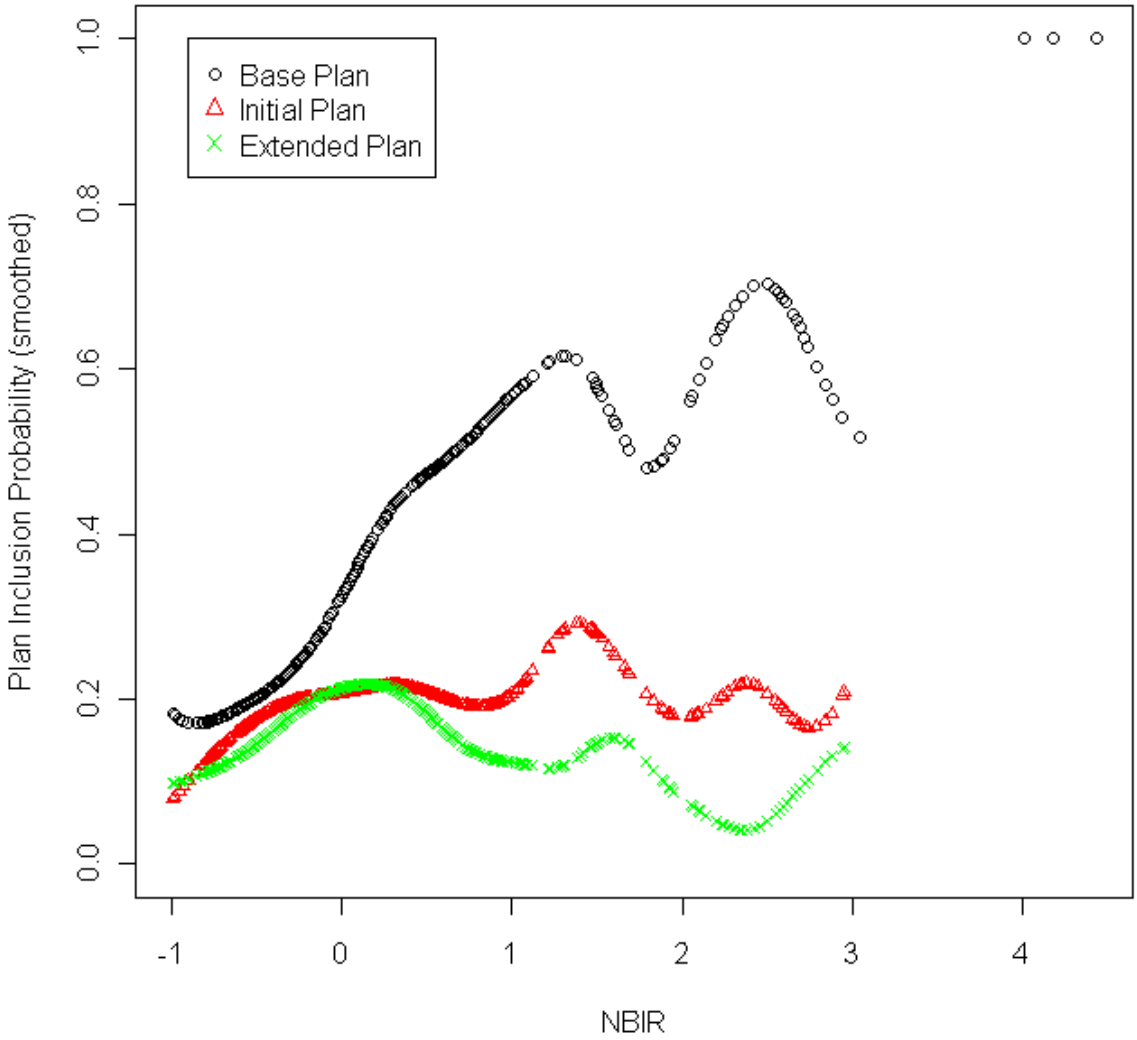

Figure 2: The probability (vertical axis) that an investment is included in each part of the plan depending on the NBIR (horizontal axis). The lines are constructed using a normal kernel estimator.

For the Base Plan additions, there is a clear relationship between NBIR and inclusion probability, in particular for moderate values of NBIR (NBIR<1). For larger values, the impact of a high NBIR decreases (and the material also gets rather thin, as evident from the strange-looking “dips” around NBIR=2 and 3).

For the Initial and Extended Plans, however, the correlation between the NBIR of an investment and its probability to be included in the Initial Plan is weak. There is a tendency that the probability for inclusion decreases once the NBIR falls below 0. But once NBIR>0, the inclusion probability does not increase with NBIR anymore.

Parametric estimates of the impact of NBIR on investment decisions

To validate the conclusions above, which were drawn based on inspection of non-parametric relationships, we estimate parametric models. In these models, we also take into account that national and regional investments only ”compete” with other national investments and other regional investments (within the same county), respectively. Using binary logit models on the form

$P_{incl} = \Lambda(\alpha + \beta*NBIR)$

for the plan inclusion probability, we get the results below. Separate models for national and regional plans are estimated, since these investments do not ”compete” with each other. Similarly, regional investments only compete with investments within the same county. For the regional investments, a joint parameter for the NBIR impact (β) is estimated, but a separate constant (α) for each county.

Two alternative models are estimated. The second one, replacing the single β parameter with a piecewise linear function, shows that while the NBIR strongly affects the inclusion probability for NBIR<0, the impact of NBIR decreases for higher NBIR levels and stops being significant.

Table 4: Impact of NBIR on plan inclusion probabilities. National part of plans.

	Initial plan		**Base plan (add.)**		**Extended plan (add.)**	
Observations	216		167		108	
Final log(L)	-114.317		-91.8958		-71.3339	
Rho²(0)	0.2365		0.2061		0.0471	
Rho²(c)	0.0116		0.1527		0.0051	
Variable	**parameter**	***t-stat.***	**parameter**	***t-stat.***	**parameter**	***t-stat.***
NBIR	-0.2309	-1.4	0.8871	4.6	0.1899	0.9
const	-1.1217	-6.5	-1.1634	-5.5	-0.5308	-2.6

Table 5: Impact of NBIR on plan inclusion probabilities. Regional parts of plans.

	Initial plan		**Base plan (add.)**		**Extended plan (add.)**	
Observations	234		200		113	
Final log(L)	-125.384		-116.053		-72.9647	
Rho²(0)	0.227		0.1629		0.0684	
Rho²(c)	-0.6182		0.0785		-0.3901	
Variable	**parameter**	***t-stat.***	**parameter**	***t-stat.***	**parameter**	***t-stat.***
NBIR	-0.0173	-0.1	0.742	3.5	0.2904	1.0
const for each region suppressed to save space						

Table 6: Impact of NBIR on plan inclusion probabilities, national part of plans (piecewise linear function).

	Initial plan		Base plan (add.)		Extended plan (add.)	
Observations	216		167		108	
Final log(L)	-112.504		-86.7918		-65.648	
Rho²(0)	0.2486		0.2502		0.1231	
Rho²(c)	0.0273		0.1998		0.0844	
Variable	**parameter**	***t-stat.***	**parameter**	***t-stat.***	**parameter**	***t-stat.***
NBIR in [-1.0]	1.2313	*1.4*	3.8024	*2.4*	3.6694	*3.2*
NBIR in [0,1]	-1.1514	*-2.1*	1.0332	*1.8*	-1.4231	*-1.7*
NBIR in [1, …]	-0.0785	*-0.3*	0.3009	*1.2*	0.1364	*0.2*
const	-0.5918	*-1.9*	-0.847	*-2.1*	0.6718	*1.5*

Table 7: Impact of NBIR on plan inclusion probabilities, regional part of plans (piecewise linear function).

	Initial plan		Base plan (add.)		Extended plan (add.)	
Observations	234		200		113	
Final log(L)	-96.91		-115.292		-60.3579	
Rho²(0)	0.4025		0.1683		0.2294	
Rho²(c)	-0.2507		0.0846		-0.1499	
Variable	**parameter**	***t-stat.***	**parameter**	***t-stat.***	**parameter**	***t-stat.***
NBIR in [-1.0]	6.2684	4.7	1.515	2.1	3.7155	3.7
NBIR in [0,1]	-1.3729	-2.6	0.1715	0.3	-1.2996	-1.7
NBIR in [1, …]	-0.5784	-1.0	0.9298	1.8	-0.3552	-0.3
const for each region suppressed to save space						

We may draw the following conclusions:

- For the Initial plan, the investments selected at the outset by the Government, the NBIR has little or no effect on an investment's probability of being included in the plan. The NBIR may have an effect on the regional parts of the plan for low NBIR values (below zero). On the other hand, for NBIR between 0 and 1, the estimated NBIR parameter is negative, so the significant parameter value may be spurious correlation.
- For the national investments added to form the Base plan, which were decided by the planning authorities, there is a clear impact of the NBIR on the plan inclusion probabilities. This is particularly strong for low NBIR values, while for high NBIR values (above 1), the effect fades away. A similar pattern holds for regional investments, although the effects ades away for NBIR values above 0.

Influence of CBA results in summary

Summarizing, there is a rather strong correlation between the planning authorities' selection of investments and the CBA ranking (in terms of NBIR). The correlation is weaker for the Extended Plan additions than for the Base Plan additions, and stronger for low and moderate levels of NBIR. For the Base Plan additions, the correlation is weaker but discernible also for higher levels of NBIR; for the Extended Plan additions, the correlation is only discernible for NBIR up to zero. For the investments selected directly by politicians for inclusion in the Initial

Plan, however, there is virtually no correlation at all to the NBIR. However, the insensitivity of politicians to the NBIR may be partly explained by the fact that a large part of the Initial Plan consisted of ongoing projects and a number of "shovel-ready" projects that needed to be started quickly due to the downturn of the economy. These shovel-ready projects were all included in previous plans. A possible interpretation is that the politicians may well be serious about putting more emphasis towards CBA, but that they do not want to abandon previously made promises.

Although CBA results hence affect which investments are included in the plan, it is clearly not a perfect correspondence. Around 25% of investments with NBIR>1 are excluded from the plan, despite the fact that the average NBIR of the additions in the Base Plan and the Extended Plan is 0.9 and 0.2, respectively. Conversely, over 40% of investments with negative net benefits (NBIR<0) are included in the plan.

4. HOW DO PLANNERS USE CBA RESULTS?

Opinions about the merits and usefulness of CBA vary widely among planners. While some planners are sceptical to CBA, seeing it as merely something that has to be done, others see it as a helpful tool. In this section we discuss what role the CBAs have played in the national plan preparation process. The description is based on interviews with key persons of the plan construction process. These are the planners responsible for negotiating a plan proposal, taking into account not only CBA results but also consultations with planners, politicians and special interest groups from all over the country. Hence, these are the ones who (to some extent) actually *use* CBA results to judge the relative merits of the hundreds of investments considered for inclusion in the plan.

The process of deciding which investments should be analyzed at all has been long, starting with regional multi-modal analyses of the transport system, via a number of prioritized functions of the transport system – e.g. improved opportunities for commuting or freight. This resulted in an initial list of proposed investments, comprising several hundred investments[10].

The planners responsible for negotiating a plan proposal formed two separate committees, one for rail and one for road. The committees asked the regional divisions of the National Road and Rail Administrations for a list of the most prioritized investments in each region. At the Road Administration there is a long tradition of using CBAs and the calculation methods are generally well suited for road investments. "The regions had a good grasp of the effects and of what is a cost-effective design of the suggested investments already from the beginning", says planner Maria Boman from the Road Administration.

At the Rail Administration, the shortlist from the regions turned out to be 3-4 times the expected budget. Here, cost-efficiency had apparently not been a criterion. A revision was therefore done where each region tried to find more cost-efficient ways of solving the

[10] The role of CBA results in this process is an interesting research field in itself, but it is not the scope of this paper. Instead, we concentrate upon the selection from this list into the plan proposal.

problems identified – i.e. new variants of the originally proposed investments were identified. "It is my impression that investments got a lot more cost-efficient in this process – the scaled-down investments had almost the same benefits but to a considerably lower cost", says planner Catherine Kotake from the Rail Administration.

The investments remaining after this process were collected into lists where each suggested investment was graded with respect to several criteria, of which NBIR was only one (albeit an important one). Besides the NBIR, the criteria were the extent the investment addressed certain *shortfalls* (of different types) in the transport system, to what extent it would affect *economic growth,* how the investments had been *prioritized regionally*, whether benefits were mostly *regional or national* (ceteris paribus the latter was prioritized) and that the *major cities* received enough investments (since the shortfalls of the transport system was perceived as more dire there and an awareness that the CBA methods captured less of total benefits in large urban regions than in rural areas). The result was one ranked list for rail (including sea transport) and one for road.[11]

These ranked lists were compared with lists that were ranked solely after NBIR. These lists, together with motivations for investments where there was a discrepancy between suggested ranking and ranking after NBIR, were then presented to and decided by the planning steering committee (consisting of management level civil-servants). Thus the CBAs played an important role also in this prioritization. "Our main consideration was that not too many objects with NBIR<0 should enter the plan proposal, however among the profitable investments those with high NBIR have been more likely to be chosen", says planner Catherine Kotake.

In conclusion, our impression is that the planners responsible for deciding which investments should be included in the plan see CBA as a useful tool, and evidently, CBA results played an important role in the selection process. We believe there are several reasons why the correlation between CBA results and plan inclusion is not even bigger. These can be divided into planners and politicians revealed preferences (see section 5), deficits in CBA methodology (section 6), and practical planning considerations. The latter include in what planning context the investment belong or how much time and resources can be spent on studying alternatives. These reasons have not been possible to study quantitatively, but that they do affect plan inclusion is apparent from our interviews:

1. *Too few alternatives are studied*. CBA excels at comparing variants of an investment against each other. Unfortunately, it is far too often the case that only a single version of an investment is studied. Even worse, there is often only one suggested measure to address a specific "need", be it connecting two regions to each other or reduce the volume of through traffic in a city centre. If only one solution is suggested, and the problem is important and severe enough, then it is hardly surprising that planners and politicians will accept investments even if they have low net benefits. What

[11] In the planning directives the government stated that *at least* 50 percent of the investment budget should be used for roads. The planning committee at an early stage decided to make a proposal where the investment budget was split 50/50 between rail (incl. sea) and road.

investments are included in the plan will then depend more on how severe a certain *problem* is than on the cost-efficiency of the suggested *solution*.

2. *A lack of planning context.* Investments belong to a particular planning context. Often, they are framed in a vision or ambition to develop a city or a region in a specific way, for example regarding the built environment. This planning context is not directly captured by the CBA, although CBA can be used to evaluate different investments that all address the same "need" – say, to increase the accessibility of a specific part of a region to make it more attractive for exploitation. This may explain the fact that several highly profitable investments are excluded from the Plan: it may be that they are not addressing "needs" that are prioritized in the overall strategic planning of the regions.
3. *CBA results come too late in the planning process*. Even though CBA this time did have an impact on the design of the investments, our impression is that it is common that CBA results arrive too late in the planning process to have an impact on the decision process[12]. It is likely that when an investment has been planned since long and politicians feel committed to build it, a new (less positive) CBA result will affect the plan inclusion probability less than otherwise. Interviews with planners confirm this hypothesis. "Apart from expected effects, an important prioritization criterion for the regions was how far the project had come in the physical planning process", says planner Maria Boman.

5. PLANNERS REVEALED PREFERENCES

We may hence conclude that an investment's net benefit certainly affect its probability of being included in the plan by the planning administrations (although there is no corresponding correlation for politicians' choices). However, NBIR alone does not explain inclusion in the plan. An especially conspicuous fact is that so many investments with high NBIRs are left outside the plan, and that the influence of the NBIR attenuates for high NBIR levels.

The question hence arises what may explain the difference between the NBIR ranking and the ranking planners and politicians reveal when constructing the plan. There may be several considerations explaining this discrepancy, and we will discuss them in turn.

1. *Balance between densely and sparsely populated regions*. Achieving a distribution of investment funds across the country that is perceived as "fair" is, at least, politically necessary. Another aspect of geographic consideration is the balance in using infrastructure investments to support economically growing or declining regions. Since CBA does not include distributional effects, it is theoretically possible that all investments in the plan will end up in a single region, should CBA results be used as

[12] This is for many reasons, but one important reason is the lack of model management. Databases of socioeconomic data, networks etc. are not sufficiently updated and debugged, often giving rise to confusing erroneous results. This may very well be the single most important issue to improve in CBA practice.

the sole decision criterion. Hence, it is possible that planners would want to put different weights on investments in densely and sparsely populated areas.

2. *Balance between modes*. Another consideration that planners and politicians may want to take into account is to have some predefined balance between investments in different transport modes. From a scientist's point of view such considerations make little sense (there is no reason why the need for improvements should be similar in different modes). However, the Government stated in the planning directives that in the plan proposal *at least* 50 percent of the funding should be allocated to road investments[13]. The Rail and Road Administrations in the beginning of the process made a "gentleman's agreement" to allocate 50 percent of the funding for investments to rail (incl. sea transport) and 50 percent to road in the national part of the plan. Thus, clearly "fairness" between modes was an important consideration.
3. *Balance between investment types*. It is unlikely that planners have exactly the same valuations of effects as the recommended official valuations – be it because planners are not representative of the whole population, that they believe politicians have other implicit valuations or that they do not agree with the official valuations. Examples of such potential discrepancies are the valuations of traffic safety or freight benefits.
4. *Budget constraints*. Since planners have to keep within a total investment budget, it is possible that budget constraints can lead to some costly projects being rejected if they consume a large part of the available budget. Thus the total investment cost of each project could affect the decision to include it in the plan. Investments where other stakeholders than the Government are prepared to contribute to the financing could possibly have a larger probability to be included in the plan, since that way the total budget would increase.

Possible consideration 1: Balance between densely and sparsely populated regions

The table below presents parameter values for a logit model set up to estimate the plan inclusion probability in different regions of Sweden. (This is of course only relevant for the national part of the plan, not the regional part.) If planners and politicians consider whether investments are located in large cities or declining and sparsely populated regions, then controlling for regional location of investments should increase the explanatory power of the NBIR and one should also get significant values of regional dummy parameters.

The model in table 4 is based on the model in section 3, with the NBIR entering the utility function as a piecewise linear function. "Densely populated" and "sparsely populated" are dummy variables with the value 1 for the corresponding region types.

[13] Note that they also stated that CBA results should affect the allocation between rail and road investments. This could either be interpreted as a request to allocate more to road if those investments were to show higher NBIRs than rail or as a memento that the Government was prepared to change the balance when finally deciding upon the National Transport Investment Plan.

Table 8: Effect on plan inclusion probability from type of region. Densely populated regions consist of the counties where the major cities are found, i.e. Stockholm, Västra Götaland and Skåne[14], sparsely populated regions consist of the counties Norrbotten, Västerbotten, Västernorrland, Gävleborg and Dalarna.

	Initial plan		**Base plan (add.)**		**Extended plan (add.)**	
Observations	216		167		108	
Final log(L)	-108.059		-81.6969		-56.5201	
Rho²(0)	0.2783		0.2942		0.245	
Rho²(c)	0.0657		0.2468		0.2117	
Variable	**parameter**	***t-stat.***	**parameter**	***t-stat.***	**parameter**	***t-stat.***
const	-0.8667	*-2.4*	-0.8071	*-1.9*	1.3678	*2.5*
NBIR in [-1.0]	1.1105	*1.3*	3.8285	*2.4*	4.7071	*3.6*
NBIR in [0,1]	-1.0992	*-1.9*	1.0419	*1.7*	-2.0192	*-2.2*
NBIR in [1, …]	-0.2115	*-0.8*	0.1747	*0.7*	0.2753	*0.4*
densely pop region (dummy)	1.0713	*2.7*	1.0057	*1.9*	1.4606	*1.9*
sparsely pop.region (dummy)	-0.1346	*-0.3*	-0.8675	*-1.8*	-1.6744	*-3.0*

Table 8 shows that investments in densely populated regions have a larger probability to be included in the plan than the CBA results suggest. Both the Government and planners prioritize major urban regions. Moreover, planners put lower priority on investments in sparsely populated regions. This is even more obvious when studying the additions in the Extended Plan. One explanation could be that the government in their planning directives emphasised that the plans should lead to economic growth and an increasing number of jobs. Planners may therefore want to direct investments to regions with rapid economic growth, especially since the agglomeration effects that are not captured in traditional CBAs (Venables, 2007) are more likely to be found for investments in such regions. There are also, in general, more other benefits that are not captured correctly in these areas (such as improved urban environment or capacity improvements under congested conditions – see section 6).

The table also shows that the NBIR parameters stay about the same as in the original utility function in most cases, so the conclusions regarding how NBIR affect plan inclusions still hold.

Possible consideration 2: Balance between transport modes

As described above, planners decided to achieve a "fair" distribution of investments between transport modes no matter what the CBA outcome would be. Table 9 shows the resulting average NBIRs for road and rail investments. Note that there are only a small number of rail investments, and almost none of those where complete CBAs were carried out were eventually excluded from the plan. Hence, conclusions for rail investments should be drawn with care. The table shows that the NBIR is in most parts of the plan higher for *a typical* rail investment than for a road investment. However, this does not hold true when the average

[14] Investments in purely rural areas of Västra Götaland and Skåne have been put in the category "other regions".

total NBIR for all investments in each part of the plan is calculated. In for example the Base Plan additions the average NBIR for all rail investments was 0.8 and the corresponding NBIR for road 1.0[15].

Table 9: Number of suggested investments and average NBIRs for road and rail investments respectively.

	Road investments		Rail investments	
	Number	**Average NBIR**	**Number**	**Average NBIR**
All	417	0.36	62	0.74
Initial Plan	67	0.50	23	0.31
Base Plan additions	135	0.83	17	1.55
Extended Plan additions	59	0.09	15	0.72
Excluded	156	0.00	7	0.25

To explore if plan inclusion can be explained by fairness between modes, logit models were again set up – see Table 10. (Again this question can only be studied in the national part of the plan, since there are no regional rail investments left outside the Base Plan.)

Table 10: Effect on plan inclusion probability from mode.

	Initial plan		Base plan (add.)		Extended plan (add.)	
Observations	216		167		108	
Final log(L)	-100.12		-81.4201		-52.867	
$Rho^2(0)$	0.3313		0.2966		0.2938	
$Rho^2(c)$	0.1343		0.2493		0.2627	
Variable	**parameter**	***t-stat.***	**parameter**	***t-stat.***	**parameter**	***t-stat.***
const	-1.3757	-3.3	-0.7693	(-1.8)	1.1571	-2.1
NBIR in [-1.0]	1.2617	1.4	3.7784	2.4	5.2438	-3.8
NBIR in [0,1]	-1.307	-2.1	1.1127	1.8	-2.4855	(-2.5)
NBIR in [1, …]	-0.3036	-0.9	0.1935	0.7	-0.0246	0
densely pop region (dummy)	1.3152	3.1	1.02	2	1.7183	2
sparsely pop.region (dummy)	0.1613	0.3	-0.9018	(-1.8)	-1.2957	(-2.2)
rail (dummy)	1.5134	3.9	-0.3506	(-0.7)	1.7181	2.5

The table indicates that maybe the Government has a ”rail bias” – but since their choices are essentially random, this might just be because they choose a little more rail projects than if projects had been *really* random from the list. Further, the selection in the Base Plan additions shows no modal bias. This is not surprising since the average NBIRs were rather similar and there existed the “gentleman’s agreement” mentioned above. The selection in the Extended Plan additions shows a tendency to rail bias. But, just as for the Initial Plan, this is perhaps just due to rail being chosen a little more frequently than just ”random picking”.

Hence, we can conclude that “fairness” between transport modes was an important consideration but that – out of chance – it is not a major explanatory factor of the observed discrepancies between CBA results and the eventual plan.

[15] An explanation is that there are some large rail investments, and several small road investments, showing low NBIRs.

Possible consideration 3: Balance between investment types

Another possible source of discrepancy between NBIR ranking and plan inclusion is that planners may want to achieve a certain balance between types of investments. For example, we know from interviews with planners that investments that were part of "freight transport corridors" were prioritised. Such criteria introduce implicit valuations that may differ from the valuations in the CBA. It is also possible that planners use other more or less tacit criteria when selecting investments, which would imply valuations of different types of benefits that may deviate from the CBA valuations.

Based on the selection of investments, we can (in principle) derive planners' implicit relative valuations of different types of benefits. Below, we have estimated such relative valuations for traffic safety, freight benefits, person travel benefits and emissions. All benefits are given in monetary values divided with the investment cost, to give the marginal addition to the NBIR from each type of benefit. If derived valuations of benefits coincided with CBA valuations, then all parameters should be equal.

Table 11: Effect on plan inclusion probability from revealed-preference valuations.

	Initial plan		**Base plan (add.)**		**Extended plan (add.)**	
Observations	216		167		108	
Final log(L)	-108.785		-82.5641		-57.75	
$Rho^2(0)$	0.2734		0.2867		0.2286	
$Rho^2(c)$	0.0594		0.2388		0.1946	
Variable	**parameter**	***t-stat.***	**parameter**	***t-stat.***	**parameter**	***t-stat.***
const	-0.61	(-2.1)	-1.9673	(-5.1)	-0.9132	(-2.1)
traffic safety	-1.4387	(-2.8)	-0.1499	(-0.4)	-1.3418	(-2.0)
freight	0.1805	-0.6	2.2949	-3.4	3.5918	-2.2
person travel	-0.2547	(-1.1)	0.9338	-3.3	0.7862	-1.8
emissions	-1.605	(-1.1)	-1.0586	(-0.6)	-1.153	(-0.2)
other	-0.1354	(-0.4)	1.0234	-1.8	0.3795	-0.5

From Table 11 it is again seen that selections in the Initial Plan are essentially random. We can also conclude that in the Base Plan additions traffic safety benefits do not seem to be valued – they are not significant, and do not even have the right sign. The same holds true for emissions benefits, although this should be interpreted with care, since the value of these effects are very small and also correlated with other benefits. What is certain, though, is that freight benefits are implicitly valued much higher than person travel benefits – about twice as high as the standard CBA valuation. This supports that planners have in fact emphasized "freight transport corridors" and other similar criteria. The Extended Plan additions show similar results, although less significant. Thus, freight benefits are again worth more than person travel benefits. Note that safety is valued negatively: this picks up a phenomenon that a few investments with high NBIR and high safety benefits are left outside the plan.

The above phenomenon is apparent when another question is asked: what characterizes investments with high NBIRs that are still excluded from the plan? As will be shown below, it does not seem to be budget constraints. There is only one investment with an investment

cost above 0.5 billion SEK found in the list of 61 investments excluded from the plans and showing a positive NBIR. Instead, a study of the list reveals that a majority of these "unfairly" excluded investments have a large share of the benefits coming from traffic safety effects. Out of the top twenty excluded investments (ranked after NBIR), twelve have traffic safety as their largest benefit, often accounting to 90 percent of the total benefit. This can be compared to the average across all road investments, where traffic safety benefits only account for 14 percent of the total benefits in the Base Plan. Thus, it seems that planners' implicit relative valuation of traffic safety is significantly lower than the official valuation.

Possible consideration 4: Budget constraints

If budget constraints would explain the discrepancies between CBA results and plan inclusion probabilities then large investments should have a smaller probability to be included than their CBA result suggest. Reversibly, it is possible that planners and politicians are biased towards large investments, since these often give positive media attention. Table 12 shows that none of these hypotheses seem to be true.

Table 12: Effect on plan inclusion probability from investment cost.

	Initial plan		**Base plan (add.)**		**Extended plan (add.)**	
Observations	216		167		108	
Final log(L)	-98.3841		-81.3719		-51.3084	
$Rho^2(0)$	0.3429		0.297		0.3146	
$Rho^2(c)$	0.1493		0.2498		0.2844	
Variable	**parameter**	***t-stat.***	**parameter**	***t-stat.***	**parameter**	***t-stat.***
const	-1.5286	(-3.5)	-0.792	(-1.8)	1.3411	-2.3
NBIR in [-1.0]	1.1231	-1.2	3.7793	-2.4	5.5704	-3.9
NBIR in [0,1]	-1.0938	(-1.7)	1.1384	-1.8	-2.8015	(-2.7)
NBIR in [1, …]	-0.2776	(-0.9)	0.1948	-0.7	-0.0795	(-0.1)
densely pop region (dummy)	1.1701	-2.7	1.0206	-1.9	1.8053	-2.1
sparsely pop.region (dummy)	0.2005	-0.4	-0.8936	(-1.8)	-1.3469	(-2.3)
rail (dummy)	1.3853	-3.5	-0.385	(-0.8)	2.0829	-2.9
investment cost	0.0001	-1.4	0	-0.3	-0.0002	(-1.3)

This said, it should be noted that there are several very expensive investments currently discussed in Sweden for which no CBAs have been made (at least not presented) in the investment planning process. These include the high speed rail investments Götalandsbanan between Stockholm and Göteborg and Europabanan between Stockholm and Malmö. Another example is the rail investment Norrbotniabanan in the northern part of Sweden. The main reason they are not even included in the list for Excluded investments is that they would consume (more than) the entire available investment budget. Thus, for very large investments, it is clear that budget constraints do affect plan inclusion probability but this cannot be seen in our data material.

Increasing the total investment budget through co-funding has been a prominent element in the planning process this time. This could affect plan inclusion probabilities in two ways. More cost-effective investments may be selected, the hypothesis being that local stakeholders will be more inclined to keep investment costs down if they bear part of them and/or that they only want to co-fund investments that give large benefits. Less cost-effective investments may be selected if co-funding is seen as a way of getting a higher prioritization for an investment that would else risk being excluded from the plan.

We cannot set up a logit model to test the importance of co-funding since no such investments have been excluded from the plan. Instead we compare median NBIRs for investments in the national part of the plan – see Table 13.

Table 13: Median NBIR for national investments in the Base Plan additions

All investments	0,9
Co-funded investments	1,0
Investments fully financed by Government	0,9

As can be seen the median NBIRs are similar, showing a slight indication that co-funding have led to more cost-effective investments being selected. The same holds true when studying the national investments in all parts of the plan.

6. NEED FOR IMPROVEMENTS IN CBA METHODOLOGY

The consultant or civil servant making the CBA had to give an opinion on whether the project would show a positive or negative NBIR if all effects could have been assessed correctly. Out of the projects with a negative calculated NBIR that are included in the national plan, roughly 4 percent were thus judged to be positive and for another 30 percent the sign of the NBIR was judged uncertain[16]. Also, in roughly half the CBAs showing positive NBIR there are comments about certain benefits (or intrusion costs) that cannot be captured correctly. In other words, it is clear that deficits in the CBA methodology were perceived.

This section is devoted to identifying the areas where improvements of CBA practice is most needed and to analyze whether the deficits can explain the discrepancy between CBA result and plan inclusion. The objective is certainly not to identify *all* the ways in which CBA methodology can be improved. Instead, our approach has been to go through the investments that have been analyzed with CBA during the planning process, and identify what types of benefits that are consistently ill-captured by the CBA, and where this means that the CBA does a particularly poor job of reflecting the true merits of an investment. By comparing the verbal description of the purpose of the investment and its anticipated effects (positive and negative) with the CBA results, we identify whether the intended benefits of the investments are possible to capture in the CBA, at least in principle. Going systematically

[16] There were also some investments judged uncertain although the calculated NBIR was positive.

through all investments, a number of particularly significant and conspicuous deficits in the CBA methodology emerge.

Improved urban environment. A common type of investment is a bypass around a town to reduce car traffic in its central parts, thereby improving the perceived urban environment. Such benefits are not included in the CBA. Some of the dimensions of "better urban environment" can sometimes be captured: exposure to emissions and reduced accidents are possible to include (although the calculations are sometimes too coarse to be of value). But on the whole, the failure to include benefits related to better (perceived) urban environment means that many "bypass" investments have CBAs that are virtually irrelevant – and the number of such investments is considerable. This is also clear from the written comments to the CBAs. For one third of the most expensive investments showing negative NBIRs (8 out of 24 projects with a cost above 0.5 billion SEK), improved urban environment is mentioned as an important effect.

Capacity improvements in highly congested road systems. The failure of static equilibrium models to correctly reflect travel times in the presence of severe congestion is well known. Since static equilibrium models is still the standard tool for most transport modeling and hence for CBA, investments in highly congested transport systems will have underestimated benefits. This is particularly important for various types of capacity improvements. A telling example is a suggested investment in Stockholm where the NBIR changed from -0.4 with a static model to 14 (!) when a mesoscopic simulation model was used instead. Since a significant share of investments is road improvements in the large cities, this is an important problem. However, many of the investments where this is an important effect already shows a positive NBIR. Thus, this deficit is probably not an important explanation of the discrepancies between CBA result and plan inclusion[17].

Reductions of train delays. There is a rather recent but by now fairly mature literature on the valuation of unexpected delays. However, there is still a lack of reliable methods to predict the effects of a suggested investment on the frequency and length of delays. A large share of rail investments aim at reducing "primary" delays (external events causing a train to be delayed) or "secondary" delays (where a primary delay propagates through the network, delaying other trains). More robust hardware is one way of achieving the former and capacity improvements a way of achieving the latter. The difficulty of quantifying the effects on delays of such investments obviously limits the usefulness of CBAs of such investments. Nevertheless, quantifications have been made for many of the rail investments. A majority of the 24 most expensive projects with a negative NBIR are rail projects. Still in only two of these, reduced train delays are said to be an important un-quantified effect. Thus, this deficit does not seem to be an important explanation of the discrepancies between CBA result and plan inclusion.

Improvements for freight transport. Freight modelling and freight benefit valuation are riddled with multiple problems. First, generalized transport costs do not capture all relevant costs – in

[17] However, if these effects were better captured it is possible that the original list of suggested investments would include more investments aiming at improving road capacity.

particular, scheduling costs and unexpected delays are usually not included. Second, the current[18] Swedish freight model SAMGODS is a deterministic model, where only the choice of transport chain (mode/route) changes when transport costs change – other logistic decisions, e.g. shipment size, are not modelled. It is unclear how this affects overall results. Third, a very simplistic method is used by the Rail administration for "small" rail capacity improvements, based only on the difference in average cost per tonne-kilometre between rail and road transport and the assumption that all "new" rail freight moves from road transport. Obviously, there are multiple issues with this simplistic method and in our opinion it is likely to lead to overestimated benefits.

Regional development. It is unclear to what extent the issue of "improved regional development" or "agglomeration effects" is a significant problem for CBA. Often, in the political debate, the term "regional development" includes location effects on population and employment. This is essentially a zero-sum game between regions, and is hence intentionally left outside the CBA. However, it is well known that the way consumer surplus is evaluated, benefits relating to others than the traveller are excluded – the most important being productivity and employment effects resulting in higher net tax revenues and lower unemployment benefit costs. Moreover, there may be similar "external benefits" in the form of increased productivity in the economy. Extensive efforts have been devoted to this issue, both in general and during the plan preparation process. In short, the conclusion is that the benefits of enlarged labour markets would be equivalent to a "mark-up" on the consumer surpluses in the magnitude of perhaps 10–15 percent – a little more for investments mainly affecting short trips, less for investments mainly affecting long-distance trips.

7. CONCLUSIONS

Cost-benefit analysis (CBA) has been used for evaluating proposed transport investments for several decades. Considerable efforts have been spent on developing forecasting and valuation methodology. Swedish transport planning puts a strong emphasis on CBA, and standard Swedish methodology can reasonably be described as state-of-the-art. At the outset of the preparation of the Swedish National Transport Investment Plan 2010-2021, the Government had emphasized the importance of cost-efficiency in general and CBA in particular.

That investments should be evaluated with respect to cost-efficiency is not new, and probably an uncontroversial statement. However, earlier studies of the connection between CBA results and investment decisions have concluded that this connection is weak or non-existent (Nilsson, 1991; Fridström and Elvik, 1997; see also Nyborg, 1998, and Sager and Ravlum, 2005). Obviously, the strength of this connection may vary considerably between countries, contexts and points in time. For the Swedish National Transport Investment Plan

[18] A new version of the SAMGODS model is currently being implemented, where several issues have been addressed. Among other things, the number of goods types has been increased, and a logistics model has been developed which e.g. include the choice of shipment size.

2010-2021, though, we find a fairly strong (although obviously far from perfect) correlation between CBA results and investment decisions. One positive interpretation of this is that CBA methodology is evidently sufficiently well developed to be trusted and used by planners and decision-makers in a real-life planning context. Fears that CBA can only ever be of an academic interest hence seem unfounded.

The conclusions in this study can be summarized as follows:

- CBA results do affect which investments are included in the National Transport Investment plan. An investment with a high benefit-cost ratio has a higher probability to be included in the plan. This is particularly true for low and moderate benefit-cost ratios: the higher the benefit/cost ratio, the weaker the correlation between benefit/cost ratio and probability of inclusion in the plan.
- However, the connection between CBA results and investment decisions only exists for the parts of the plan prepared by the Rail and Road Administrations. For the investments selected directly by politicians, there is no link between high benefit/cost ratios and selection of investments. However, it might be that the politicians are serious about putting more emphasis towards CBA, but not at the price of abandoning previously made promises.
- CBA results do not seem to have affected which investments are included when the Rail and Road Administrations made plans for more money (the Extended Plan additions). This may be because they did not believe this money would materialize and thus put less effort into this part of the plan. It may also be that rather than use the CBA result for ranking, it is used to check that a suggested investment is not “too bad”, i.e. has NBIR well below zero, and once the NBIR is above the zero threshold, then it is not used as a selection tool anymore.
- The fact that CBA was used as a prioritization instrument also had effects that are not visible from the final material: interviews with planners reveal that the focus on high benefit-cost ratios made planners “trim” proposed investments by trying to reduce investment costs without significantly reducing the benefits of the investment. In other words, the mere awareness that CBA is used as a prioritization instrument makes investment suggestions more cost-efficient.
- Planners also take other things than benefit-cost ratio into consideration, e.g. the importance placed on the investment by regional planning authorities and geographical fairness.
- Considerations regarding balance between regions can explain part of the discrepancy between CBA results and probability of inclusion in the plan. Perhaps surprising though, this seems to favour urban areas and disfavour rural areas. One likely explanation is that planners are aware that the standard CBA captures less of total benefits in urban areas. Another is the selection criterion that the large urban region should get prioritized.
- In their investment decisions, planners implicitly value freight benefits higher and traffic safety benefits lower compared to recommended relative valuations. The higher valuation of freight benefits is likely induced by the selection criterion that freight investments should be prioritized.

- Certain costs and benefits are not very well captured in the CBA – sometimes not at all. For certain types of investments, this will in fact mean that the intended purpose of the investment falls outside the CBA, in the worst cases rendering the CBA virtually useless. This is a particularly severe problem for certain classes of investments: road bypasses meant to improve perceived urban environment, rail investments meant to reduce train delays, and road investments in extremely congested networks.

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