

Some issues in the European Investment Bank methods for evaluating public transport project: shifted users' benefits

Jérôme MASSIANI

¹ Università Milano Bicocca

The European Investment Bank documents a method to evaluate urban public transport projects. This method uses, among other things, the difference of travel time between the “origine mode”, used in the no-policy scenario and the destination mode, used in the policy scenario. This approach is intuitive but provides distorted results whenever one cannot measure the exact and exhaustive value of each attribute for each diverted traveller. This paper shows the simplest example of how this distortion takes place and how it can be avoided by using surplus based methods.

Parole Chiave: Cost benefit analysis, surplus, transferred users, generalized costs

1 Introduction

Governments and funding organizations routinely have to evaluate collective transport project. In doing this they have to account for transport users benefits and especially transferred users (also called: diverted users, shifted users): travelers that shift from other modes to the improved mode. Several methodological options are available for this purpose, not all of them being of equal validity :

1. Using surplus based measures, like Logsum, Marshalian/Hicksian surplus or their Rule of Half approximation.
2. Using the variation of measured Generalized Costs, typically transport expenditures and time savings. This compares the observed generalized cost on the origin mode (for instance car) to the improved mode (for instance tram). Note that this comes with some variations, as it can be done by using market prices or net of tax prices in the computation of generalized costs.

To make things more complicated, in practice, some computations use a mix of different methods, for different traffics or different attributes. For instance, time savings could be based on the

difference in measured travel time between the origine and destination mode, while expenditure savings could be based, in the same computation, on other methods.

Among international bodies, EIB is one of the most active in using CBA and for this reason several methodological documents have been issued over time. The proposed computation is described in various documents (EIB, 2013 chap. 33, p 188; European Investment Bank, 2023, 2nd edition chapter 33). In appendix, we include some tables from these documents that summarize the method. All these methodological documents mention several times the Rule of Half and recommend its use to compute various items (chapter 14 in EIB 2023): But they describe another computation for at least one item: the time savings of transferred users. It is based on the difference in observed generalized costs. Specifically, travel time saving (item 10 and 11 in table 33.1) is accounted for as the difference in travel time between origin and destination modes. For a traveler shifting from car to tram, this would be the difference between the no-project car duration and the project tram duration¹.

This short article shows how this approach is methodologically inconsistent. The distortion, resulting from using the difference in measured generalized costs, has been occasionally discussed referring to evaluations methods used by some other institutions. Nagel et al (2015) make a particularly neat analysis of how this distortion impacts a given evaluation procedure in Germany. Massiani and Maltese (2019), Delle Site and Salucci (2018) also provide similar analysis.

The present note provides a concise example of how the distortion takes place. This distortion would disappear when one uses, with similar data requirements, surplus and its empirical counterparts such as the Rule of Half (RoH).

2 A concise example

When a project shifts users from one mode to another, users experience a change in generalized costs. Yet only part of the generalized costs are measured. This generates a distortion.

Not all costs are observed, certainly not for each individual. It is expected that part of the generalized costs is unobserved: 1 - it is virtually impossible to measure costs without error, be it only for measurement issues. 2 - certain variables are difficult to measure and, often, not included in calculations, for instance: comfort, reliability or others. Analysts may try to handle this with alternative specific constants, but when this is not done, the problem persists and when it is done, this may not suffice as alternative specific features are most likely different from one individual to another. 3- apart from this, the aggregation of data among zones; will create a distortion : certain individuals will have the same measured access time to transport modes in the model when in reality these would differ. This means that the measured door to door time will be erroneous for most users. All these implies that the attributes or generalized cost will differ from their assumed average value in each group of population (typically OD pairs), while the average itself may not be accurate.

In the simplified numerical example provided below, inspired by the EIB case study, we suppose two modes, car and tram, with given travel time, given expenditures and given other costs or attributes. The analyst instead can only measure time and cost.

¹ Instead, travel costs are included with a slightly different method (cost savings on the origin mode and operating costs on the destination mode) that can be investigated in other documents.

We suppose the tram network is extended. This modifies the travel time for some travelers. As a consequence, some users are now interested in using the tram because their full individual generalised cost is lower than that of the alternative car option. An analyst wants to measure transferred user benefits. Several methods can be used. A first method is to compute the change in observed generalized costs. The simplest case to consider is when there is only one individual. Even in this case, the generalized cost method can produce an error.

Table 1: costs and benefits for a shifted user (negative numbers indicate a cost)

Attributes	Car Project/no project (a)	Tram		Δ Generalized Costs (Transferred users)	
		No project (c)	Project (b)	Total (b-a)	Observed (b-a)
Time * v.o.t.	- 10	- 20	- 18	- 8	- 8
Cost	- 10	- 2	- 2	+ 8	+ 8
Other (unobserved)	0	+1	+1	+ 1	unavailable
Total	- 20	- 21	- 19	+ 1	0

Note: v.o.t = value of time

Table 1 presents the benefits for a single user shifting mode. The first two columns provide the cost of the two modes in the project/no project situations. Last two columns compute the change in total and observed generalized costs. The first one provides the correct measure of benefits. It is, correctly, a positive number. The second is a distorted measure and shows a null benefit ; this is because it neglects the unobserved component. This example illustrates that when the change in observed generalized cost is used to measure benefits, users' benefits measure is biased.

3 A possible solution, exploiting the distribution of unobserved components: surplus based measures

The described issue has a solution. A temptation is to rely on a better measure of Generalized Costs by adding observed components. This can be done up to a certain point, but this provides only finite improvements. The issue requires a more structural solution that eliminates the distortion for any quality of the data. Such a solution is to use surplus measures. These exploit some properties of the unobserved component of users' generalized cost.

To present this approach, it is convenient to add additional users to the simplified example in table 1. Table 2 is similar to table 1 with the addition of two other individuals: B and C. We assume three users who differ by the value of their unobserved generalized costs. For instance, one may live farther from the station than the other; this will normally not be reflected in data used by the analyst because he uses only one measure of each OD pair. Other differences may relate to a different valuation of some attributes like comfort or others.

Table 2: costs and benefits for three shifted users (negative numbers indicate a cost)

Attributes		Car Project/no project	Tram		ΔCG (Transferred users)	
			No project	Project	Total	Observed
Identical across individuals (observed)	Time * v.o.t	- 10	- 20	- 18	- 8	- 8
	Cost	- 10	- 2	- 2	+ 8	+ 8
Other attributes Individual specific (unobserved)	A:	0	1	1	1	.
	Total A	- 20	- 21	- 19	1	.
	B:	-0,1	0	0	0,1	.
	Total B	- 20,1	- 22	- 20	0,1	.
	C:	0	+ 1,8	+ 1,8	1,8	.
	Total C	- 20	- 20,2	- 18,2	1,8	.
Total Surplus calculation (individual A, B and C):					2,9	0

Based on this situation, we can measure the change of observed Generalized Costs for each individual and compare it to the real change in Generalized Costs. We can also compare the total benefit of three individuals together. We note that the change of observed Generalized Costs is null, while the real change in Generalized Costs is a benefit of 2,9. This illustrates again that the first result, 0, based on observed Generalized Costs, provides a distorted result. It also suggests a solution to the problem. As long as the unobserved components follow or, at least, can be approximated by a tractable distribution, the benefits of transferred users can be estimated by looking at the change in observed Generalized Costs on each single mode. This is not the difference of generalized cost across modes, but the change in Generalized Costs in each single mode (in the case of interest this is the value of the time savings of tram).

In the illustrated case, the RoH estimate of transferred users' surplus is:

$$\frac{1}{2} * \text{Number of shifted users} * \text{Change in observed GC within each single mode}$$

This provides $\frac{1}{2} * 3 \text{ users} * (20-18) = 3$. This estimate would miss the real value, 2.9 only by 0,1 (the reason for the small deviation is that users are not exactly fitting a uniform distribution, which can happen in reality).

Surplus measure, and their empirical counterparts, such as RoH (logsum is also a valid candidate) necessarily produce results of the correct sign. They provide good, by any meaning, estimates, although the exact correspondence depends on the actual distribution of unobserved component of generalized costs.

4 Conclusion

Like other institutions, the EIB proposes a method for evaluating transferred users benefits of a public transport project is based on the difference in observed generalized costs (exactly so for time savings, with some extra complexity for costs). Observed generalized costs have also been used by other institutions in the past and, in various occasions, it has been investigated and rejected for an intrinsic distortion. The example we provide illustrates this bias, in the most simple and concise way we can imagine. The main conclusion actually generalizes to more complicated

situations (more than two modes, change of cost for two or more modes, segmentation of demand, etc).

An alternative that avoids this complication is to use surplus-based methods, that are advocated by academics, included in many guidelines, recommended by the EIB methodological document itself (chapter 15 pp. 85, 88) and used by the EIB for the calculation of other benefits. For instance, EIB method prescribes Rule of Half (RoH) based measures for induced traffic. RoH may not be perfect, but they avoid the analyzed distortion without, to our best knowledge, having significant drawbacks. Additionally, their use would increase the homogeneity of methods used in EIB evaluation.

Note that other related methodological issues in the EIB procedure are worth discussing:

- 1- To our best understanding, EIB introduces an additional complication : while travel time savings are based on differences of travel time, costs are accounted for with a more complex calculation : ceasing costs on the origin mode and operating costs on the destination mode. In our view, this additional complication does not change the conclusion on the preferability of surplus based measures compared to (variously defined) changes in observed costs. On the contrary we presume this will create another complexity This conjecture can be confirmed using a more elaborate model that does not fit in this concise note.
- 2- The question of taxation in CBA, that is often discussed among economists and where an interesting scientific discussion could be fruitful. Our understanding is that BEI uses net-of-tax prices. If so, even if using the difference in generalized costs is erroneous, it is better implemented with net-of-tax prices... this actually implies that public transport modes usually carry a negative taxation (subvention), which should increase the cost compared to market prices. The actual procedure used by the BEI should be clarified and possibly investigated on this.

Appendices

Appendix A - Extract from EIB “the economic appraisal of Investment Projects at the EIB” 2013. Chapter 33

We reproduce the example table provided by EIB document in chapter 33.

Based on comments received by EIB interlocutors, the operating costs of the destination mode are those in item (25) “additional operating costs”.

Table 33.1:
Calculation of urban public transport project returns

NPV			2010	2011	2012	2013	2014	2015	2043
Traffic									
(1)	Total traffic: (m journeys/year)		0.0	0.0	0.0	0.0	20.9	21.3	30.7
Existing users									
(2)=%(1)	Tramway		0.0	0.0	0.0	0.0	0.0	0.0	0.0
(3)=(2)*Time_Saving"/VoT	Time savings compared to tramway	MEUR 0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diverted users									
(4)=%(1)	Bus		0.0	0.0	0.0	0.0	14.6	14.9	21.5
(5)=%(1)	Car		0.0	0.0	0.0	0.0	1.0	1.1	1.5
(6)=%(1)	Heavy car		0.0	0.0	0.0	0.0	1.0	1.1	1.5
(7)=(4)+(5)+(6)	Total diverted users		0.0	0.0	0.0	0.0	16.7	17.0	24.5
(8)=(5)*Car_load_factor*Car_VOC	Car savings	MEUR 31.8	0.0	0.0	0.0	0.0	2.1	2.2	3.0
(9)=(6)*Car_load_factor*Heavy_Car_VOC	Heavy car savings	MEUR 9.5	0.0	0.0	0.0	0.0	0.7	0.7	0.9
(10)=(5)+(6)*Time_Saving"/VoT	Time savings compared to car	MEUR 39.0	0.0	0.0	0.0	0.0	2.0	2.1	5.2
(11)=(4)*Time_Saving"/VoT	Time savings compared to bus	MEUR 261.9	0.0	0.0	0.0	0.0	13.4	14.0	35.1
Generated users									
(12)=%(1)	Generated traffic		0.0	0.0	0.0	0.0	4.2	4.3	6.2
(13)=(12)*Time_Saving"/VoT/2	Benefits	MEUR 36.4	0.0	0.0	0.0	0.0	1.9	1.9	4.9
Environmental benefits									
(14)	Nox	MEUR 0.2	0	0	0	0	18,717	19,473	13,179
(15)	PM	MEUR 2.7	0	0	0	0	532,292	605,317	66,220
(16)	VOC	MEUR 0.0	0	0	0	0	2,316	2,410	6,057
(17)	SO2	MEUR 0.1	0	0	0	0	5,653	5,381	14,733
(18)	CO2	MEUR 1.8	0.00	0.00	0.00	0.00	0.13	0.13	0.13
(19)	Noise	MEUR 0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other benefits									
(20)	Reduction in fatalities	MEUR 3.5	0.00	0.00	0.00	0.00	0.16	0.19	0.17
(21)	Bus Savings	MEUR 107.6	0.00	0.00	0.00	0.00	8.53	8.53	8.40
(22)	Time savings for users remaining on roads	MEUR 101.6	0.00	0.00	0.00	0.00	5.99	6.14	12.32
Costs									
(23)	Investment cost	MEUR 320.9	81.50	137.39	120.01	64.03	0.00	0.00	180.75
(24)	Electricity generation social cost	MEUR 2.0	0.00	0.00	0.00	0.00	0.12	0.13	0.22
(25)	Additional operating cost	MEUR 195.1	0.00	0.00	0.00	0.00	15.42	15.42	15.42
(26)	Upgrades	MEUR 64.4	0.00	0.00	0.00	0.00	0.00	0.00	0.00
(27)=(3)+(8)-(9)+(10)-(11)+(13)-(14)+(15)-(16)+(17)+(18)+(19)+(20)+(21)+(22)	Benefits	MEUR 596.0	0.00	0.00	0.00	0.00	35.53	36.45	70.50
(28)=(23)+(24)+(25)+(26)	Costs	MEUR 507.4	81.50	137.39	120.01	64.03	15.55	15.55	186.10
(29)	EIRR	5.1%							
(30)=(27)/(28)	NPV	MEUR 4.7							
(31)=(27)/(28)	B/C	1.01							

Appendix B - Computation in EIB 2023

We reproduce the tables of the EIB method (table 33.1, p187-188 in EIB 2023).

		NPV	
Project demand			
(1)	Total demand (M passengers/year)		
Existing users			
(2)=%(1)	Tramway (M passengers/year)		
(3)=(2)*(Min/pax)/60*(€/h)	Time savings compared to tramway	M EUR	-
Diverted users			
(4)=%(1)	Bus (M passengers/year)		
(5)=%(1)	Car (M passengers/year)		
(6)=(4)+(5)	Total (M passengers/year)		
(7)=(4)*(Min/pax)/60*(€/h)	Time savings compared to bus	M EUR	311.5
(8)=(5)*(Min/pax)/60*(€/h)	Time savings compared to car	M EUR	6.7
Generated users			
(9)=%(1)	Generated demand (M passengers/year)		
(10)=(9)*(Min/pax)/60*(€/h)/2	Time savings for additional journeys	M EUR	9.2
Environmental benefits			
(11)=(g/bus*km)*(Mbus/km)+(g/car*km)*(Mcar*km)*(€/t/1M	Reduction in NOx emissions	M EUR	3.2
(12)=(g/bus*km)*(Mbus/km)+(g/car*km)*(Mcar*km)*(€/t/1M	Reduction in PM emissions	M EUR	1.3
(13)=(g/bus*km)*(Mbus/km)+(g/car*km)*(Mcar*km)*(€/t/1M	Reduction in VOC emissions	M EUR	0.1
(14)=(g/bus*km)*(Mbus/km)+(g/car*km)*(Mcar*km)*(€/t/1M	Reduction in SO2 emissions	M EUR	0.1
(15)=(g/bus*km)*(Mbus/km)+(g/car*km)*(Mcar*km)*(€/t/1M	Reduction in CO2 emissions	M EUR	10.8
(16)=(11)+(12)+(13)+(14)+(15)	Total environmental benefits	M EUR	15.5
Other benefits			
(17)=(#Mcar*km)*(Mcar*km)*(M€/#)	Reduction in road fatalities	M EUR	4.9
(18)=(#Mcar*km)*(Mcar*km)*(M€/#)	Reduction in road severe injuries	M EUR	3.7
(19)=(17)+(18)	Total benefits of road safety	M EUR	8.6
(20)=(€/bus*km)*(Mbus*km)	Bus savings	M EUR	60.2
(21)=(€/car*km)*(Mcar*km)	Car savings	M EUR	42.8
(22)=(20)+(21)	Total OPEX savings	M EUR	103.0
(23)=(Mpax)*(Min/pax)/60*(€/h)	Time savings for users remaining on roads	M EUR	72.9
Costs			
(24)	Project investment costs	M EUR	279.5
(25)	Project upgrades	M EUR	51.7
(26)=(€/tram*km)*(Mtram*km)	Project operating costs	M EUR	135.5
(27)=(kWh/tram*km)*(Mtram*km)*(g/kWh)*(€/t/1M	Project CO2 emissions	M EUR	11.3
(28)=(3)+(7)+(8)+(10)+(16)+(19)+(22)+(23)	Total benefits	M EUR	527.3
(29)=(24)+(25)+(26)+(27)	Total costs	M EUR	478.1
(30)	EIRR		6.1%
(31)=(28)-(29)	NPV	M EUR	49.2
(32)=(28)/(29)	B/C		1.10

Riferimenti bibliografici

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