Sensitivity analysis of socio-economic values of time for public transport projects

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1. Abstract

The socio-economic time benefits of two light rail projects in Copenhagen are investigated using three different sets of values of time. The first set is the one the Ministry of Transport recommends for use in socio-economic analysis in Denmark; this is used as basis for comparison with the two other sets of values of time. The second set is the expected new recommended values of time that has the same time values for non-business travel. The third set is estimated from traffic modelling parameters and operates with different in-vehicle time values; the reason for this is thoroughly described supported by examples. Traffic modelling of the two light rail projects has been performed and the results are used to generate the time benefits. The time benefits for the two light rail projects using the expected new values of time will increase around 20% compared to the result when using the values recommended by the Ministry of Transport. Differentiated in-vehicle values prove to generate an even higher increase in time benefits, but vary depending on the projects.

Keywords: Public transport, light rail, value of time, time benefits, socio-economic analysis

2. Introduction

In the evaluation of public transport projects, socio-economic analyses are often the most important factor. This is because they provide a good comparability between different projects. In the socio-economic analyses the time savings that will occur in the public transport system because of the infrastructural improvement is nearly always the biggest benefit for the project. This means that the time benefits have to be of a quite reasonable size to neutralize and, at highest, exceed the cost of construction and operation so that the project can be amortized over a certain period.

Looking at different evaluation of public transport projects (e.g. Copenhagen County et. al 2003, Andersen 2005 and Landex & Nielsen 2005) it appears that large public transport projects rarely displays socio-economic viability. This can be due to many factors (e.g. Landex & Nielsen 2005), but it might also indicate that the socio-economic values of time used in the analyses are, either to low or do not represent the utility concept of travel well enough. It has for some time been well known that the existing values of time recommended to use in socio-economic analysis of public transport projects are insufficient when using more complex (and realistic) traffic models to calculate time benefits in the public transport system.

2.1. Objective

The objective of this paper is to investigate how different socio-economic values of time for public transport affect the time benefit of infrastructural public transport projects. The emphasis is laid on the values of time that are recommended to use in socio-economic analyses of public transport project by the Danish Ministry of Transport. The intention is to see which results can be obtained by the present recommended and the expected new recommended values of time. Furthermore, the recommended socio-economic values of time do not distinguish between the different means of transportation. Thereby, it is not taken into consideration that some means of transportation are more attractive than others especially in terms of comfort and constructive time use during the travelling. Theoretically, this leads to lower time benefits since more complex traffic models takes this into consideration. Therefore, also a set of values that is differentiated over the different means of transportation is evaluated.

To investigate impacts for practice, two potential light rail projects in the Copenhagen region is examined. Each project is evaluated separately for their time benefit using the different set of socio-economic values of time.

The study does not question the appearance of the different values of time, but uses them only to analyze and compare their socio-economic results. Therefore, the values will not be questioned in terms of actual travel behaviour as such questions rather should be founded in observed data. The study questions the values worth when using traffic models to generate the input for the socio-economic time calculation.

3. The projects

The public transport projects chosen for this study are two light rail projects with alignments running across the radial urban structure of greater Copenhagen. These projects have been a part of the public debate for the future transport planning of greater Copenhagen and one of them (maybe both) is likely to be constructed within the near future. Also, a whole new infrastructure improvement as a light rail should show more significant time benefits in the public transport system than an upgraded solution in the existing network. The two light rail projects selected for the examination are Ring 2½ and Ring 3.

3.1. Ring 2½

The alignment and stop pattern of the Ring 2½ light rail follows the proposal from Andersen (2005), except for the extension to Nærum station. This means a light rail running from Friheden station in the south to Lyngby station in the north with 20 stops. Along its route the light rail services areas such as Hvidovre, Rødovre, Husum, Gladsaxe, Buddinge and Lyngby. Providing close connection to all the radial S-train lines at Friheden, Rødovre, Husum, Buddinge and Lyngby stations. The earlier described extension to Nærum station is considered to be more likely constructed in a later phase. The alignment and stop pattern of the Ring 2½ light rail can be seen in figure 1.

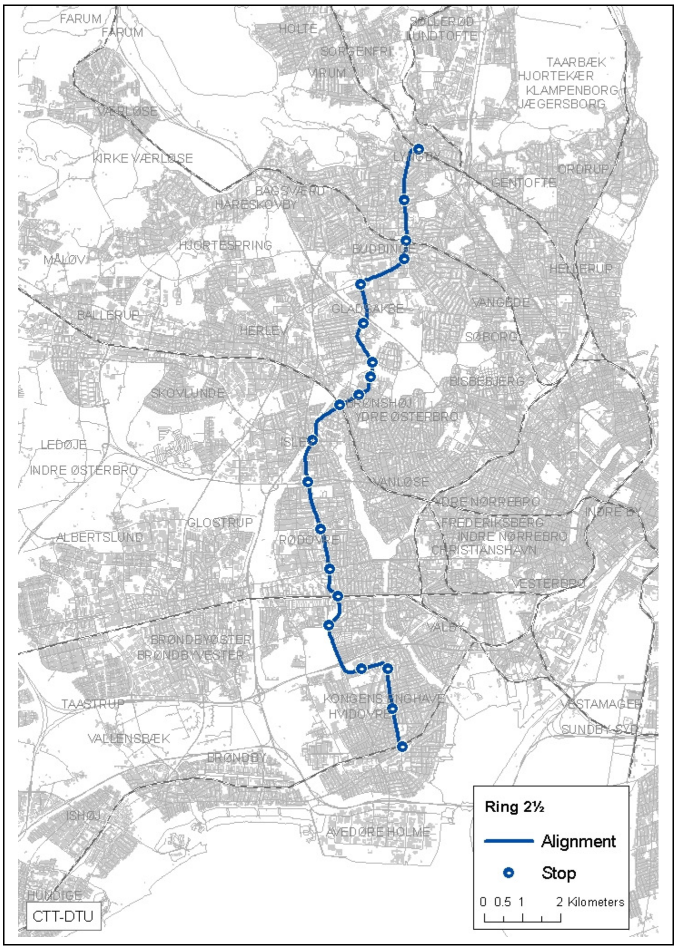


Figure 1 – Alignment and stop pattern of the Ring 2½ light rail

The plan of operation also follows a proposal from (Andersen 2005). The light rail will have 10 minutes frequency during daily operation and will be stopping at all stops. The driving time from end to end will be 34 minutes. This equals a 24% time reduction compared to the existing bus service of bus line 200S.

Bus adjustments for the Ring 2½ light rail situation is closing of the parallel bus line 200S which runs from Friheden station to Lyngby station. The bus and the light rail only have slight deviations in the alignment and have many common stops. However, the light rail has fewer stops than the bus line, but still they will be so competing that the closing of the bus line seems as the only correct option. No further bus adjustment has been made in this study.

3.2. Ring 3

The alignment and stop pattern of the Ring 3 light rail is one of the alternatives proposed in (Copenhagen County et. al 2001 & 2003) running from Ishøj station to Lyngby station and with a total of 26 stops. It serves areas such as Ishøj, Vallensbæk, Glostrup, Herlev, Gladsaxe, Buddinge and Lyngby and also has close connections to all radial S-train lines at Ishøj, Vallensbæk (same S-train line as Ishøj), Glostrup, Herlev, Buddinge and Lyngby. The alignment and stop pattern can be seen in figure 2.

The plan of operation is also proposed in (Copenhagen County et. al 2003) with 12 departures per hour in each direction – meaning 5 minutes frequency in daily operation. All departures of the light rail are planned to stop at all stops. The driving time from one end to the other will be 46 minutes. This equals a 16% time reduction compared to the existing bus service of line 300S.

Bus adjustments for the Ring 3 light rail situation is closing of bus line 300S on their common alignment. This means that the service of bus line 300S in this study is closed down between Ishøj/Hundige station and Lyngby station. The service that the bus line provides in areas north of Lyngby[1] is left unchanged.

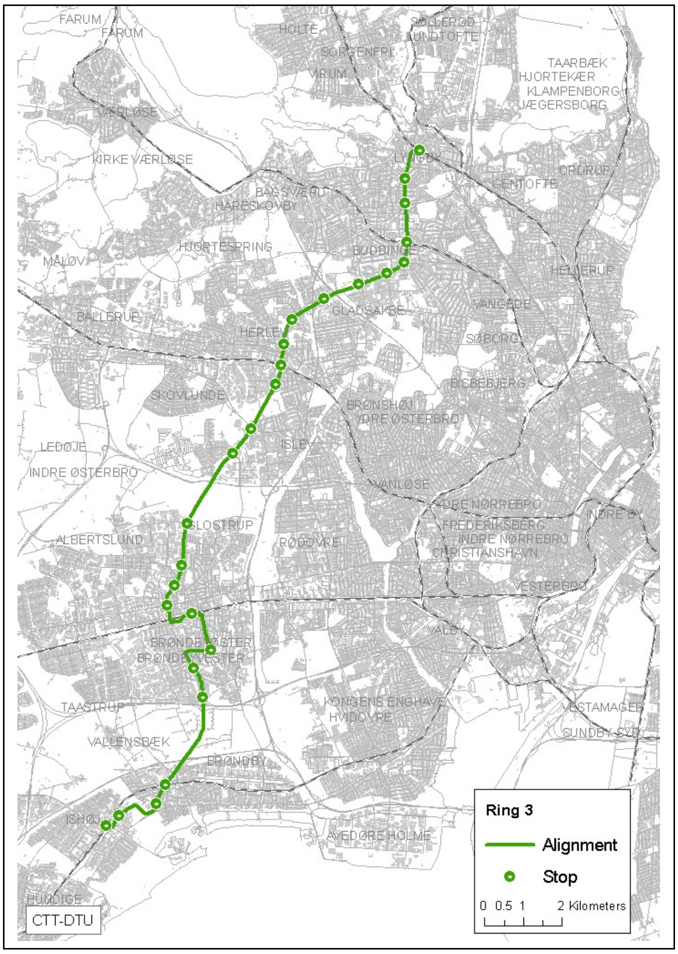


Figure 2 – Alignment and stop pattern of the Ring 3 light rail

4. *Traffic modelling*

Traffic modelling is used to evaluate the socioeconomic impacts of public transport projects. The most important results from the modelling are the time used in the system to determine time benefits, whereas the network impacts are not relevant for this study.

4.1. Model database

For the traffic modelling a time-table based public route choice assignment model based on stochastic utility theory is used, as described in: (IMV 2006). This model includes all departures in the public transport network of the greater Copenhagen area in an average working day in year 2004. The data has been imported from the national Danish journey planner (www.rejseplanen.dk) and has been linked to a digital map (Kraks geodatabase, www.krak.dk) in ArcGIS. The actual route choice modelling (assignment) is carried out using the Traffic Analyst extension to ArcGIS (www.trafficanalyst.dk). For more information about the model database see (Nielsen, Hansen & Daly 2001)

[1] In the 2004-situation where the traffic modeling has been performed, the bus line runs all the way to Kokkedal station opposed to its current line end stop at Nærum, hence it is even more important to keep the northern service

As base for the route choice modelling is used the zone structure and corresponding trip matrixes from the Orestads Trafik Model (OTM) version 4.0. (Jovicic & Hansen 2003). This zone structure covers the greater Copenhagen area (a population of 1.8 million inhabitants) and it consists of a total of 618 zones. The trip matrixes contain travel for three different trip purposes:

1. Home-Work (commuter travel)
2. Work-Work (business travel)
3. Other (leisure travel)

This means that the traffic modelling is performed separately for each of the trip purposes.

4.2. Route choice modelling

The route choice modelling has been performed on a specific time interval (the calculation period), which is the morning rush hour (7.00-9.00) and the following socio-economic calculation will be performed in this time interval. However, to ensure that all public transport lines are operational during the calculation period, all runs in the period 5.00-12.00 is loaded into the calculation graph.

The route choice modelling has been performed with six launches of traffic per hour, meaning a total of 12 launches during the calculation period. Furthermore, the number of iterations has been set to 5, meaning a displacement of the launch times that corresponds to launch of traffic every second minute during the entire calculation period.

The procedure is to start of by modelling the present situation (the base scenario). Thereafter, the light rail project is encoded in the model and the situation with the light rail (the scenario) is then modelled. Induced traffic because of the improved public transport system is taken into account by updating the trip matrixes. This is done by using the considerations and percentages for new travel that was suggested in (Nielsen, Israelsen & Nielsen 1998).

The assignment produces some level-of-service matrixes (cost matrixes). A cost matrix with the average time used for travel between each zone relation and a cost matrix in-vehicle where the time is distributed into the mean of transportation. These cost matrixes are the foundation of the time calculation that will be presented later (cf. section 6. Time calculation).

The two light rail projects are investigated separately and therefore separate route choise assignments have been performed for each project.

5. Values of time

To price the used time in the public transport system, values of time must be appointed to the different time components in a door-to-door public transport journey. In this study the base set of values are the ones recommended by the Ministry of Transport to use in socio-economic analysis of public transport projects (Danish Ministry of Transport 2006). The result using these recommended values are compared to the results of two other set of values, where the first set is an estimation of what is expected to be presented as the new recommended socio-economic values of time very soon. The third set is a former estimated set based on route choice assignment parameters that handle an issue which the values recommended by the Ministry of Transport neglects.

To be able to compare the results, all values of time are here presented in 2004-prices. This means one set of values have been forecasted to this yearly level, the others are already in 2004-prices. The procedure for forecasting values is like suggested in (Landex, Salling & Andersen 2006).

5.1. Values of time recommended by the Ministry of Transport

The Danish Ministry of Transport has a guide line and key figures to evaluate socio-economics of public transport projects (Danish Ministry of Transport 2003 & 2006). It is recommended that these are used when evaluating public transport projects in Denmark. Therefore, these values of time are used as the basis for comparison of the study. The set of values can be seen in table 1.

	Home-Work	Work-Work	Other
In-vehicle	60	266	35
Waiting/interchange	120	532	70
Hidden waiting	30	133	18

Table 1 – Socio-economic values of time recommended by the Danish Ministry of Transport (Danish kroner per hour in 2004-prices)

Travel time in public transport systems, as seen in table 1, consist of the in-vehicle time which is the time used in a public transport vehicle ("driving time"). Waiting and interchange times are waiting and walking times in transfers and hidden waiting time is waiting time in the start zone. The set lacks a value for access and egress to the public transport system, which in the traffic model is represented by the connector time. Therefore, this value is appointed the same value as estimated in section 5.3.2 The differentiated set of values.

5.2. Similar time values for non-business travel – the expected new values

Another set of values is here estimated using the same value of time for non-business travel. Also the level of the travel time value is higher than the level of the values recommended by the Ministry of Transport. The set of values can be seen in the table 2.

	Home-Work	Work-Work	Other
In-vehicle	67	315	67
Waiting/interchange	134	631	134
Hidden waiting	34	158	34
Access/egress	101	473	101

Table 2 – The expected new socio-economic values of time with same value of travel time for non-business travel (Danish kroner per hour in 2004-prices)

This set of values originates from studies conducted at the Danish Transport Research Institute (DTF). However, the In-vehicle value for business travel has been derived from the in-vehicle time for commuting and leisure using factors estimated from the values recommended by the Ministry of Transport. Hereafter, the time value for hidden waiting; waiting and interchange values are estimated using the factors of the in-vehicle values recommended by the Ministry of Transport (0.5, 2 and 2 respectively) (Danish Ministry of Transport 2006). The time value for access/egress is estimated from a factor 1.5 of the in-vehicle time as DTF suggests in their study. It is expected that this set of values will be very close to the new values of time that the Ministry of Transport will recommend when they update the key figures. However, they are not yet published and the set should, therefore, for now be regarded as an estimate.

5.3. Differentiated in-vehicle values of time

The values of time that are recommended by the Ministry of Transport and customarily used for socio-economic evaluation of public transport projects do not have separated values for in-vehicle travel. This can be a problem when using different values for different means of public transportation in the route choice assignment since these results constitute as the base for the socio-economic evaluation.

In the route choice assignment used in this study, different values for different means of transportation is used as parameters in the assignment to simulate that some means are more attractive than others, largely regarding comfort and constructive time use during the travelling. For instance, some travellers are willing to accept longer travel time if the journey can be conducted by rail instead of bus – the so-called rail effect (Truder 2005). When this issue is handled in the assignment but not in the following socio-economic analysis, the paradoxical situation can occur that improvements will result in negative time benefits (disbenefits) and thereby lower the total time benefits of the system. Following example is taken from (Landex, Salling and Andersen 2006) and illustrates the problematic:

If a traveller is going from A to B, the traveller can go by bus from A to B with transfer at C. If a new metro, light railway or suburban railway is built between A and D (without changes in the existing bus connections), some travellers will choose to go by railway from A to D and then transfer to the bus going to B (cf. figure 3).

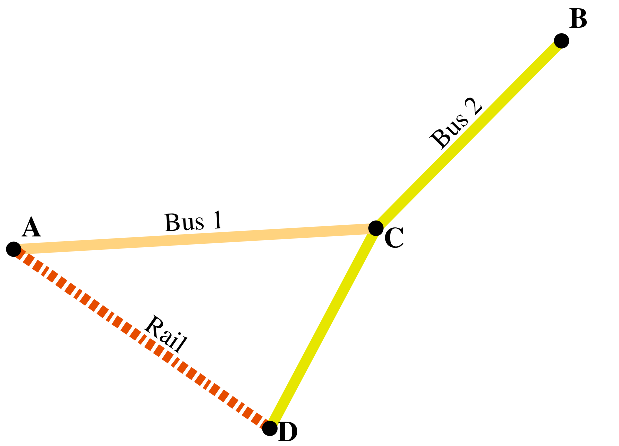


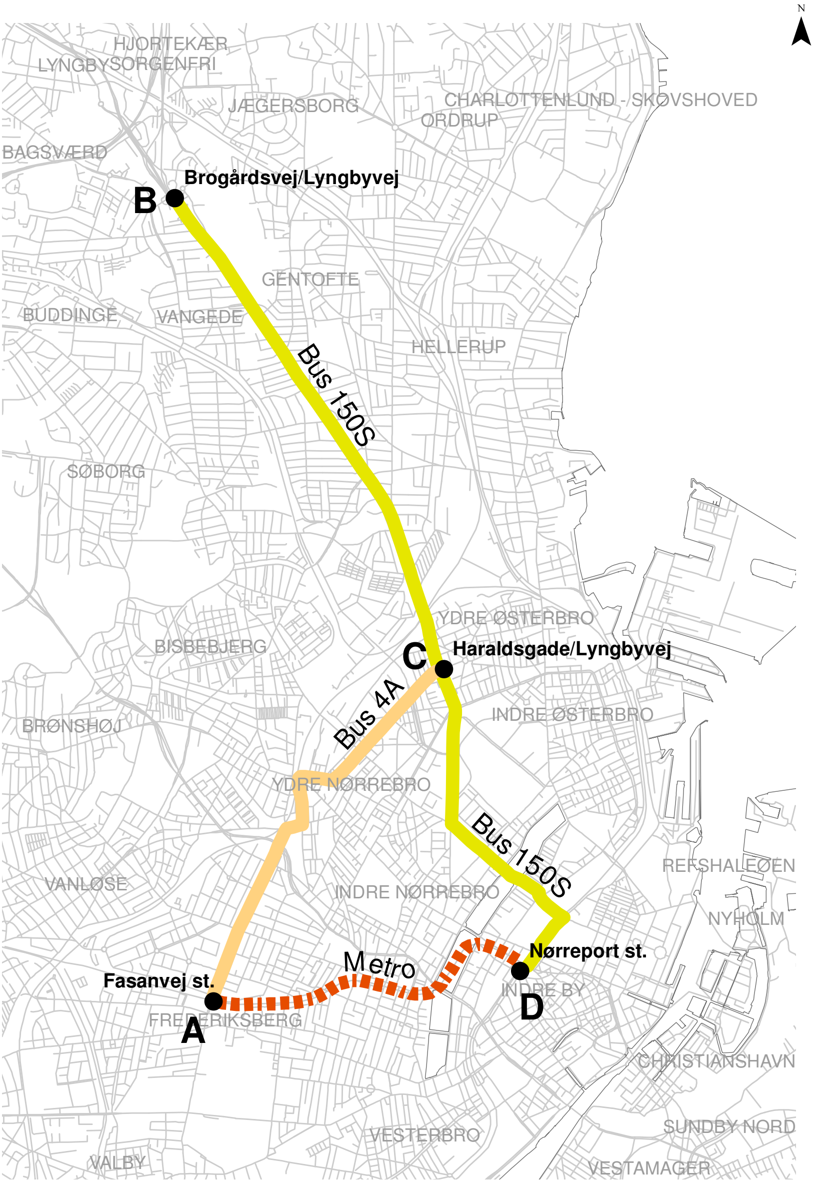
Figure 3 – Travel opportunities between A and B (Andersen 2005)

The number of travellers from A to B via D depends on the time they save[2], but although it may take just as long or maybe even a little longer to travel via D, there is still people who will chose that as it is more comfortable to go by train than by bus. If the socio-economic benefit of time saved on travelling is calculated based on a general value for in-vehicle, the route via the new rail line (via D) is considered a disadvantage since it takes longer time than before. There is, however, passengers that choose to travel via D because they obtain a higher utility with the new railway line and therefore it should be considered as a benefit. However, this will only occur if the actual values of inconvenience and time are taken into consideration for each mean of transportation.

[2] Using a All-or-Nothing assignment model all passengers with a specific trip purpose would choose either the route A-C-B or A-D-B

5.3.1 Case example from Copenhagen

A practical example of obtaining negative time benefits can be viewed in figure 4 below:



A → D → B

First wait at Fasanvej st. (A):
1 min

Fasanvej st. (A)
via Metro to Nørreport st. (D):
9 min (including 4 min transfer time at Nørreport st.)

Nørreport st. (D) via bus 150S to Brogårdsvej (B):
18 min*

Total time: 28 min

A → C → B

First wait at Fasanvej st. (A):
3 min

Fasanvej st. (A) via bus 4A to Haraldsgade/Lyngbyvej (C):
16 min (including 2 min transfer time at Haraldsgade)*

Haraldsgade/Lyngbyvej (C) via bus 150S to Brogårdsvej (B):
8 min*

Total time: 27 min

* the travel time for busses can vary during the day (depending on the level of road congestion and the amount of passengers)

Figure 4 – Travel opportunities between A and B – Example from Copenhagen

The example in figure 4 is an example taken as an extract from the public transport network in Copenhagen, where the Metro stretch from Fasanvej st.[3] to Nørreport st. opened in 2003. Although it can be slightly faster to travel from Fasanvej st. to Brogårdsvej (and IKEA) using bus 4A with a transfer at Haraldgade/Lyngbyvej to bus 150S, some people will chose to take the Metro instead and then transfer to bus 150S at Nørreport st. This is because the Metro is regarded as a more attractive mean of transportation. Travellers choosing the Metro in the

[3] At the time of the opening of the Metro the station name was Solbjerg station. However, this has been changed to Fasanvej st. in 2007

specific travel relation in the example will obtain a higher travel time than before the metro line was in operation. However, they only choose this route because they thereby experience a higher utility and this should somehow be reflected in the socio-economic time calculation.

Note that there are other travel opportunities between Fasanvej st. and Brogårdsvej, but they are left out of the example for simplicity.

To illustrate how the above-mentioned example will turn out in a route choice assignment, the following calculation is done. In the traffic modelling the route choices are determined by a utility function that roughly corresponds to the following expression[4]:

Formula 1

$$GC = P_{InVehicle} \bullet InVehicleTime + P_{Waiting} \bullet WaitingTime + P_{Transfer} \bullet TransferTime$$

Where:

GC is the generalized cost

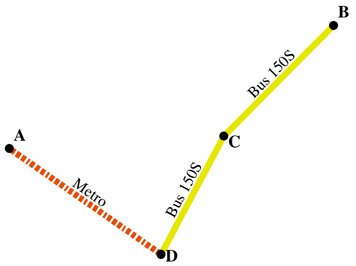
P is parameter weight or value of time

Taking the P-values directly from the assignment parameters where:

$P_{Metro} = 0.45$, $P_{Bus} = 0.583$, $P_{Waiting} = P_{Transfer} = 0.633$

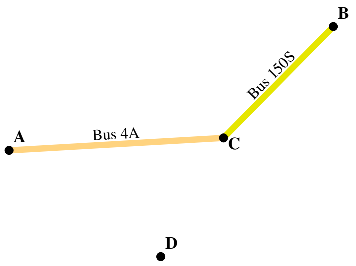
will produce following results when used on the above-mentioned example from Copenhagen:

A→D→ B



$$GC = P_{Metro} \bullet 5\ min + P_{Bus} \bullet 18\ min + P_{Waiting} \bullet 1\ min + P_{Transfer} \bullet 4\ min = \mathbf{15.91}$$

A→C→ B



$$GC = P_{Bus} \bullet 22\ min + P_{Waiting} \bullet 3\ min + P_{Transfer} \bullet 2\ min = \mathbf{15.99}$$

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[4] The utility function is here a bit simplified. Factors such as change penalty and access/egress are normally implemented. However, for the illustration of the example they are not relevant; the change penalty is always the same and both set of route choices have one transfer. Furthermore, the access is considered to be the same for the start stop whether Metro or bus. Also stochastic variables are not implemented and the expression represents an "All-or-Nothing" situation.

Although the route A→D→B has a higher total travel time it still has a lower generalized cost, meaning higher utility and is therefore the route that will be chosen in an All-or-Nothing assignment.

If the socio-economic values of time recommend by the Ministry of Transport are used on the same example, a person taking the A→C→B route before the Metro line opened and then changing to A→D→B route after the Metro opened because of the higher utility will get a time benefit at:

Socio-economic cost for travel before the Metro – Socio-economic cost for travel after the Metro:

(60 DKK/hour • (22 min/60) + 120 DKK/hour • (5 min/60))
– (60 DKK/hour • (23 min/60) + 120 DKK/hour • (5 min/60)) = **-1 DKK**

When using the socio-economic values of time recommended by the Ministry of Transport the person travelling from A to B will obtain a disbenefit of 1 DKK even if the route is chosen because of higher utility. This illustrates a mismatch between the results from the route choice assignment and the result from the socio-economic analysis that leads to time disbenefits in spite of improvements. In fact, building the metro can result in a socio-economic loss of time benefits although the service of the busses remains the same.

5.3.2 The differentiated set of values

On the base of the above-mentioned issue that improving the transport system can lead to a time disbenefit, a set of time values has been estimated that has differentiated values for in-vehicle travel time.

The set is a slightly modified version of the values of time used in (IMV 2006) and has its origin from (Andersen 2005). The appearance of the in-vehicle values is based on the route choice parameters used for the traffic modelling. These parameters have their origin from the KRM-research[5] (Nielsen 2000). The parameters have been scaled to the level of the socio-economic values recommended by the Ministry of Transport using scale factors derived from the share of the time used in each mean of transportation[6]. This ensures that the level of the differentiated in-vehicle values corresponds to the level of the in-vehicle value recommended by the Ministry of Transport; this can be seen to fit quite satisfying when comparing the time cost of the base situation calculated with both the differentiated values of in-vehicle time and the values of time recommended by the Ministry of Transport (cf. 7.2 Differentiated in-

[5] Copenhagen-Ringsted Model

[6] Travel time for each zone pair based on output from a route choice assignment multiplied with the number of travelers for each zone pair from the OD trip matrix

vehicle values of time). The access/egress values are also scaled to that level using the same factors as for the in-vehicle time. The hidden waiting, waiting and interchange time is taken directly from the values recommended by the Ministry of Transport.

The procedure for estimating the set of values is described more thoroughly in (Andersen 2005). The set of time values can be seen in table 3:

	Home-Work	Work-Work	Other
Bus	72	322	42
S-train/Metro	56	257	32
Train	56	219	32
Light rail	61	278	35
Waiting/interchange	120	532	70
Hidden waiting	30	133	18
Access/egress	93	305	70

Table 3 – The differentiated set of socio-economic values of time with differentiated values for in-vehicle travel (Danish kroner per hour in 2004-prices)

If the estimated set of values is used on the same example as in section 5.3.1 Case example from Copenhagen, a person taking the A→C→B route before the Metro line opened and then changing to A→D→B route after the Metro opened because of the higher utility will get a time benefit at:

Socio-economic cost for travel before the Metro – Socio-economic cost for travel after the Metro:

(72 DKK/hour • (22 min/60) + 120 DKK/hour • (5 min/60))
– (56 DKK/hour • (5 min/60) + 72 DKK/hour • (18 min/60) + 120 DKK/hour • (5 min/60))
= **0.13 DKK**

The person travelling will (with this set of time values) obtain a time benefit as result of the improvement in the public transport system which is in accordance to the result of the route choice assignment.

5.3.3 General raise in time benefits when using differentiated in-vehicle time values

Because some means of transportation are more attractive than others, it is generally expected that the set of values with differentiated values for in-vehicle time will provide a better result (higher time benefit) for the light rail projects than the result provided when using the values of time recommended by the Ministry of Transport. This is because it is more attractive to travel with light rail than bus and this is also reflected in the differentiated in-vehicle values where light rail travel has a lower value of time than bus travel. Normally, light rail has lower travel time than busses and because of that, time benefits will be obtained in the system when a new light rail is introduced instead of a bus. However, when calculating the socio-economic time benefits with the values of time recommended by the Ministry of Transport, the time benefit will be lower than when using the differentiated in-vehicle values of time as illustrated in the example below:

A journey from A to B is in the present situation travelled by bus in 10 minutes. In the light rail situation the same journey is now travelled by light rail in 8 minutes (see figure 5). Using the values recommended by the Ministry of Transport the time benefit will be:

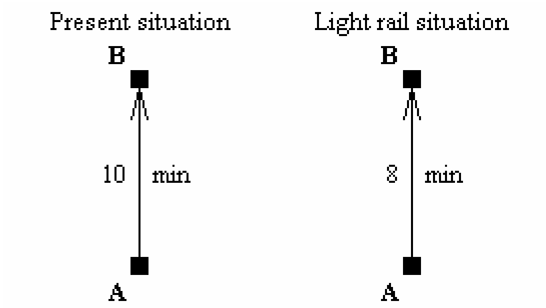

Figure 5 – Travel from A to B

Socio-economic cost for travel in the present situation – Socio-economic cost for travel in the light rail situation:

(60 DKK/hour • (10 min/60)) – (60 DKK/hour • (8 min/60)) = **2.0 DKK**

Using the differentiated in-vehicle values the time benefit will be:

(72 DKK/hour • (10 min/60)) – (61 DKK/hour • (8 min/60)) = **3.9 DKK**

In this case, using the differentiated in-vehicle time values will raise the time benefit by 1.9 DKK per passenger. The example shows that higher time benefits generally can be expected when using the differentiated in-vehicle time values in the socio-economic time calculation of new high quality public transport.

Note that all the above-mentioned issues of raising time benefits applied to the differentiated in-vehicle values of time are only relevant when upgrading the public transport system to a higher class than the existing system. This could for instance be a light rail line replacing a bus line whereas for instance a bus optimisation will not display any differences in time benefits.

6. Time calculation

The actual time calculation is performed using the output from the assignments of the two light rail projects and the base situation. The procedure is performed using Rule-of-the-Half as seen on figure 6 and thoroughly described in (Landex, Salling & Andersen 2006). The concept is that Rule-of-the-Half also includes the effect from the new travellers (the induced traffic) by a fairly simple calculation approach where the demand curve is presumed to be linear.

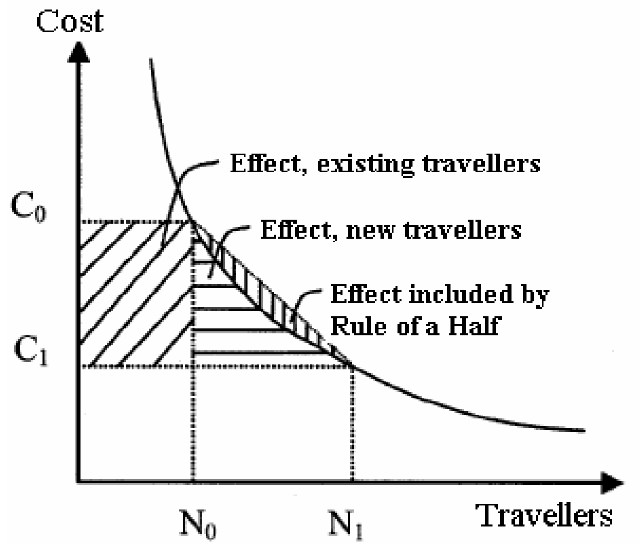

Figure 6 – Calculation of time benefit (Landex, Salling, & Andersen 2006)

Looking at the figure 6 C_0 is the existing travel cost, C_1 is the new travel cost, N_0 is the existing number of travellers and N_1 is the new number of travellers (induced traffic). The time benefit for existing travellers (without induced traffic) can be found as:

Formula 2 *The time benefit for existing travellers = (C0 – C1) • N0*

The time benefit for new travellers can be found as:

Formula 3 *The time benefit for new travellers = ½ • (C0 – C1) • (N1 – N0)*

The total time benefits of the public transport system can then be found as:

Formula 4 *Total time benefit = (C0 - C1) • N0 + ½ • (C0 – C1) • (N1 – N0)*

= ½ • (C0 • N0 – C1 • N0 + C0 • N1 – C1 • N1)

The calculation of the time benefit uses the OD trip matrixes (the original from OTM version 4.0 and the updated) and the cost matrix from the base scenario together with the cost matrixes from the scenarios with and without induced traffic. The calculation of time benefits is performed separately for each zone pair and for each trip purpose and then summarized in the end.

7. Results

The results are presented as the time benefits in the morning rush hour (7.00-9.00) for the situation with both the Ring 2½ and the Ring 3 light rail projects. When calculating the time benefits using the values recommended by the Ministry of Transport, the result for Ring 2½ is

21,900 DKK for all travel purposes per morning rush hour while Ring 3 has 19,400 DKK as time benefit for the public transport system. These results constitute the basis of comparison in the further study[7].

7.1. Similar time values for non-business travel – the expected new values

The figure 7 below presents the time benefits from using the socio-economic values of time recommended by the Ministry of Transport and the expected new values with the same travel time for non-business travel.

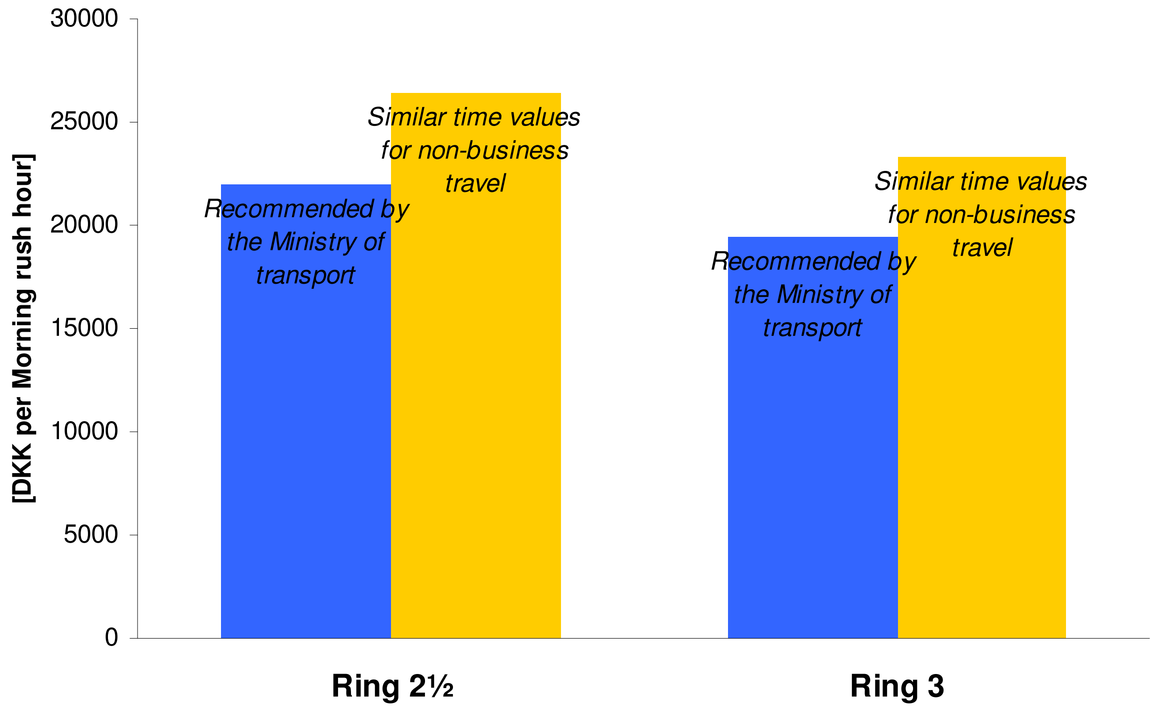

Figure 7 – Time benefits for Ring 2½ and Ring 3 calculated with the recommended values of time and the expected new values of time

The figure 7 illustrates that the expected new values of time will result in higher time benefits than the present recommended by the Ministry of Transport. The increase in time benefits can be seen in table 4 below.

	Home-Work	Work-Work	Other	Total
Ring 2½	12%	19%	87%	20%
Ring 3	12%	18%	89%	20%

Table 4 – Increase in time benefits when using the expected new values of time

[7] Note: The time benefits are not comparable with previous studies as no larger bus adjustment has been conducted

Since the level of the values generally has been raised, the increase in time benefits was expected. The general increase in the level can be investigated by calculating the total time cost in the system in the base situation using both set of time values. When using the expected new values of time the increase in time cost in the base situation is 18%. Furthermore, it can be concluded that the raise of the values for the leisure travel ("Other") to the level of the Commuter travel (similar time values for non-business travel) result in a significant increase in the time benefits for leisure travel. All in all indications that the new socio-economic values of time will result in higher time benefits for public transport projects and thereby better socio-economic viability for the projects.

7.2. Differentiated in-vehicle values of time

The figure 8 below presents the time benefits from using the socio-economic values of time recommended by the Ministry of Transport and the time benefits using the set with differentiated values for in-vehicle time.

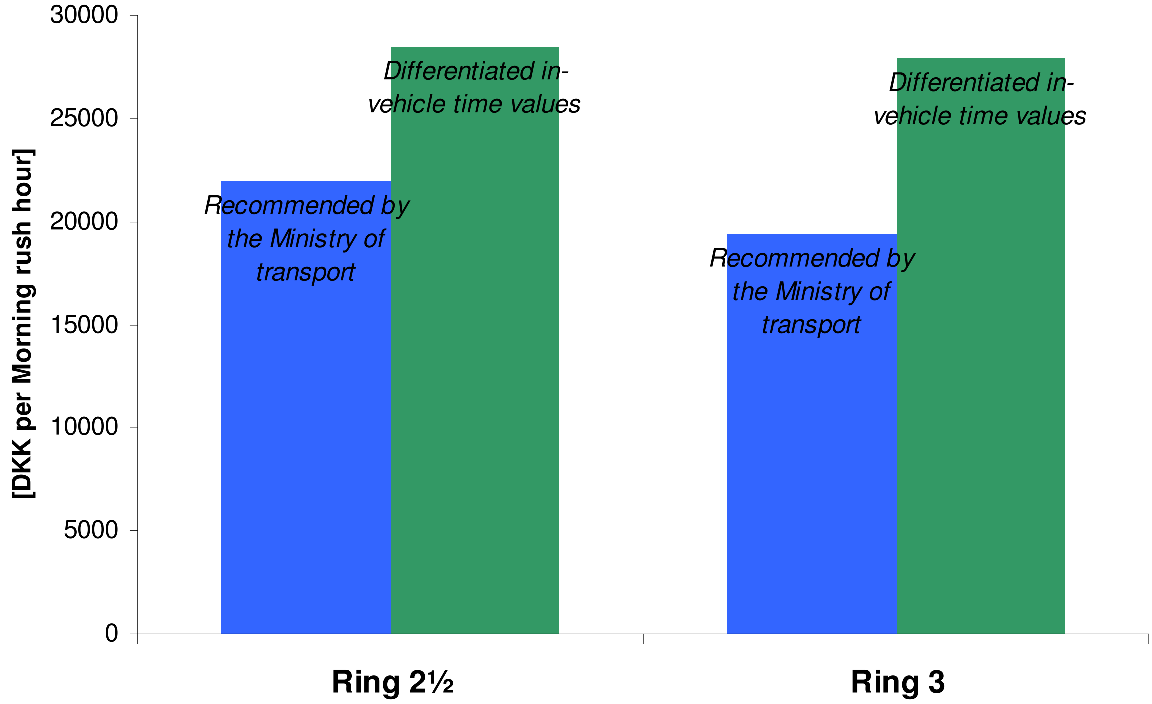

Figure 8 – Time benefits for Ring 2½ and Ring 3 calculated with the recommended values of time and the estimated values of time with differentiated in-vehicle values

The figure 8 illustrates that the estimated values of time with differentiated values for in-vehicle time will result in significantly higher time benefits than the present recommended by the Ministry of Transport. The increase in time benefits can be seen in table 5.

	Home-Work	Work-Work	Other	Total
Ring 2½	31%	31%	17%	30%
Ring 3	46%	37%	34%	44%

Table 5 – Increase in time benefits when using differentiated in-vehicle values of time

Unlike the situation with the expected new values (cf. section 7.1 Similar time values for non-business travel – the expected new values) the increase in time benefits when using differentiated in-vehicle time values can not result from an increase in the general level of the values since they are scaled to the level of the values recommended by the Ministry of Transport. This is supported by the total cost in the system in the base situation calculated with both set of time values. When using the differentiated in-vehicle values of time the increase in time cost in the base situation is less than 1%. This means that the increase in time benefits is solely a result of the differentiation of the in-vehicle time values and supports the problem definition regarding use of differentiated or non-differentiated in-vehicle values (cf. section 5.3 Differentiated in-vehicle values of time).

Also it seems that the in-vehicle time fragmentation have different impact on different projects depending on how travel is changing in the system. This is illustrated by the fact that the relative increase in time benefit for Ring 3 is larger than for Ring 2½ as opposed to the expected new values where the relative increase was the same for both projects (cf. section 7.1 Similar time values for non-business travel – the expected new values).

8. Conclusions

This study has shown that changing the values of time used to calculate socio-economic time benefits for public transport projects also means significant changes in the results. The results can be evaluated directly since they are adjusted for inflation by calculating all values in the same year (2004).

The expected new set of values to be recommended has higher values and will therefore raise the level of the time benefits for public transport projects. Also the raised value of the leisure travel to the level of the commuter travel will lead to higher time benefits. When using the expected new values of time an increase in time benefit at around 20% for new infrastructural public transport projects can be expected compared to using the present values of time recommended by the Ministry of Transport. In perspective this conclusion will favour the chances of obtaining socio-economic viability for public transport projects.

To differentiate values of in-vehicle time also show significant results that prove the theoretically notion of improved time benefits. The differentiated in-vehicle time values corresponds to route choices made in the traffic modelling and might thereby also be considered to reflect the preferences of actual travellers. I.e. that when using the differentiated in-vehicle values of time, the paradox that time disbenefits and thereby accompanying lower socio-economic viability occurs in spite of infrastructural improvements will be avoided. Overall the differentiated in-vehicle time values ensure consistency between traffic model and subsequent socio-economic analysis. Furthermore, the increase in time benefits when using differentiated in-vehicle values of time is more significant than the increase when using the expected new values of time. Also the increase is very different for the two light rail projects, where Ring 3 obtains a larger relative increase than Ring 2½. When using the differentiated in-vehicle values the increase in the time benefit can vary, but still seems to be of a significant size. A characteristic that will assist the chances of socio-economic viability for new infrastructural public transport projects.

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