Transport Infrastructure Planning: Assessment of Strategic Mobility by Use of the POINTER Impact Model.

Associated Professor Jacob Kronbak

&

Research Professor Steen Leleur

Centre for Traffic and Transport (CTT), Technical University of Denmark

Abstract

When evaluating large infrastructure projects one point to be made is the importance of supplementing the more traditional effects captured by a cost-benefit analysis as presented for example by use of the benefit cost ratio (BCR) with strategic effect modelling to obtain a more comprehensive view of the societal importance of the examined project. The focus of this paper is to present the first results of a comparison of the use of a strategic impact measurement (the POINTER index) for road traffic on the Great Belt Link, the Øresund Link and the proposed Fehmarn Belt link. Specifically a number of calculation scenarios have been made to assess the possibility of the POINTER approach to indicate the changes in strategic mobility (accessibility) associated with the implementing of one or more of the three fixed links. Finally, conclusions and a research perspective are outlined.

Introduction

The POINTER (POtenial INTERaction) model has previously been used for strategic impact assessment of the Great Belt Fixed link (Kronbak, 1998) and the Øresundsbron (Kronbak, & Rehfeld, 1999, Kronbak, 1999). The geographical areas included in those investigations were for the Great Belt link limited to Denmark and for the Øresund link to Denmark and the southern part of Sweden. In this paper the geographical area of interest has been extended to most countries in the northern part of Europe with the purpose in mind not to leave outside the analysis areas that may gain in accessibility due to the new fixed links. The paper is disposed as follows: First a short introduction is given to the POINTER index. Thereafter the calculation scenarios are defined (referred to as the “1,2,3-fixed link scenarios”). Then follows a section with selected results of the POINTER calculations. In a final section conclusions and a research perspective are given.

The POINTER index

The POINTER index gives an indication of the potential for interaction based on the spatial distribution of the population and the impedance (in this case travel time) in the transport network.

The POINTER(T_A,T_I) indicator in the location (i) is defined as the product of total existing population (P_j) attached to the location (j) and the available time for interaction in that location. The locations (j=1,…,N) that are reachable are determined using a required time of interaction (T_I) which is part of the total available time-limit (T_A). (T_A) can be set at any length of time in order to evaluate feasible trips with (T_I) being the minimum contact time required to perform the interaction. In the equation below (t_{ij}) denominates the minimum time it takes to reach the node (j) from (i) using the shortest path.

$$\text{POINTER}_i(T_A, T_I) = \sum_{j=1}^{N} P_j(T_A - 2 \cdot t_{ij}); \text{ for } t_{ij} \leq \frac{T_A - T_I}{2}$$

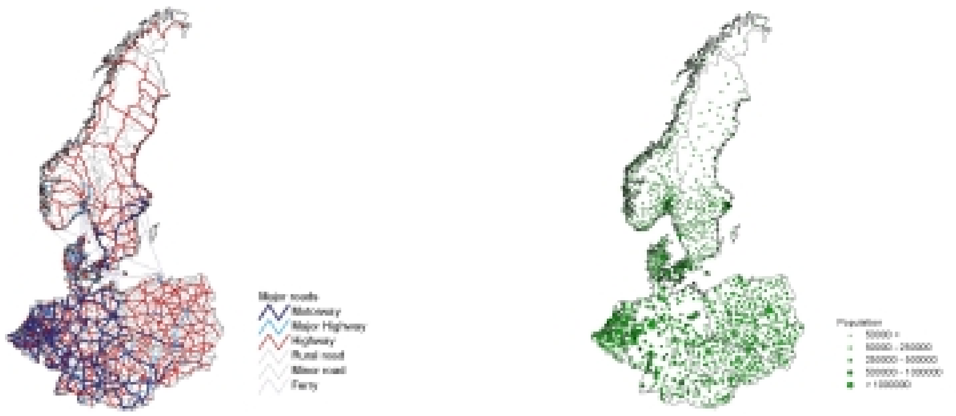
For $T_A = T_I + 2 \cdot t_{ij}$ the possible interaction time is equal to (T_I). A reduction in travel time will correspond to in an increase in time for interaction.

The unit of the POINTER(T_A,T_I) indicator will be man-hours with the measurement of the potential contact hours per day attached to the location represented by node (i). Suitable values for (T_A) and (T_I) should be defined corresponding to the type of travel under investigation.

The 1,2,3-fixed link scenarios

The focus of previous investigations of the potential interaction for the Great Belt Link and the Øresund fixed link has mainly been the national perspective. In the 1,2,3-fixed link scenarios the scope has been widened to include influence from most of the countries in the northern part of Europe. This means that the network used for calculating the POINTER index includes the roads and population in: Denmark, Norway, Sweden, Germany, The Netherlands, Belgium, Austria, Czech republic, Slovakia and Poland. The total network consists of approximately 23300 links, 17200 nodes and the population are attached to 2272 points in the network. Both the network and the spatial distribution of the population can be seen in Figure 1.

Figure 1. The network and the spatial distribution of the population.



The calculation scenarios consist of four base scenarios (each representing a stage in a possible end situation with 3 fixed links having been implemented) and 6 difference scenarios indicating various changes in strategic mobility (accessibility). An overview of the calculation scenarios is given in table 1.

Table 1. The 4 base- and 6 difference scenarios.

Base scenarios	Difference scenarios		
0-fixed links (only ferries)			
1-fixed link (Great Belt)	**0-1 Fixed link**		
2-fixed links (Great Belt and Øresund)	**0-2 Fixed links**	**1-2 Fixed links**	
3-fixed links (Great Belt, Øresund and Fehmarn)	**0-3 Fixed links**	**1-3 Fixed links**	**2-3 Fixed links**

As stated above suitable values for (T_A) and (T_I) in the POINTER index have to be chosen corresponding to the type of travel under investigation. In order to evaluate the effect that the links have on a European basis, T_A=14 and T_I=4 have been chosen for exemplification in this paper. This corresponds to a travel-type with a total time limit of 14 hours (an extended workday) and a demand for minimum 4 hours of interaction (e.g. a meeting). The maximum travel time will then be $(T_A-T_I)/2 = 5$ hours. A POINTER calculation has been made for the network in each of the 4 base scenarios and from these 4 calculations the 6 difference scenarios have been calculated.

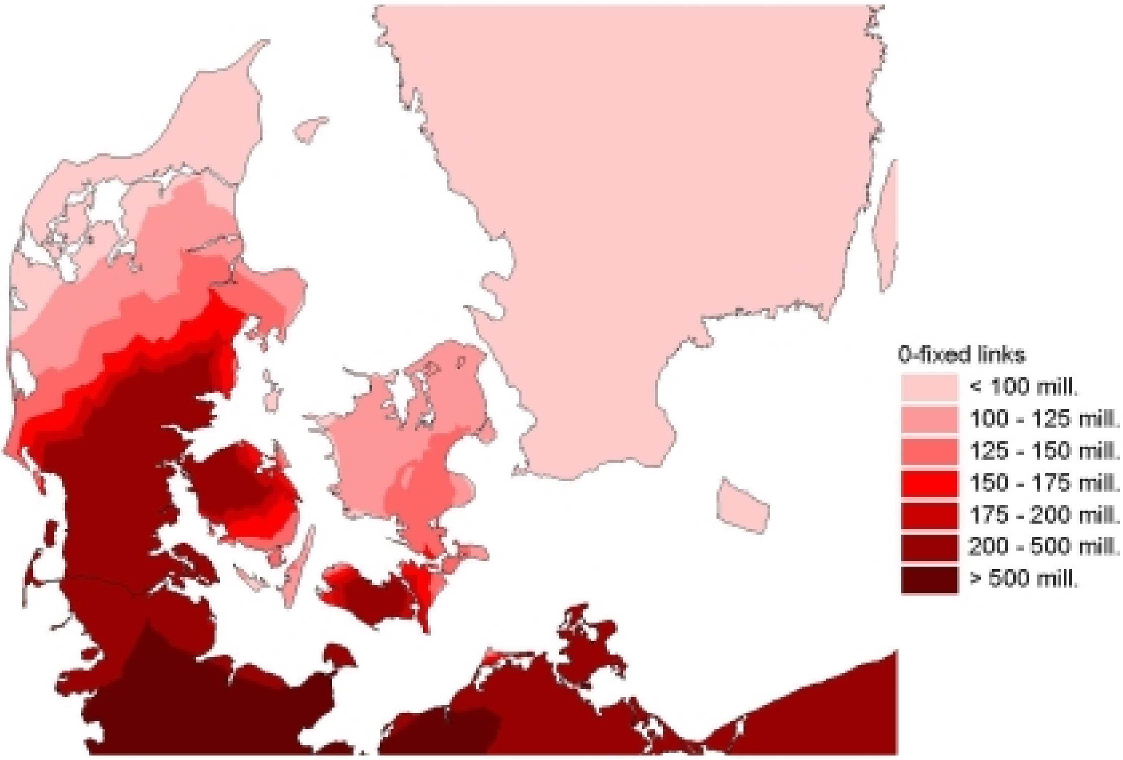
For this paper the geographical information system ArcInfo has been used to calculate and illustrate the change in the POINTER index.

Results

The model runs presented in this paper still have their focus on the investment in fixed links from a Danish point of view, but with a maximum travel time of 5 hours (T_A=14 and T_I=4) the result-maps are influenced by the transport network and the population in most of the northern part of Europe. A maximum travel time of 1-2 hours (e.g. T_A=4 and T_I=2) would have given a more local/regional perspective but is not within the scope of this paper.

Figure 2 shows the POINTER index for the 0-fixed link scenario (before the completion of the Great Belt fixed link).

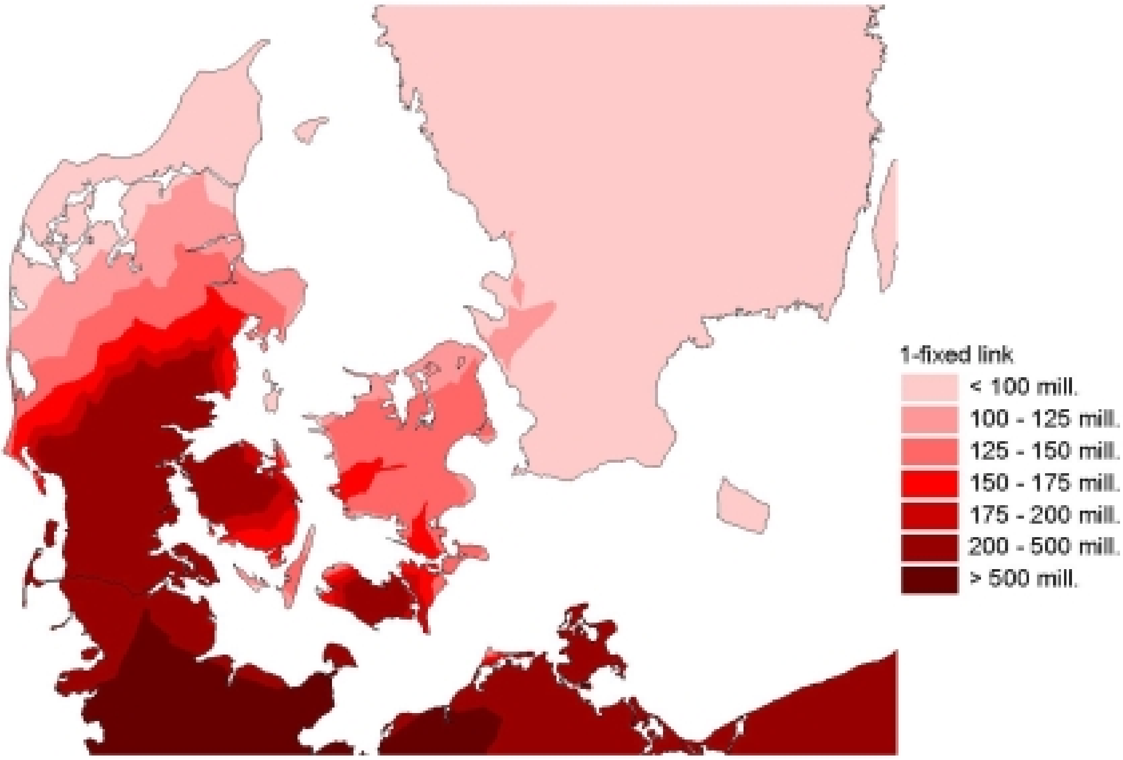
Figure 2. The POINTER index (potential contact hours) for the 0-fixed link scenario. Please note the non-linear legend that enhances the spatial distribution of the index in the Danish area.



It can be seen on Figure 2 how the proximity (with in 5 hours travel time) to the more densely populated northern part of Germany increases the index in the central and southern part of Jutland, the western part of Funen and on Lolland. An example of the effect of the major motorways can be seen on Zealand where the index is “stretched” along E47.

Figure 3 shows the POINTER index for the 1-fixed link scenario (after the completion of the Great Belt fixed link).

Figure 3. The POINTER index (potential contact hours) for the 1-fixed link scenario. Please note the non-linear legend that enhances the spatial distribution of the index in the Danish area.



The completion of the Great Belt link causes the POINTER index to increase on most parts of Zealand and the effect of the motorways can again be seen along E47 and E20.

Figure 2 and Figure 3 can be “subtracted” in order to show the spatial distribution of the relative change in POINTER index. The result of such a subtraction can be seen on Figure 4.

Figure 4. The relative increase in POINTER index due to the construction of the Great Belt fixed link.

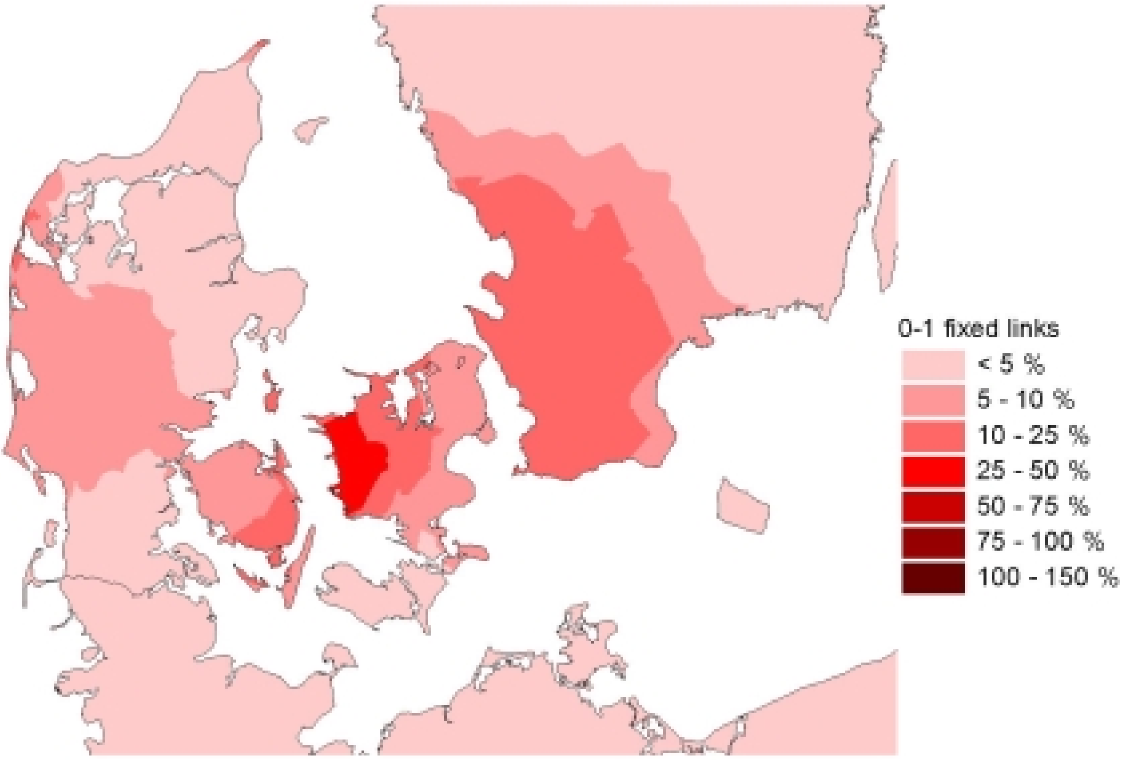
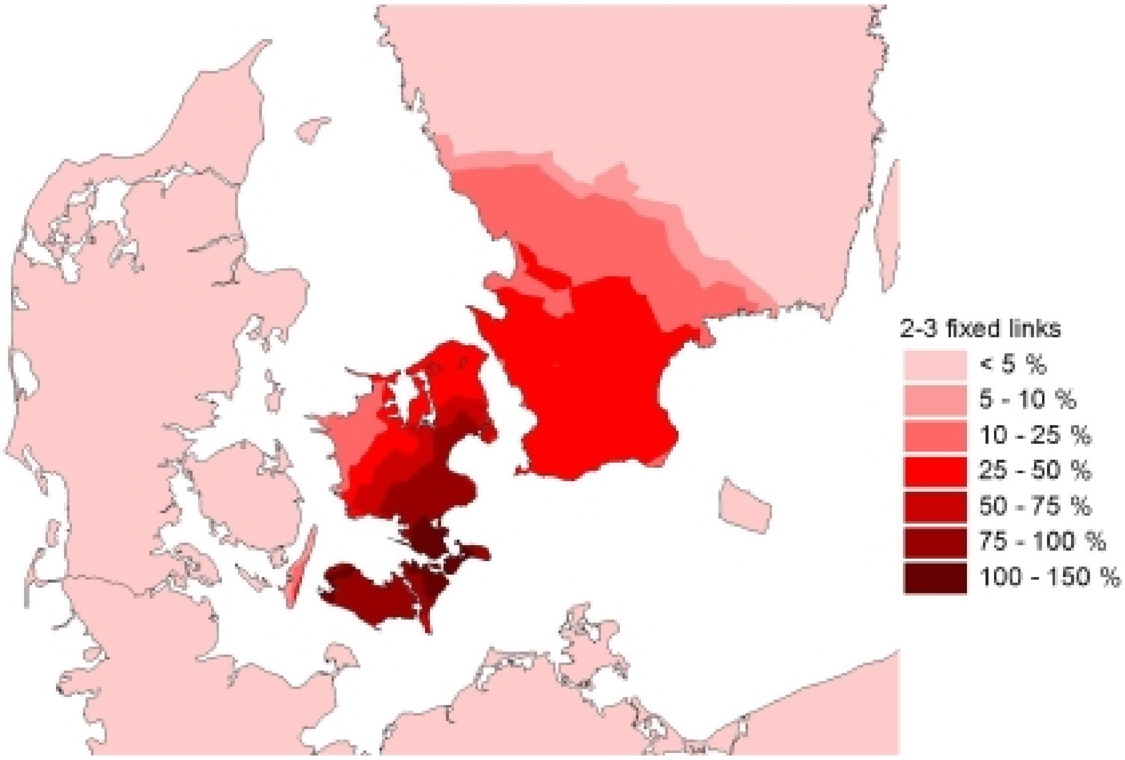


Figure 4 shows, that the completion of the Great Belt fixed link causes the POINTER index to increase on Funen, Zealand and the central part of Jutland. Compared to the situation before the completion of the fixed link the western part of Zealand achieves the highest relative increase in potential interaction. Less obvious is properly that the southern part of Sweden also benefit substantially from the Great Belt fixed link. This is due to the effect that the travel time saving by taking the Great Belt fixed link makes it possible to spend more time interacting with population on Funen, in Jutland and the northern part of Germany.

In this way all the Table 1 calculations have been carried out. It is not possible to present and discuss all the results within this paper but it should be noted that all the calculation results will be available at the site: http://www.ctt.dtu.dk/group/bmg/ beneath the "downloads". In the following we concentrate on relative changes in the POINTER index associated with the possible implementation of the Fehmarn Belt link.

Figure 5 shows the relative increase in POINTER index due to a completion of a fixed Fehmarn Belt link.

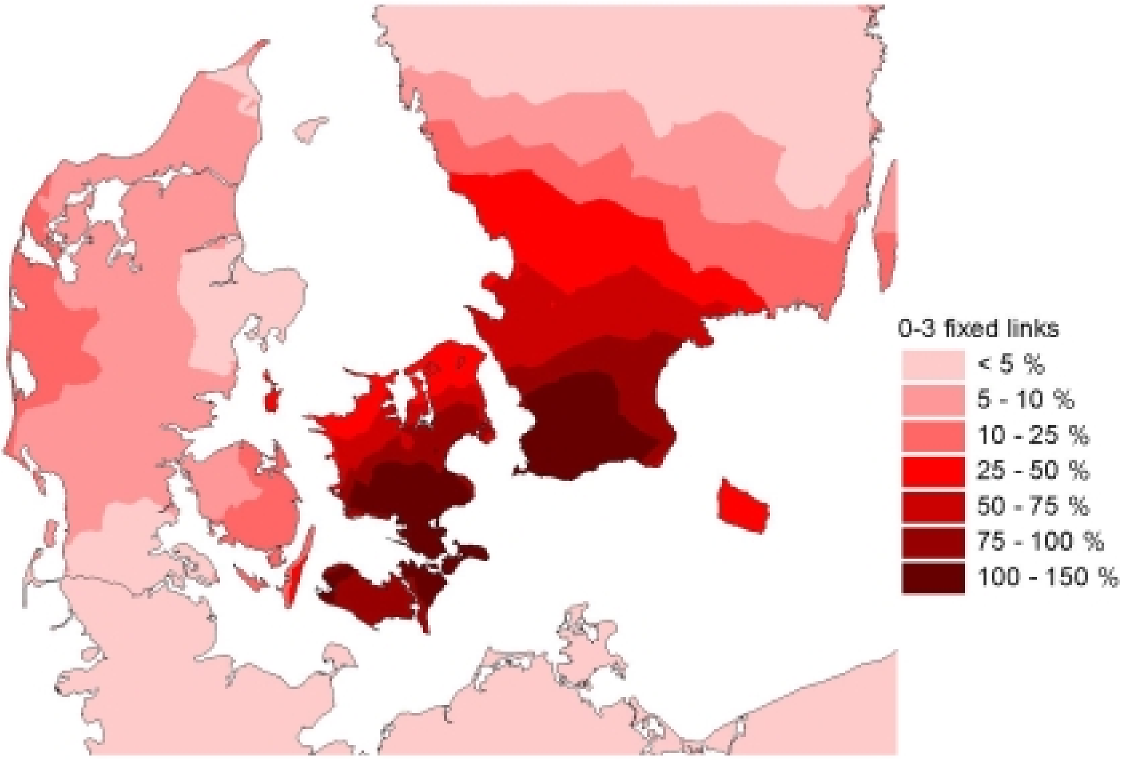
Figure 5. The relative increase in POINTER index when comparing the 2-fixed links scenario with the 3-fixed links scenario (a completion of a fixed link across Fehmarn Belt).



As it can be seen on Figure 5 most of Zealand would expect a substantial impact in potential interaction from a fixed link across Fehmarn Belt. The relative change will be highest in the Lolland–Falster area but the Copenhagen area will also experience an increase in the POINTER index. In the southern part of Sweden the POINTER index will increase from 25-50% whereas Funen and Jutland will see none or a less than 5% increase. The low increases on Funen and in Jutland are caused by the existing good infrastructure connection to Germany and thereby to the rest of Europe.

Figure 6 shows the relative increase in POINTER index due to the combined effect of building the Great Belt, Øresund and Fehmarn Belt fixed links.

Figure 6. The relative increase in POINTER index when comparing the 0-fixed links scenario with the 3-fixed links scenario.



Generally speaking Jutland and Funen benefits the least from the construction of the three fixed links with most of the benefits coming from the construction of the Great Belt fixed link. This is, however, not an indication of a low potential for interaction in those areas - it is more a result of the already existing proximity to the more densely populated northern part of Germany. Zealand and Lolland-Falster benefit quite substantially from a construction of the three fixed links but also the southern part of Sweden gains with regard to potential for interaction.

Conclusions and perspectives

The calculations presented in this paper show POINTER calculations based on a new updated and extended network for Northern Europe. The POINTER parameters have been set to (T_A=14 and T_I=4) to model a so-called extended workday. Calculations have been carried out that depict both absolute gains in no. of potential contact hours and the relative changes due to the implementation of fixed links. For the different calculations results have been discussed as concerns the regions and areas that seem to benefit most with regard to a specific network improvement.

Interpreting the model results it should be borne in mind that the model with regard to strategic mobility (accessibility changes) is very much tied to the particular parameters chosen. To depict accessibility changes more generally several trip types should be examined.

However, with these limitations, it is found that the geographical distribution of the accessibility benefits obtained by using the model can provide the decision-makers with interesting information about the consequences of major infrastructure improvements such as those obtained by implementing fixed links across belts and straits.

Strategic mobility is but one of the strategic impacts; two other of importance are strategic environment and strategic development. An ongoing discussion as concerns the appraisal of large infrastructure transport projects is whether the cost-benefit analysis (CBA) captures all the benefits of relevance or if so-called "wider economic effects" should be included as being additional to the CBA. In upcoming research work it will be examined whether the POINTER model (as part of the wider economic benefits) can be included in a practical appraisal methodology that will be able to in a more comprehensive way to support decisions about large transport infrastructure projects (Leleur, 2000).

All figures can be seen on http://www.ctt.dtu.dk/group/bmg

References:

Kronbak 1998: Traffic planning and GIS-based impact analysis (in Danish), Ph.D. Thesis, Department of Planning, Technical University of Denmark.

Kronbak 1999: The impact on mobility of the fixed Øresund link (in Danish), Trafikdagene, Aalborg Universitet 1999.

Kronbak & Rehfeld 1999: Mobility and accessibility aspects of the fixed link between Denmark and Sweden, PTRC European Transport Conference, 27 - 29 September 1999.

Leleur, S. 2000: Road Infrastructure Planning – A Decision-Oriented Approach. Second edition. Polyteknisk Forlag.