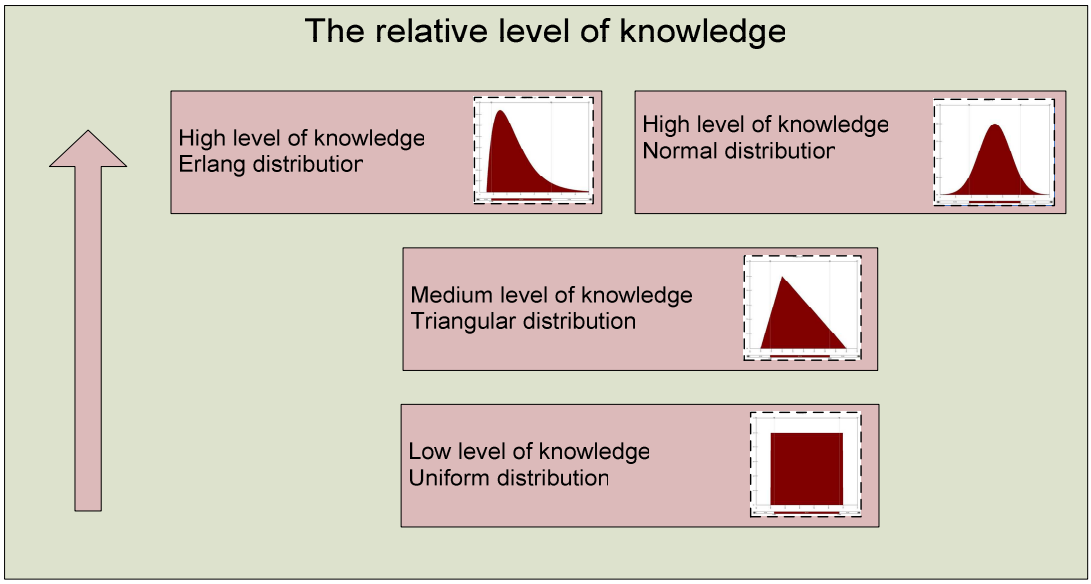
EAST WEST TRANSPORT CORRIDOR

REPORT

Cost Benefit analysis of the Infrastructure projects at the port of Esbjerg

East-West - Danish Report



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1 Summary

This present report is the documentation of the Danish part of the East West Transport Corridor project WP3.

The report concerns the development of a new decision model, COSIMA-ES-PORT, for the assessment of 3 pre-feasibility studies; a road project, a railway project and an intermodal terminal situated at Port of Esbjerg.
The COSIMA-ES-PORT model is developed on the basis of the COSIMA-ROAD model, which was originally developed for assessment of road infrastructure projects. The COSIMA-ROAD model is changed in order to make it possible to handle road, rail and cargo-handling projects in the same model.

The pre-feasibility study of the road connection to Port of Esbjerg using COSIMA-ES-PORT shows that the project is very profitable due to large travel time savings, and it is recommended to start the construction as soon as possible.
This is not the case for the railway connection to the Port, as the pre-feasibility study shows that it is not economically profitable. Port of Esbjerg estimates that the railway will only obtain a small increase in cargo transportation, which is not sufficient compared with the construction costs.
The pre-feasibility study of the new intermodal terminal using COSIMA-ES-PORT shows that the project is very profitable. It is estimated by Port of Esbjerg that the transportation of cargo will be doubled in size with the new terminal, and the impact of this creates a large positive benefit.

The COSIMA-ES-PORT model shows some promising perspectives in the handling of the 3 pre-feasibility studies. It is seen that parameters such as cargo handling and ship related issues can be successfully implemented in a decision model and forecasted in the same way as road infrastructure impacts. The development of COSIMA-ES-PORT further shows, that it is possible to implement other means of transportation into a decision model of this kind.

2 Introduction

This report documents the Danish part of the East West Transport Corridor project WP3. Chapter 1 gives a summary of the report, while chapter 2 describes the purpose and tasks for the project work. Chapter 3 describes the decision model COSIMA-ROAD developed for assessment of road infrastructure projects. In Chapter 4 the present case is described, and in chapter 5 the COSIMA-ROAD model is being adapted to the case. The adapted model, COSIMA-ES-PORT, is hereafter used in the assessment of the case in chapter 6, 7 and 8.

2.1 Main objectives and outcome

The Danish parts of WP3 are to perform a pre-feasibility study, including urban planning, environmental impact and capacity issues, for:

- Road and railway connections to the port of Esbjerg
- An intermodal terminal at port of Esbjerg

The main objective of the Danish part of WP3 is therefore to perform and report these Danish pre-feasibility studies. The secondary objective is to generate added value to the decision process associated with the pre-feasibility studies. This objective has been achieved by an innovative adaptation and application of cutting edge decision support systems to the pre-feasibility studies.
The municipality and port of Esbjerg has made a preliminary study of both the road and railway connections to the port of Esbjerg. This study will be used as the starting point for the East West Transport Corridor pre-feasibility studies. This means that the two East-West pre-feasibility studies will not only focus on the effects of the investments but also include innovative ways of handling the uncertainties associated with the effects.
The East West Transport Corridor activities will therefore fall within two main tasks:

- Adaptation of the state of the art decision support system COSIMA-ROAD to port of Esbjerg (COSIMA-ES-PORT)
- Performing elaborated pre-feasibility studies of the investments using the COSIMA-ROAD and COSIMA-ES-PORT

For a closer description of COSIMA-ROAD see section 3.

2.2 Work plan and sub-tasks

The work plan has consisted of the following sub-tasks:

1. Background studies
2. Pre-feasibility study of the road and rail connections to port of Esbjerg using COSIMA
3. Adaptation of COSIMA-ROAD to Port of Esbjerg (COSIMA-ES-PORT)
4. Pre-feasibility study of the intermodal terminal using COSIMA-ES-PORT

The content of each of the sub-tasks are described in the following sections.

Background studies

All existing materials and background studies with relevance to the investments have been collected. Based on a review of the existing studies and knowledge the need for additional information has been evaluated. The port and municipality of Esbjerg have provided CTT with expert knowledge and access to existing information.

Pre-feasibility study of the road and rail connections to port of Esbjerg using COSIMA-ROAD

In order to test the methodology and gain knowledge and experience, the existing version of COSIMA-ROAD is modified to perform an extended pre-feasibility study of the road and rail connections to the port of Esbjerg. This study is performed in close cooperation with the both the municipality and the port of Esbjerg. The port and municipality of Esbjerg have provided the necessary expert input to the study.

Adaptation of COSIMA-ROAD to Port of Esbjerg (COSIMA-ES-PORT)

CTT has adapted the COSIMA-ROAD tool to handle the pre-feasibility study of the investment in the multimodal terminal at Port of Esbjerg. This adaptation has utilised the experiences gained from the road/rail pre-feasibility study and has been supplemented with an investigation of conditions of specific relevance for the Port of Esbjerg. The outcome is the COSIMA-ES-PORT version of the COSIMA-ROAD tool.

Pre-feasibility study of the intermodal terminal using COSIMA-ES-PORT

Finally the pre-feasibility study of the multimodal terminal has been performed by CTT in close cooperation with the port and municipality of Esbjerg using the COSIMA-ES-PORT tool.

3 COSIMA-ROAD

The following section is a description of the COSIMA-ROAD tool from (Salling & Leleur 2006):

3.1 Introduction

A few years ago the Danish Ministry of Transport released a manual for socio-economic analyses on transport issues (DMT 2003). Based on this work and the guidelines presented in this manual the Danish Road Directorate decided to develop a software program COSIMA-ROAD for use in evaluating Danish road investments. In co-operation with the Centre for Traffic and Transport (CTT) at the Technical University of Denmark (DTU) a proto-type model was finished in the spring of 2005. Current research and further development of this model is presented here with emphasis on risk analysis carried out by use of @RISK (Palisade 2002).

Due to limited resources Danish infrastructure proposals are prioritised by use of socio-economic analysis. By use of COSIMA-ROAD this examination is structured to provide decision-makers with support that enables them to make more informed decisions. The main purpose is not to give strict answers but to assist by facilitating the right choice.

COSIMA-ROAD is an Excel based software model for road and infrastructure evaluation consisting of a cost-benefit analysis (CBA) part and risk analysis (RA) part. The software model consists of 9 different worksheets contributing to the CBA component also referred to as the deterministic calculation and 2 worksheets contributing to the RA component referred to as the stochastic calculation, cf. Figure 3-1.

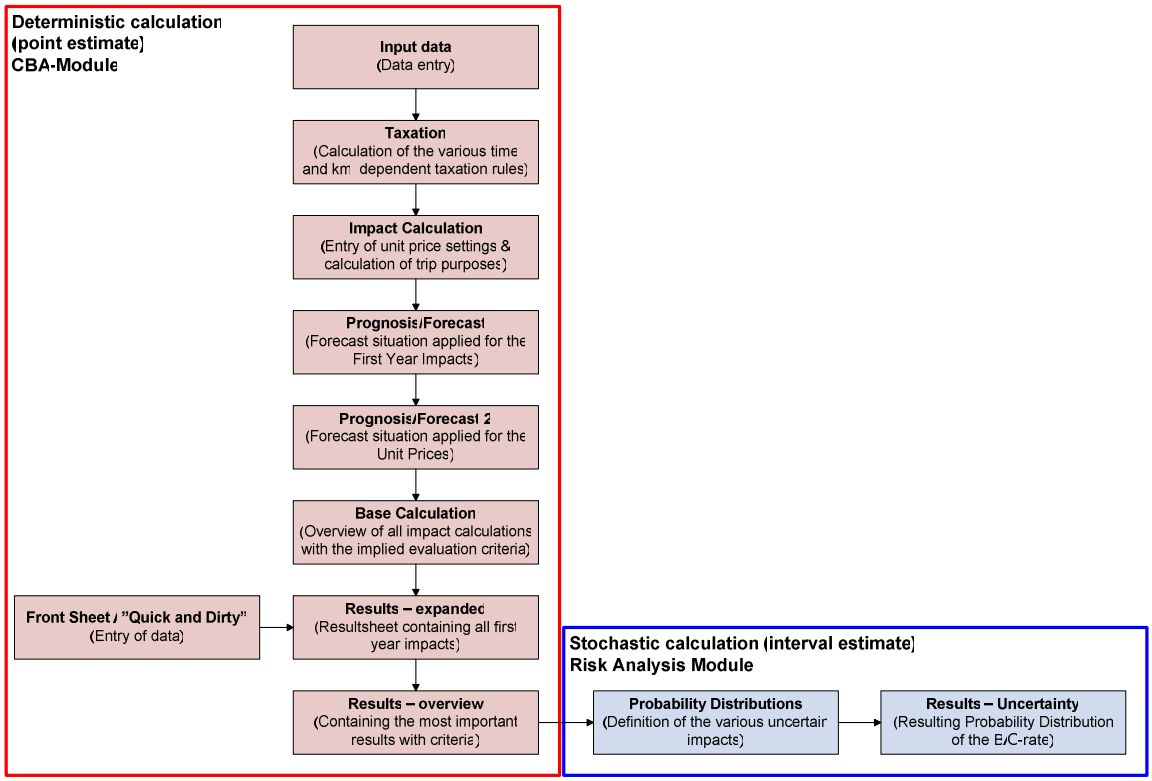


Figure 3-1. The module structure of COSIMA-ROAD illustrated by the various worksheets (Salling et al. 2004)

3.2 The Deterministic Calculation

The CBA module of COSIMA-ROAD consists of traditional cost-benefit analysis (CBA) split into 4 sub-categories: Passenger Cars, Lorries, Heavy goods vehicles and External Effects. The three vehicle groups are further divided into impact groups for each group consisting of travel time savings, vehicle operating costs, congestion and changing traffic. The external effects are of different types such as accidents, pollution, barrier and perceived risk and noise. Additional entries in the input sheet are the main data concerning the case project: construction cost (investment cost), operating and maintenance costs, evaluation period and key parameters such as discount rate, growth in the economy, etc. Figure 3-2 is showing the input data sheet.

By applying the net changes within the user impacts and the external effects as input to a socio-economic analysis, it is possible to obtain decision criteria such as the Benefit-Cost ratio (B/C-rate), Net Present Value (NPV), Internal Rate of Return (IRR) and First Year Rate of Return (FYRR). A run of COSIMA-ROAD ends up with a result sheet shown in Figure 3-3. The two bars on the right depict the costs and the benefits presented in the same absolute scale. By comparing the decision criteria from different runs on different projects a prioritisation can be made (Ibid. pp. 99-105).

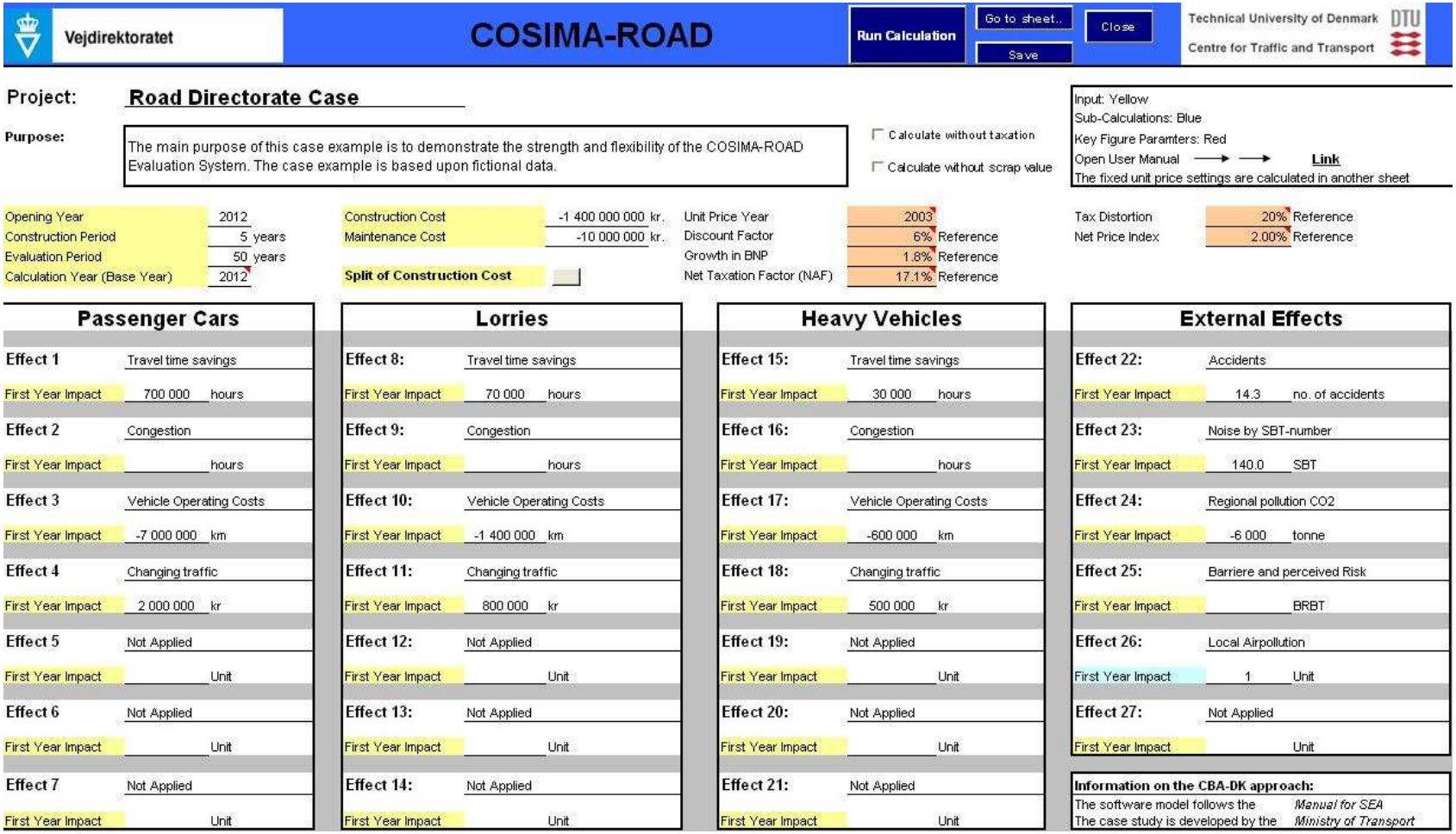


Figure 3-2. Screen dump of the Input data sheet

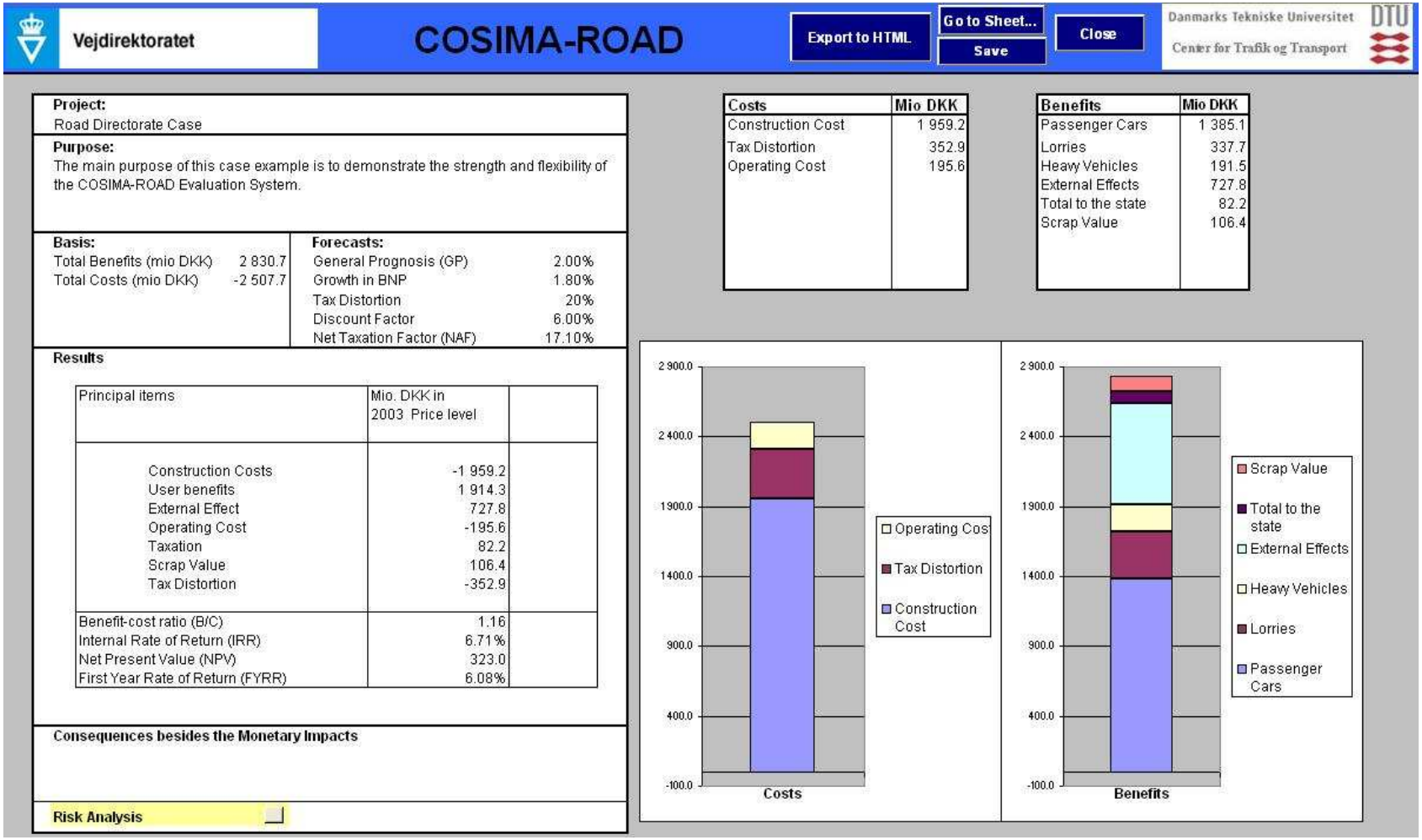


Figure 3-3. Screen dump of the results overview sheet containing the most important results from this case

After such deterministic runs it is possible to make risk analyses with B/C-rate intervals as the output. This provides a broader basis for assessing the individual projects.

3.3 The Stochastic Calculation

To make a CBA, as performed in the COSIMA framework, it is necessary to obtain information from various traffic and impact models. The various types of models combined with varying degrees of effort and resource input for impact modelling result in different degrees of uncertainties. In this respect it is necessary to use different probability distributions in accordance with the variability/uncertainty that characterises the parameters set focus upon in the risk analysis. The Danish Manual from the Ministry of Transport determines unit prices which in COSIMA-ROAD remain fixed (time unit price, vehicle operating costs a.o.). In the view of this work these parameters are assumed as certain. The COSIMA model examines selected parameters that are considered the most important for RA such as: construction costs, number of hours saved per year for travelling time, maintenance unit costs and safety unit price (Salling 2006). The current four types of distributions used within COSIMA from high to low level are: Erlang (Gamma), Normal, Triangular and Uniform distribution. Figure 3-4 shows how the various distributions are related to the level of knowledge applied on the variable or parameter.

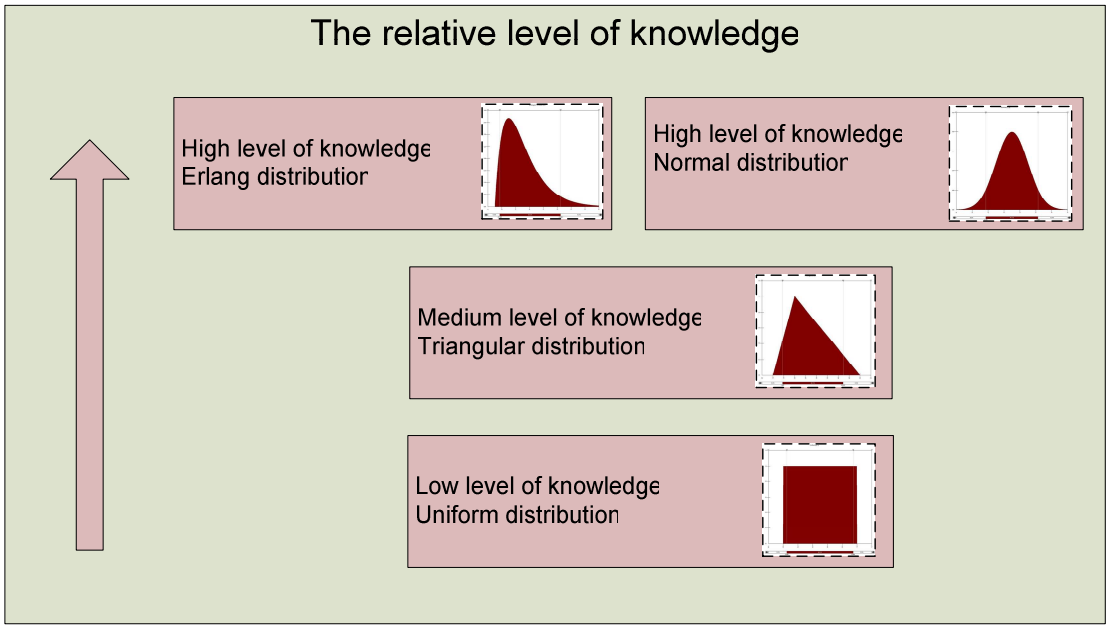


Figure 3-4. Overview of probability distributions applied in COSIMA-ROAD

Construction Costs

The cost of investing in a project before the event is often predicted lower than the actual cost e.g. due to technical problems, delays, etc. A Danish mathematician has developed this experience into a principle based upon successive calculation (Lichtenberg 2000). The strength of applying Lichtenberg's principle is that the decision-maker only has to consider a minimum, most likely (ML) and maximum value. Then by

use of a so-called triple estimation approach the mean and standard deviation are calculated.

Travel Time Savings

The travel time savings have been found to follow a Normal distribution where the mean is based on the first year effect entry determined as the net change in hours spent on travelling in the influence area of the road project. Standard deviations relating to traffic models applied in Denmark have been found to be around 10-20% (Knudsen 2006). By testing a traffic model in several scenarios it has been proven that the standard error within this model is around 11% for the transport mode and 16% for the traffic loads. Further investigations show that standard deviations in the area of 10% for smaller projects and 20% for large projects are not unlikely (Ibid.).

Maintenance Costs

The maintenance costs (MC) are developed based on empirical accounting formulas considering different cost factors (Leleur 2000 p. 158). It has been found suitable to use a Triangular distribution (Salling 2006). Specifically, the uncertainty assigned to this parameter using the Triangular distribution is defined by 10% possibility of achieving a lower MC and 50% possibility of achieving a higher value at the tails. It should be noted that this effect is a detriment towards society.

Accident Unit Price

The accident benefits are determined by their value to society stemming from multiplying the expected number of accidents saved with a societal unit price. The Uniform distribution shows the assumed uncertainty included in the price-setting where information on a high and low range is estimated (Ibid.). In the actual case run a rather conservative estimate with $\pm$ 10% to the standard unit price has been applied.

The Risk Analysis and its Results

The actual Monte Carlo Simulation shown in Figure 3-5 is based on the previous parameters and distributions. The purpose of the COSIMA-ROAD RA result sheet is to give the decision-makers a mean to widen their assessment of the possible B/C-rate (Hertz & Thomas 1984). Specifically, Figure 3-5 shows three COSIMA reports based on @RISK: Histogram showing the most frequent B/C-rate, a descending accumulated graph that shows the "certainty" of achieving a certain B/C-ratio or better and finally a correlation tornado graph that illustrates the impact (correlation) of each variable or parameter to the overall B/C-ratio (Salling 2006).

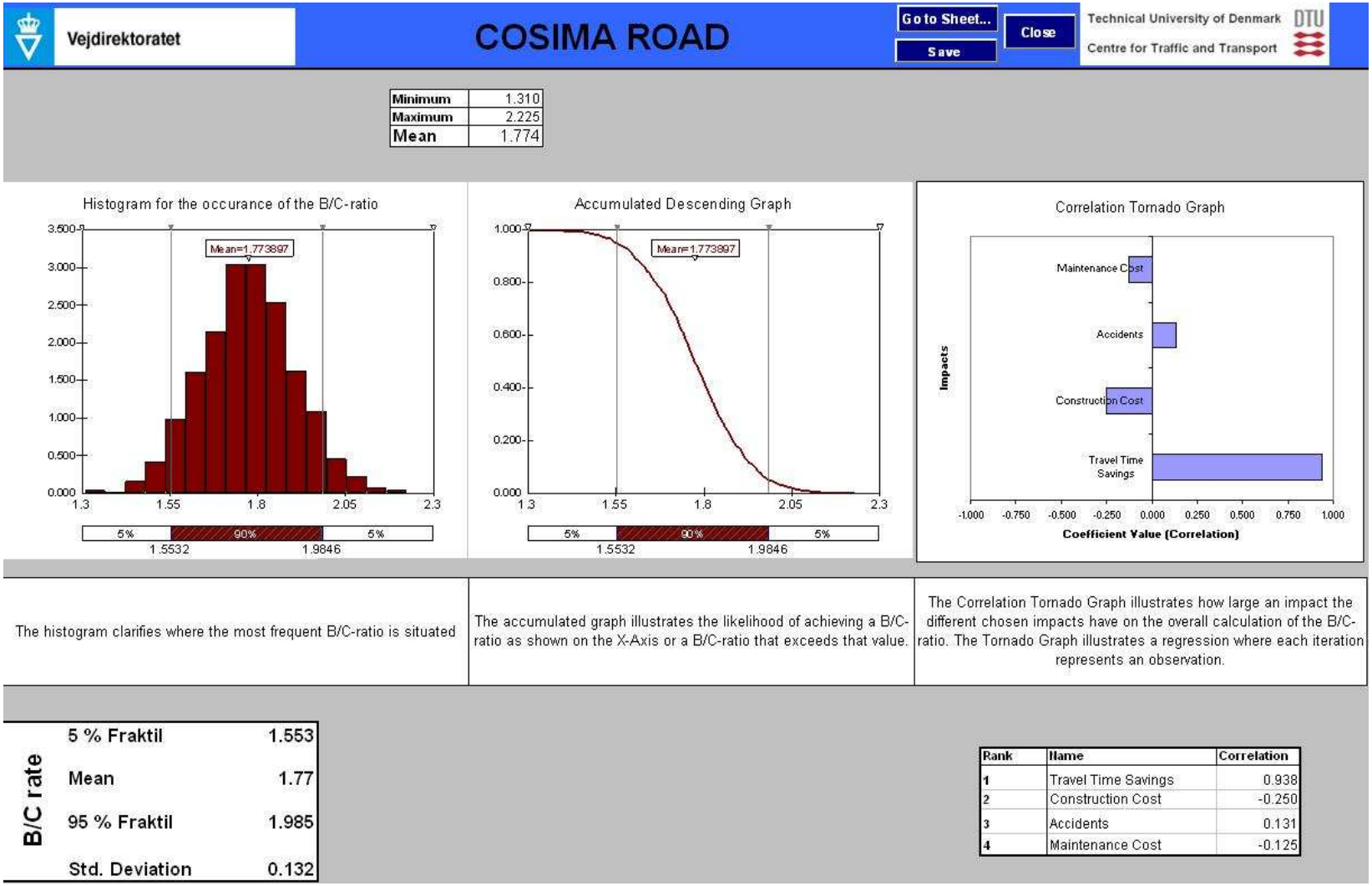


Figure 3-5. Screen dump of the resulting sheet from a Monte Carlo Simulation in COSIMA-ROAD

3.4 Conclusion and Perspective

With COSIMA-ROAD it is possible to carry out a Danish project appraisal study according to the principles determined in the manual developed by the Danish Ministry of Transport (DMT 2003). The software model has been designed as a combined approach in determining the feasibility of a road infrastructure project by use of both a deterministic and a stochastic approach based on @RISK. Thus a deterministic point estimate and a stochastic interval measure make it possible to assist the decision-makers by an accumulated graph whereby risk aversion can be taken into consideration.

4 Case description

The municipality and port of Esbjerg wish to make the road and rail connections to port of Esbjerg more suitable for the development in the years to come.

Companies situated at the port and citizens and neighbours of the by-pass road in Esbjerg have pointed out, that the present road connection is inadequate due to sensitivity of operating disturbances, and that the road and rail connections causes environmental nuisance in the urban area.

The purpose of constructing a new road is to create an efficient connection to motorway E20 for the northern part of the port and the eastern part of Esbjerg. The new by-pass road has to handle the main part of the traffic from distant and surrounding areas, including heavy traffic, so that the existing road will achieve a more local function. The purpose of the railway proposal is to create an efficient and safe transportation of cargo to and from the port.

As a result of increasing cargo traffic by ships, Port of Esbjerg wishes to construct a new intermodal terminal to handle the cargo transportation more efficiently. The terminal is to be situated on an empty area on the eastern side of the existing port, where it will have good conditions for connections to the superior road network.

5 Adaptation of COSIMA to Port of Esbjerg (COSIMA-ES-PORT)

In order to make COSIMA capable of handling a road project, a railway project and an intermodal terminal at the same time it is necessary to identify the impacts that need to be included in the model. According to this the COSIMA-ROAD tool will first be used on the road connection. Hereafter the impacts characterising the railway and intermodal projects will be identified and included in the model.

5.1 Adaptation of COSIMA-ROAD for the Road connection to Port of Esbjerg

The Input-sheet in the COSIMA-ROAD model is capable of handling 27 impacts as it can be seen in Figure 3-2, however an ordinary analysis of a road connection only needs to include 17 impacts as seen in Figure 5-1.

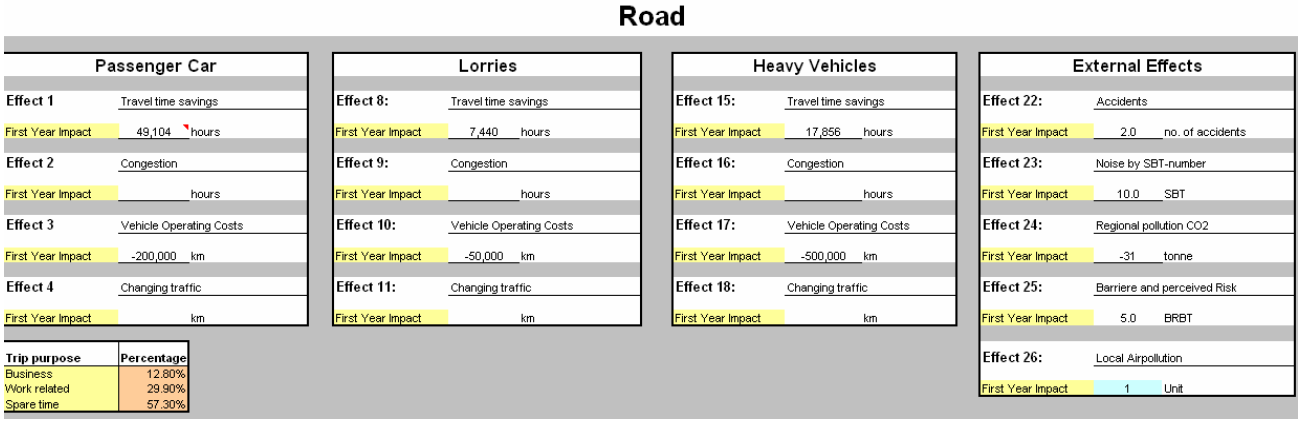


Figure 5-1: Screen dump of the Input-sheet in COSIMA-ES-PORT

The 3 vehicle categories are handling Travel Time Savings, Congestion, Vehicle Operating Costs and Changing Traffic (in the present project only travel time savings and VOC is used), while the External Effects handles Accident, Noise, Regional and Local Pollution and Barrier and Perceived Risk.
The handling of road impacts is in this way not changed compared to what is described in Chapter 3.

The additional 10 possible impacts out of the 27 are hereafter used to include the railway connection and the intermodal terminal in the model, which will be described in the following sub-chapters.

5.2 Adaptation of COSIMA-ROAD for the Rail connection to Port of Esbjerg

COSIMA-ROAD is originally not designed to handle impacts concerning railway connections. However it is possible to obtain this by making a few changes in the model.
The railway connection to Port of Esbjerg is only going to handle cargo transportation, not passengers. It is estimated by Port of Esbjerg, that the only impact from the railway will be taxation. In the Input-sheet this is marked with Figure 5-2.

Effect 14:	Railway taxation	
First Year Impact	1	Unit

Figure 5-2: Screen dump of the Input sheet in COSIMA-ES-PORT

The number 1 on the blue background indicates that the calculation of the impact is taken place in another sheet (the Cargo-sheet), see Figure 5-3.

Railway

Taxation of railway cars	Number	DKK per car	Total
Track use taxation	5,000	51	255,000
Infrastructure taxation		51	0
Sum			255,000

Figure 5-3: Screen dump of the Cargo-sheet in COSIMA-ES-PORT

The taxation impact is divided into to sub-impacts; Track Use Taxation and Infrastructure Taxation.
It is estimated by Port of Esbjerg, that it is not interesting to include a parameter such as travel time savings for railway cargo transportation into the model. It is expected that the need for transportation on railway will be of very little significance compared to transportation on heavy goods vehicles.

5.3 Adaptation of COSIMA-ROAD for the Intermodal terminal at Port of Esbjerg

The intermodal terminal is intended to handle all kinds of cargo and ship related issues at Port of Esbjerg. By using Port of Esbjerg's price catalogue as base the following impacts on Figure 5-4 are listed in the Input-sheet:

Port

Cargo			Ship	
Effect 5	Cargo in tonne		Effect 19:	Taxation on ships
First Year Impact	1	Unit	First Year Impact	1 Unit
Effect 6	Cargo in units		Effect 20:	Handling of garbage
First Year Impact	1	Unit	First Year Impact	1 Unit
Effect 7	Reload taxation			
First Year Impact	1	Unit		
Effect 12:	Rent of area			
First Year Impact	1	Unit		
Effect 13:	Rent of cranes			
First Year Impact	1	Unit		
Effect 14:	Railway taxation			
First Year Impact	1	Unit		

Figure 5-4: Screen dump of the Input-sheet in COSIMA-ES-PORT

As in the case with the railway all the cargo and ship impacts are calculated in another sheet. The cargo impacts are calculated in the Cargo-sheet, which is seen on Figure 5-5.

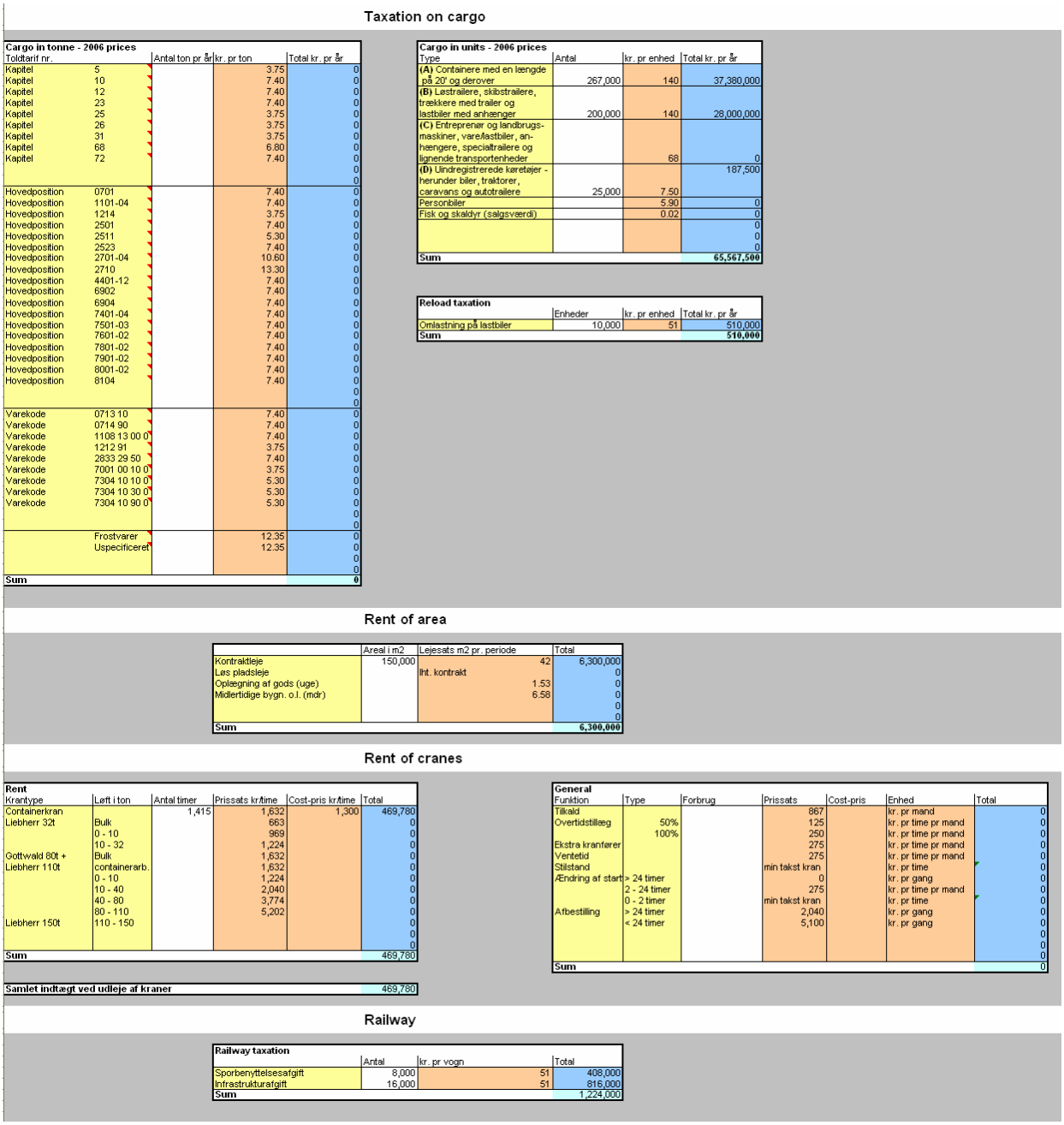


Figure 5-5: screen dump of the Cargo-sheet in COSIMA-ES-PORT

Likewise the ship impacts are calculated in the Ship-sheet, see Figure 5-6.

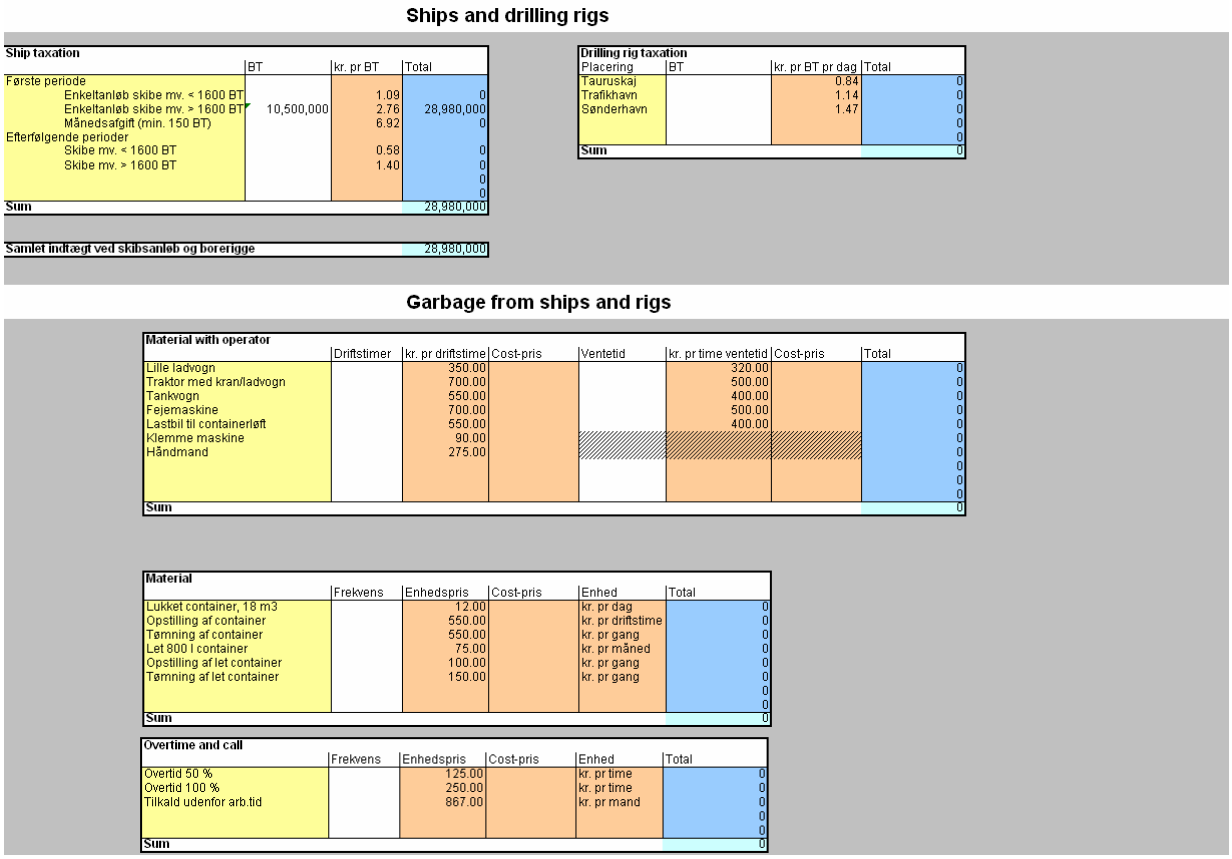


Figure 5-6: Screen dump of the Ship-sheet in COSIMA-ES-PORT

Aside from the above mentioned impacts, which all concern the handling of cargo and ships, there has been added another impact to the model, see Figure 5-7.

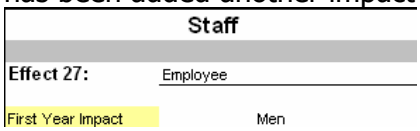


Figure 5-7: Screen dump of the Input-sheet in COSIMA-ES-PORT

The impact is included in the model in order to add in the benefits that an improvement in efficiency in the intermodal terminal will have on the need for staff.

Finally it is necessary to review the operating costs so that port activities also are included, see Figure 5-8.

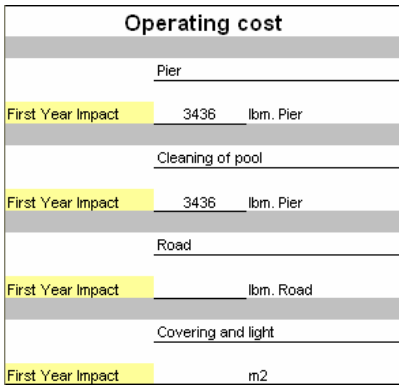


Figure 5-8: Screen dump of the Input-sheet in COSIMA-ES-PORT

The new categories added to the model; Ship, Cargo and Staff, are applied to the additional sheets in the model, in a way so that all forecasting and calculations are processed exactly as described in Chapter 3 concerning the COSIMA-ROAD model.

Aside from the described impacts the model also gives opportunity for including so called strategic impacts in the assessment. Strategic impacts are normally impacts that cannot directly be given a price, but by making an appraisal using a pair wise comparison method it is possible to give these impacts a monetary value and include them in the assessment.
This has not been done for the current project at Port of Esbjerg, which only concerns one project alternative for each case, as the method has its strength in comparison between several project alternatives.

6 Pre-feasibility study of the road connection to port of Esbjerg using COSIMA-ES-PORT

6.1 Strategic Impacts

Effect on urban planning

Environmental impact

The construction of a new road connection will result in some environmental impacts. The impacts noise and local and regional air pollution will be dealt with in the CBA part. However other impacts due to the construction period are not included in the CBA, and will be described in the following.
The construction period will contain a lot earth moving work, which can affect the groundwater. There is no knowledge about polluted sites in connection with the construction of the road, but it is most likely not possible to avoid affecting the groundwater entirely. This however has to be cleared up at a later stage in the planning process.
The plant and animal life in the area will also be affected by a new connection, as the new road will go through an untouched natural resort and decrease the living conditions for plants and animal life. It is however not a large area that will be affected and the influence is as a result minimal.

Capacity issues

The preliminary study (COWI, 2006) is dealing with the capacity issues in the roundabouts on the existing road and in the planned roundabouts on the new by-pass road. The rest of the network is assumed to have sufficient capacity.
The results of the investigations show, that the growth in traffic will create load rates up to 130 % of the capacity on the existing road in 2015, which will result in low service levels in the roundabouts. By the construction of a new by-pass road the service level will be improved and the traffic will be processed acceptably.

6.2 Input for the deterministic calculation (CBA)

The impacts used for the COSIMA-ES-PORT model are based on the results of the preliminary study (COWI, 2006), which concerns capacity issues for the existing and the planned new roundabouts along the by-pass road in Esbjerg. The results are based on a DanKap calculation. With the results of the preliminary study it is possible to estimate the most important traffic impacts without the use of a new traffic model calculation.
The inputs used for the CBA for the road connection can be seen in Table 6-1.

Impacts	
Opening year	2015
Construction period	2 years
Evaluation period	30 years
Construction cost	65 million DKK
Operating cost	0.23 million DKK
Passenger cars – time savings	49,104 hours
Lorries – time savings	7,440 hours
Heavy goods vehicles – time savings	17,856 hours
Passenger cars - VOC	-200,000 km
Lorries - VOC	-50,000 km
Heavy goods vehicles - VOC	-500,000 km
Accidents	2
Noise by SBT-number	10 SBT
Regional pollution – CO2	-31 tonne
Barrier and perceived risk	5 BRBT
Local pollution - tonne	-3.8 (NOx), -3.6 (HC), -85 (CO), -0,05 (SO2), -0,06 (Particles)

Table 6-1: Impacts used for the CBA of the road connection

The largest impact for the study is the travel time savings for heavy goods vehicles as about 25 % of the traffic on the by-pass road consist of these.
According to the relatively small size of the project and the low construction costs of 65 million DKK, it is decided to analyse the project's costs and benefits over a 30 year period beginning in 2015.
All unit prices used for the CBA of the road connection are taken from the Danish Key Figure Catalogue (Ministry of Transport, 2006) and will not be listed here.

Variables

In Denmark the discount rate is set to 6 % by the Ministry of Finance.
According to Ministry of Transport (2003) socio economic analyses have to include the Net Taxation Factor (NTF) and tax-distortion. The NTF converts factor prices to market prices, where market prices are an expression for the expenses experienced by the consumer. The NTF can be calculated as the ratio between the GNP and the value creation stated in factor prices, and is in Denmark 1,17. The tax-distortion is calculated by multiplication of the need for tax financiering with the societal marginal costs of tax financiering on 20 %. The calculated tax-distortion is subsequently included in the total assessment as a cost.

Growth scenarios

2 different growth scenarios will be examined for the road connection:

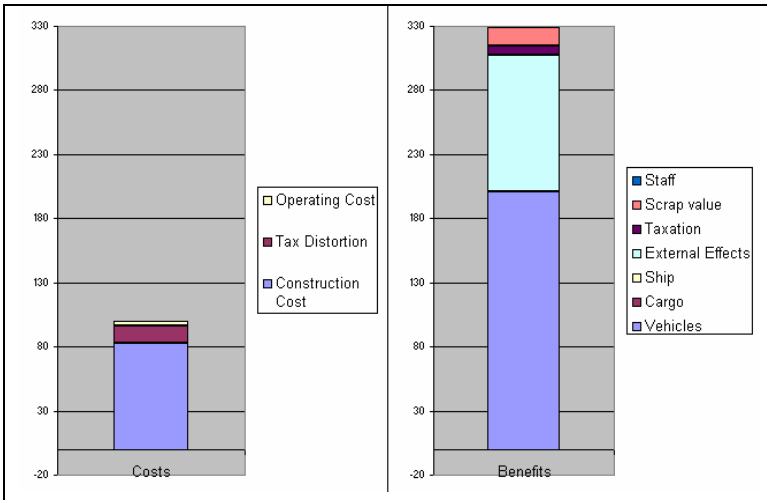
Scenario 1 - It is estimated by the Danish Road Directorate, that the growth in traffic on the main roads around Esbjerg is 2.0 % per year. This growth factor will be used for the first 20 years of the evaluation period after which it will be set to 0 % per year for the remaining period. The growth factor is applied on travel time savings, VOC and accidents.

Scenario 2 - A study concerning the development in cargo transportation at ports in Denmark has stated that transportation using heavy goods vehicles will increase with 170 % within the next 20 years. This factor is applied on travel time savings and VOC for heavy goods vehicles. Passenger cars, lorries and external effects are expected to have the same growth as in scenario 1.

6.3 Results of the deterministic calculation (CBA)

Scenario 1

The results of the deterministic calculation for scenario 1 in COSIMA-ES-PORT are seen in Figure 6-1:



Costs	Million DKK
Construction cost	82.6
Tax distortion	13.6
Operation cost	3.9

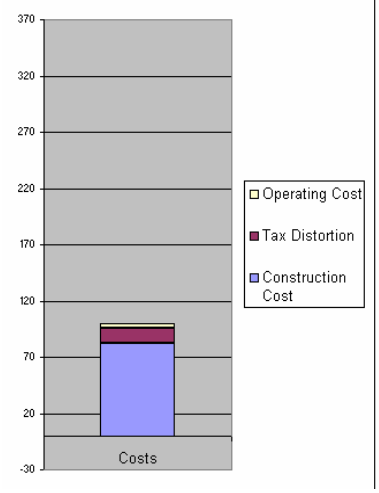
Benefits	Million DKK
Vehicles	201.4
External effects	106.2
Taxation	6.9
Scrap value	14.4

Figure 6-1: Costs and benefits for scenario 1

As shown in Figure 6-1, the benefits derived from the road project are much larger than the costs of constructing it. The main part of the benefits is coming from travel time savings for heavy goods vehicles and passenger cars, but the decrease in accidents under the external effects also has a large positive influence on the project.

Scenario 2

The results of the deterministic calculation for scenario 2 in COSIMA-ES-PORT can be seen in Figure 6-2:



Costs	Million DKK
Construction cost	82.6
Tax distortion	13.6
Operation cost	3.9

Benefits	Million DKK
Vehicles	235.4
External effects	106.2
Taxation	6.9
Scrap value	14.4

Figure 6-2: Costs and benefit for scenario 2

With the larger growth factor applied the benefits for vehicles rise with 34 million DKK over the evaluation period on 30 years, and it is as expected the largest benefit by far.

Decision criteria

The decision criteria computed in COSIMA-ES-PORT for each of the 2 scenarios are given in Table 6-2.

	Scenario 1	Scenario 2
B/C ratio	3.77	4.18
IRR	20.08 %	20.92 %
NPV	228.8	262.8
FYRR	20.99 %	20.99 %

Table 6-2: Decision criteria

As seen by the decision criteria the project is very profitable in both the growth scenarios. The B/C ratio is much larger than 1, the IRR and the FYRR are both much larger than the discount rate on 6 % and finally the NPV has a large positive value compared to the construction costs.

6.4 Inputs for the stochastic calculation (RA)

It is necessary to perform a risk analysis in order to decide how sensitive the project is to changes in the main impacts. The risk analysis contains uncertainties on construction costs, travel time savings and accidents and is carried out identically for the 2 scenarios. The distributions are chosen due to the level of knowledge as described in chapter 3.3.
The input for the calculation can be seen in Table 6-3.

Impact	Distribution	
Construction cost	Erlang	60 – 65 – 100 million DKK

Operating cost	Erlang	0.2 – 0.23 – 0.5 million DKK
Time savings	Normal	15 %
VOC	Normal	20 %
Accidents	Uniform	0.5 – 2 – 2.5 numbers
Noise	Triangular	5 – 10 – 12 SBT
Barrier	Triangular	2 – 5 – 6 BRBT
Local pollution	Triangular	0.25 – 1 – 1.2 Units

Table 6-3: Input for the stochastic calculation

The distributions are entered in the Distribution-sheet and the simulation is processed with 2000 iterations. Normally it is not appropriate to simulate on more than 4 parameters at the same time, as there is a chance that too many parameters applied can neutralise the distributions in the calculation. However tests for the present project have shown that all the distributions with advantage can be applied at the same time.
It should however be noted, that the project is most sensible towards changes in travel time savings. This seems reasonable as the benefits derived from travel time savings is the largest impact for the project.

6.5 Results of the stochastic calculation (RA)

The results of the risk analysis for both scenarios are listed below in Figure 6-3 and Figure 6-4.

Scenario 1

The distributions shown in Table 6-3 applied on scenario 1 deliver the results shown in Figure 6-3:

Minimum	2.078
5 % Fractile	2.689
Mean value	3.412
Mode (most likely value)	3.697
95 % Fractile	4.138
Maximum	4.777
Standard deviation	0.446

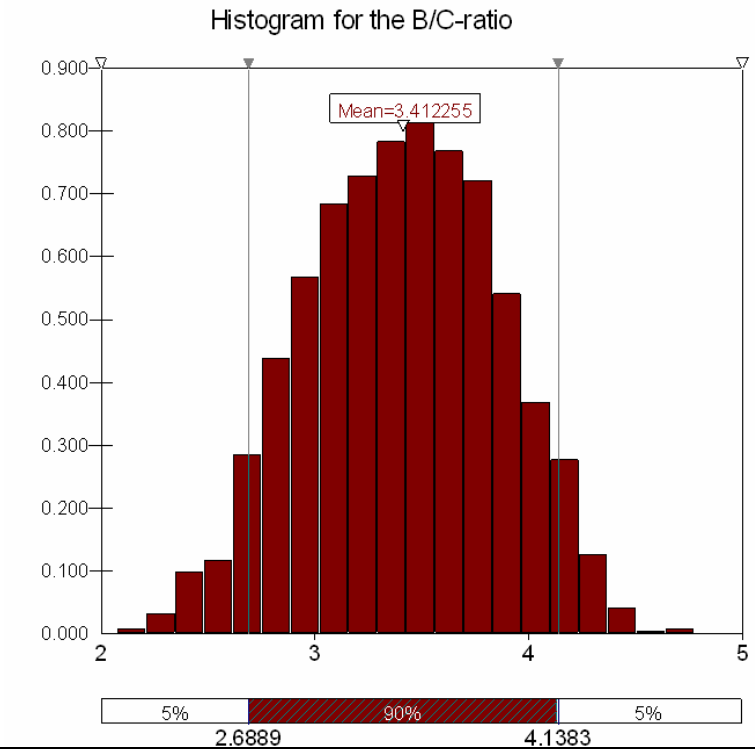


Figure 6-3: Results of the RA for scenario 1

The results show, that the B/C ratio will stay in a profitable interval at all times. In the 90 % confidence interval the B/C ratio stays between 2.7 and 4.1 with a mean value on 3.4. The mode value indicates the value obtained the most times during the simulation is 3.7.
According to the risk analysis it is most likely that the project will be profitable. The risk analysis does not show any weaknesses in the parameters that can change this assumption.

Scenario 2

The distributions shown in Table 6-3 applied on scenario 2 deliver the results shown in Figure 6-4:

Minimum	1.913
5 % Fractile	2.974
Mean value	3.824
Mode (most likely value)	3.556
95 % Fractile	4.634
Maximum	5.472
Standard deviation	0.506

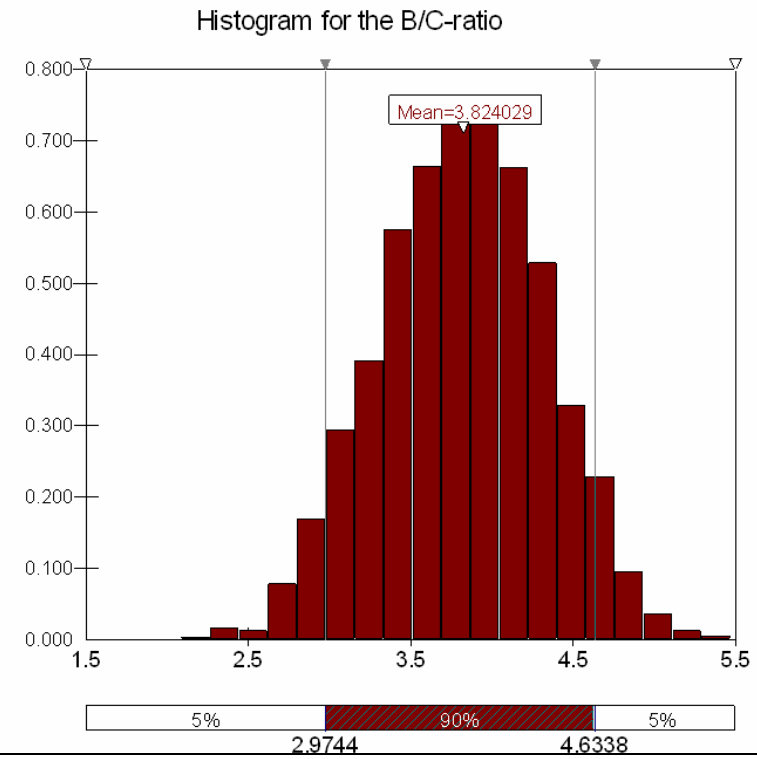


Figure 6-4: Results of the RA for scenario 2

As for scenario 1 the results of scenario 2 show, that the B/C ratio will stay in a profitable interval at all times. In the 90 % confidence interval the B/C ratio stays between 3.0 and 4.6 with a mean value of 3.8. The mode value is 3.6.
The project will according to the risk analysis also be profitable in scenario 2.

6.6 Conclusion and recommendation

The analysis in COSIMA-ES-PORT shows that the construction of a new road without a doubt will be a profitable socio economic project in both the scenarios applied.
The risk analysis with the presumed distributions does not point out any alarming weaknesses about the project, however the project is most sensible toward changes in travel time savings as this is the largest impact.
In conclusion it is recommended that the project should be started as soon as possible as it is very profitable and will improve the conditions on the road network in Esbjerg.

7 Pre-feasibility study of the rail connection to port of Esbjerg using COSIMA-ES-PORT

7.1 Strategic Impacts

Effect on urban planning

Environmental impact

The new part of the railway will mostly be situated on Port of Esbjerg's already built on area, and will as a result of this not have any direct impact on the environment. However it must be assumed that a lot of noise and earth moving work will follow the construction of the railway, and cause an environmental impact.
It is not possible to estimate the size of this impact as the information about the project is very sparse, but it should be dealt with at a later stage in the planning as more information is available.

Capacity issues

The capacity of the rail connection is, according to the preliminary study (COWI, 2006), sufficient as it is today, and it should be possible to increase the traffic load with 50 % without taking any further action. However, the increase in cargo transportation due to the new intermodal terminal will create a larger demand for transportation on railway, which sets the need for a more up-to-date railway connection to the port.

7.2 Input for the deterministic calculation (CBA)

The inputs concerning the rail connection is based on meager information as the preliminary study (COWI, 2006) is not dealing with the issue in detail. However, Port of Esbjerg has made some estimates showing that a new railway connection will have a positive impact on the cargo transportation. This impact is relatively small as it is predicted by Port of Esbjerg, that most cargo transportation in the future will be on heavy goods vehicles.

It can be argued that the construction of the new railway connection will free up some area at Esbjerg Station given that all cargo related activity will be moved from the station to Port of Esbjerg. This area could be used for other purposes, and in that way create a benefit for the project. This has however not been included in the calculation as there are no available estimates for this.

The impacts used in the analysis are shown in Table 7-1.

Impacts	
Opening year	2015
Construction period	1 year
Evaluation period	25 years
Construction cost	85 million DKK
Operating cost	1 million DKK
Containers	10,000 units
Trailers	2,500 units
Track use taxation	5,000 railway cars

Table 7-1: Impacts used for the CBA of the railway connection

Unit prices for the impacts are estimated in Port of Esbjerg's price catalogue (Port of Esbjerg, 2006).

Variables

As for the analysis of the road connection the following variables are used for the analysis of the railway connection:

The discount rate is set to 6 % by the Ministry of Finance.

The Net Taxation Factor (NTF) is 1.17, and the tax-distortion is set to 20 %.

Growth scenarios

Two different growth scenarios are investigated; a scenario where the impacts are assumed to follow a regular growth (scenario 1) and a scenario where the impacts experience a sudden growth after a few years with regular growth:

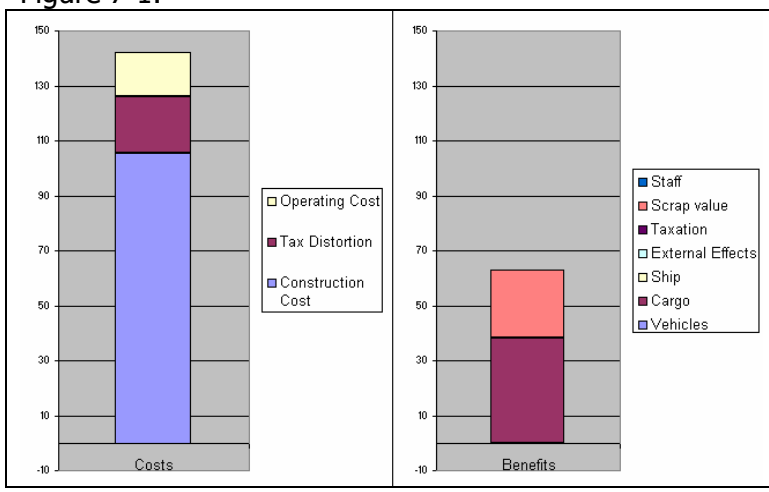
Scenario 1 - Port of Esbjerg estimates that cargo transportation will increase by 2.0 % per year the next 20 years. After 20 years the growth factor will be set to 0 %. This is applied on all the cargo and ship related impacts.

Scenario 2 - The cargo transportation will increase by 2.0 % per year for the first 5 years as in scenario 1. After 5 years Port of Esbjerg estimates that the cargo transportation will experience a "boom"-effect and increase by 5 % per year.

7.3 Results of the deterministic calculation (CBA)

Scenario 1

The results of the deterministic calculation for scenario 1 in COSIMA-ES-PORT can be seen on Figure 7-1.



Costs	Million DKK
Construction cost	105.5
Tax distortion	20.7
Operation cost	15.9

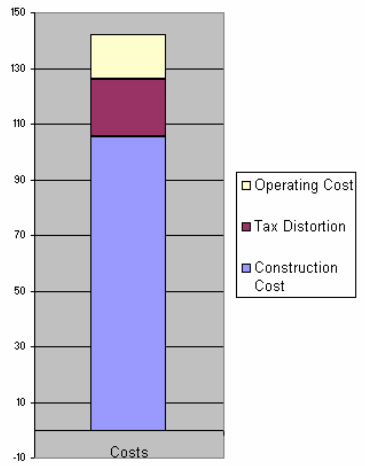
Benefits	Million DKK
Cargo	38.2
Scrap value	24.6

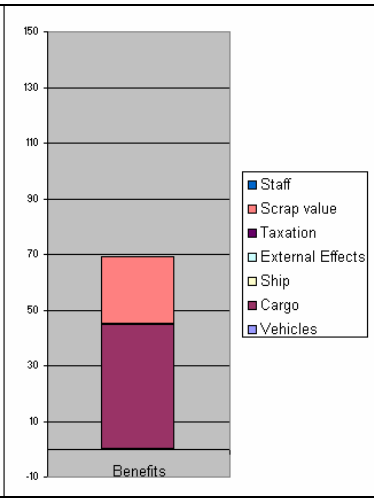
Figure 7-1: Costs and benefits for scenario 1

It is seen from Figure 7-1 that the benefits derived from the railway project are much smaller than the costs of constructing it. The main part of the benefits is coming from the increase in containers transported by railway, but this is a relatively small posting compared to the construction costs.

Scenario 2

The results of the deterministic calculation for scenario 2 are seen on Figure 7-2.





Costs	Million DKK
Construction cost	105.5
Tax distortion	20.7
Operation cost	15.9

Benefits	Million DKK
Cargo	44.7
Scrap value	24.6

Figure 7-2: Costs and benefits for scenario 2

With the larger growth factor applied on the transportation of cargo the benefits rise with 6.5 million DKK over the 25 year evaluation period. However, the impact is not nearly the same size as the construction costs.

Decision criteria

The decision criteria computed in COSIMA-ES-PORT for each of the 2 scenarios are given in Table 7-2.

	Scenario 1	Scenario 2
B/C ratio	0.13	0.31
IRR	0.83 %	1.43 %
NPV	-91.7	-72.9
FYRR	1.75 %	2.23 %

Table 7-2: Decision critera

The decision criteria indicate that the project is unprofitable in both scenarios; The B/C ratio is smaller than 1, the IRR and the FYRR are both smaller than the discount rate of 6 %, and the NPV is negative.

The decision criteria are set low in response to the missing benefit from the free area at Esbjerg Station. The benefit should be at about 100 million DKK in order to make the project profitable. This is however not likely as the area is of a minor size.

7.4 Inputs for the stochastic calculation (RA)

The risk analysis for the railway connection contains uncertainties on construction costs, operating costs and the cargo transportation on railway.

The risk analysis is carried out identically for the 2 scenarios. The input for the calculation can be seen in Table 7-3.

Impact	Distribution

Construction cost	Erlang	80 – 85 – 120 million DKK
Operating cost	Erlang	0.8 – 1 – 1.5 million DKK
Cargo	Triangular	0.25 – 1 – 1.1 units
Railway	Triangular	0.25 – 1 – 1.1 units

Table 7-3: Input for the stochastic calculation

The distributions are entered in the Distribution-sheet and the simulation is processed with 2000 iterations.
The simulation is processed with only 4 parameters, which should not course any problems in the simulation as described in chapter 6.4.

7.5 Results of the stochastic calculation (RA)

The results of the risk analysis for both scenarios are listed below in Figure 7-3 and Figure 7-4.

Scenario 1

The distributions given in Table 7-3 applied on scenario 1 deliver the results shown in Figure 7-3.

Minimum	-0.165
5 % Fractile	-0.022
Mean value	0.131
Mode (most likely value)	0.185
95 % Fractile	0.267
Maximum	0.361
Standard deviation	0.086

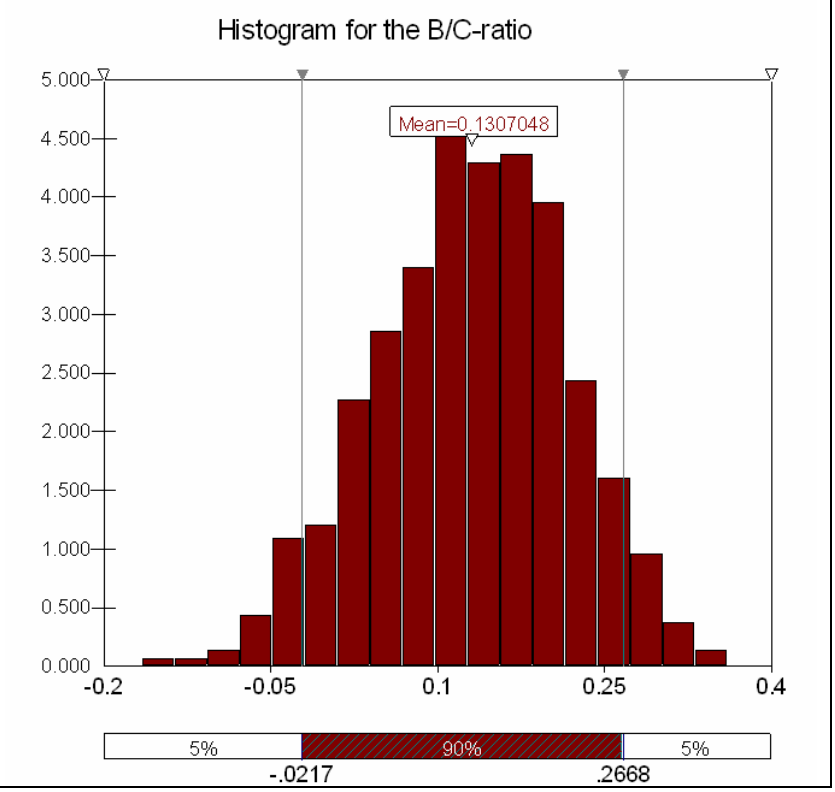
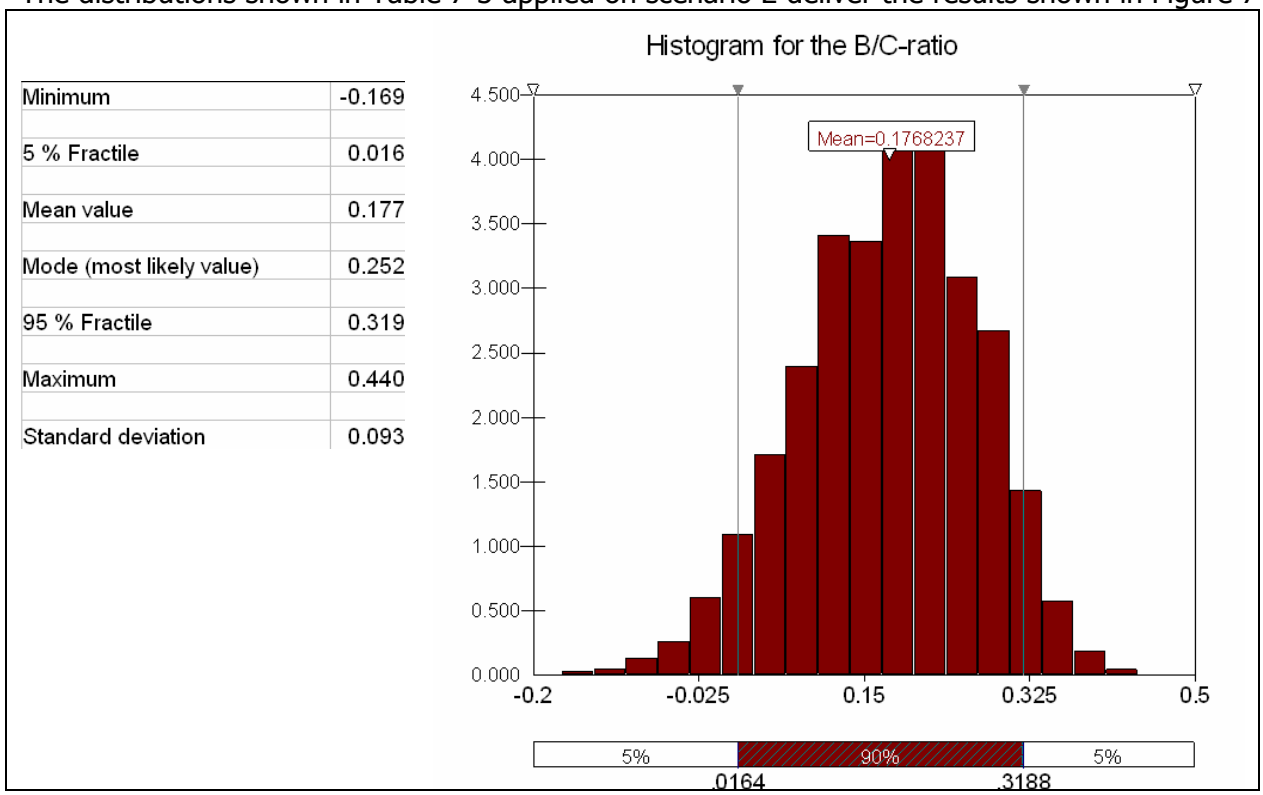


Figure 7-3: Results of the RA for scenario 1

The results show, that the B/C ratio will not at any time have a profitable value. In the 90 % confidence interval the B/C ratio stays between -0.02 and 0.27 with a mean value of 0.13. The mode value is 0.19.
According to the risk analysis it is not likely that the project will be profitable at any time.

Scenario 2

The distributions shown in Table 7-3 applied on scenario 2 deliver the results shown in Figure 7-4.



Minimum	-0.169
5 % Fractile	0.016
Mean value	0.177
Mode (most likely value)	0.252
95 % Fractile	0.319
Maximum	0.440
Standard deviation	0.093

Figure 7-4: Results of the RA for scenario 2

As for scenario 1 the results of scenario 2 show, that the B/C ratio will stay in an unprofitable interval at all times. In the 90 % confidence interval the B/C ratio stays between 0.02 and 0.44 with a mean value of 0.18. The mode value is 0.25.

The project will not be profitable at any time according to the risk analysis, but it is seen that the higher growth factor in scenario 2 has a very positive effect on the result. However the cargo volume is not big enough to carry the project.

7.6 Conclusion and recommendation

The analysis in COSIMA-ES-PORT shows that the construction of a new railway connection to Port of Esbjerg will not be a profitable socio economic project in neither of the 2 scenarios, as the benefits, derived from the increase in transportation of cargo on railway, are much smaller than the high construction costs. The area at Esbjerg Station, which will be free after the construction of a new railway connection, is however not included in the assessment.

The quantity of cargo transported on railway is estimated to be relatively small by Port of Esbjerg, as it is predicted that most cargo in the future will be transported on heavy goods vehicles.

The difference between scenario 1 and scenario 2 shows that the profitability of the project is very sensible towards changes in the quantity of cargo transported on the railway.

However the risk analysis does not show any signs that the project might be profitable at any time, and according to this it is recommended that the project should not be carried out.

8 Pre-feasibility study of the intermodal terminal using COSIMA-ES-PORT

8.1 Strategic Impacts

Effect on urban planning

Environmental impact

Decontamination of sand and other materials in the dock of the port will be pumped to land and dried with purpose of being used to fill up the dock in order to increase the land area of the port. Tests of the sand and materials will be taken to clarify the level of pollution, but due to the traffic in the dock through many years it is expected that a certain amount of heavy metals and environmentally alien substances will be found.
The traffic for both ships and vehicles at the Port will increase by the construction of an intermodal terminal. This will also result in increased pollution of both sea and air. It is however not possible to estimate the size of this impact on this early stage in the planning process.

Capacity issues

The construction of a new intermodal terminal at Port of Esbjerg will eliminate all issues regarding limited capacity for well into the future. The terminal is designed for setting a new standard for handling of cargo and ships at Port of Esbjerg so that the Port's total capacity will be increased significantly.

8.2 Input for the deterministic calculation (CBA)

The inputs used for the COSIMA-ES-PORT model are Port of Esbjerg's estimates and expectations to the increase in transportation of cargo as a result of a new intermodal terminal.
The impacts used for the CBA for the intermodal terminal are shown in Table 8-1.

Impacts	
Opening year	2015
Construction period	3 year
Evaluation period	25 years
Construction cost	300 million DKK
Operating cost	5.2 million DKK
Cargo	
Containers	267,000 units
Trailers	200,000 units
Un-registered cars	25,000 units
Tax on reload	10,000 units
Rent of area	150,000 m2
Rent of cranes	1,415 hours
Rail – track use tax	8,000 units
Rail – infrastructure tax	16,000 units
Arriving ships	10,500,000 BT
Track use taxation	5000 railway cars

Table 8-1: Impacts used for the CBA of the intermodal terminal

The largest impacts for the study are the increase in containers and trailers, which will be doubled in size according to Port of Esbjergs estimates.
Unit prices for the impacts are from Port of Esbjerg's price catalogue (Port of Esbjerg, 2006) and will not be listed here.

Variables

As for the analysis of the road and rail connections the following variables are used for the analysis of the intermodal terminal:
The discount rate is set to 6 % by the Ministry of Finance.
The Net Taxation Factor (NTF) is 1.17, and the tax-distortion is set to 20 %.

Growth scenarios

Similar with the railway project two different growth scenarios are investigated; a scenario where the impacts are assumed to follow a regular growth (scenario 1) and a scenario where the impacts experience a sudden growth after a few years with regular growth:

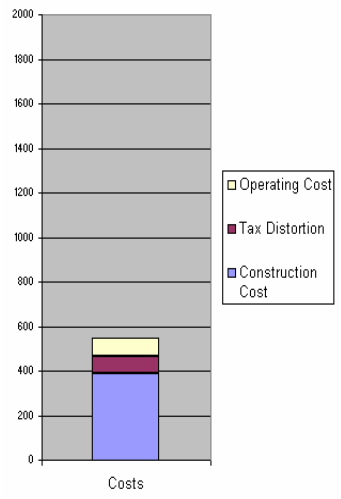
Scenario 1 - Port of Esbjerg estimate that cargo transportation will increase by 2.0 % per year the next 20 years. After 20 years the growth factor will be set to 0 %. This is applied on all the cargo and ship related impacts.

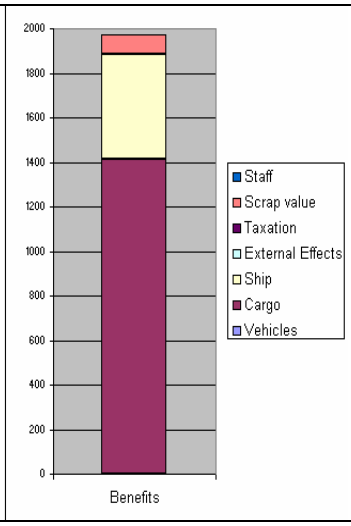
Scenario 2 - The cargo transportation will increase by 2.0 % per year for the first 5 years as in scenario 1. After 5 years Port of Esbjerg estimates that the cargo transportation will experience a "boom"-effect and increase by 5 % per year.

8.3 Results of the deterministic calculation (CBA)

Scenario 1

The result of the deterministic calculation for scenario 1 in COSIMA-ES-PORT can be seen in Figure 8-1.





Costs	Million DKK
Construction cost	387.0
Tax distortion	80.1
Operation cost	81.8

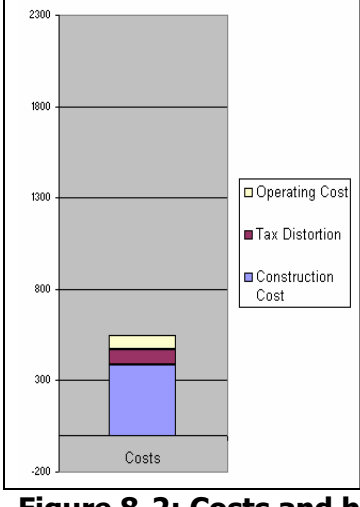
Benefits	Million DKK
Cargo	1,411.5
Ship	472.1
Scrap value	90.2

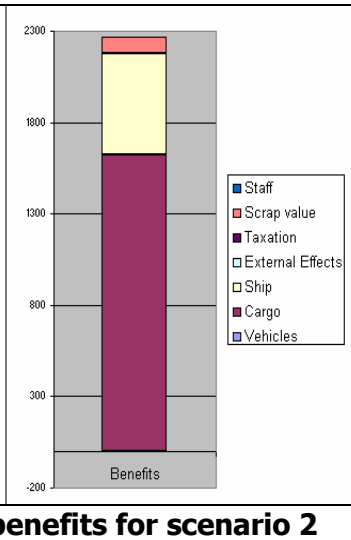
Figure 8-1: Costs and benefits for scenario 1

It is seen from Figure 8-1 that the benefits derived from the road project are much larger than the costs of constructing it. The largest part of the benefits is coming from the transportation of cargo, mainly containers and trailers, but ship taxation is also a large posting.

Scenario 2

The result of the deterministic calculation for scenario 2 in COSIMA-ES-PORT can be seen in Figure 8-2.





Costs	Million DKK
Construction cost	387.0
Tax distortion	80.1
Operation cost	81.8

Benefits	Million DKK
Cargo	1,625.3
Ship	551.3
Scrap value	90.2

Figure 8-2: Costs and benefits for scenario 2

With the larger growth factor applied the total benefits rise with 293 million DKK over the 25 year evaluation period, and the cargo transportation is as expected the largest impact by far.

Decision criteria

The decision criteria computed in the COSIMA-ES-PORT for each of the 2 scenarios are given in Table 8-2.

	Scenario 1	**Scenario 2**
B/C ratio	3.95	5.44
IRR	24.67 %	25.39 %
NPV	1,139.9	1,717.9
FYRR	25.52 %	29.90 %

Table 8-2: Decision criterion

The decision criteria indicate that the project is very profitable: The B/C ratio is much larger than 1, the IRR and the FYRR are both larger than the discount rate of 6 %, and the NPV has a very large positive value for both the scenarios.
It is seen that with a relatively small change in the growth factor the profitability of the project rises dramatically. This is the result of the very high estimates for the increase in cargo transportation provided by Port of Esbjerg.

8.4 Inputs for the stochastic calculation (RA)

The risk analysis contains uncertainties on construction costs, operating costs and all cargo related impacts. The risk analysis is carried out identically for the 2 scenarios. The input for the calculation can be seen in Table 8-3.

Impact	**Distribution**	
Construction cost	Erlang	270 – 300 – 450 million DKK
Operating cost	Erlang	4.5 – 5.2 – 7 million DKK
Cargo in units	Triangular	0.25 – 1 – 1.1 units
Rent of areas	Normal	20 %
Railway	Triangular	0.25 – 1 – 1.1 units
Ship taxation	Normal	20 %

Table 8-3: Input for the stochastic calculation

The distributions are entered in the Distribution-sheet and the simulation is processed with 2000 iterations. As for the risk analysis of the road connection all parameters are applied at the same.
However it should be noted that the project, not surprisingly, is most sensible towards changes in the quantity of container and trailer transportation.

8.5 Results of the stochastic calculation (RA)

The results of the risk analysis for both scenarios are listed below in Figure 8-3 and Figure 8-4.

Scenario 1

The distributions in Table 8-3 applied on scenario 1 deliver the results shown in Figure 8-3.

Minimum	1.733
5 % Fractile	2.745
Mean value	3.945
Mode (most likely value)	4.314
95 % Fractile	4.889
Maximum	5.691
Standard deviation	0.666

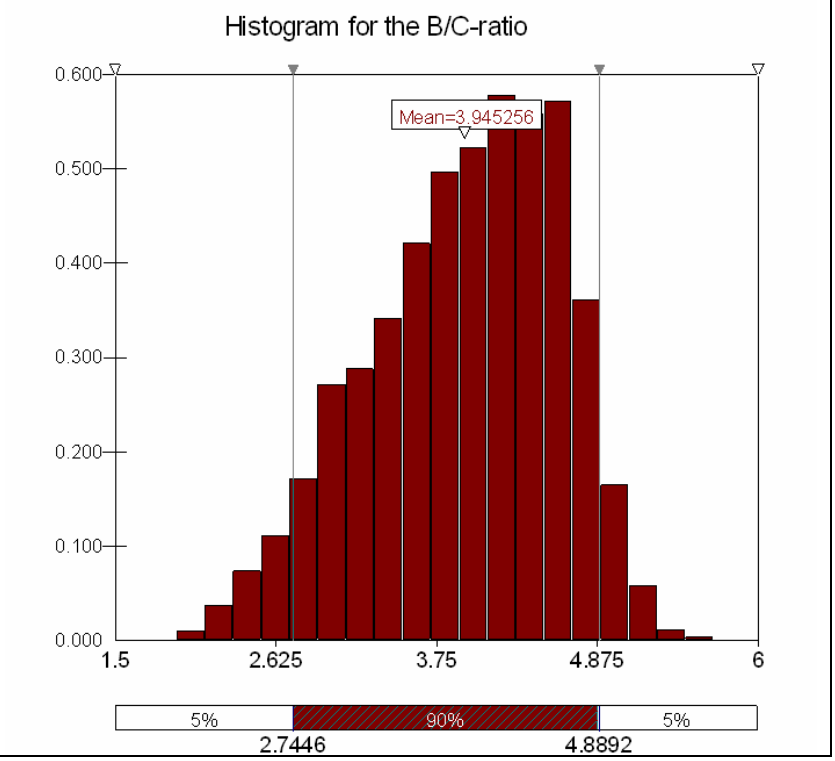


Figure 8-3: Result of the RA for scenario 1

The result shows, that the B/C ratio will stay in a profitable interval at all times. In the 90 % confidence interval the B/C ratio stays between 2.75 and 4.89 with a mean value of 3.95. The mode value is 4.31.

According to the risk analysis it is most likely that the project will be profitable. The risk analysis does not show any weaknesses in the parameters that can change this assumption.

Scenario 2

The distribution in Table 8-3 applied on scenario 2 delivers the results shown in Figure 8-4.

Minimum	2.259
5 % Fractile	3.154
Mean value	4.583
Mode (most likely value)	5.348
95 % Fractile	5.679
Maximum	6.467
Standard deviation	0.769

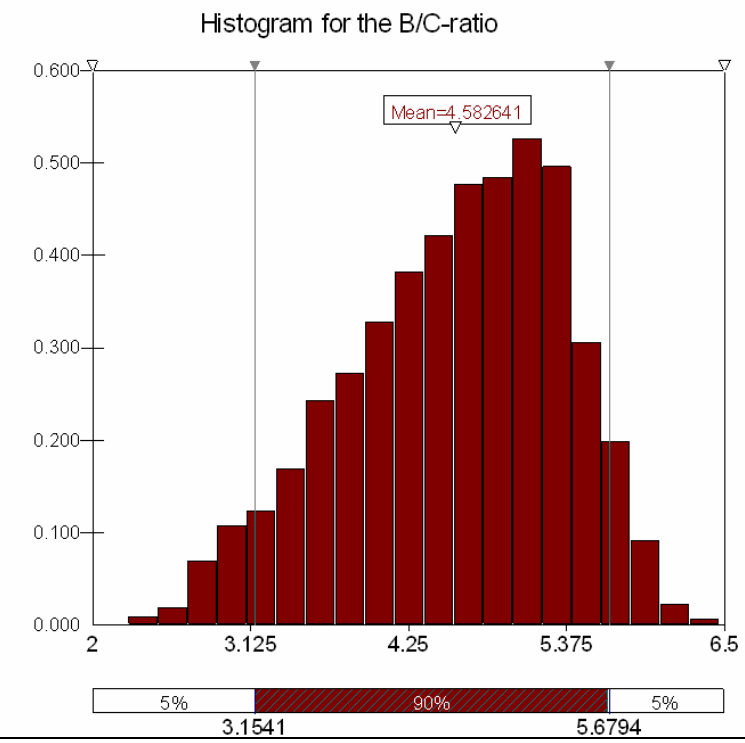


Figure 8-4: Result of the RA for scenario 2

As for scenario 1 the results of scenario 2 show that the B/C ratio will stay in a profitable interval at all times. In the 90 % confidence interval the B/C ratio stays between 3.15 and 5.68 with a mean value of 4.58. The mode value is 5.35.

The project will according to the risk analysis also be profitable in scenario 2, and it is seen that the change in the growth parameter has a large positive effect on the result.

8.6 Conclusions and recommendations

The analysis in COSIMA-ES-PORT shows that the construction of an intermodal terminal at Port of Esbjerg will be a very profitable economic project in both scenarios if the estimates with the high increase in cargo transportation are true.

The risk analysis does not point out issues that can change the statement, but it is essential for the project with a large increase in cargo transportation.

According to the analysis it is recommended that the project should be carried out.

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