



## **COSIMA-ES-PORT**

A new Decision Support Model for the handling of road/rail/cargo related impacts

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# COSIMA-ES-PORT

## A new Decision Support Model for the handling of road/rail/cargo related impacts

### *English summary:*

*This article describes the results of the research project – WP3 East-west, Interreg IIIB – concerning the development of a new composite decision model, COSIMA-ES-PORT, for the assessment of three pre-feasibility studies situated at the Port of Esbjerg: a road project, a railway project and a multimodal terminal. The three studies indicates that a new road connection to the Port of Esbjerg is a very profitable project due to large travel time savings, whereas a new railway connection is not economically viable. However, a new multimodal terminal is also a very profitable project.*

*The COSIMA-ES-PORT model showed some promising perspectives in the handling of the three pre-feasibility studies. Parameters such as cargo handling and ship related issues could with advantage be implemented in the decision model and forecasted similarly to road infrastructure impacts. Furthermore, the development of COSIMA-ES-PORT showed some promising perspectives with regard to the implementation of other means of transportation for composite decision model assessment.*

### *Dansk resume:*

*Denne artikel beskriver resultaterne af forskningsprojektet WP3 East-west, Interreg IIIB som omhandler udviklingen af en ny komposit beslutningsmodel, COSIMA-ES-PORT, som benyttes til evaluering af forundersøgelser af tre projekter ved Esbjerg Havn: et vejprojekt, et jernbaneprojekt og anlæggelsen af en multimodal terminal. COSIMA-ES-PORT indikerer, at en ny vejforbindelse til Esbjerg Havn vil være et meget rentabelt projekt pga. af store trafikale tidsbesparelser, hvorimod en ny jernbaneforbindelse ikke vil være rentabel. Ligeledes vil en ny multimodal terminal være et meget rentabelt projekt.*

*COSIMA-ES-PORT modellen viste ved behandlingen af de tre forundersøgelser en række lovende perspektiver. Parametre såsom fragthåndtering og skibsrelaterede spørgsmål kunne med fordel implementeres i beslutningsmodellen og fremskrives i lighed med vejinfrastruktur-effekter. Derudover viste udviklingen af modellen lovende perspektiver i henhold til implementering af andre transportformer for komposit beslutningsmodel vurdering.*

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Economic decision models have during the last decade been successfully implemented into the Danish road sector. The models provide the decision-makers with an economic viable foundation for making a sustainable decision as costs and benefits can be appraised over a long period of years. The increase in transport on sea has created a demand for ports and their surroundings to be expanded in order to handle the new large cargo volumes more efficiently. This creates a need for an evaluation methodology, which is capable of handling the new issues confronting the ports, and which can furthermore assess the impacts over a longer time period.

This issue has been dealt with in the Danish part of WP3: the East-west Interreg IIIB project. The main objective of the Danish part of WP3 was to perform and report three Danish pre-feasibility studies situated at the Port of Esbjerg by use of a, for the purpose developed, decision model COSIMA-ES-PORT.

The secondary objective was 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.

Preliminary studies of road and railway connections to the port of Esbjerg were conducted by the municipality and the port of Esbjerg<sup>1</sup>. These studies were used as input for the calculations in the pre-feasibility studies, so that the focus was not only on the effects of the investments, but also included innovative ways of handling uncertainties associated with the effects.

The activities in the East-West project fell 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

To test the methodology and gain knowledge and experience, the existing version of COSIMA-ROAD was modified to perform an extended pre-feasibility study of the road and rail connections to the port of Esbjerg. The adaptation utilised experience and was supplemented with an investigation of conditions of specific relevance for Port of Esbjerg and other similar ports. The outcome of the work is the COSIMA-ES-PORT version of the COSIMA-ROAD tool, which is, as a special feature, set up to handle impacts derived from a new multimodal terminal.

### The COSIMA-model

In 2003 the Danish Ministry of Transport released a manual for socio-economic analyses on transport issues<sup>2</sup>. 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. The further development, COSIMA-ES-PORT, was finished in the autumn of 2006.

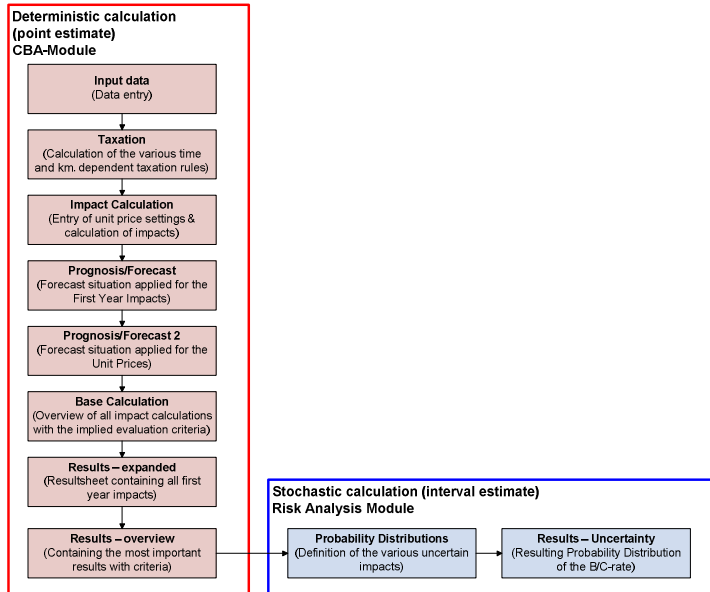


Figure 1: The module structure of COSIMA-ES-PORT illustrated by the various worksheets<sup>4</sup>

COSIMA-ES-PORT is an Excel based software model with a set-up consisting of a cost-benefit analysis (CBA) part and risk analysis (RA) part. The software model consists of 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, see Figure 1.

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).

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

To conduct a CBA, as performed in the COSIMA framework, it is necessary to obtain information from various 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 characterizes the parameters focused on in the risk analysis.

The COSIMA model examines selected parameters that are considered the most important for RA, and four types of uncertainty distributions are used within COSIMA according to the level of knowledge that the parameters are based upon. The distributions are from high to low level: Erlang (Gamma), Normal, Triangular and Uniform distribution, see Figure 2.

The COSIMA-ES-PORT software model has been designed as a combined approach in determining the feasibility of projects by use of both deterministic and stochastic approaches based on @RISK<sup>3</sup>. 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.

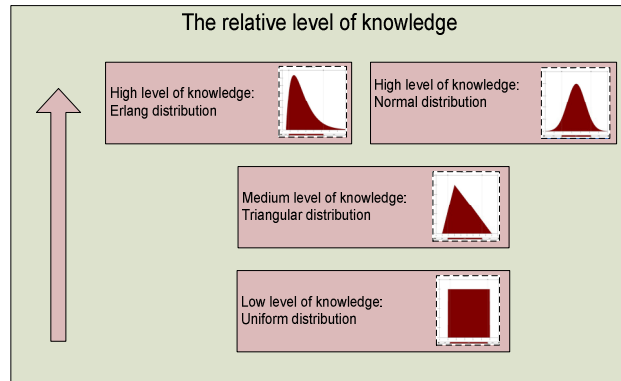


Figure 2: Probability distributions applied in COSIMA-ES-PORT<sup>4</sup>

### The process

In order to make COSIMA capable of handling a road project, a railway project and a multimodal terminal at the same time, it was necessary to identify all relevant impacts that needed to be included in the model, so that the set-up could be modified in a comprehensive way.

According to tradition within road appraisals, the road part was set to handle travel time savings, congestion, vehicle operating costs, changing traffic and in addition external effects including: accidents, noise, pollution and barrier effects. The railway part was only required to handle cargo volumes and the taxations attached to transportation on railway. Furthermore, three impact categories related to ships, cargo and staff were implemented with the additional sheets in the model, in such a way that it was made possible to add forecasts to the impacts and their unit prices.

Aside from the described impacts, the model also provides the decision-makers with an opportunity for including so-called strategic impacts into the assessment. Strategic impacts are non-monetary impacts that usually cannot directly be assigned with a value, but can be of great importance to the project and therefore need to be included in the assessment in a comprehensive way. This article will not deal with this issue, but more information can be achieved by contacting the authors.

### The decision model applied on the road case

Applied on a road case the COSIMA-ES-PORT model uses its basic road appraisal functions, and the inputs to the model were derived from the results of the preliminary study<sup>1</sup>, which concerns capacity issues for the existing and the planned new roundabouts along the by-pass road in the city of Esbjerg.

As for most other road projects the largest impact for the current study is also the travel time savings; in this case particularly for heavy vehicles, as about 25 % of the traffic on the by-pass road in Esbjerg consists of these. By applying different forecasts for the growth in traffic, COSIMA-ES-PORT is capable of assessing two different scenarios, describing respectively a high and a low prognosis for the traffic.

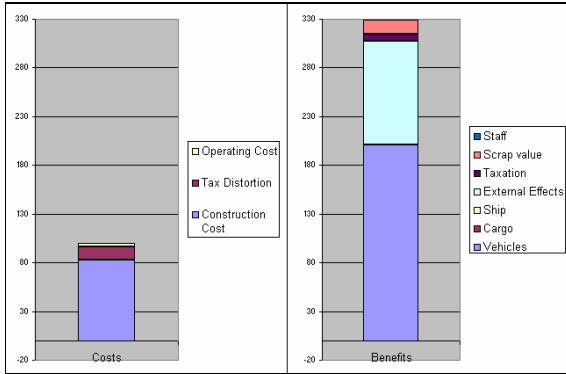


Figure 3: Scenario 1, low prognosis

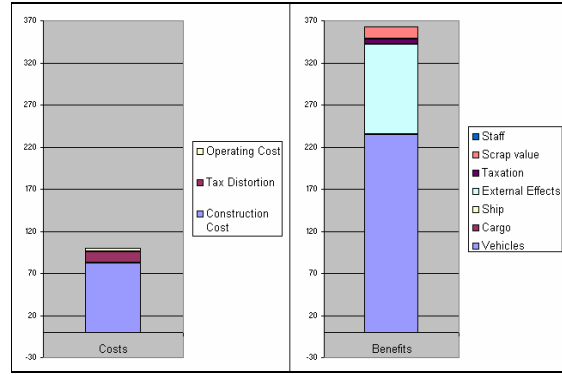


Figure 4: Scenario 2, high prognosis

As seen in Figure 3 and Figure 4, which show the results of the deterministic calculations for the scenarios in COSIMA-ES-PORT, in both scenarios the benefits derived from the road project are much larger than the costs by constructing it, which makes it economically viable. The main part of the benefits is travel time savings for heavy vehicles and passenger cars, as an upgrade of the road will create a higher accessibility in the area.

Risk analysis (RA) is performed in order to determine how sensitive the project is to changes in the main impacts. The RA applies uncertainties on construction costs, travel time savings and accidents. The analysis is carried out identically for the two scenarios, and the results are seen on Figure 5 and Figure 6 as a 90 % confidence interval.

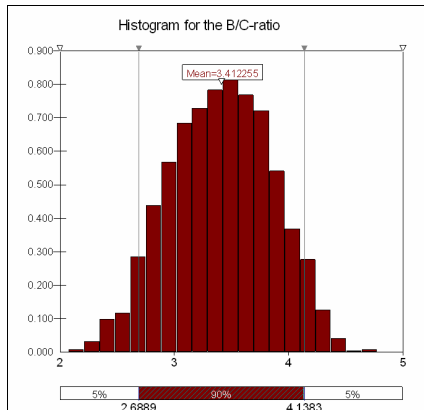


Figure 5: RA for low prognosis

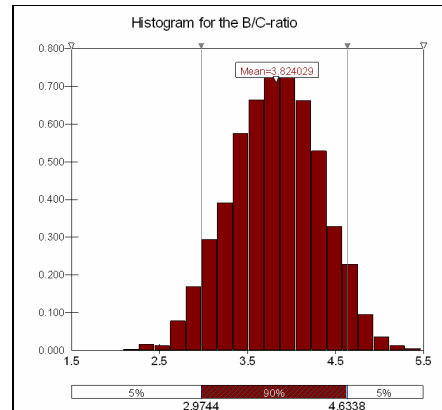


Figure 6: RA for high prognosis

The composite assessment in COSIMA-ES-PORT shows that the construction of a new road without doubt will be a profitable socio-economic project in both the scenarios applied. The RA with the applied distributions does not point out any alarming weaknesses in the project. However, the project is very sensible toward changes in travel time savings, but not to a degree where the profitability of the project is in danger.

### The decision model applied on the railway case

COSIMA-ES-PORT was, as described earlier, set up to handle impacts derived from cargo transportation by railway. The inputs concerning the rail connection at the Port of Esbjerg were, however, based on scanty information, but estimates provided by the Port, pointing out that a new railway connection would have a positive impact on the cargo transportation, were used as input to the model. A high and a low growth scenario, as described for the road case, were examined.

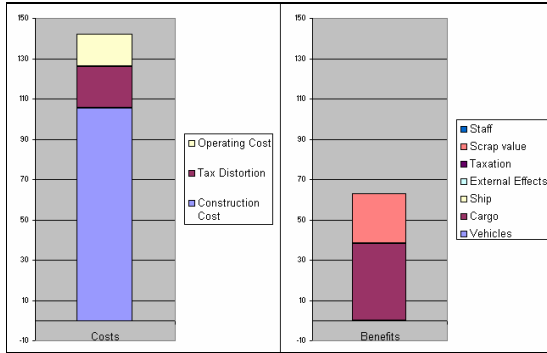


Figure 7: Scenario 1, low prognosis

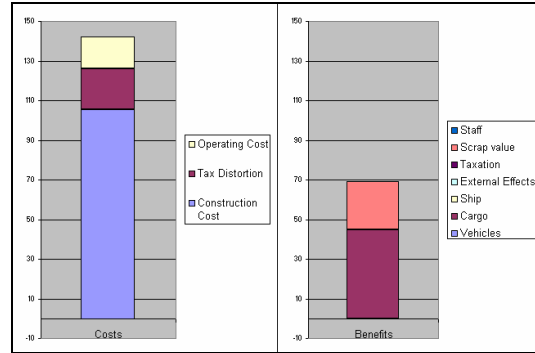


Figure 8: Scenario 2, high prognosis

Figure 7 and Figure 8 show the results of the deterministic COSIMA-ES-PORT calculations, and as can be seen, the benefits derived from the railway project are much smaller than the costs by constructing it. The main part of the benefits derives from the increase in containers transported by railway, but this is a relatively small posting compared to the construction costs, and as a result of this it will not be economically viable to implement the project.

The RA for the railway connection applies uncertainties on construction costs, operating costs and the cargo transportation on railway. The RA is carried out similarly for both scenarios, and the stochastic interval results can be seen on Figure 9 and Figure 10.

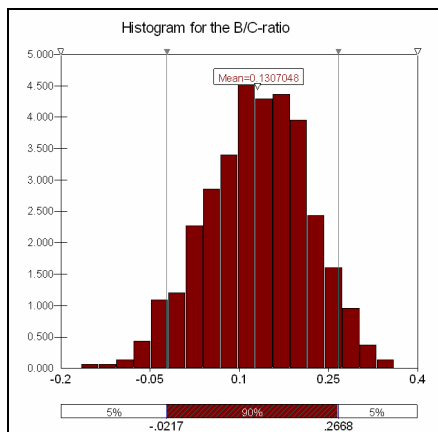


Figure 9: RA for low prognosis

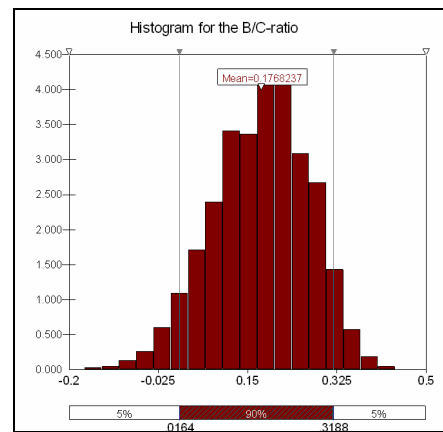


Figure 10: RA for high prognosis

The analysis in COSIMA-ES-PORT determines that the construction of a new railway connection to the Port of Esbjerg will not be a viable socio-economic project in either of the two scenarios, as the benefits, derived from the increase in transportation of cargo by railway, are much smaller than the high construction costs. The quantity of cargo transported by railway is estimated to be relatively small, as it is predicted that most cargo in the future will be transported on heavy vehicles. The RAs conducted on the scenarios show that the profitability of the project is very sensitive towards changes in the quantity of cargo transported on the railway, but that much larger cargo volumes are needed before the project comes close to being profitable.

### The decision model applied on the multimodal terminal case

The COSIMA-ES-PORT model was set up to handle shipped cargo volumes in detail, and provided with input estimated by the Port of Esbjerg describing the expectations to the increase in cargo transportation as a result of a new multimodal terminal.

A scenario analysis with two different growth scenarios was conducted: a scenario where the impacts were assumed to follow a regular growth (scenario 1) and a scenario where the impacts, as a result of the multimodal terminal, experience a sudden growth after a few years with regular growth.

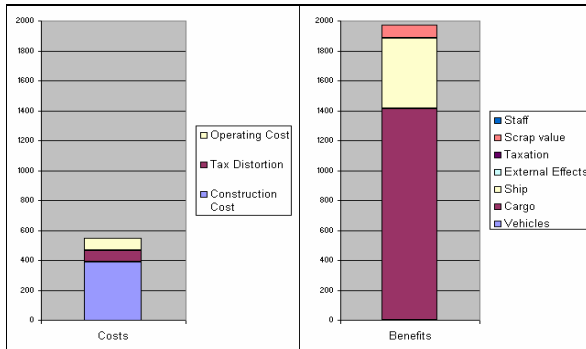


Figure 11: Scenario 1, regular growth

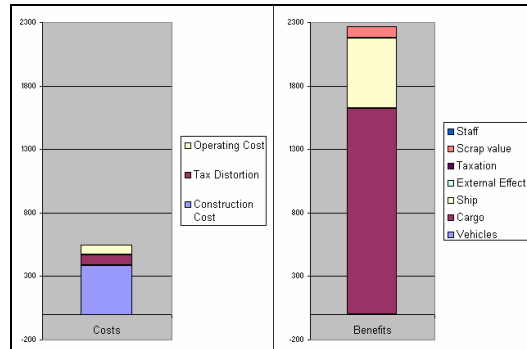


Figure 12: Scenario 2, sudden growth

Figure 11 and Figure 12 determine that the benefits derived from the project are much larger than the costs by constructing it in both scenarios. The main part of the benefits comes from the cargo transportation – mainly containers and trailers – but ship taxation also represents a large posting.

The RA is conducted with uncertainties on construction costs, operating costs and the cargo related impacts. The two scenarios are again handled similarly, and the result is shown on Figure 13 and Figure 14 as a stochastic 90 % confidence interval, which implies the plausible results.

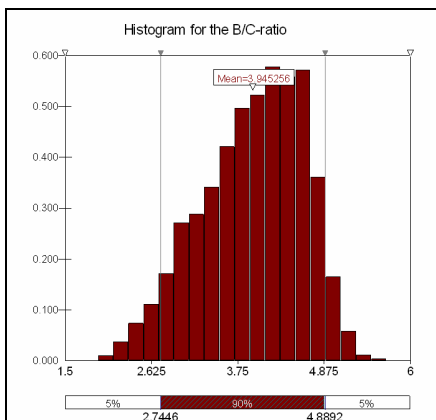


Figure 13: RA for regular growth prognosis

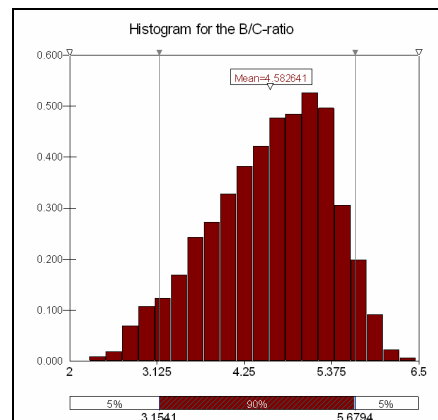


Figure 14: RA for sudden growth prognosis

The COSIMA-ES-PORT appraisal shows that the construction of a multimodal terminal will be an economically very profitable project in both scenarios if the expected high increase in cargo transportation is sustainable.

The RA results on Figure 13 and Figure 14 do not point out any strong weaknesses that can change the above statement, but it is essential for the project that a large increase in cargo transportation happens.

### Perspectives

The COSIMA-ES-PORT model shows some promising perspectives in the handling of the three pre-feasibility studies described, as the assessments provide the decision-makers with a sustainable foundation for their long-term decision making.

The appraisals show that parameters such as cargo handling and ship related issues with advantage can be implemented in a decision model and forecasted in the same way as road infrastructure impacts. Furthermore, the development of COSIMA-ES-PORT shows some promising perspectives with regard to implementing other means of transportation into a composite decision model, as this type of model is very flexible.

The COSIMA-ES-PORT model is capable of handling different issues in its framework and can thereby be a very useful tool for project assessment on many different levels. The model is developed for the use on port related projects, however, its foundation as a road appraisal model also makes it appropriate then for assessing economic consequences of road projects. Furthermore the model can assess issues related to transportation of cargo on railway, and thereby be of use for companies operating in this area.

The model is multi-applicable and can be adapted to all issues where an assessment of the economic consequences over a longer time period is needed. The work in this WP3, Interreg IIIB project has shown that many restrictions, faced by more conventional models, can be overcome by using the presented modelling approach.

## References

1. COWI (2006). Road and rail connection to port of Esbjerg, January 2006 (in Danish)
2. Danish Ministry of Transport (2003). *Manual concerning socio economic analysis – applied methodology in the transport sector*, June 2003 (in Danish).
3. Palisade Corporation (2002). *@RISK – Risk Analysis and Simulation Add-In for Microsoft Excel*, Version 4.5, Newfield USA.
4. Salling, K. B., Jensen, A. V. & Leleur, S. (2004). COSIMA-VEJ version 2.0 – Software for Project Appraisal in the Danish Road Sector. *Manual developed by Centre for Traffic and Transport in co-operation with The Danish Road Directorate* (In Danish).