Contract No. FP6-2002-SSP-1/502481

HEATCO

Developing **H**armonised **E**uropean **A**pproaches for **T**ransport **Co**sting and Project Assessment

Specific Support Action

PRIORITY SSP 3.2: The development of tools, indicators and operational parameters for assessing sustainable transport and energy systems performance (economic, environmental and social)

Deliverable 6
Case Study Results

Due date of deliverable: 28 February 2006
Actual submission date: 18 September 2006

Start date of project: 29 February 2004 Duration: 27 months

Lead contractor for this deliverable: IER, Germany

Final

Table of Contents

List of Tables

List of Figures

List of Abbreviations

BCR	Benefit-Cost (B/C) Ratio
CBA	Cost Benefit Assessment
FYRR	First Year Rate of Return
GWP	Global Warming Potential
HGV	Heavy Goods Vehicle
IPA	Impact Pathway Approach
IRR	Internal Rate of Return
LGV	Light Goods Vehicle
NPV	Net Present Value
PDFH	Passenger Demand Forecasting Handbook (UK)
PPP	Purchasing Power Parity
PVB	Present Value of Benefits
PVC	Present Value of Costs
RNPSS	Ratio of NPV and Public Sector Support
VOC	Vehicle Operating Costs
VSL	Value of a Statistical Life
VTTS	Value of Travel Time Savings
WTP	Willingness to Pay
YOLL	Years of Life Lost

0. Summary

The purpose of this Deliverable is to test the appraisal methodology for major transport investments developed in the HEATCO project (see Deliverable 5 "Proposal for Harmonised Guidelines"). Case studies on four TEN-T projects were selected, the HEATCO methodology applied and compared with the national methodologies and outputs. The outcome can be judged as positive, since the HEATCO methodology was successfully applied in all four cases. No major difficulties were reported on scientific, methodological or technical problems related to the application of HEATCO.

The most important differences between national and HEATCO guidelines are:

- Market prices used in national appraisal vs. factor costs recommended by HEATCO,
- the choice of the social discount rate and
- the duration of the appraisal period.

An analysis of the case study outputs reveals that the Value of Time plays a dominant role in the appraisals. For the road projects roughly 80%-90% of the benefits are generated through travel time savings (VTTS) and reduced Vehicle Operating Cost (VOC). Quantifiable environmental costs and the reduction of accidents play only a minor role in the assessments.

A number of sensitivity tests were conducted. The research revealed that the social discount rate and the value of travel time savings VTTS are of particular importance for the outcome of the appraisals and thus sensitivity tests are highly recommended. Sensitivity tests for climate change and noise revealed only minor changes (<5%) of overall benefits. Test for accident values entailed no uniform results, which was mainly due to the different design of the researched projects. Another sensitivity test was carried out in order to compensate for the "optimism bias" often observed in past large scale transport projects. The tests revealed strong effects on the projects' cost efficiency that might put into question decisions based on data that include an "optimism bias".

To conclude, HEATCO has developed a feasible methodology, which does not only reflect the state of the art, but has proved as well to be applicable in practice. Recommendations given on the methodology, the guidance values and the sensitivity tests are valuable and ready to be used in practice.

However, some questions outside the scope of HEATCO remain to be addressed in future research projects, such as the estimation of future transport volumes, the ascertainment and valuation of induced traffic, and the design of transport models.

1. Objectives and description of Case Studies

Transport investments on the Trans European Network (TEN) level are usually of large scale and thus require thorough appraisals. The methodology for these investments needs to be consistent, reflect the state of the art and be feasible in its application. HEATCO had the task to develop a harmonised European approach towards transport appraisals that fulfils these requirements. The recommendations were developed and compiled in Deliverable 5[1].

Additionally, in this Deliverable 6, four case studies in Europe were selected, with the objective to apply the harmonised guidelines on TEN-T infrastructure projects in order to

- demonstrate that the proposed HEATCO methodology is workable and meets its intended objectives,
- compare the HEATCO methodology with existing practice and
- explore the changes in project ranking/selection if HEATCO methodology would be applied.

For this purpose four projects which are part of the TEN-T network (Van Miert List), were considered:

- United Kingdom: A120 Stansted to Braintree
- Denmark/Germany: Fixed link across the Fehmarn Belt (road/rail bridge)
- Greece: Skarfia Motorway
- Italy: New rail freight link between Bussoleno and Torino

Figure 1 gives an overview of the projects covered in the case studies. With this combination of case studies, projects from the South and North/West of Europe are covered as well as road and rail transport. Furthermore projects in operation and in the planning stage are included.

United Kingdom:
The improvement of the A120 between Stansted and Braintree was named on List 0 of TEN-T projects, which implies highest priorities. Appraisal was carried out in the 1980s and the two lane trunk road was opened in 2004. The new road passes largely through agricultural area. The old road, a single carriageway was downgraded as a local road (B)

Denmark/Germany:
The fixed link across the Fehmarn Belt, an estuary in the Baltic Sea between Denmark and Germany, consists of a cable stayed bridge with 4 road lanes and two railway tracks. The assessment was done in 2004, the project not yet realised. The second project alternative, presented in the original appraisal was a tunnel link, which shall not be part of this study. Since the project concerns two countries, Denmark and Germany, the assessment for both countries are presented in order to compare the difference between the original approach and HEATCO.

[1] Bickel, P., Friedrich, R., Hunt, A., De Jong, G., Laird, J., Lieb, Chr., Lindberg, G., Mackie, P., Navrud, S., Odgaard, Th., Shires, J., Tavasszy, L. (2005): Proposal for Harmonised Guidelines. HEATCO (Developing Harmonised European Approaches for Transport Costing and Project Assessment) Deliverable 5. Institut für Energiewirtschaft und Rationelle Energieanwendung, Universität Stuttgart.

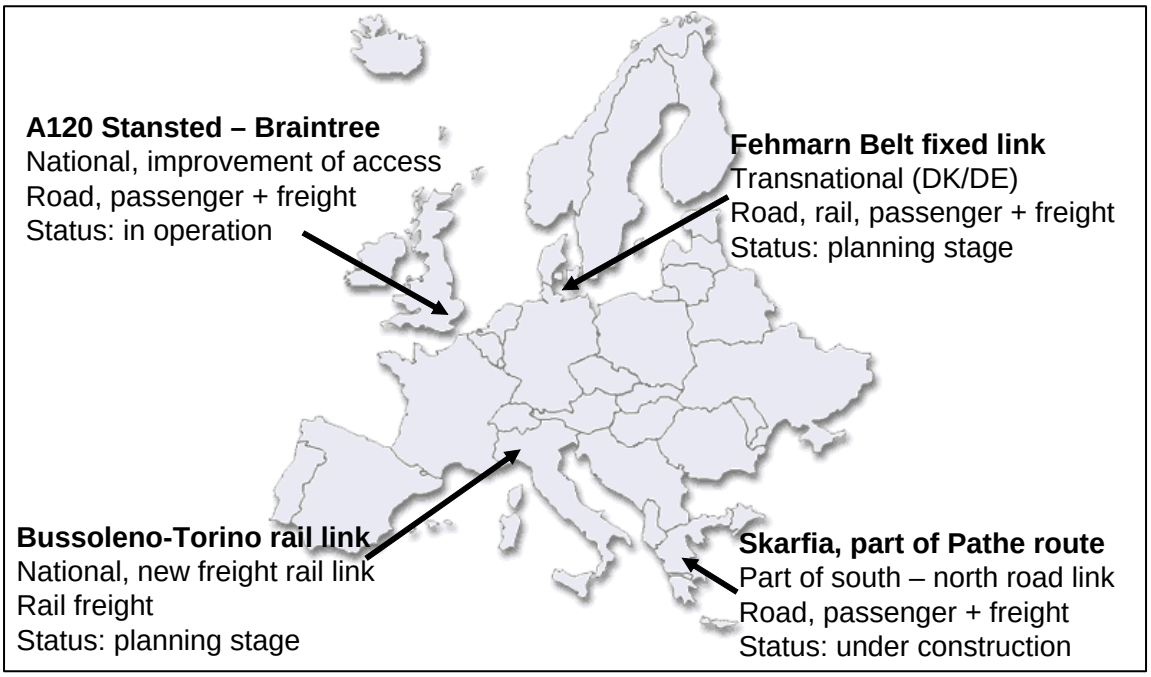

Figure 1: Overview of TEN-T projects covered in the case studies

Greece:
The Skarifa Motorway links the port of Patras, one of the biggest ports in the Mediterranean, with the northern boundaries. The project consists of an upgrading of the existent motorway on a total length of 17.5 km. For this project, the HEATCO assessment methodology was applied and compared to Greek standard methodologies.

Italy:
The project comprises the construction of a new freight link avoiding the agglomeration of Torino using a newly constructed by-pass of 45 km named "Gronda". The by-pass will improve trans-alpine freight transport from Lyon through the "Tunnel de Chartreuse" to Milan and Navarra. The project is related to the TEN-T network (Corridor n. 6, "Mixed railway line Lyon-Trieste/Koper-Ljubljana-Budapest", included in the Van Miert List 1) and is part of a wide investment program focusing on the rail node of Turin.

2. Overview of Case Study results

The Net Present Value (NPV) is the most important element of CBA as it informs us of the total economic impact of the project. Another important value estimated in the Case Studies is the Benefit-Cost Ratio (BCR), which is used for project ranking and selection. Table 1 compares the results using the HEATCO recommendations to those applying country specific 'national' assessment methods. HEATCO presents its data with and without adjustment of prices by purchasing power parities (PPP). This does not affect the BCRs, because all cost and benefit elements in the appraisal are multiplied with the PPP adjustment factor.

The UK national approach leads to higher benefits (and thus a higher NPV) compared to HEATCO, which mainly results from the longer appraisal period and the use of market prices instead of factor costs. In general the UK and HEATCO approaches for the treatment of the main cost and benefit items are either equivalent or similar. .

The comparison of the Danish appraisal with the HEATCO approach shows that both result in a comparable outcome. Using the HEATCO methodology for the appraisal of the Fehmarn Belt project results in a higher BCR compared to the national assessment method. If the NPV is compared, HEATCO appraisals are 25-50% higher, than the original assessment. This can be explained by higher Values of Time (+10%-30%) combined with a lower estimation of costs (-20%-30%). This compensates the shorter HEATCO appraisal period and the use of factor prices in HEATCO.

In Greece no common assessment methodology exists. Thus consultants employ well tested methods from other countries and apply commonly used values. Therefore, no comparison can be made between national and HEATCO methodology. In the Italian Case Study, it has not been possible to carry out a full-fledged CBA analysis and the case study focused on the assessment of accident and environmental costs.

Table 1: Overview of BCR and NPV in the case studies[a)]

Approach	UNITED KINGDOM	DENMARK	GREECE
Net Present Value			
1. HEATCO	547	7878	153
2. HEATCO (PPP)	487	6531	195
3. National	947	5215	n/a
HEATCO vs. National	-42%	51%	
HEATCO PPP vs. National	-49%	25%	
Benefit Cost Ratio			
1. HEATCO	3.4	2.4	2.7
2. HEATCO (PPP)	3.4	2.4	2.7
3. National	3.8	1.7	n/a

[a)] Italian case study not included, because not all relevant items were available for calculating NPV or BCR

Figure **2** shows how the benefits generated by the Case Studies using the HEATCO PPP approach are distributed. A valuation without PPP adjustment produced a similar distribution. For the road projects in UK and Greece, the vast majority of benefits was generated through time savings (VTTS) and reduced Vehicle Operating Cost (VOC) (77%-86%). This underlines the major importance of the value of time for the overall outcome of the assessment.

This is not true for the Fehmarn Belt project, which generates large scale effects mainly through ticket revenues amounting to more than half of all benefits, while time savings and reduced VOC amount to 40% of all effects. The main difference in benefit distribution between the road projects and the Fehmarn Belt is the levy of bridge tolls, which is designed to generate the large benefits in order to compensate for the enormous financial costs. If this producer surplus for the railway and the bridge operators is subtracted from the Present Value of Benefits PVB, the share of benefits generated by VOC and VTTS rises above 90% and is thus comparable to the other road projects. It is worth mentioning that the deduction of the producer surplus generates large scale deficits using the Danish approach, while the HEATCO methodology computes a positive NPV. Thus according to HEATCO, the project would be feasible without bridge tolls and ticket revenues. The question arises, whether HEATCO overestimates user benefits..

According to Figure **2** environmental effects are negative in the UK but positive in Greece and Denmark ranging between -1% and +11% of all benefits. The reduction of accidents

contributes with 0 to +16% to the overall benefits. In the Danish project the increased number of accidents entails small disbenefits from the project.

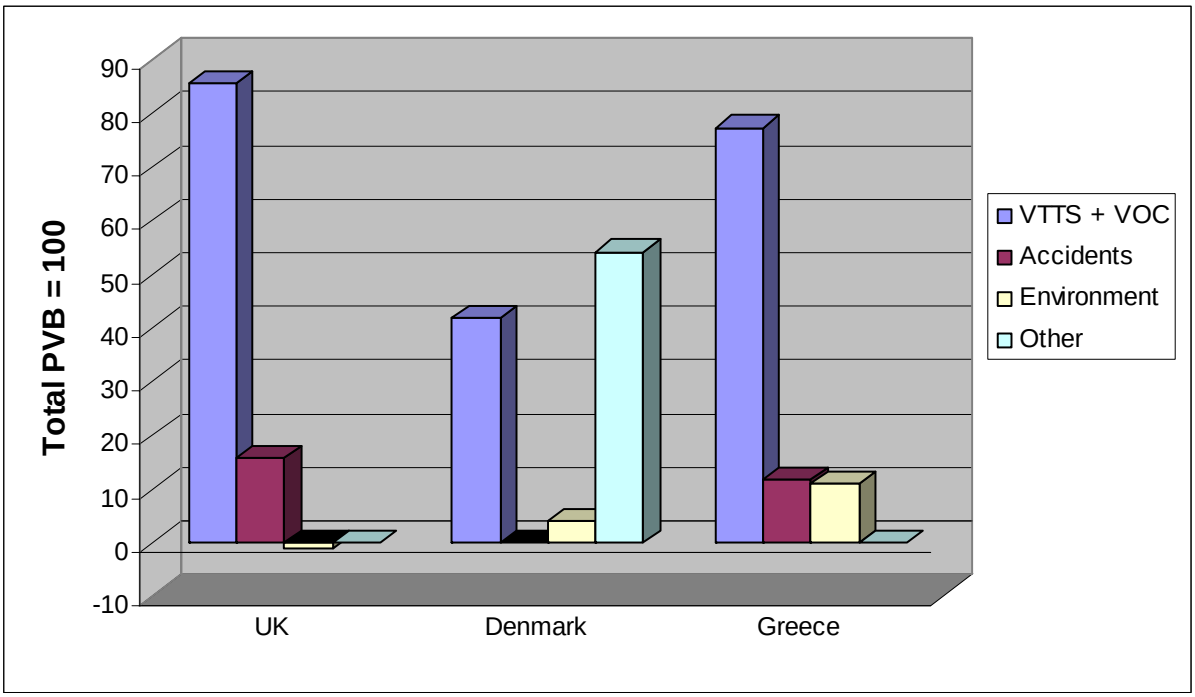

Figure 2: Distribution of benefits (PVB) in the Case Studies

On the basis of the experience of the Case Studies it can be said that the HEATCO methodology has been successfully applied and no major methodological or theoretical problems were detected. It shows a high degree of applicability in most of the countries, and represents a major advancement in the quality of appraisals for the others.

Another output of the Case Studies was the assessment of the impacts of the price adjustment using purchasing power parities. This adjustment was made in order to compensate for the variation in purchasing powers in the different countries. Table 2 shows that the effects of applying PPP are not to be neglected. Changes in NPV, induced by the application of PPP, range from -11% to +27%. The changes are in line with the PPP factors given in the following table.

Table 2: PPP adjustment factors in the Case Study Countries

Country	PPP adjustment factor	Change in NPV
Denmark	1.314	-17%
Greece	0.785	+27%
Italy	0.956	-
UK	1.124	-11%

3. The general approach

3.1 An overview of HEATCO and country approaches

Table 3 gives an overview o the general approaches in HEATCO and at the country level. The following text gives some explanation on the methodologies used.

Table 3: Overview of general assessment approaches

	HEATCO	UNITED KINGDOM	DENMARK	GREECE	ITALY
Appraisal period	Planning and construction + 40 years	60 years	50 years	No official guidelines	Planning and construction + 40 years
Discount Rate	National values of risk premium-free rate and sensitivity testing at 3%.	3.5% for the first 30 years, 3.0% for the remaining 30 years	6% DK 3% D = 4.5% Project	3% not defined, but commonly used	5%
Unit of account	Factor Costs	Market prices	Market prices	No official guidelines	Market prices. shadow prices
Currency	Euro	GBP	Euro	Euro	Euro
Marginal costs of Public Funds	MCPF = 1 and use a cut-off value of RNPSS = 1.5	MCPF =1 (all UK) (RNPSS = 1.5 in England only)	20% shadow prices	No official guidelines	Not considered
Scenario Definition	Reference scenario as "do-minimum"	Reference scenario as "do-minimum"	Reference scenario as "do-nothing"	No official guidelines	Reference scenario as "do-nothing"
Decision criteria	NPV, BCR, RNPSS	NPV, BCR	NPV, BCR, IRR	No official guidelines	NPV, IRR
Treatment of future risk and uncertainty	Sensitivity analysis at a minimum, Monte Carlo simulations as a more sophisticated approach.	UK provides less prescriptive advice and just recommends undertaking a risk analysis.	The robustness of the result was assessed on the basis of a number of sensitivity and risk analyses.	No official guidelines	Sensitivity analysis
Equity issues (inter-generational)	Winners and losers tables at a minimum, distributional matrices as a more sophisticated approach.	Disaggregation of impacts between stakeholders categories and modes to identify winners and losers	No official guidelines.	No official guidelines	No disaggregation of impacts between stakeholders categories.
Treatment of indirect socio-economic effects	Qualitative assessment at a minimum. Use of Spatially Computable General Equilibrium Models when possible.	Framework approach to appraisal based around the five core objectives: environment, safety, economy, integration, accessibility. Wider economic impacts form a sub-objective of the economy objective	Qualitative assessment.	No official guidelines	Not included
Price Base	2002, constant prices, + PPP adjusted prices	2002	2003	2002	Constant prices

	HEATCO	UNITED KINGDOM	DENMARK	GREECE	ITALY
Treatment of values over time	Adjustment on the basis of national GDP growth rates (elasticity =1), except for global warming and VTTS (0.7)	GDP growth rates	GDP growth rates	No official guidelines	Not included

HEATCO

HEATCO recommends the following general principles:

1. Decision criteria. HEATCO recommends the use of NPV (net present value) to determine, whether a project is beneficial or not. In addition, depending on the decision-making context respectively the question to be addressed, BCR (benefit cost ratio) and RNPSS (ratio of NPV and public sector support) decision rules could be used.
2. The project appraisal evaluation period. HEATCO recommends the use of a 40 year appraisal period, with residual effects being included, as a default evaluation period. Projects with a shorter lifetime should, however, use their actual length. For the comparison of potential future projects, a common final year should be determined by adding 40 years to the opening year of the last project.
3. Factor costs should be the adopted unit of account. This requires measures expressed in market prices - which include indirect taxes and subsidies – to be converted to factor costs. Table 4 gives an indication on the Rate of indirect taxation on consumer expenditure in the Case Study countries. In the researched countries market prices are 18%-34% higher than factor costs.

Table 4:Average Rate of Indirect Taxation on Consumer Expenditure in 2002[2]

Country	Rate
Denmark	33.7%
Germany	18.3%
Greece	18.1%
Italy	17.1%
UK	21.3%

4. Treatment of future risk and uncertainty. For the assessment of (non-probabilistic) uncertainty, HEATCO considers a sensitivity analysis or scenario technique as appropriate. If resources and data are available for probabilistic analysis, Monte Carlo simulation analysis can be undertaken.
5. Discounting. It is recommended to adopt the risk premium-free rate or weighted average of the rates currently used in national transport project appraisals in the countries in which the TEN-T project is to be located. The rates should be weighted with the proportion of total project finance contributed by the country concerned. In lower-bound sensitivity analyses, in order to reflect current estimates of the social time preference rate, a common discount rate of 3% should be utilised. For damage occurring beyond the 40 year appraisal period (intergenerational impacts), e.g. for climate change impacts, a declining discount rate system is recommended.
6. Intra-generational equity issues. HEATCO recommends, at minimum, that a "winners and losers" table should be developed, and presented alongside the results of the

[2]http://europa.eu.int/comm/eurostat/newcronos/reference/display.do?screen=welcomeref&open=/economy/gov/taxes&language=en&product=EU_economy_finance&root=EU_economy_finance&scrollto=197

monetised CBA. Distributional matrices for alternative projects might be created and compared amongst each other. Additionally stakeholder analyses should be undertaken as well. It is recommended to use local values to assess unit benefit and cost measures.

7. Non-market valuation techniques. If impacts in transport project appraisals cannot be expressed in market prices, but are potentially significant in the overall appraisal, HEATCO recommends that – in the absence of robust transfer values – non-market techniques to estimate monetary values should be considered. HEATCO recommends that the choice of technique used to value individual impacts should be dictated by the type of impact and the nature of the project. However, Willingness to Pay (WTP) measures is preferable to cost-based measures. Values should be validated against existing European estimates.
8. Value Transfer. Value transfer means the use of economic impact estimates from previous studies to value similar impacts in the present appraisal context. Value transfers can be used when insufficient resources for new primary studies are available. The decision as to whether to use unit transfers with income adjustments, value function transfer and/or meta-analyses will depend on the availability of existing values and experience to date with value transfers related to the impact in question.
9. Treatment of non-monetised impacts. HEATCO recommend, at a minimum, that if impacts cannot be expressed in monetary terms, they should be presented in qualitative or quantitative terms in addition to evidence on monetised impacts. As far as possible, impacts should be expressed in both physical and monetary terms. If only a small number of non-monetised impacts can be assessed, sensitivity analysis may be used to indicate their potential importance. Alternatively, non-monetised impacts may also be included directly in the decision-making process by explicitly eliciting decision maker's weights for them vis-à-vis monetised impacts.
10. Treatment of indirect socio-economic effects. HEATCO recommends that if indirect effects are likely to be significant, an economic model, preferably a Spatially Computable General Equilibrium (SCGE) model, should be used. Qualitative assessment is recommended, if indirect effects cannot be modelled due to limited resources (high costs for the use of advanced modelling), insufficient availability of data, or lack of appropriate quantitative models or unreliable results.
11. Marginal Cost of Public Funds. Our recommendation is to assume a marginal cost of public funds of 1, i.e. not to use any additional cost (shadow price) for public funds. Instead, a cut-off value for the RNPSS of 1.5 should be used when applying decision criteria.
12. Producer Surplus of Transport Providers. HEATCO recommends to estimate (changes in) the producer surplus generated by changed traffic volumes or by the introduction and adjustment of transport pricing regimes.
13. Accounting procedures. a) HEATCO recommends to convert all monetary values into € with a price level for a fixed year. In HEATCO Deliverable 5, monetary values are given as €2002, i.e. with 2002 as base year. However, the monetary values should be adjusted with the Purchasing Power Parity (PPP) as explained in Annex B of HEATCO D5, which also contains a table with PPP adjustment factors. However, these factors are only available for past years, whilst future PPP factors are likely to change as the economic growth rates differ amongst countries. As it is assumed, that income and prices grow faster in EU countries with currently low income, PPP factors will tend to converge closer to 1 in the future. Therefore, HEATCO recommends that two calculations are made – one with and one without PPP adjustment – assuming that the true value will lie between the two results. c) Monetary values, i.e. preferences, for non-market goods like reduced risk of getting ill or reduced damage to the environment will increase with increasing income; thus

HEATCO recommends increasing monetary values based on GDP growth – a table with possible country-specific GDP growth is given in Annex B of HEATCO D5 .

14. Up-dating of values. The unit values supplied in HEATCO D5 represent the state-of-the-art for the individual impacts addressed. Nevertheless, all values will be subject to change as new empirical evidence becomes available and methodological developments take place. As a consequence, HEATCO recommends that values are reviewed and up-dated on a regular basis e.g. after three years at maximum.
15. Presentation of results. As far as possible, impacts should be expressed in both physical and monetary terms. The results of the sensitivity analysis and the non-monetised impacts should be reported together with the central monetised results.

United Kingdom

There are a number of similarities and differences between the HEATCO and UK approaches. The key general approach differences that have been applied to the case study example are:

- the use of a 60 year appraisal period
- the presentation of values using market prices
- the presentation of the values using £ sterling.

A considerable impact on the assessment had the transformation of market prices to factor prices. The conversion used for the UK (2002 price base) was 1.212. The social discount rate in the UK amounts 3.5% for the first 30 years of the project, the remaining 30 years are discounted at 3.0%.

Denmark

A comparison of the general principles for conducting CBA used in the original assessment (Danish guidelines) and the recommendations made in HEATCO shows quite substantial differences. Most important ones:

- In line with the national Danish guidelines a discount rate of 6% was applied in the original assessment, whereas HEATCO recommends using an average of the discount rates used in the countries in which the project is to be located. The project concerns two countries Denmark and Germany, that uses a discount rate of 3%. Hence the HEATCO assessment is based on a discount rate of 4.5%.
- The original analysis referred to market prices whereas HEATCO recommends referring to factor costs. In Denmark factor costs are 34% cheaper than market prices.
- A shadow cost of 20% was applied for public funds in the original assessment, whereas HEATCO recommends not using shadow pricing.
- The original assessment was based on a project appraisal evaluation period of 50 years (i.e. planning and construction phase plus 50 years of operational phase), whereas HEATCO recommends using 40 years.
- The Danish guidelines recommend to use an inter-temporal elasticity to GDP per capita growth of 0 (i.e. unit values are constant over time), whereas the HEATCO recommends using a default inter-temporal elasticity to GDP per capita growth of 1.0 (with a sensitivity test of 0.7).

Greece

A common methodology for the evaluation of transport projects doesn't exist in Greece, although independent studies, for other projects, have been carried out utilizing different methodologies. Therefore, the author of the Greek Case Study considered it preferable to apply HEATCO guidelines in Greece in order to establish a consistent assessment methodology.

The Greek Case Study used the following features for the assessment: The appraisal period of the original project is 40 years, with 2006 as the starting year and 2045 as the closing one. The discount rate used in the valuation of the project is 3%, which is common in the evaluation of projects currently in Greece. According to HEATCO values should be presented in factor costs, in terms of Euro and Euro PPP, while the price base will be 2002. The adjustment from market prices to factor costs amounts to 1.181. Equal to UK the difference between market prices and factor costs comprises roughly 20%.

In order to estimate the price base for future costs it is necessary to use the national GDP growth rate according to which unit values will change. Unit values do not require currency conversion since they are expressed in Euro. Nevertheless unit values should be expressed in purchasing power equivalents. The adjustment factor, to convert unit values expressed in Euro to Euro PPP, in Greece is 0.785 for the year 2002.

Italy

In Italy a methodology for the appraisal of rail projects has been issued (and recently updated) by the rail infrastructure manager RFI. The main differences compared to the HEATCO approach are the following:

- In Italy a discount rate of 5% is used in transport appraisals.
- As a general rule market prices are applied in Italy. In order to derive economic values from financial values, accounting/shadow prices are estimated.
- In Italy the reference scenario is defined as "do-nothing".
- For the overall economic assessment the NPV and the IRR are calculated, while the BCR is not used as an indicator.
- For the treatment of future risks and uncertainty a sensitivity analysis is usually conducted.
- With regard to the inter-generational and social equity issues no disaggregation of impacts between stakeholder categories is foreseen in the Italian methodology.
- No treatment of indirect socio-economic effects is included.
- A treatment of values over time is not included in the Italian methodology.

3.2 Sensitivity testing of the Social Discount Rate

The sensitivity tests in all Case Studies demonstrate that the choice of the social discount rate has a tremendous impact on the outcome of the C/B assessment. Figure 3 depicts the results of the sensitivity test made for this Deliverable. It depicts the changes in the Net Present Values (NPV) compared to a discount rate of 3%. E.g. in Greece a discount rate of 4% decreases the NPV by 31% compared to a discount rate of 3%. In the case of a discount rate of

6% the NPV decreases by 73%. This implies a change in the Greek BCR from 2.7 to 1.4. Even if a small change in discount rate (+0.5%) is assumed, as in the case of the UK, the overall NPV will decrease by 19%.

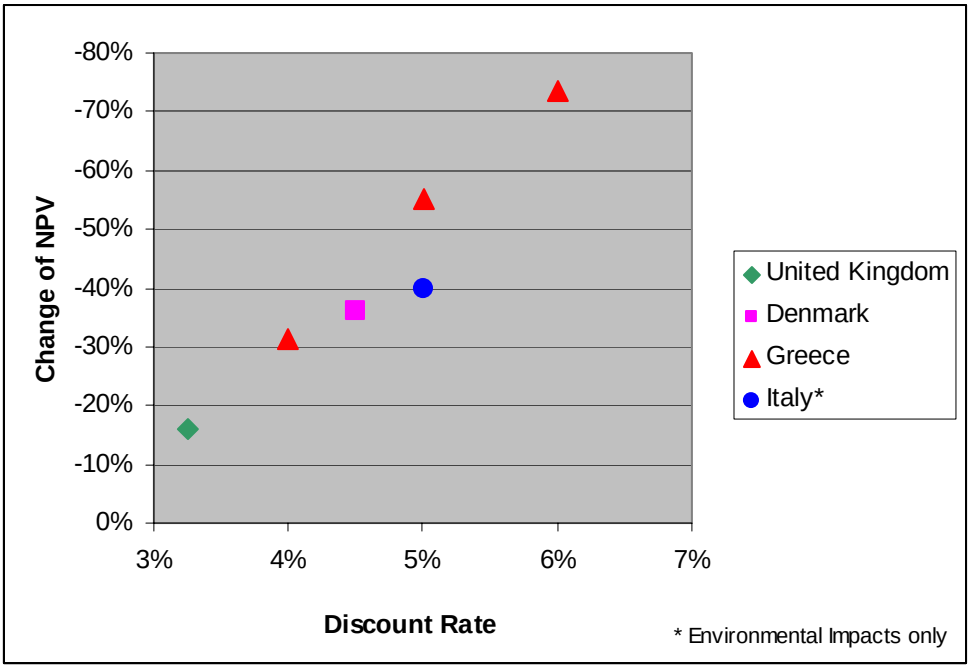

Figure 3: Change of NPV compared to a discount rate of 3%

Thus, the sensitivity tests of the discount rates show very clearly, that the choice of the discount rate can influence the overall results of the calculation tremendously. Therefore, HEATCO recommends to use national values and conduct sensitivity test at a discount rate of 3%.

3.3 Other general sensitivity tests

The Danish Case study conducted other sensitivity tests that go beyond variations for the different cost components, which are presented in Figure 4. One of the important assumptions is the growth of the entire economy and – related to that – the assumed growth of the transport volume. Sensitivity calculations were done, assuming a 50% increase or decrease of the original values. Growth of GDP has an impact on the Present Value of Benefits with an elasticity of roughly 0.2, i.e. a 50% higher growth rate will increase benefits by 10%. Since the project assessment is extremely dependant on the traffic volume, the elasticity of the growth rate in transport is much higher. The Danish case study reveals an elasticity of 0.4 to 0.5. Remarkably, a decrease of the growth rates results in a comparatively smaller reduction of overall benefits than an increase, i.e. the point elasticity for decreases is smaller, than for increases. This fact makes the appraisal more robust.

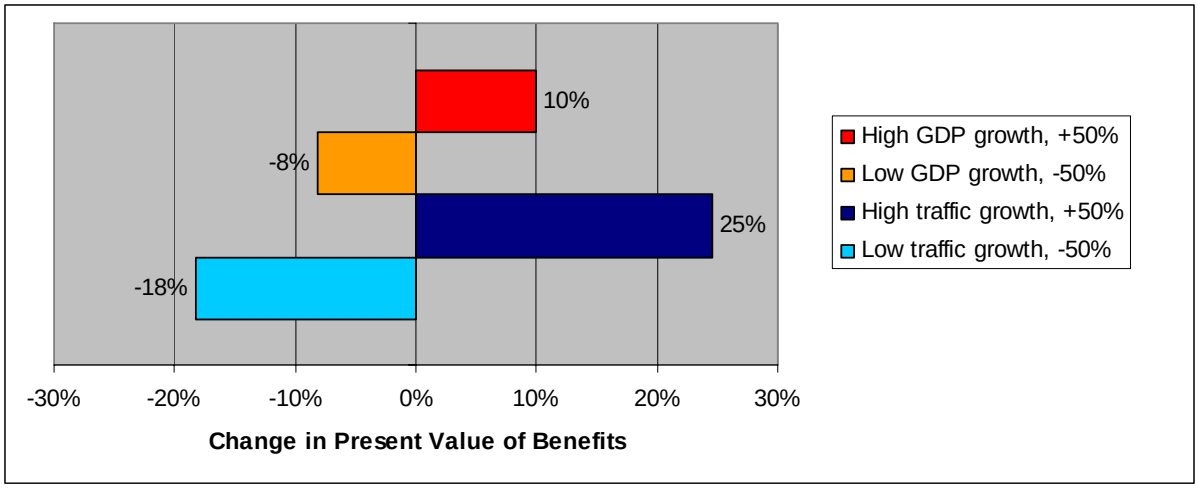

Figure 4: Sensitivity tests for the Fehmarn Belt Case Study

4. Value of time and congestion

The value of time and congestion is the most important cost figure ranging between 57% and 85% of overall benefits[3]. Table 5 summarises the present values of the benefits generated by time savings and by reduced vehicle operating costs[4]. The biggest share (80% - 92%) of the benefits is generated through time savings.

As mentioned above, in the UK the HEATCO guidelines lead to smaller values than the national approach due to the use of factor costs and HEATCO's shorter project appraisal period. For Denmark the opposite is the case: HEATCO's values of time are 20-50% higher than the original Danish assessment. In the Greek Case Study the HEATCO approaches produce benefits that double or even triple the values generated through the chosen assessment methodology. Explanation for the differences are given in the text below.

Table 5: Value of Travel Time Savings and Vehicle Operating Costs

[million Euro]	United Kingdom	Denmark	Greece
1. HEATCO	659	5,714	308
2. HEATCO (PPP)	587	4,752	392
3. National	1,086	4,714	138
HEATCO vs. National	-39%	45%	123%
HEATCO (PPP) vs. National	-46%	21%	184%

The HEATCO guidelines

The underlying principle in the VTTS (value of travel time savings) guidelines is that national values should be used wherever possible, providing that they have been developed using an appropriate methodology. If no such national values exist then the HEATCO 'fallback' values derived from an international meta-analysis of value of time studies should be used.

Table 6 sets out the HEATCO recommended minimum acceptable methodology for the valuation of time savings. At a minimum VTTS values should also be disaggregated between the three passenger types in passenger-work, passenger-non-work and commercial goods traffic. Though it should be noted that due to the very different functions served by the various transport modes when transporting freight, commercial goods traffic should be disaggregated by mode at a minimum.

Table 6: Recommended valuation methodologies by HEATCO

Trip Purpose	Minimum approach[1]	More sophisticated approach
Passenger – work	Cost saving	Hensher approach
Passenger – non-work	Willingness-to-pay	
Commercial Goods traffic	Cost saving	Willingness-to-pay
Note 1: In the absence of sufficient resources to survey VTTS using the minimum approach the mathematical relationships derived from the HEATCO VTTS meta-analysis should be used.		

[3] If for the Fehmarn Belt the producer surplus is deducted as explained on page 8
[4] The VOC had to be added, in order to make the Case Studies comparable

HEATCO also recommends treating walk, wait and interchange time differently from in-vehicle time and applying a constant unit value for VTTS (i.e. per hour, per minute, per second) should be applied irrespective of the size or sign of the time saving.

In the absence of National data, a default inter-temporal elasticity to GDP per capita growth of 0.7 with a sensitivity test at 1.0 (for all passenger travel purposes, work and non-work and also for commercial goods traffic) is recommended by HEATCO.

The effect of congestion on increased travel times should always be taken into account in an appraisal. More sophisticated approaches to capturing the impacts of congestion on reliability and overcrowding can however be considered.

Uncertainty in the values should be managed by undertaking sensitivity tests using the various unit values depending on the source of the value of travel time data, examining the sensitivity of the results to an inter-temporal elasticity to GDP/capita growth of 1.0 and identifying the proportion of the time saving benefits that are attributed to a time saving of less than 3 minutes.

United Kingdom

The UK approach is fully consistent with the HEATCO approach. Values of time for work and freight trips are valued using the cost saving approach and for non-work trips using willingness-to-pay. The level of disaggregation in the values provided in the UK guidance exceeds the minimum recommended, as does the treatment of congestion.

The major differences between the UK and HEATCO approaches are generated by the use of market prices and the longer assessment period in the UK guidelines. A smaller difference arises in the treatment in the growth of the values over time. HEATCO recommends an elasticity to GDP/capita growth of 0.7 for all trip purposes whilst the UK uses an elasticity of 0.8 for non-work and 1.0 for work trips. The other difference arises in the treatment of uncertainty in the valuations: HEATCO recommends specific sensitivity tests whilst the UK provides less prescriptive advice and just recommends undertaking a risk analysis.

The original appraisal work showed that under the new A120 road traffic speeds would reduce travel times by an average of 13 minutes during the peak period and 9 minutes during the inter peak. These increases appear large given the new road is 24km long and explain why the benefits from vehicle travel time savings are a large element of the PVB.

Denmark

Two main differences distinguish the Danish approach from the HEATCO proposal. Firstly, in Denmark market prices are used, while HEATCO suggests factor prices. Secondly, in Denmark non-working trips are valued as a share of the wage rate. This method contradicts the HEATCO approach, which recommends WTP values for non-work trips. Table 7 compares the Danish values with the HEATCO fallback values. The cost figures do not differ between public and private transport. However, HEATCO has significantly higher values for non-works trips, which are of major importance for the project appraisal[5]. This explains why the NPV given in Table 5 is higher for the latter approach.

[5] It can be assumed, that on the bridge the share of working and commuting trips is smaller and the share of leisure trips higher compared to national averages.

Table 7: Comparison of VTTS in Denmark

Category	Trip purpose/type of vehicle	Original assessment	HEATCO	
		All countries	Denmark	Germany
		Market prices	Factor costs	Factor costs
Passenger transport - passenger car	Work	36.5	31.2	22.0
	Non-work, commuting	8.1	11.2	6.0
	Non-work, other	4.9	9.4	6.0
Passenger transport - public transport	Work	36.6	31.3	22.0
	Non-work, commuting	8.2	11.2	6.0
	Non-work, other	4.9	9.4	6.0
Source: Danish Case Study, see Annex				

Some sensitivity calculations were done and the following results observed:

- If a discount rate of 6% were applied in the HEATCO assessment the net benefits of passenger travel time savings would be about the same for the two approaches.
- The inter-temporal elasticity to GDP per capita growth is of relatively little importance for the assessment.

However, a new value of time study is presently conducted in Denmark and in the future national Danish values should be used for all categories of VTTS.

Greece

The approach applied in the Greek case study differs significantly from HEATCO: the value of time is estimated per trip and per vehicle. A distinction is made between trips shorter and longer than one hour. The use of national VTTS values implies that the appraisal results should be sensitivity tested to VTTS values ±20% of those national values. The strong difference (double or triple, see Table 5) between HEATCO and the Greek approach can be explained by the very different valuation methodologies. Definitely, a sensitivity testing with 20% using the Greek method would not be sufficient to compensate for the difference compared to the HEATCO approach.

Italy

The information available from the modelling carried out on the Lyon-Torino provide some information about travel time savings on the corridor when the whole investment will be in place. However, no detailed information is available about the passenger and freight travel time savings related to the small section under study (the Torino-Bussoleno link). The apportionment of the total benefits to the section on the basis of the length of the section would entail a high degree of uncertainty and is therefore not carried out.

Sensitivity Tests

In order to test the sensitivity of the VTTS, the values were increased or decreased by 20%. The impacts of this test on the PVB are given in Figure 5. The general impression is that a change in the VTTS has considerable effects on the outcome of the appraisal. The strongest changes occur in the UK (15-20%). The smallest impacts are assessed in Denmark where the changes amount to 6%-7%. The sensitivity analysis demonstrates clearly, that it is imperative to test the sensitivity of the VTTS.

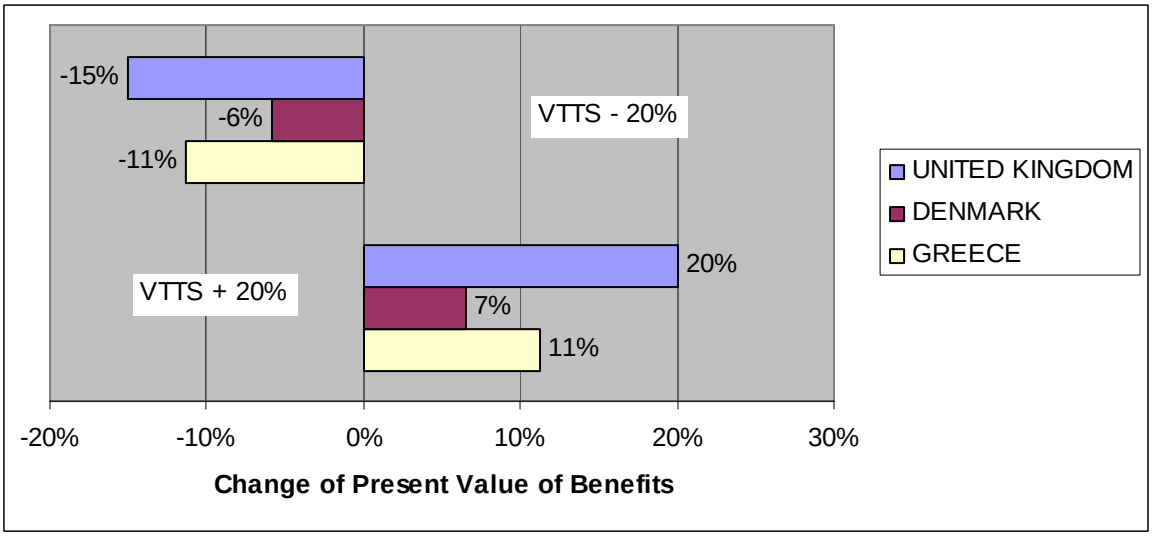

Figure 5: Sensitivity tests for the Value of Travel Time Savings

5. Value of changes in accident risks

Accident costs range between 0% and 16% of total benefits of the observed projects (compare Figure 2). Table 8 summarises the effects of the different assessments in accident risks. The major difference is the opposite sign of the assessments, which is due to the different type of the projects. While in the UK and Greece the new road will increase road traffic safety, in Denmark the shift from ferry to road transport will cause an increase of traffic accidents. However, the overall effects in Denmark are so small, that they can be neglected.

In the UK the assessment of accidents using the national approach results in significantly higher total costs compared to HEATCO[6]. This holds not true for Denmark, where HEATCO costs amount to double or even triple compared to the national method. In Greece and Italy no standard cost figures for accident assessments have been adopted and thus no comparison to national assessments can be made.

Table 8: PVB for accidents

[million Euro]	United Kingdom	Denmark	Greece	Italy
1. HEATCO	122	-13	28	26
2. HEATCO (PPP)	108	-16	36	27
3. National	200	-4	-	-
HEATCO vs National	-39%	225%		
HEATCO PPP vs National	-46%	300%		

The HEATCO Approach

HEATCO adopts a modified accident impact definition based on EUNET (Nellthorp et al. 1998)

- Fatality: death arising from the accident.
- Serious injury: casualties which require hospital treatment and have lasting injuries, but the victim does not die within the fatality recording period.
- Slight injury: casualties whose injuries do not require hospital treatment or, if they do, the effect of the injury quickly subsides.
- Damage-only accident: accident without casualties.

A pragmatic approach is chosen which assumes a 30 day period restriction for fatalities. As there is evidence for considerable under-reporting, HEATCO recommends correcting the available statistical data to include all fatalities due to accidents.

Underreporting of road accidents is a well recognized problem in official (road) accident statistics. Therefore, the official figures underestimate the true number of accidents. Based on a literature review, HEATCO concludes that underreporting of accidents is only relevant for road transport. HEATCO recommends applying the correction factors for unreported accidents.

[6] UK: appraisal period 60 years, market prices
HEATCO: appraisal period 40 years, factor cost),

The valuation of an accident can be divided into direct economic costs, indirect economic costs and a value of safety per se. HEATCO recommends using values as follows:

a) Value of safety per se: WTP for the safeguard of a human life based on stated preferences studies carried out in the country concerned.
b) Direct and indirect economic costs: cost values for the country under assessment.
c) Material damage from accidents: cost values for the average material caused by accidents in the country under assessment.

If such values are not available for a) and b) HEATCO provides appropriate values.

Since the uncertainties in estimating the value of safety per se are comparably large, HEATCO recommends carrying out a sensitivity analysis for this value. Based on European Commission (2005) it is recommended to use v/3 as lower boundary and v*3 as high boundary of the sensitivity analysis (with v = value of safety per se).

United Kingdom

UK assessments are nearly double compared to HEATCO, which is mainly due appraisal period and market prices as the accident methodologies and values between the UK and HEATCO are almost the same. The largest effect is caused by the appraisal period, which amounts to 60 years in the UK and 40 year using the HEATCO approach. Table 9 shows the differences in the number of casualties derived by the different approaches. The longer UK evaluation period entails 23% more fatalities and 36% more casualties. The remaining variation of costs can be explained by the difference between market prices and factor costs (roughly 20%) and the distortions due to exchange rates (Pounds and EURO).

Table 9: Effects of appraisal period on the number of casualties

Approach	UK Approach	HEATCO Approach
Appraisal Period	60	40
Fatalities	34	26
Serious Injuries	495	317
Slight Injuries	4188	2700

Denmark

The Danish accident impact definition is in line with the HEATCO definition. However, the Danish assessment of road safety is based on the number of accidents with passenger injuries. The value per road accident amounts to 293,000 Euro. If the HEATCO values are applied and adjusted for unreported accidents this value per accident amounts to 662,000 Euro. The value per fatality amounts to 1,160,000Euro/fatalitiy in the Danish appraisla compared to 2,200,000 Euro in the HEATCO guidelines. The change in the unit values explains the main differences in total accident costs, given in Table 8. However, even if the HEATCO guidelines are applied, the impact on total PVB is minor, since the change of the number of casualties is relatively low.

Finally it is important to notice that HEATCO recommends that values grow over time with GDP/capita, while the Danish guidelines recommend that values are constant over time.

Greece

Since no national assessment methodology is available in Greece, only HEATCO calculations were made and no comparison can be made.

Italy

For rail, the trend of the number of accidents observed over the last 10 years has been extrapolated. In order to account for the severity of the accident, the average rate of mortality and morbidity has been applied to the rate. The extrapolation of the number of accidents has been preferred to the direct extrapolation of the number of deaths and injured because the latter shows a more erratic behaviour, while the former shows a constantly declining trend. Following HEATCO recommendations, underreporting was assumed to be negligible for rail. It has to be highlighted that damage costs are not included in the analysis, due to difficulties in collecting the relevant data.

For road, national statistics on the number of casualties disaggregated at county level (county of Torino) have been used to estimate the accident rate, and corrected for underreporting as per HEATCO recommendations. Statistics on the number of injuries do not allow a distinction between severe and slight inuries.

In Italy no national cost parameters are available for the valuation of the value of safety per se and of the direct and indirect economic costs. Usually, the unit costs developed in INFRAS/IWW 2004 are applied for cost-benefit calculations of railways, which amount to 1.5 m Euro in 1998. If this value is adjusted for GDP/cap and PPP, the value of an Italian fatality amounts to 1.493 m Euro.

Sensitivity tests for accidents

The sensitivity of the Value of Safety Per Se is tested in Figure 6. For this purpose the values of safety are tripled or divided by three and the change of Present Value of Benefits PVB is compared. In Denmark the tests show no impacts at all. The reason is that the investments have practically no impacts on the number of accidents and casualties. For the remaining two countries, the reduction of Value Per Se to one third results in a 4%-7% decrease of the benefits. A tripling of the accident costs increases the PVB by roughly 20%. The changes induced by the latter test justify sensitivity calculations for the high accident values.

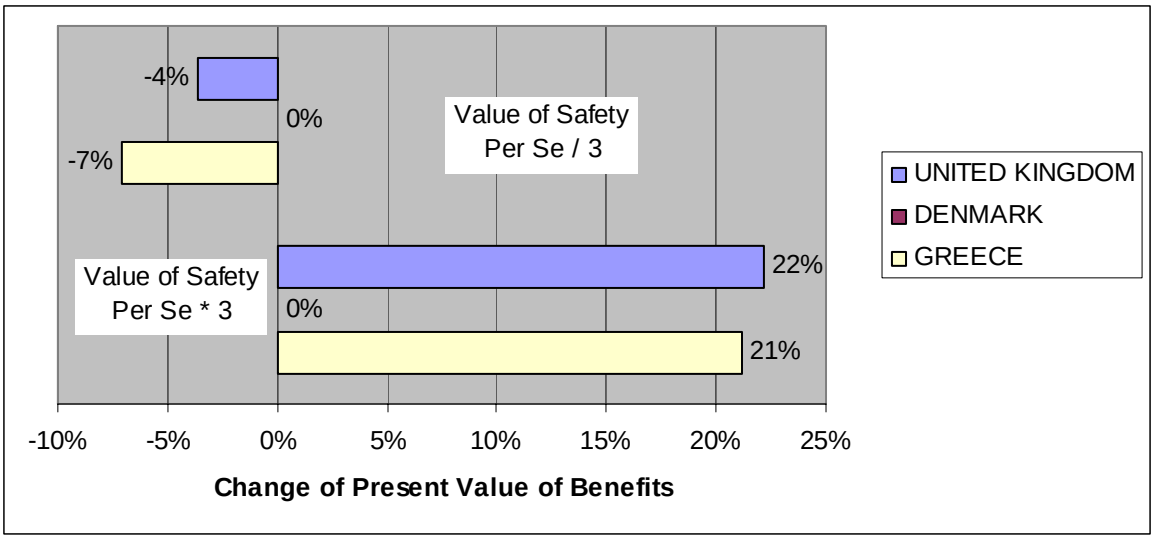

Figure 6: Sensitivity of the Values of Safety per Se

6. Environmental costs

Environmental costs range between -1% and 11% of total benefits of the observed projects (compare Figure 2). While in the UK and in Denmark impacts are below 5%, in Greece this share amounts to 11%. Quantified environmental costs comprise climate change, air pollution and noise. Table 10 gives an overview of the different HEATCO and National approaches for the assessment of environmental impacts. The different sign of the impacts can be explained by the type of the project. In the UK, the increased volume of traffic generates higher costs for air pollution and climate change, while in Greece a constant traffic volume is assumed, and thus the improved traffic flows generate positive environmental benefits.

UK and Denmark show very strong deviations between the National Assessments and the HEATCO approach. While in the National UK assessment positive benefits were generated, the HEATCO approach produced negative figures, which is mainly due to the fact, that the UK approach only includes monetised values for noise. In Denmark HEATCO roughly doubles the national environmental costs.

Table 10: PVB of environmental costs

[million Euro]	United Kingdom	Denmark	Greece
1. HEATCO	-9.6	548	27
2. HEATCO (PPP)	-8.5	461	34
3. National	4.3[1]	260	
HEATCO vs. National	-323%	111%	
HEATCO PPP vs. National	-298%	77%	
Note 1: UK National figures only include noise, whilst the HEATCO figures include noise, climate change and air pollution.			

HEATCO

Air Pollution

HEATCO recommends using country-specific values taking into account local population density and regional climate. Cost factors measured in Euro per tonne of pollutant emitted in different environments (urban areas, outside built-up areas) are provided. The list of pollutants should cover

- Primary $PM_{2.5}$ for transport emissions (PM_{10} for emissions from power plants),
- NO_x as precursor of nitrate aerosols and ozone,
- SO_2 for direct effects and as precursor of sulphate aerosols, and
- NMVOC as precursor of ozone.

Project related emissions should be calculated using national emission factors; if such factors are not available, emission factors from international sources can be applied, taking into account national vehicle fleet compositions as far as possible.

Existing research identified damage to human health as the most important effect in terms of quantifiable costs. In particular the reduction of life expectancy in terms of Years of Life Lost (YOLL) contributes to health costs. Therefore, YOLL is a good indicator for physical impacts caused and impact factors are provided alongside the cost factors.

Noise

The noise calculations in the HEATCO appraisal are used to determine two outputs. Firstly the change in the number of people highly annoyed by road, rail and air traffic noise as a result of the scheme and secondly, the change in PVB for noise as a result of the introduction of the scheme.

For the first calculation HEATCO recommends basing the data on an impact indicator for noise exposure using the percentage of adults highly annoyed by road traffic noise. The noise function is split into 1 dB(A) bands from 43 dB(A) to 80 d B(A) showing the percentage of the population that would be highly annoyed at each of these noise levels. The percentages are then multiplied by the number of people exposed to each band in the scenarios to determine the change in number of people highly annoyed as a result of the proposed new scheme. Monetary values for calculating the change in PVB are given for the same noise bands.

Climate Change

The method of calculating costs due to the emission of greenhouse gases (usually expressed as CO_2 equivalents) basically consists of multiplying the amount of CO_2 equivalents emitted with a cost factor. Due to the global scale of the damage caused, there is no difference how and where in Europe the emissions of greenhouse gases take place. For this reason, HEATCO recommends to apply the same values in all countries. However the factor proposed is dependent on when (in which year) the emission takes place. HEATCO recommends using the values given in Table 11 for valuing greenhouse gas emissions.

Table 11: Values in € per tonne of CO_2-equivalent emitted (see HEATCO Deliverable 5)

	Central guidance	For sensitivity analysis	
Year of emission		**Lower central estimate**	**Upper central estimate**
2000 – 2009	22	14	51
2010 – 2019	26	16	63
2020 – 2029	32	20	81
2030 – 2039	40	26	103
2040 – 2049	55	36	131
2050	83	51	166

The CO_2 equivalent of a greenhouse gas is derived by multiplying the amount of the gas by the associated Global Warming Potential (GWP). The GWP for methane is 23, for nitrous oxide 296, and for CO_2 it is 1.

United Kingdom

Air Pollution

The inclusion of air pollution in appraisal provides one of the key differences in approach between current UK practice and the HEATCO recommendations. Currently in UK appraisal air pollution is considered on the local scale only, in terms of changes in concentrations of pollutants, the number of households where air quality has improved/worsened and total emission changes for any particular strategy. Obviously using the current methodologies of the two approaches are not directly comparable. While the HEATCO recommendations focus on quantifying damages from changes in air pollutant concentration on the local and European scale and valuing these in monetary terms, the UK approach assesses the number of properties

where the air quality changes due to project impacts, without quantifying the impacts. The missing monetary values for air pollution are the reason, for the big difference of the approaches given in Table 10.

The UK approach shows that at the local level based on households within a 200m distance of the road the household's pollution levels have improved. The key reason for this is that the old road which had 435 fronted properties has been forecast to have a reduced traffic flow and the new road has been designed to pass through mainly agricultural areas thus reducing the number of households affected in the direct vicinity of the road. A comparison of the two approaches is interesting, as while the HEATCO approach shows that the air pollution levels increase (when including a wider scale in the assessment) with increased traffic, while the UK approach, looking at the very local level only, considers only those households in the immediate vicinity with reduced air pollution levels, i.e. a 743 household for NO_x and 115 households for PM_{10}.

One of the advantages of the HEATCO approach is that the UK data could easily be modified to produce tonnes output per year per pollutant using national emission factors and the transport model. The main difference is the focus on monetary impacts for the HEATCO approach whereas the UK approach focuses on localised impacts. A minor issue is the size of the primary particle fraction considered: PM_{10} for the UK, $PM_{2.5}$ for HEATCO.

Climate Change

The methodology used to include global warming in appraisal provides another key difference between the HEATCO and UK approaches. The difference lies in the presentation of the data as HEATCO recommends calculating the PVB for global warming and the UK approach focuses on presenting the total emissions produced in tonnes. Again the UK approach does not monetise the effects, but generates data that can be used as an input into the HEATCO methodology. One of the key difficulties will be in calculating CH_4 for the UK where previously this has not been a requirement.

Noise

The methodology for including noise in the UK and HEATCO approaches has some similarities. Both approaches consider the impact of noise annoyance in the appraisal, although have differing annoyance functions. In February 2006 the UK moved to including noise as a monetised impact in a transport appraisal, which is one of the HEATCO recommendations.

The UK approach, like the HEATCO method, focuses on two outputs. Firstly the change in the number of people annoyed by noise from the scheme and secondly a PVB of noise. In the UK a noise annoyance response function similar to that recommended for HEATCO has been developed. It shows the percentage of the population annoyed by road traffic noise in the longer term as a function of the noise level. This relationship was developed through a questionnaire and shows the percentage of the population who have been estimated as being either 'bothered very much' or 'bothered quite a lot' by road noise for each of the noise bands. The appraisal compares the change in people annoyed as a result of the new option with the people annoyed before the scheme opened.

The calculations show that the UK approach generates a larger PVB of noise than the HEATCO approach. This is purely down to the way that the method is applied and the fact that the UK has an appraisal period of 60 years compared to the 40 year appraisal approach of

HEATCO. Under both approaches the noise levels remain unchanged after the first 15 years of the project running. When converted using the HEATCO recommendations to factor prices and € the UK approach generates noise PVB that are 2.75 times the value generated by the HEATCO approach.

Denmark

Environmental costs are positive in Denmark, since it has been predicted, that emissions will be reduced by the project.

Assessment methods for air pollution in Denmark are quite similar to HEATCO, only the values differ due to the use of market prices in the country. Table 12 shows that the values for Germany are higher than in Denmark. In general the values for Germany are on level with those used in the original assessment except for particles, where the HEATCO fall-back values are considerably higher compared to the Danish values used in the original assessment. This results in 40% higher costs for air pollution if only Denmark is considered or 50% for all countries involved.

Table 12: Unit Values in HEATCO and in Denmark for air pollution

€$_{2003}$ per kg of pollutant emitted	Original assessment	HEATCO	
	All countries	Denmark	Germany
	Market price	Factor costs	
SO_2	4.2	2.0	4.6
NO_x	2.8	1.9	3.2
HC (NMVOC)	1.4	0.8	1.1[4]
CO	0.0008	-	-
Particulates	18.8	56.2	81.9

The Danish approach contains a constant value over time at a level of approx. 16.9 €/ton CO_2. HEATCO recommends unit values increasing from 22 €/t CO_2 eg. for 2000-2009 to 83 €/t CO_2 eg. in 2050+. Thus, HEATCO generates roughly triple the value of the original assessment.

Noise effects are not considered in the original assessment, and no data are available on noise effects.

Greece

According to the Geek environmental impacts study, there is no evidence that the construction of the new road, which is an upgrade of an existing one, will increase the traffic volume. However, due to the increase in travel speeds, the emissions, as well as the fuel consumption is assumed to be lower in the case of the new road. Therefore the Greek assessment generated positive environmental values, which comprise 11% of all benefits.

According to the Greek National Guidelines, monetary valuation or air pollution is based on the Impact Pathway Approach, and are in accordance with HEATCO recommendations. In the specific project no valuation of air pollution has been done and only a qualitative assessment was conducted. The HEATCO methodology could be applied without major problems.

Greek appraisal methodology for noise comprises only a qualitative method used for facades of buildings. The noise index that is used and measured in the specific project is $L_{A10,18h,}$ which describes only noise measured during daytime. The outputs of these measurements are compared to national noise level limits. $L_{A10,18h}$ was converted to L_{den}, which describes noise levels for day, evening and night, and wich is used in the HEATCO cost assessment.

No appraisal framework for the evaluation of pollutants related to global warming currently exists in Greece. Therefore, only HEATCO guidelines were applied in the study. The respective Figures are given in the Annex.

Italy

The Italian rail appraisal practice is mainly based on the INFRAS/IWW 2004 study. Since for this specific project no original assessments were made, a comparison of the HEATCO approach is not possible. Instead, the HEATCO methodology on environmental impacts was successfully applied for road and rail.

The estimation of the amount of pollutants emitted for rail has been carried out starting from data of the major railway undertaking Trenitalia (2005). Trenitalia publishes annually the direct and indirect emissions of NO_X, PM_{10}, SO_2 on the whole network. Emissions for road have been calculated applying the CORINAIR emission factors (g/v-km) for NO_X, $PM_{2.5}$, NMVOC to the vehicle stock circulating in the county of Torino. The outcomes are given in the Annex.

The estimation of the impact on global warming of the project is carried out on the basis of CO_2 emissions. No data were available on other greenhouse gases such as methane and nitrous oxides. Data on carbon dioxide emissions are available from the railways undertaking Trenitalia for 2002. The evolution of CO_2 emissions during the appraisal period is based on the growth scenarios formulated by the Italian energy agency ENEA. The respective tables are listed in the Annex.

For the assessment of the rail noise costs the number of receptors has been estimated in an area of 500 m around the railway line for the whole length on the link (46 km). The following data have been taken into account to carry out the appraisal:

- length of railway line passing through galleries (natural or artificial) vs. taking course in open air,
- statistics on the population of the municipalities affected by the new rail link infrastructure in 2004;
- forecasts of population growth to 2054.

Cost factors and methodology was derived from HEATCO and successfully applied.

Sensitivity tests for environmental effects

The sensitivity tests for environmental effects were conducted for noise and CO_2 and the results are presented in Figure 7. For CO_2 sensitivity calculations were done for the lower central and upper central estimates as given in Table 6.9 of HEATCO D5. Noise sensitivity is assessed by using the high values and the alternative approach presented in Table 6.7 of

HEATCO D5. The sensitivity calculations generally reflect the low overall importance of environmental effects in the CBA. In the United Kingdom and in Denmark, where the share of environmental costs is low, only minor changes of the Present Value of Benefits (max 1.5%) are generated in the sensitivity test. Even in Greece, where the share of environmental cost on overall benefits is higher, the maximum deviation is below 5%. The main conclusion from the sensitivity analysis is, that even a strong variation of environmental cost has only little impacts on overall benefits and thus on the outcome of the assessment.

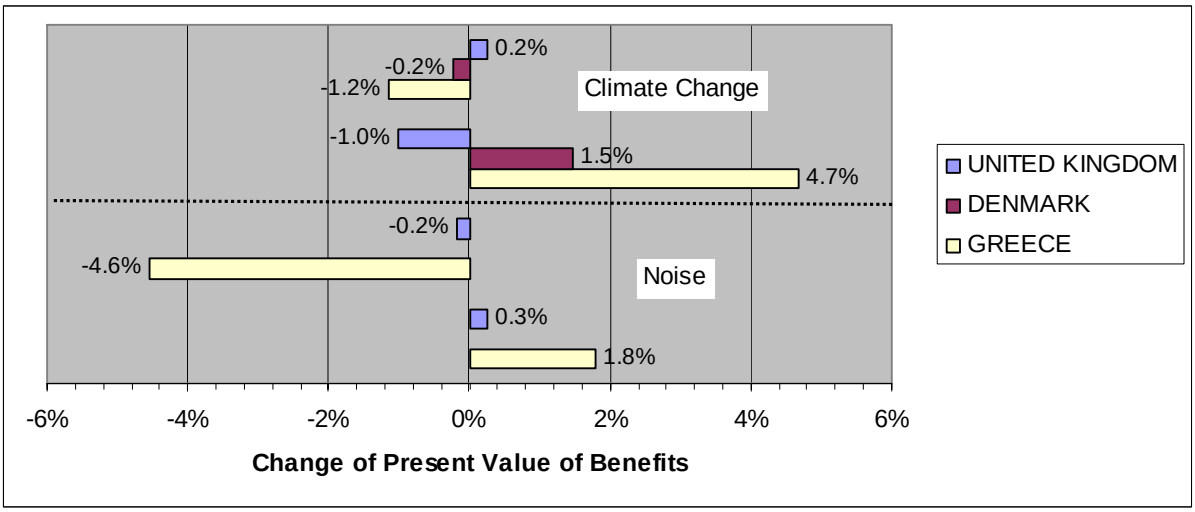

Figure 7: Impacts of environmental sensitivity tests on total benefits

7. Costs and indirect costs of infrastructure investment

The assessment of the costs of infrastructure investments is the most important element in the Cost Benefit appraisal, since this value determines the denominator, which determines the BCR. Table 13 compares the different approaches and their impact on the assessment of investment costs. Generally, the HEATCO approach results in cost assessments which are 19% to 42% lower than National assessments. This is a result, which has to be considered with care, since significant lower cost figures will result in a more positive assessment of projects. This is unproblematic if the B/C assessment is used for comparison of investment projects or scenarios, since all of them are affected in the same manner. The case is different if an appraisal is made only for one project, in order to justify its economic efficiency. If so, sensitivity testing, e.g. using the national method, is essential.

Table 13: Investment costs of the case studies

[m Euro]	United Kingdom	Denmark	Greece
1. HEATCO	224	5,744	91
2. HEATCO (PPP)	200	4,804	116
3. National	343	7,089	
HEATCO vs. National	-35%	-19%	
HEATCO PPP vs. National	-42%	-32%	

The HEATCO Approach

HEATCO recommends using the following definition of capital costs of the infrastructure investment;

- Construction costs, including materials, labour, energy, preparation, professional fees and contingencies
- Planning costs, including design costs, planning authority resources and other planning costs
- Land and property costs, including the value of the land needed for the scheme (and any associated properties), compensation payment necessary under national laws and the related transactions and legal costs
- Disruption costs, e.g. the disruption to existing users to be estimated using the same values of time as are used for travel time savings arising from the scheme.

Furthermore the cost assessment should be based on the following two general principles;

- Costs should be attributed to the project year in which the resources become unavailable to alternative uses.
- It is necessary to distinguish between costs incurred before and after the decision whether to go ahead with the project or not; and retrievable and non-retrievable costs.

As the cost-benefit analysis only concerns costs that will be incurred due to the decision to go ahead with the project, non-retrievable costs incurred prior to the decision should not be included in the cost-benefit analysis.

The residual value is an item in the appraisal which captures the net benefits beyond the formal evaluation period. If the evaluation period is longer than the lifetime of a certain part of the infrastructure, reinvestments are necessary. If the evaluation period is shorter than the lifetime of another part, the residual value of this part has to be taken into account. In the cost-benefit analysis, the capital costs of the infrastructure are reduced by the net present value of the residual value of the infrastructure. HEATCO recommends a pragmatic approach for estimating the residual value, which includes:

- Determination of the fixed lifetime of the infrastructure - or its sub-components
- Determination of a depreciation profile

A range of recommended lifetimes for road and rail projects is provided by HEATCO.

The HEATCO approach includes as well the costs of maintenance, operation and administration and the changes in infrastructure costs on existing network. The distinction between (short run) fixed costs and the variable costs (costs that vary with traffic use) are determined on the basis of national accounts/statistics and a general classification of cost categories. In order to estimate these costs, it is recommended - for pragmatic reasons - to assume that the marginal costs per vehicle can be approximated by the average variable costs and that average variable costs/marginal costs are constant (and not for instance increasing with traffic).

United Kingdom

The methodologies of HEATCO and in the UK are very similar. In the UK the COBA programme is used to calculate the capital costs (PVC) for a transport appraisal. The costs that are included are:

- Construction Costs
- Land and property Costs
- Preparation Costs

COBA operates using factor costs which then need converting to market prices for the UK appraisal calculations. Inline with the HEATCO recommendations one of the key criteria is that only the costs incurred due to a decision to go ahead with the scheme are included and costs are recorded at time of use.

In terms of a residual the UK approach states that “residual values should not be included in the appraisal of projects with infinite lives”. It does however suggest that in the appraisal “analysts may wish to estimate residual values for these projects as a sensitivity test”. One of the key differences between the UK approach and the HEATCO approach is the longer appraisal period (60 years for the UK and 40 years for HEATCO). This means that certain lifetimes proposed by the HEATCO recommendations do not exceed the UK appraisal period.

The treatment of the underestimation of costs (optimism bias) is included in the UK appraisal.

The UK guidance states that the optimism bias that should be included in the appraisal changes depending upon whether a quantified risk assessment has been completed. For the HEATCO case study 15% optimism bias was used, as the project has gone ahead and it is unknown whether a risk assessment has been completed. The UK uplifts for road projects

without risk assessment between range between 15% and 45% and are thus comparable HEATCO values.

The key methodology used to calculate the construction costs is:

- Convert the capital and land and property costs to 2002 prices
- Calculate the preparation and supervision costs.
- Apply optimism bias
- Create the profile of costs
- Discount the costs back to the base year of 2002.
- Calculate the NPV of the residual value (if needed)

In the UK the COBA programme is also used to calculate the maintenance costs for the appraisal. The maintenance costs are split into two groups. The first group focuses on non traffic related maintenance costs. The second focuses on works costs.

The key differences between HEATCO and the UK are listed in Table 14. The key difference is the market prices used in the UK compared to the factor costs in HEATCO and the longer appraisal period. Together with the distortions due to exchange rates, the UK approach results in 53% higher investment costs compared to HEATCO. This amount could be even higher if the UK approach considered the residual value as well.

Table 14: Cost comparison UK Approach - HEATCO

	UK Approach	HEATCO Approach	
Appraisal period	60	40	40
Discount Rate	UK	UK	UK
Factor/ Market Prices	Market Prices	Factor Prices	Factor Prices
Life Time Assumption	N/a	60	60
Capital Costs	302	217	193
Residual Value		19	17
Maintenance Costs	41	27	24
Total Costs	**343**	**224**	**199**

Denmark

In general the overall approach taken in the original assessment is in line with the HEATCO recommendations. However some differences distinguish the Danish approach from the HEATCO methodology:

- Capital costs: Another categorisation for the definition of capital cost is used in Denmark than suggested in HEATCO. Disruption from construction not included in the Danish approach.
- Residual value: No depreciation of residual values, since necessary costs for maintenance and re-investments are included in the running costs.
- Optimism-bias: Optimism-bias is not considered in the original Danish assessment. For the estimation of uplifts, a 43% increase for the fixed link and a 34% increase for the rail investments was calculated, amounting to a total increase of 40%.
- Costs for maintenance and changes in infrastructure costs on existing network: Running costs for the fixed link is based on the realised costs of the two other major fixed links in Denmark. Running costs for the infrastructure manager is assessed on the basis of national default values (first best).

Table 15: Comparison of Danish and HEATCO cost assessments

NPV 2015	Original Assessment	HEATCO Approach	
	Mill € 2003	Mill € 2003	Mill € 2003 PPP
	Market prices	Factor costs	Factor costs
Construction costs - fixed link	-4,478	-3,599	-2,989
Residual value - fixed link	202	251	209
Additional investments	-1,839	-1,458	-1,247
Residual value - fixed link	78	97	83
Operating costs of fixed link	-1,052	-1,035	-860
Total Costs	**-7,089**	**-5,744**	**-4,804**

Again, due to the use of market prices and factor costs, the Danish cost appraisal is significantly more expensive than the HEATCO assessment. A compensation is achieved through the positive residual values, which are higher in the HEATCO assessment. However, their contribution to total costs is minor.

Greece

The Greek case study states, that "Greek national guidelines for the assessment of infrastructure costs are consistent with HEATCO." Since the project is an expansion of an existing motorway, no land and property costs are included. Disruption costs are missing as well.

The NPV of the total costs amount to 91 m Euro or, if the costs are PPP adjusted 116 m Euro. Compared to the first costs figure, this value increases to 94 m Euro if instead of 3% a discount rate of 6% is assumed in a sensitivity test.

Italy

The following methodological differences between HEATCO and the Italian approach have been reported in the Case Study:

- Capital costs of infrastructure: Italy uses as well a whole life costing approach, which includes construction costs (materials, labour), professional fees (including planning) and compensation payments.
- Infrastructure operating costs; maintenance and administration: Italy includes ordinary maintenance (materials, services and personnel), clearing, energy consumption and renewals.
- Changes in infrastructure costs on existing network are usually not included in Italian C/B assessments.

Since no full fledged assessment was made, no further indication is given in the Case Study.

Sensitivity test for Optimism Bias

HEATCO emphasizes the "Optimism-bias", which refers to the systematic tendency for project appraisers to underestimate construction costs. It is recommended that a side-analysis is conducted where optimism-uplifts are applied to the estimated construction costs (including

contingencies). HEATCO uplifts amount to 22% for roads, 34% for rail and 43% for fixed links.

The effect of the optimism bias was assessed for the road project in the UK, where the sensitivity calculation decreased the NPV by 5%. In Denmark, where a road and a rail link were planned, the optimism bias amounted to 40%. The application of this bias brought the NPV down by 28%.

8. Vehicle Operating Costs

The inclusion of vehicle operating costs in the HEATCO guidelines does not feature to the same extent as the other costs and benefits that are included in a cost benefit analysis. Whilst not included in the original specification of the HEATCO project its inclusion came about because it was felt that it was a key element of the cost benefit analysis and so recommendations on how it was to be approached should be reported.

The share of Vehicle Operating Costs on total benefits amounts to 3%-6% in the Danish Case Study and to 21% in the Greek Case Study. A comparison of Assessment Approaches for VOC is only possible in the Danish Case Study, where HEATCO values VOC considerably (-45%) cheaper than National assessments.

The HEATCO Approach

HEATCO recommends that local country specific data on prices and relationships for modal operating costs should be utilised in project appraisals. The following cost components are included in that model:

Standing cost components	Operating cost components
Depreciation (time dependent share) Interest on capital Repair and maintenance costs Materials costs Insurance Overheads Administration	Personnel costs (if not included in travel time savings); Depreciation (distance related share) Fuel and lubricants

For the assessment of VOC HEATCO stipulates the use of a model, which requires the following input data:

(i) Demand - the number of vehicles making a particular origin-destination trip for the Do-Minimum and the Do-Something cases;
(ii) Vehicle kilometres – the change in vehicle kilometres induced to the traffic on that particular origin-destination trip for the Do-Minimum and the Do-Something cases; and
(iii) The unit cost of a vehicle kilometre – this in turn will require data on:
    a. the transport network characteristics (e.g. gradient)
    b. vehicle characteristics (e.g. vehicle type, speed, cost of replacement parts and maintenance, load, etc.)
    c. vehicle utilisation

Similar to travel time savings, the user benefit associated with vehicle operating cost savings is calculated for origin-destination pairs using the rule-of-half and then summed over all pairs. Ideally, all data for the appraisal should be local. However, it is possible to transfer relationships and prices from other countries, though this is most appropriate for road vehicles rather than rail, air or water modes.

United Kingdom

The two approaches UK and HEATCO differ only in terms of the appraisal period used, the price unit and currency. The vehicle operating costs for road vehicles are calculated in the UK using a recommended model that is consistent with the HEATCO guidelines regarding the attributes that need to be included in such a model.

Due to technical problems, the UK Case Study was only able to quantify the benefits from VOC and VTTS as given in Table 5.

Denmark

The minimum acceptable methodology of HEATCO for the valuation of time savings for commercial goods traffic is the cost saving approach. The Danish and German unit values meet the HEATCO minimum requirements. A comparison of the values used in the original assessment and the HEATCO approach is given in Table 16. Except for buses, the Danish and German unit values are at the same level. Due to a high level of taxation on transport there is a large difference between 'factor costs' and 'market prices'.

Table 16: VOC on the Fehmarn Belt

Commercial goods traffic and vehicle operating costs (€2003)	**Cost driver**	**Original assessment**	**HEATCO**	
		All countries	**Denmark**	**Germany**
		Market price	**Factor costs**	**Factor costs**
Passenger cars	Distance	0.26 €/vkm	0.11 €/vkm	0.12 €/vkm
Buses	Time	37 €/vehicle-hour	27.0 €/vehicle-hour	21.5 €/vehicle-hour
	Distance	0.41 €/vkm	0.27 €/vkm	0.59 €/vkm
Trucks	Time	41 €/vehicle-hour	29.9 €/vehicle-hour	25.3 €/vehicle-hour
	Distance	0.37 €/vkm	0.25 €/vkm	0.27 €/vkm

Regarding the inter-temporal elasticity to GDP per capita growth HEATCO recommends that a default figure of 0.7 is used for time dependent costs. The original assessment distinguishes between salary and non-salary cost savings, which comprise 25% resp. 75% of time related VOC savings. Tor the first a time elasticity of 0 is assumed and only salaries saved are adjusted to GDP with an elasticity of 1. Thus, roughly a comparable time elasticity can be assumed.

As already mentioned above, the HEATCO assessment of VOC resulted in costs that were 45% lower than the original Danish assessment. This can be explained by the differences in unit costs, already explained above and the appraisal period (50 years instead of 40years for HEATCO). A lower discount rate, which amounted to 4.5% instead of 6%, caused opposed effects, which were more than outweighed by higher unit prices.

Greece

The HEATCO approach was applied without major constraints to the Greek Case Study. As already mentioned above, the savings in VOC amount to 21% of the overall benefits. A considerable share of the VOC are the fuel costs, which comprise roughly one third of the

VOC savings. Given the recent increase in fuel prices, this amount is bound to comprise a larger share of VOC in the future.

Italy

The Italian appraisal method comprises the following cost elements to estimate the VOC for rail investments:

- Maintenance,
- clearing,
- traction energy (distance-related components)
- personnel,
- vehicle depreciation (time-related components).

The Italian appraisal method comprises the following cost elements to estimate the VOC for road investments:

- Depreciation,
- Fuel and lubricants,
- Materials, Maintenance,
- Insurance and
- circulation tax

Since no full fledged appraisal was undertaken vehicle operating costs were not calculated.

9. Summary and Conclusions

The purpose of this Deliverable was to test the appraisal methodology for major transport investments developed in HEATCO D5. Four case studies of TEN-T projects were selected and the National methodologies and outputs compared to those using the HEATCO recommendations.

One of the major purposes of the Case Studies was to test if the methodology developed in HEATCO D5 is applicable in practice. This is the case, since the HEATCO methodology was successfully applied in all four cases. No major difficulties were reported on scientific, methodological or technical problems related to application of the HEATCO guidelines. Problems observed were rather of practical nature, such as difficult access to relevant information and applicability of data. All these problems would have occurred as well with any other methodology to be used for investment appraisals.

Another purpose of the Case Studies was to show the major differences in European appraisal methodologies compared to HEATCO. The most important differences can be summarised as follows

Market prices vs. Factor Costs
Some national appraisal methodologies use market prices for the assessment of costs. The HEATCO guidelines recommend the use of factor costs. The difference between the two approaches is that factor prices reflect the production costs since they do not include taxes and subsidies. Comparing the two approaches, market prices are significantly higher than factor costs. In the researched countries market prices are 18%-34% higher than factor costs. Since it is only a unit of account, the outcome of the appraisal is not influenced, however.

The social discount rate
The social discount rate indicates how much future consumption a household is ready to give up consuming now. Future costs and benefits are discounted with this rate in order to calculate the Net Present Value. A high discount rate requires a fast return on investment and thus has a high time preference. The discount rates used in Europe differ considerably. It is at 3% in Germany, 3.5 in the UK[7], 5% in Italy and 6% in Denmark. HEATCO recommends the use of National values and sensitivity testing at 3%. Sensitivity calculations (given below) show, that the choice of the discount rate has a strong impact on the project output.

The appraisal period
The appraisal period determines over which period costs and benefits have to be taken into account. HEATCO recommends appraising the project during planning and construction and then another 40 years. The appraisal period in Denmark amounts to 50 years and in the UK 60 years. Direct effects of the appraisal period on the NPV have not been assessed, however it can be concluded that a longer appraisal period tends to result in higher benefits.

Adjustment of costs with Purchasing Power Parity
From the European perspective the comparison of projects in different countries is of utmost relevance. Thus, HEATCO recommends PPP adjustments to take into account the different purchasing power of the population affected. Since the adjustment with PPP affects cost as well as benefits, the BCR will remain unchanged, while the NPV varies. The PPP adjusted

[7] For the first 30 years after investment, then it is reduced to 3%.

NPV in UK and Denmark is 11% and 17% lower than the non-adjusted value, while in Greece an adjustment with PPP increases the NPV by 27%.

Share of benefits

The Case Studies also provide the opportunity to make an international comparison of transport investment appraisals using a comparable methodology for projects, which are very different in nature. The results of this analysis are given in Figure **2**. The analysis reveals that the Value of Time plays a dominant role in the appraisals. For the case studies where there is no producer surplus 77-86% of the benefits are generated through time savings (VTTS) and reduced Vehicle Operating Cost (VOC). This is not true for the Fehmarn Belt project, which generates large scale effects mainly through ticket revenues (producer surplus) amounting to more than half of all benefits, while time savings and reduced VOC amount to 40% of all effects. The main difference in benefit distribution between the road projects and the Fehmarn Belt is the levy of bridge tolls, which is designed to generate the large income stream necessary to compensate for the enormous financial costs. However, if the producer surplus is deducted more than 90% of total user benefits and externalities are generated by VTTS and VOC.

While VTTS seems to be crucial for all appraisals, environmental effects only comprise a small share of the benefits: They range between -1% and +11% of all benefits. The reduction of accidents contributes with 0 to +16% to the overall benefits.

Sensitivity tests

Given the above discussion on National values, such as discount rate and Value of Time, the test of sensitivities is of major importance for the assessment. Sensitivity calculations are not only necessary to test the effects of uncertain inputs, such as the Climate Change costs, they should be as well be used to test the effects of major control variables, such as the value of time. And last not least, sensitivity tests reflect the robustness of the appraisal. For example, if the ranking of investment projects does not change after the sensitivity tests have been applied, the outcomes can be regarded as stable and thus provide a scientifically sound and robust input for decision making. Table 17 gives an overview of the sensitivity tests conducted within HEATCO. The tested effects are ranked according to their importance.

Table 17: Compilation of sensitivity tests

Effect	Sensitivity Test	Change of NPV	Change of PVB
Social discount rate	4% compared to 3% 5% compared to 3% 6% compared to 3%	-31% -40% - -55% -73%	-
Optimism Bias	Denmark (-40%) UK (-22%)	-28% -5%	-
Transport Volume*	Growth rate -50% Growth rate +50%	-	-18% +25%
GDP*	Growth rate -50% Growth rate +50%	-	-8% +10%
Value of time	VTTS -20% VTTS +20%	-	-15% - -6% 7% - 20%
Accidents	Value of Safety per Se / 3 Value of Safety per Se * 3	-	-7%- 0% 0% - 22%
Noise	High values** Alternative approach**	-	-4.6% - -0.2% 0.3% - 1.8%
Climate Change	Lower central estimate** Upper central estimate**	-	-1.2% - 0.2% -1% - 4.7%

* Fehmarn Belt only
** Tables 6.7 and 6.9 of HEATCO D5

Sensitivity of the social discount rate
As already mentioned above, the choice of the discount rate has a tremendous impact on the outcome of the assessment. In this study the National discount rates are compared to a 3% discount rate that is recommended by HEATCO as a test of sensitivity. In Greece a discount rate of 4% decreases the NPV by 31%; in the case of a discount rate of 6% the Greek NPV decreases by 73%. This implies a change in the Greek BCR from 2.7 to 1.4. Even if a small change in discount rate (+0.5%) is assumed, as in the case of the UK, the overall NPV decreases by 19%. Thus a sensitivity test of the discount rate is indispensable.

Sensitivity test for Optimism Bias
Another sensitivity test was conducted in order to compensate for the "optimism bias" observed in past large scale transport projects. The "optimism-bias" refers to the systematic tendency for project appraisers to underestimate construction costs. Background is major underestimations of implementation cost of major European transport projects, such as the Channel Tunnel and the Øresund Link. Therefore, HEATCO recommends uplifts of the costs, which amount to 22% for roads, 34% for rail and 43% for fixed links. The effect of the optimism bias was assessed for the road project in the UK, where the sensitivity calculation decreased the NPV by 5%. In Denmark, where a road and a rail link were planned, the optimism bias amounted to 40%. The application of this test brought the NPV down by 28%. The Case Studies have shown how a sensitivity test can illustrate optimism bias in project assessments and thus highlight the danger of overestimating a project's cost efficiency. The tests can be recommended, since they revealed strong effects on the project's cost efficiency that might put into question decision maker's "optimism bias".

Sensitivity of Value of time
Since VTTS comprises a large share of the benefits, it is crucial to conduct a test, which reveals how sensitive the benefits react to input changes. The sensitivity test reveals that a change in the VTTS has strong effects on the outcome of the appraisal. A variation of 20% of VTTS resulted in 7-20% change in PVB. The calculations demonstrate clearly, that it is imperative to test the sensitivity of the VTTS in order to achieve robust results.

Sensitivity tests for Accidents
In order to test the Safety Per Se, the values are tripled or divided by three and the change of the benefits is compared. The outcomes of these tests are heterogeneous. In Denmark the tests show no impacts at all. The reason is that accidents have practically no impact on the assessment. Strongest impacts can be observed, in the road projects, where a triple value of safety boosts the PVB by more than 20%. This magnitude justifies a sensitivity test.

Sensitivity test of Noise and Climate Change
The cost figure chosen for climate change represents a default value chosen from a wide range of scientifically elaborated prices. Thus a sensitivity test with the central upper and central lower values is essential. For noise high values and the alternative approach given in Table 6.7 of HEATCO D5 were tested. The sensitivity calculations generally reflect the low overall importance of environmental effects in the CBA. In the United Kingdom and in Denmark, where the share of environmental costs is low, only minor changes of the Present Value of Benefits (max 1.5%) are generated in the sensitivity test. Even in Greece, where the share of environmental cost on overall benefits is higher, the maximum deviation is below 5%. The main conclusion from the sensitivity analysis is, that even a strong variation of environmental cost has only small impacts on overall benefits and thus on the outcome of the assessment.

Sensitivity of assumptions on future growth
There are a number of remaining issues that influence the outcome of project appraisals. What happens if the macro economic framework grossly over- or underestimates future growth rates? Sensitivity calculations were done for the Fehmarn Belt, assuming a 50% increase or decrease of the original values. The Danish study reveals, that growth of GDP has an impact on the PVB with an elasticity of roughly 0.2, i.e. a 50% higher growth rate will increase the NPV by 10%. Since the project assessment is extremely dependant on the traffic volume, the elasticity of the growth rate in transport is much higher. The Danish Case Study reveals an elasticity of 0.4 to 0.5. This underlines the importance of sensitivity testing for future growth assumptions.

Research Issues Identified

Choice of the discount rate
Using the NPV or the BCR requires the use of a discount rate for future benefits and investments. Figure 3 reveals that the choice of the discount rate has a strong impact on the NPV of the project. Changing the discount rate is an easy method for decision makers to influence the overall assessment of a project. The determination of the discount rate might reflect the political will for or against a project and thus distorts ex-ante the outcome of the C/B assessments. This can be of importance e.g. if a project with long term effects is compared to a project where benefits occur after a short period of time. Projects with long term benefits might be disadvantaged by a high discount rate.

IRR vs. C/B Factor and NPV
HEATCO recommends the use of NPV and C/B ratio instead of the IRR for decision making, since methodological problems related to IRR have been observed, which are documented in HEATCO D5[8]. However, the above discussion on the discount rate makes it worth to deliberate one more time if the IRR would be more appropriate. Since the IRR does not need any ex-ante determination of a discount rate, this method has the advantage of being less sensitive to external influence. However, a counter argument is that other important inputs, such as VTTS are as well subdue to political influence. Additionally, the IRR, used by Banks such as EIB and World Bank reflects rather a banker's thinking about return on investment than government's duties to maximise social welfare. An IRR threshold of 10%, presently used by the World Bank would crowd out projects with long term social welfare benefits. Thus, the use of IRR would require as well a political decision on the appropriate IRR. The advantage of the IRR would be that no ex-ante decision on the cut off rate would have to be done. The above discussion, reflecting the contradicting views of bankers and governments shows the need for further scientific research.

Transport Modelling
A number of questions outside the scope of HEATCO remain unanswered, which have mainly to do with transport modelling. Traffic forecasts are essential for the CBA of transport investments. This is corroborated by the above sensitivity analysis on transport volume. Since the forecasts are mainly undertaken with the use of traffic models, the design and methodology of these models is essential for the results achieved in the CBA. Next to technical questions, such as mathematical functions and calibration of the transport model, other issues such as quality of input data and the treatment of induced traffic remain crucial for the outputs of the appraisal. Especially the inclusion of induced traffic might have strong impacts on the overall B/C assessment. Within the EU a number of contradicting approaches exist, how to

[8] Chapter 3.6.3

treat induced traffic. However, guidelines harmonising the national approaches and defining a consistent methodology are missing.

To conclude, HEATCO has developed a feasible methodology, which does not only reflect the state of the art, but has proved as well to be applicable in practice. Recommendations given on the methodology, the guidance values and the sensitivity tests are valuable and ready to be used in practice.

Annexes

List of Annexes

A1 United Kingdom: A120 Stansted to Braintree Case Study
A2 Denmark/Germany: Fixed link across the Fehmarn Belt (road/rail bridge)
A3 Greece: Skarfia Motorway
A4 Italy: New rail freight link between Bussoleno and Torino