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Economy-wide benefits – Technical report
Dynamic and Strategic Effects of a Fehmarn Belt Fixed Link

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A report from
Copenhagen Economics ApS, Denmark
and
Prognos AG, Germany

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Introduction to the technical report

This technical report presents the results of the activities in the requested study as described in the terms of reference[1]. The main conclusions of the study are presented in a separate summary report[2]. The technical report consists of 5 appendices giving the details of each of the requested analyses. These are:

Appendix A: An overview of **relevant literature**.

Appendix B: A description of different **methodologies** that can be used to analyse the dynamic and strategic effects associated with the establishment of a fixed link across Fehmarn Belt. There is also a description of the methodology chosen for this study.

Appendix C: A description of the **current** employment/economic/structural **situation** in Northern Germany and Denmark.

Appendix D: A description of the model used for the **quantification** of the most important dynamic and strategic effects – i.e. in terms of economic growth or employment effects.

Appendix E: A description of the **socio-economic value** of the main quantified effects (present value of these effects expressed in socio-economic terms).

[1] Trafikministeriet: Terms of Reference for Analysis of dynamic and strategic effects of a Fehmarn Belt fixed link, 25 July 2003 page 7.

[2] Copenhagen Economics and Prognos (2004), "Economy-wide benefits – Dynamic and Strategic Effects of a Fehmarn Belt Fixed Link", prepared for the Danish Ministry of Transport and The Federal Ministry of Transport in Germany.

Appendix A Literature survey

In this appendix we give an overview of the literature and reports that are relevant for this study[3]. We present a survey of the literature on dynamic and strategic effects associated with the establishment of major infrastructure investments.

A.1. Survey of relevant literature

We study the relevant literature on the relationship between transport improvements and regional growth[4]. Today international transport becomes increasingly important for specialised firms serving global markets, using inputs from all over the world, and relying on global information networks.

The economic importance of transport infrastructure could be considered in different ways. The logistics effect has extensive impacts on regions and enterprises. In the future the importance and economic dependency of logistics is predicted to rise, caused by reducing of vertical range of manufacture, global sourcing and disposal as well as increase of division of labour.

Analyses of the link between infrastructure and regional economic underline the importance of location decisions of entrepreneurs. The accessibility as a location factor generally ascends with the intensity of transport of each company or branch.[5] For example several German automotive groups have recently shown their dependency of transportation connections by deciding to relocate to convenient locations in terms of accessibility and infrastructure (esp. Leipzig, Chemnitz/Mosel, Hambach (France)). The decisions have been accompanied by extensive analyses of the transport connections to and within those regions.

The literature shows that infrastructure improvements could affect transportation costs by reducing the distance, rising the cruising speed or simplification of cargo handling. Traffic investments achieve generally their highest regional economic impact if they obtain extensive improvements on basic interfaces, like “hubs”-locations in the pattern of interregional trade[6].

The importance attached by business to the need for transport improvements has also been questioned in the literature. Some analysts argue that the small transport cost reductions usually associated with large infrastructure projects imply that they will only be of limited benefit

3 The relevant literature is shown in the list of selected literature in the final section of this report. We present only key results from the literature, and we are not aiming a full coverage of the literature.

4 There is a large amount of literature on the economic impacts of infrastructure, see for example Blonk (1979) or Rietveld and Bruinsma (1998) for overviews.

5 Cp. Hartmann, H.: Der Logistikeffekt in seinen Auswirkungen auf die Wettbewerbsfähigkeit von Regionen und Unternehmen; Baum, H., Willeke, R. (Hrsg.), Zeitschrift für Verkehrswissenschaft, H. 3, 1996, Düsseldorf

6 Cp. Zachial, M, Strauss. J., Motzkus, A. Aktualisierung und Weiterentwicklung verfügbarer Modelle zur Einschätzung des Einflusses von erwogenen Maßnahmen an der verkehrlichen Infrastruktur auf die regionale Beschäftigungssituation; Bundesministerium für Verkehr, Bau- und Wohnungswesen (Auftraggeber), Bonn 1999

to businesses. Others have called into question whether the small time savings for individual journeys can in practice be translated by business into enhanced productive capacity.

Thus Parkinson (1981), for example, pointed out that transport costs were a small proportion of total production costs (5-10%). He concluded that, given the small reduction in transport costs typically arising from a new or improved road, it is implausible that the fall in prices that could result from this small reduction in transport costs would lead to a significant increase in GDP.

Other empirical evidence paints a somewhat different picture. An Ernst and Young study (1996) made clear that the ranges of transport costs as a proportion of total business costs, identified by Parkinson (1981) and others, masked significant variation between sectors. For some firms, transport costs can represent a major item.

While there remains debate about the scale of the direct benefits to businesses arising from transport improvements, attention has also focused on potentially wider, indirect micro-level benefits: indirect impact on competitiveness by enabling firms to restructure their logistical systems, or infrastructure investments which improve the reliability of journey times.

The literature regarding the methodology and the modelling is described in the subsequent sections of this technical report.

Appendix B Methodology

In this appendix we briefly discuss the different methodologies that can be used to analyse the dynamic and strategic effects associated with the establishment of a fixed link across Fehmarn Belt. We also describe the methodology chosen for this study.

B.1. The wider economic effects

This study is concerned with the wider relationship between transport and the economy – the so-called *dynamic and strategic effects*. There are good reasons why governments should seek to understand the nature of the relationship between transport provision and economic growth. Governments are committed to promoting sustainable development, embracing environmental, economic and social objectives. It is important that the economic justification for transport schemes is robust, also taking into consideration their environmental and social impacts, to ensure effective decision-making. Governments also directly and indirectly finances significant investment in transport. Where investment is justified on the basis of promoting economic growth, Governments need to know that such aims are likely to be achieved, and in the most cost-effective manner, particularly given the scarcity of public funds.

Direct and indirect effects

According to Oosterhaven & Elhorst (2003) we identify two dimensions: first the distinction between the direct and indirect effects (shown horizontally in the diagram below) and second between the temporary and permanent effects (shown vertically in the diagram below).

	Direct effects	**Indirect effects**
Temporary (construction phase)	Construction effects Environmental effects	Backward expenditure effects Crowding-out effects Indirect emissions
Permanent (operation phase)	Exploitation and time saving effects Environmental, safety etc. effects	Backward expenditure effects ***Productivity and location effects*** Indirect emissions etc.

Temporary effects are those that will only occur during the construction phase, while permanent effects are related to the use of the infrastructure (operation phase). Permanent *direct* economic effects include exploitation cost and revenues, and transport cost and time benefits for freight. Permanent *indirect* economic effects relate, firstly, to the backward expenditure effects of the exploitation and use of infrastructure and, secondly, to the so-called strategic and dynamic effects. These are defined as the consequences of the reduction in transport cost for production and location decisions of people and firms, and the subsequent redistribution effects between regional economies with respect to income and employment of the population at large (Rietveld and Nijkamp, 2000). Naturally, these supply-driven indirect effects in turn will also have demand effects. In addition to both permanent direct and indirect effects, which work through markets, there will be effects that are external to the market, such as noise, safety, emissions and environmental disturbances. This study applies to the *permanent indirect market* effects and benefits of a Fehmarn Belt fixed link. We do not analyse any external effects.

B.2. Description of different methodologies

There are a large variety of methods to estimate the dynamic and strategic impacts (see Oosterhaven and Knaap (2003) for an overview). The methods most commonly used are the following:

- micro surveys with firms,
- estimations of quasi production functions,
- partial equilibrium potential models
- macro and regional economic models,
- land use/transportation interaction (LUTI) models, and
- spatial computable general equilibrium (SCGE) models.

The type of model used in this study is a spatial computable general equilibrium model (SCGE). SCGE models typically are comparative static equilibrium models of interregional trade and location based on microeconomic theory, using utility and production functions with substitution between inputs.

B.3. Analytical framework

In this section we set up the analytical framework for the quantification of the dynamic and strategic effects. We also define the key element in the study: The total benefit multiplier.

Cost-benefit analysis is a standard framework, which is intended to aid decision-making in the public sector. Within the transport sector it is used to evaluate the costs and benefits of large infrastructure projects. Cost-benefit analysis is a member of the family of investment appraisal methods. A pure cost-benefit analysis involves the enumeration and valuation in monetary terms of all the costs and benefits, to whomever they accrue, over the life of the project being evaluated. Future costs and benefits should be expressed in present value terms using an appropriate discount rate. According to Holvad and Leleur (2002) traditional CBA has two limitations:

- It tells nothing about the distribution of costs and benefits among regions (or social strata, e.g.);
- “Wider economic effects” are not taken into consideration.

There are well-established appraisal techniques for assessing the costs and benefits of transport changes. Economists have repeatedly demonstrated that, in a *perfectly* competitive economy, a fully specified cost-benefit analysis would capture all the economic impacts of a change to the transport system.

However, markets are not perfectly competitive. Where some degree of monopoly power is prevalent in the market, firms will – as usual - charge prices to maximise profit, but these prices will be larger than under perfect competition. In a similar manner, if markets before the construction of the infrastructure project are small, it may not be possible to reap economies of scale and prices will again be larger than need be. In these circumstances and provided prices in the transport sector reflect marginal social cost, an infrastructure project that opens the small local market to wider competition may bring prices down, stimulate employment, spur economically advantageous relocations and, in turn, generate economic growth and potentially significant gains in social welfare. In this case the traditional cost-benefit analysis may significantly underestimate the total benefits of the infrastructure project.

In order to measure the additional benefits associated with such dynamic effects it is important to use an internally consistent analytical framework that enables the analyst – within the same framework - to calculate both traditional CBA-based measures of (costs and) benefits as well as the broader measure of benefits including the dynamic gains. If this is the case, the risk of double counting, that is including some effects both simultaneously within the CBA-measure and within the dynamic measure, will be significantly reduced. We propose to use such an internally consistent analytical framework that has previously been used to evaluate the dynamic effects of large infrastructure project for SACTRA[7] in the UK, see Venables and Gasiorek (1998). The analytical framework is based on general equilibrium theory, incorporates all major linkages between the transport sector and other sectors and allows for imperfect competition in some or all sectors.

“Wider economic effects” (also called dynamic and strategic effects) of transport projects stem from:

- Employment expansion (positive effect) or contraction (negative effect) on imperfect labour markets,
- Output expansion (positive effect) or contraction (negative) effect in industries with a high degree of monopoly or large economies of scale,
- Intensified competition (positive effect) due to market integration
- Improved knowledge diffusion.

B.4. Definition and interpretation of the total benefit multiplier

The **total benefit multiplier** (TBM) is defined as the ratio between total economic benefits/disbenefits (ΔW) and transport benefits/disbenefits (ΔCBA) and is calculated within an internally consitent framework as mentioned above.

Total benefit multiplier: $TBM = \Delta W/\Delta CBA$

SACTRA (1999) examines, from a theoretical perspective, the possible combinations of externalities and imperfect competition and their implications on the total benefit multiplier. We therefore analyse the sign of the TBM in three cases: one where the market for the transported goods is characterised by prices that are greater than marginal costs, one where prices of the transported goods are equal to marginal costs and one where they are less than marginal costs. Concerning the transport costs these can also be in one three cases. The transport prices can be less than marginal social costs, equal to marginal social costs or greater than marginal social costs.

This gives us nine possible combinations to consider. The key issue is whether the TBM is greater than, equal to or smaller than 1. If the TBM takes value 1 a standard transport CBA will be sufficient in order to measure all benefits/disbenefits. Otherwise, a standard transport CBA will exclude benefits if the TBM is greater than one and exclude disbenefits if the TBM is less than one. The results are summarised in Table B.1.

Therefore, it is important as part of transport infrastructure appraisal to consider which cell in the matrix given in Table B.1 is of relevance. However, the assessment will be difficult, as it is a exercise traditionally not undertaken. In box 3 the various cells are given practical interpretations with different examples.

[7] Standing Advisory Committee on Trunk Road Assessment.

Table B.1 Imperfect Competition, Externalities and the Evaluation of Transport Projects

Transport sector	Transport using sector		
	Prices greater than marginal costs	*Prices equal to marginal costs*	*Prices less than marginal costs*
Transport prices less than marginal social costs	Transport prices and general prices pull in opposite directions: indeterminate effect on CBA (Cell 1) TBM=?	Ignore general price effects, but reduce traffic levels by increasing user charges (Cell 4) TBM<1	General subsidies and uncharged external costs: CBA will overestimate economic benefits of transport improvements. Better to reduce traffic levels (Cell 7) TBM<1
Transport prices equal to marginal social costs	External costs can be ignored, but benefits are underestimated in standard CBA (Cell 2) TBM>1	Perfect competition: CBA results unbiased (Cell 5) TBM=1	Ignore external costs but benefits overestimated (Cell 8) TBM<1
Transport prices greater than marginal social costs	Goods overpriced because of monopoly. Transport also overpriced: CBA will underestimate benefits of transport improvements. Should reduce transport prices (Cell 3) TBM>1	Ignore general price effects, but should increase transport usage, reduce user charges (Cell 6) TBM>1	Transport prices and general prices pull in opposite directions: indeterminate effect on CBA (Cell 9) TBM=?

Source: SACTRA (1999) and Goodwin and Persson (2001).

Some exploratory analysis of the frequency of the various cells was mentioned in SACTRA (1999) with respect to the British manufacturing industry. The analysis, undertaken in Harris (1998), covered 13 industry groups in 11 administrative regions for 1968-1991. Nearly all price-cost margins were positive, although there were seven negative cases. This means that almost all observations would be placed in Cells 1, 2 or 3.

An infrastructure project such as the Fehmarn Belt fixed link, may in the case of cell 1 contribute to increase competition in the economic sectors, where competition could come both from companies in other parts of the Denmark and from abroad. This would contribute to lower prices over and above the price reduction reflected in reduced transport costs. However, the lower transport costs generated from the transport infrastructure scheme may also result in higher traffic levels (generated traffic) implying increases in external costs (e.g. additional pollution costs from higher levels of emissions). Therefore, it is not possible from a theoretical perspective to determine whether extension of standard transport appraisal to consideration of wider economic effects and external costs will result in higher or lower net-benefits. However, it should be noted that the lowering of transport costs may generate less rather than more competition (e.g. if existing firms are able to utilise economies of scale).

The issue of unaccounted external costs is less problematic in the context of Danish appraisal practice, where impacts of transport schemes on air pollution and noise are taken into account in the CBA of transport investments.

Box 3 Interpretations of the cells in Table B.1

Cell 1 would be appropriate in the context where: (1) the economic sectors involve a high degree of market concentration or dominance, e.g. breweries in Denmark dominated by the Forenede Bryggerier, (2) the cost to society of transport is higher than the prices faced by the users of transport, e.g. due to non-charged effects of traffic on pollution.

Cell 2 concerns the same situation concerning high levels of market concentration or dominance for one or more of the business sectors in the economy, (e.g. breweries). However, there are no problems in terms of unaccounted external costs. In this case transport prices correspond to the marginal social costs, e.g. through road pricing schemes. Therefore, it is possible to conclude that the extension of standard transport appraisal with wider economic effects and external costs will imply higher net-benefits.

Cell 3 concerns the same situation concerning high levels of market concentration or dominance for one or more of the business sectors in the economy, (e.g. breweries). In this situation though transport prices are higher than marginal social costs. Reduced transport costs will therefore provide additional benefits to society. Therefore, it is possible to conclude that the extension of standard transport appraisal with wider economic effects and external costs will imply higher net-benefits.

Cell 4 represents the case where the economic sectors can be characterised by perfect competition. However, the cost to society of transport is higher than the prices faced by the users of transport, e.g. due to non-charged effects of traffic on pollution. Therefore a standard transport appraisal without account of external costs will overestimate the value of net-benefits of a given project.

Cell 5 is the case where the standard CBA transport appraisal without inclusion of external costs is appropriate because the economic sectors can be characterised by perfect competition and there is no presence of external costs.

Cell 6 represents the case where the economic sectors can be characterised by perfect competition. In this situation though, transport prices are higher than marginal social costs. Reduced transport costs will therefore provide additional benefits to society. Therefore, it is possible to conclude that the extension of standard transport appraisal with wider economic effects and external costs will imply higher net-benefits.

Cell 7 would reflect the (relatively uncommon) situation where prices are lower than costs. In this case goods and services are underpriced. This means that the willingness to pay for these goods and services is lower than the costs of producing them. If the new price level with the infrastructure improvement remains lower than the cost, wider economic effects are negative. Furthermore, the cost to society of transport is higher than the prices faced by the users of transport, e.g. due to non-charged effects of traffic on pollution. Therefore a standard transport appraisal without account of wider economic effects and external costs will overestimate the value of net-benefits of a given project.

Cell 8 is identical to Cell 7 in terms of negative wider economic effects. However, external costs of transport can be ignored because the transport prices correspond to the marginal social costs. In this case a standard appraisal will overestimate the net-benefits of an infrastructure scheme.

Cell 9 is also identical to Cell 7 in terms of negative wider economic effects. However, in this situation though transport prices are higher than marginal social costs. Reduced transport costs will therefore provide benefits to society. Therefore, the net-benefits from a CBA with account of wider economic effects and externalities in transport usage are indeterminate compared to a standard CBA appraisal.

Source: Holvad & Leleur (2002).

B.5. Savings in logistics costs

In this section we reconsider the cost savings envisaged by the transport buyer. For goods transport by rail the monetary costs savings (due to shorter distance etc) are assumed to be zero vis-à-vis the transport buyer, whereas the rail operator and/or the bridge operator will gain these savings. This is based on a price of 2.200 euro per freight train as reported in Tetraplan (2003). However, the time savings also constitute an economic gain to the transport buyer. Using the evaluation made in Tetraplan (2003) the time saving is valued at 12,6 mill. euro (2002-price level) using a value of time of 0,76 euro per tonnes hour.

In Tetraplan (2003) freight prices and cost reductions are calculated for two examples: Malmö-Maschen and Östersund-Stuttgart. The timesaving for these two examples corresponds to a reduction of 13 percent and 5 percent respectively.

Whether the goods are transported across the Rødby-Puttgarden link by ferry or by a fixed link the firm will incur almost the same direct vehicle running costs (Fuel costs, vehicle depreciation, ferry ticket or bridge toll and other direct running costs). These costs will be approximately equivalent in both cases (with and without the fixed link) given that the bridge toll is set equal to the ferry ticket.

However, other cost elements in the total transport costs will be affected by a fixed link – especially those related to time – such as drivers' salaries etc. With a fixed link across Fehmarn Belt instead of a ferry service, firms selling goods across the North-South divide (either across Fehmarn Belt, across the Baltic sea or by road using the Great Belt link) will experience the improvements shown in box B.

Box B Logistics improvements for goods transport by road (lorry)

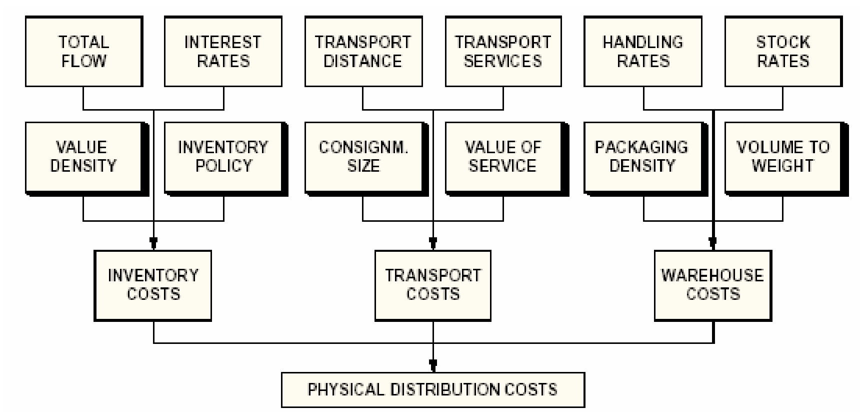
A fixed link has the following advantages over ferry service

- **Time savings** (faster door-to-door delivery because of less waiting time and faster crossing of the Belt)
- **Increased flexibility** leading to improved transport planning because of continuous departures instead of discrete departures.
- **Reduced risk of delays** (with the ferry a delay of 5 min. in the approach to the ferry can imply a delay in 30 min. if you "just miss" the ferry.

The advantages in box B are based on a view of goods transport as one link in the total production chain running from production to final consumption taking into account the total physical distribution costs (logistics costs), Figure B.1.

These improvements <u>are not</u> taken into account in the traffic-forecasting model (FTC, April 2003) with regard to the overall trade volume (in the so-called traffic generation model).

Figure B.1 Total physical distribution costs (logistics costs)



How to access the economic value of the improvements mentioned in box B?

How can we attach an economic value to the benefits mentioned in box B? In the model for analysing the dynamic effects of a fixed link we like to think of transport costs as a mark-up on the marginal production cost. Therefore, we need to "translate" the elements in box B into economic terms (euros per tonnes of goods transported or even better in euros per value of the goods transported).

Two options seem relevant. The first option is to use estimates from interviews of transport buyers regarding the value they express for time savings, flexibility and reduction of risk. Such studies have not been carried out in a Danish context; however Swedish studies seem to be advanced in this field[8]. Applying parameter estimates from these studies could lead to the following model of the extra cost reductions:

Model one: Value-of-time estimates

$$\Delta c_{ij} = \alpha(t_{ij}^{WC} - t_{ij}^{FL}) + \beta(f_{ij}^{WC} - f_{ij}^{FL}) + \delta(\sigma_{ij}^{WC} - \sigma_{ij}^{FL})$$

where the parameters *α, β and δ* are expressed in value terms per unit (i.e. euro per minute or euro per 1/1000 reduction of risk). The variables *tij, fij* and *σ* being time, flexibility and delay risk respectively. The subscripts denote the relation between region *i* and region *j*. Superscripts *WC* (for *without case*) and *FL* (for *fixed link*) are used for the two scenarios.

The second option is to use specialised logistic software that simulates and optimises transport flows of representative firms on a given network. Such models predict the overall transport cost savings including the direct running costs as well as those benefits mentioned in box B. Some models have a representation of the network in Europe in the same model. These models optimise the route planning for a given trade volume and a given network. Thus, two scenarios can be constructed which are comparable to the scenarios WC and FL mentioned above. If the increased flexibility, the timesaving, and the reduced risk of delays are important to the representative firm this will show up in the optimisation software. We have opted for the second solution, since estimates for all regions will stem from the same source, and since this model captures most closely the effects we are aiming at.

[8] SIKA Institute report no. 2002:9, see http://www.sika-institute.se/utgivning/2002_9.pdf.

Appendix C Current situation and outlook for the region

In this appendix we describe the current state of employment and economic performance in Northern Germany and Denmark using the most recent official statistics. Furthermore, we describe the trade pattern between Germany, Denmark and the other Nordic countries.

Finally, we present an outlook for employment, economic growth and structural changes in the Northern European region. The outlook is based on available studies from Prognos as well as studies from the European Commission, OECD, WTO and others.

We draw special attention to the potential developments following the enlargement of Europe. It has been suggested that trade – and hence transport – with Eastern Europe will increase dramatically in the coming 10-15 years. The results from this chapter are used as input to some of the scenarios that we analyse in the following chapter.

C.1. The current employment, economic and structural situation in the region

The regional economic effects of the Fehmarn Belt link cannot credibly be estimated without precise knowledge of the initial economic situation.

In the following we give a review of the current and perspective situation of employment, economic, and structural development in Denmark, Germany and Sweden. This abstract outlines the general economic situation, the development tendencies in the economic sectors. The main source of macro-economic forecast is the Prognos Germany-Report and the Prognos World Report "Industrialized Countries". The Prognos World Reports “Industrial Countries” provide reliable base data and forecasts regarding the demographic and economic developments of 20 countries.

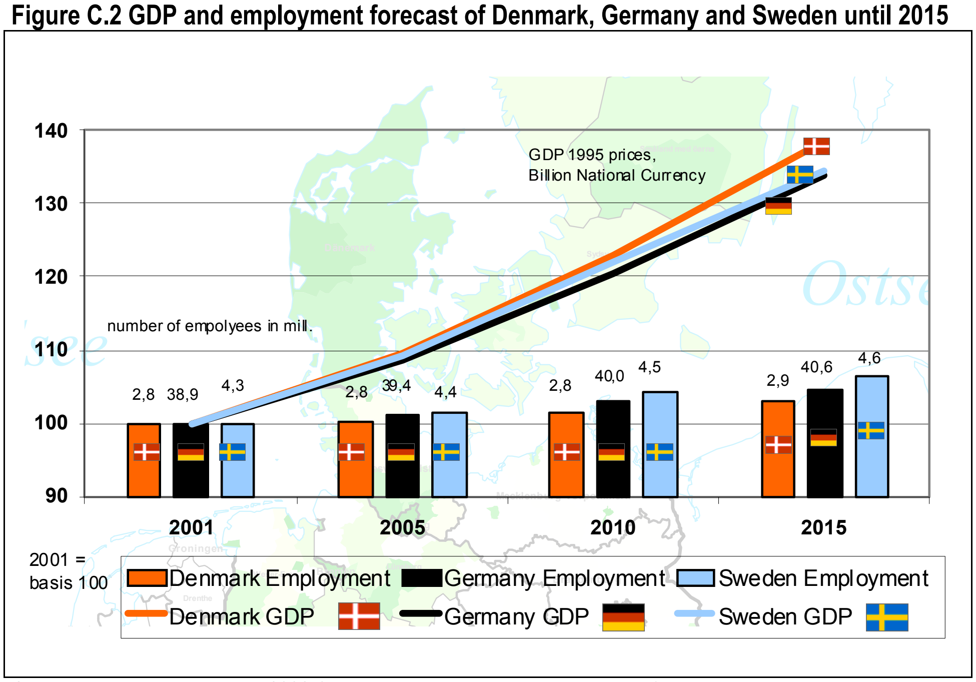
The national economies of Denmark, Germany and Sweden are presently characterised by a phase of economic slow-down. For all three countries together, the annual growth in 2000 and in 2002 has declined by 2,0 percent. Especially Germany has been hit hard by economic slow-down. Currently, the German economy stagnates on a level of 0,2 percent annual growth rate.

Figure C.1 Overview of the current economic situation in Denmark, Germany and Sweden

	Denmark	Germany	Sweden
inhabitants 2002	5,4 mill. (124 inhabitants per km²)	82,5 mill. (230 inhabitants per km²)	8,9 mill. (22 inhabitants per km²)
GDP per capita in Purchasing Power Standards (EUR 15 =100) 2002 [Eurostat]	115	103	102
Total unemployment rate - Unemployed persons as a share of the total active population 2002 [Eurostat]	4,5 %	8,6 %	4,9 %
Growth rate of GDP	2000: 2,8 % 2001: 1,4 % 2002: 1,5 %	2000: 2,9 % 2001: 0,6 % 2002: 0,2 %	2000: 4,4 % 2001: 1,1 % 2002: 1,9 %
Share in % of employees by sectors	Argricul. 3,3 % Industry 22,6 % Service 74 %	Argricul. 2,4% Industry 28,5% Service 69 %	Argricul. 2,6 % Industry 23,2 % Service 74 %
Main trade parter	Germany Schweden Great Britain	France Netherlands/ Great Britain USA	Germany Great Britain Norway / Denmark

Source: Prognos AG 2003, according to http://www.bfai.de, BBR Inkar 2002, Eurostat, Prognos World-Report

Figure C.2 GDP and employment forecast of Denmark, Germany and Sweden until 2015

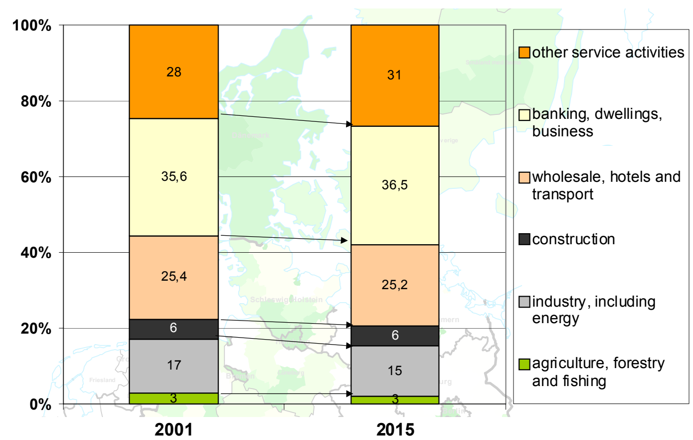


Source: Prognos World Report 2002 Current economic situation and outlook of Denmark

The Danish market covers 5,4 mill. inhabitants and its economy is regarded as healthy - despite a moderate growth of 1,4 percent to 1,5 percent in 2001 and 2002. In 2003 the economy will grow by approximately 2,0 percent. Growth engine is the private consumption.

The Danish economy is characterised by high dependence on foreign trade. Traditionally, Germany is the most important trading partner for Denmark. This applies to both the import and the export. The share of German suppliers in Danish imports remained stable in the course of the last decade at 22 percent. Sweden is the second most important trading partner for Denmark (12 % of import and export). Denmark is an attractive partner for foreign enterprises thanks to its high technological standards. Despite favourable basic conditions like narrow trade interweaving, and modern economy structures, the Danish industry will also be affected by economic challenges in the future. The high level of labour costs and other production costs causes the shift of enterprises, especially with labour-intensive production, to Eastern Europe and Asia. Among others, Danish future growth markets are wind power plants, mobile radiotelephony, bio medicine, pharmacy, transportation/logistics, electrical engineering/electronics, environmental technologies.[9]

Figure C.3 Forecast of Danish sectoral structure



Source: Prognos AG 2003, Prognos World Report 2002

Among the regarded countries, the Danish economy will develop most dynamically in a long run to 2015. The GDP will increase about 40 percent and the gainful employment increases easily by 3,0 percent. Significant growth of employment has to be expected in the sectors "transport and communication" (0,9 % p.a. 2005-2010), "electricity, gas and water" (0,9 %) and construction (0,8 % p.a.).

Current economic situation and outlook of Germany

As Europe's largest economy and most populous nation (82,5 mill. inhabitants), Germany remains a key member of the European Union. Germany's affluent and technologically powerful economy turned in a relatively weak performance throughout the 1990s. The integration and modernization of the eastern part of Germany caused financially problems. The German economy is currently characterised by ageing population, high unemployment rates and economic stagnation. The growth rate of GDP fell in 2001 and 2002 by just short of 1,0 percent. The export of machinery, vehicles, chemicals, metals and manufactures and foodstuffs especially to France, USA, Great Britain and the Netherlands are furthermore an important economy factor. Manufacturing is the mainstay of the German economy. About 28 percent of the labour force is employed in the industry sectors. Thanks to its state-of-the-art technology innovative products and emphasis on research, the chemical industry, the automobile and the construction industry play a leading role worldwide.

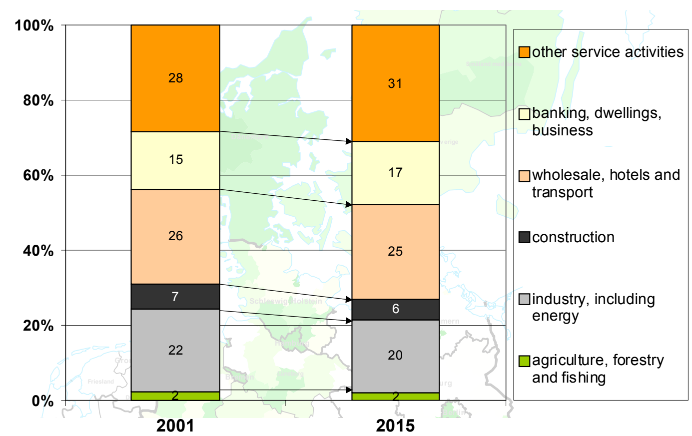
Unemployment has become a structural and chronic problem, and currently occupies the German Federal Government to undertake a social reform in the areas of labour market, health

[9] According to appraisements of the Bundesagentur für Außenwirtschaft (BAFI), German Office for Foreign Trade

and pension. A central chance for the German economy is the eastern enlargement of the European Union, which gets Germany into a leading role as neighbour, trading partner and transit country for the newcomers.[10]

In the future, the German economy will grow significant slower than the Danish or Swedish economies The GDP will improve its performance by about 30 percent to 2015 based on 2001. Employment will rise by about 4,0 percent to 2015. The employment reduction takes place substantially in the industrial sectors: Mining and quarrying (rate of -4,0 % annual decline 2005-2010), coke, petroleum, nuclear fuel (-3,3 %) and textiles and leather (-3,1 %). Germany will expect a hard process of de-industrialisation in future. The German industry and construction sectors will loose about 1,8 mill. employees until 2015.

Figure C.4 Forecast of German employment by sectors



Source: Prognos AG 2003, Prognos World Report 2002

Current economic situation and outlook of Sweden

Sweden is with 8,9 mill. inhabitants the largest national economy among the Nordic countries . Its economy has a modern distribution system, excellent internal and external communications, and a skilled labour force. The Swedish industries are specialised in iron and steel, precision equipment, wood and paper products, processed foods and motor vehicles. Timber, hydropower, and iron ore constitute the resource base of an economy heavily oriented toward foreign trade[11].

Due to the global economic slowdown revenue declines and spending increases. The annual growth rates in Sweden declined from 4,4 percent in 2000 to 1,9 percent in 2002. Germany, Great Britain, Denmark and Norway are the most important Swedish trading partners. The OECD expects economic recovery for Sweden in 2004 and forecasts an economic growth of 2,0 percent.

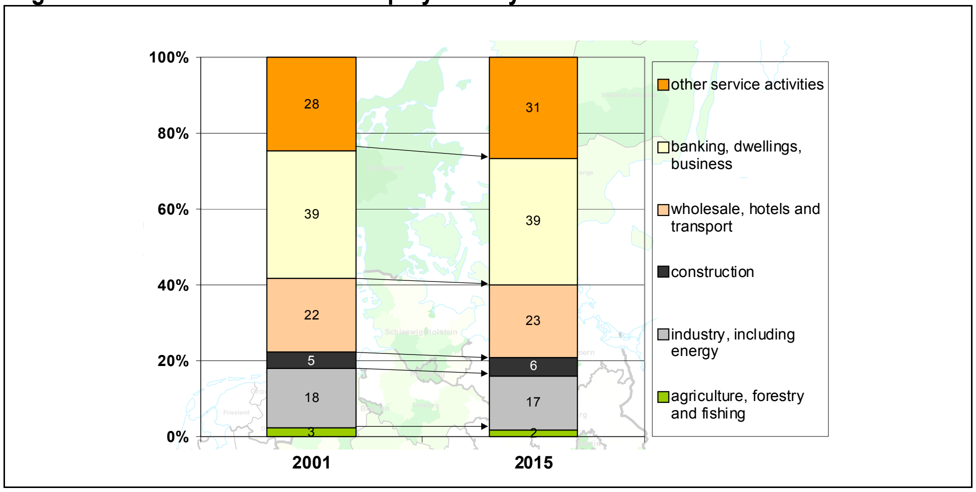
Among the three regarded countries, the Swedish labour market will develop most dynamically in a long run to 2015. The GDP will increase about 40 percent and the gainful employment increases easily by 3,0 percent. Significant growth of employment has to be expected in the sectors transport and communication (1,2 % p.a. 2005-2010), Banking (1,4 % p.a.), and Real Estate and Business Services (1,6 %).

[10] According to http://www.odci.gov/cia/publications/factbook/fields/2050.html and http://www.foreign-direct-investment.de/

[11] According to http://www.odci.gov/cia/publications/factbook/fields/2116.html

In a long-term view Sweden will be able to expect strong growth like Denmark. The GDP growth of 35 percent will lead up to 2015 into a range of 6,0 percent employment effects. The sectors banking, dwelling and business (1,6 % annual growth rate 2005-2010), and transport and communication (1,2 %) will profit mostly. In Sweden the process of the de-industrialisation has largely been completed.

Figure C.5 Forecast of Swedish employment by sectors



Source: Prognos AG 2003, Prognos World Report 2002

C.2. Forecast of the trade level and structure

Starting point of our trade forecasts are trade matrices for European regions, which classify the flow of commodities in the years 1996 and 2002 for 27 source and target countries. This comprises also eastern nations of the Baltic Sea - with exception of Russia - as well as the ten countries of the European Union enlargement in 2004. The trade matrices are descended from the Eurostat data base COMEXT.

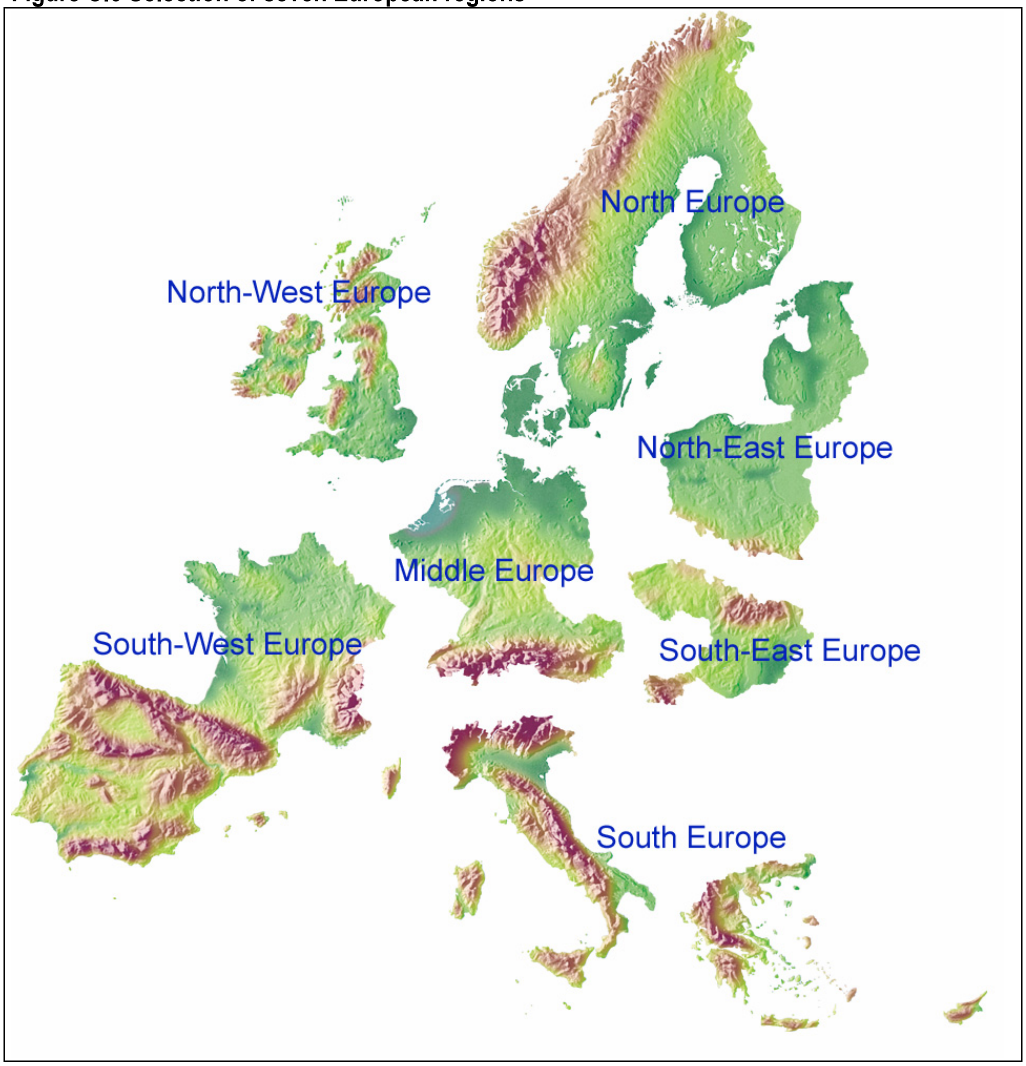
As far as we know there are no other forecasts for the trade flows in Europe up to 2015. Popular forecasts are delivered by the European Commission, the OECD and the IMF, but the actual ones are constricted to the year 2004. A comparison with our forecast is therefore not helpful.

Preparing the prognosis of the flow of commodities, first a hypothetical trade matrix is provided for the year 2002. This matrix is generated from the trade matrix of the year 1996 and the growth rate of the entire European Union foreign trade of the respective countries between 1996 and 2002. In this way a structure of the flow of commodities for 27 countries is generated, as it would be realized with a equal distribution of the foreign trade growth. Now, the hypothetical trade matrix can be compared with the existing pattern of trade matrix in 2002. From this the arising coefficients reports the above and below average increases in the foreign trade of the regarded countries.

For a better usability of the forecast model it is necessary to modify the coefficients. Thus for example the exports of Malta to Estonia increased in the examined period around approx. 2,821 %, but the initial value in 1996 was only around 0.00011 millions Euro. If somebody would apply to use such coefficients also to the forecast period 2002 up to 2015, then the exports of Malta to Estonia would constitute a multiple of the gross national product of Malta. In order to avoid such unreasonable results, in the case of deviations the coefficients are limited upward and downward by setting a margin. A further modification takes place in form of a linear upsetting of the coefficients, which likewise absorb extreme developments of trade flows. The Prognos World report and in the Eastern Europe report comprises a forecast of the entire foreign trade of the examined countries in the years 2002 to 2015. In this forecast the strengthening effects of the EU-enlargement are included. Resulting from this, in a second step the growth rates are linked now with the coefficients and applied to the output matrix 2002. As a result we have a trade matrix for the year 2015, which exhibits a similar structure of the commodity flow as in the output year 2002. In a last step the European Union trade proportion of the total trade of the countries in 2015 is compared with the proportion in the years 1996 and 2002 and adjusted - if necessary - over a modification of the coefficients. This modification takes place normally in a mark-up of the trade flows of the EU-candidates according to the stimulating effects of the accession.

Now, the selected 27 countries can be combined into seven spacious European regions (see Figure C.6), the arising commodity flows look as follows (see Table C.1).

Figure C.6 Selection of seven European regions



prognos 2003

Table C.1 Trade matrix European regions 2002 and 2015, in Billion Euro

		Export						
2002		South-West Europe	North-West Europe	Central Europe	North Europe	South Europe	North-Ost Europe	South-Ost Europe
Import	South-West Europe		52.3	212.6	22.4	53.5	4.0	6.4
	North-West Europe	53.4		123.6	28.2	21.1	3.5	4.3
	Central Europe	138.9	106.5		63.6	68.9	20.1	50.2
	North Europe	14.5	18.1	59.5		7.4	5.5	2.0
	South Europe	50.1	20.0	104.4	10.2		3.0	6.5
	North-Ost Europe	6.1	2.9	26.5	6.6	5.3		4.3
	South-Ost Europe	8.4	3.8	48.7	2.4	8.3	3.6	
2015		South-West Europe	North-West Europe	Central Europe	North Europe	South Europe	North-Ost Europe	South-Ost Europe
Import	South-West Europe		96.5	409.5	41.6	94.9	10.0	16.8
	North-West Europe	98.0		233.2	47.6	35.9	8.2	11.2
	Central Europe	221.2	199.1		107.3	104.3	41.9	118.5
	North Europe	25.4	29.8	107.4		12.4	13.1	4.7
	South Europe	88.2	35.7	193.4	19.3		6.4	13.7
	North-Ost Europe	16.4	5.7	61.9	14.2	11.6		9.4
	South-Ost Europe	22.7	9.6	121.5	5.4	18.0	11.1	
% p.a. 2002 - 2015		South-West Europe	North-West Europe	Central Europe	North Europe	South Europe	North-Ost Europe	South-Ost Europe
Import	South-West Europe		4.8	5.2	4.9	4.5	7.2	7.7
	North-West Europe	4.8		5.0	4.1	4.2	6.8	7.7
	Central Europe	3.6	4.9		4.1	3.2	5.8	6.8
	North Europe	4.4	3.9	4.6		4.0	7.0	6.9
	South Europe	4.5	4.6	4.9	5.0		6.0	5.8
	North-Ost Europe	7.9	5.3	6.7	6.0	6.2		6.2
	South-Ost Europe	8.0	7.4	7.3	6.4	6.1	9.0	

Data Source: Eurostat; Norway and Switzerland not complete

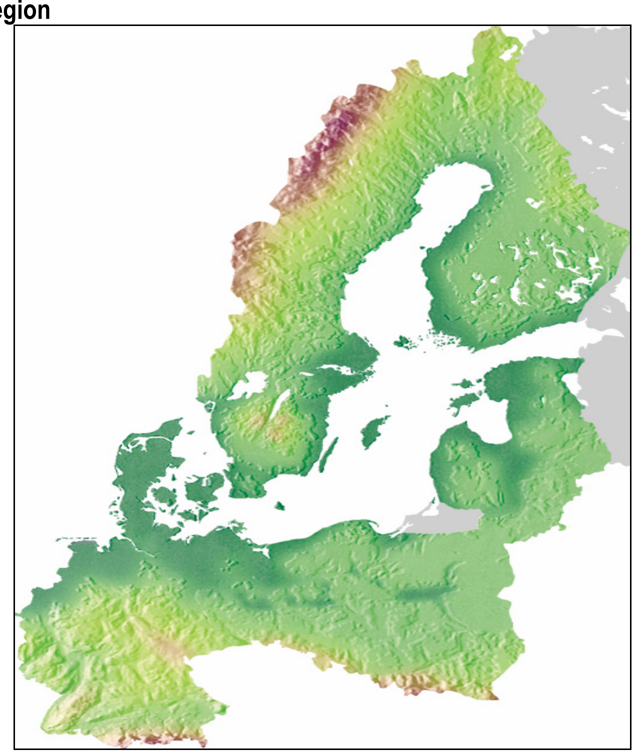
prognos 2003

Regions by Country

South-West Europe	Spain, Portugal, France
North-West Europe	United Kingdom, Ireland
Middle Europe	Germany, Austria, Switzerland, BeNeLux
North Europe	Norway, Sweden, Denmark, Finland
South Europe	Italy, Greece, Malta, Cyprus
North-Ost Europe	Poland, Estonia, Latvia, Lithuania
South-Ost Europe	Czech Republic, Slovakia, Slovenia, Hungary

As expected the largest proportional increases of the commodity flows appear between the regions, which were only small integrated so far and proceed from a low level in 2002. These are primarily the regions North and Southeast Europe, in which the European Union entry countries appear. In absolute values Central Europe are in a dominating position as well in 2002 as in 2015. For this, above all, the strong weight of Germany is crucially, whose European Union foreign trade constitutes about 20 percent of the European Union trade in 2002 and 2015. The commodity flows between North and Central Europe, which are in particular relevant for the fixed Fehmarn Belt link, will increase between 2002 and 2015 around 4,1 percent and 4,6 percent per annum. In comparison with trade growth between other European regions these increases will be rather below average.

Figure C.7 The Baltic Sea region



prognos 2003

For the Baltic Sea area the following commodity flows result for the years 2002 and 2015 (see Table C.2). Similarly to the commodity flows between the spacious European regions, the highest increases are also between those countries, which exhibited a rather small commercial integration until 2002. In absolute values, the trade between Germany and the countries Denmark, Sweden and Poland dominates. Prognos expects growth rates between 3,0 percent and 6,2 percent per annum. The expected growth of trade between Germany and Sweden, crucial for a fixed Fehmarn Belt link, is with 3,1 and/or 4,5 percent per annum rather moderately.

Table C.2 Baltic Sea Trade 2002 and 2015, in Billion Euro

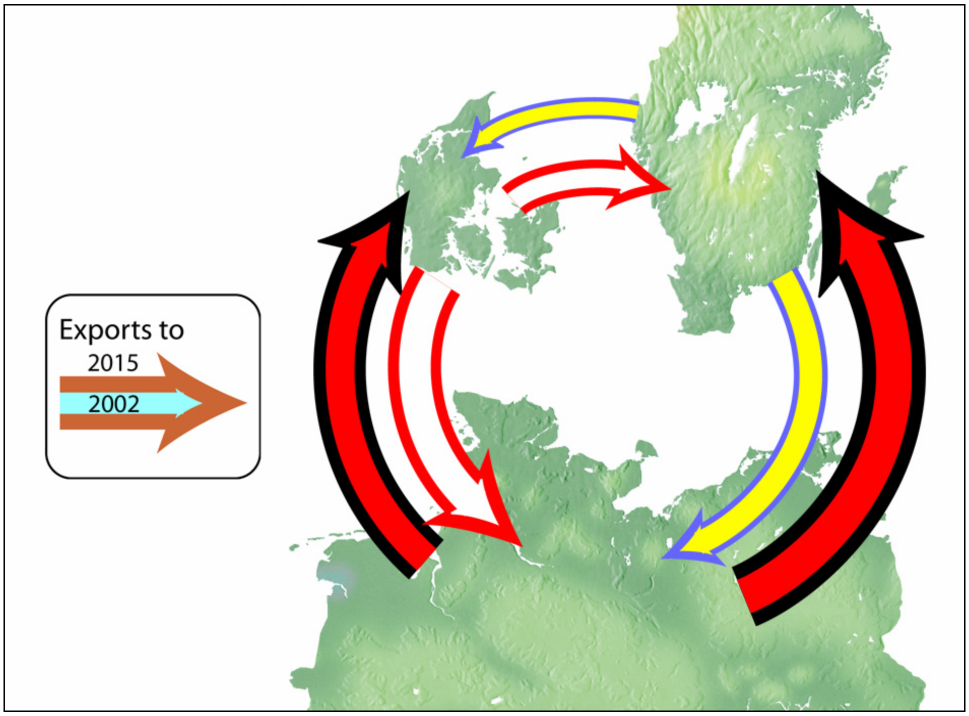
		Export							
2002		Germany	Sweden	Finland	Denmark	Estonia	Latvia	Lithuania	Poland
Import	Germany		8'508	5'674	11'950	370	406	674	14'028
	Sweden	13'470		4'180	7'113	593	346	276	1'289
	Finland	6'642	4'663		1'903	977	73	64	302
	Denmark	10'887	5'003	1'156		187	163	263	934
	Estonia	619	547	1'262	154		215	145	129
	Latvia	875	271	323	158	127		202	987
	Lithuania	1'521	287	269	277	269	534		299
	Poland	16'063	1'380	798	919	35	201	38	
2015		Germany	Sweden	Finland	Denmark	Estonia	Latvia	Lithuania	Poland
Import	Germany		12'697	10'151	19'941	815	762	1'320	30'390
	Sweden	23'839		6'892	13'382	1'403	807	807	3'161
	Finland	13'481	8'476		3'893	2'688	179	152	554
	Denmark	19'653	8'019	1'846		491	390	675	1'813
	Estonia	1'771	1'571	2'484	375		1'012	481	334
	Latvia	2'231	528	650	363	318		507	3'529
	Lithuania	4'519	813	697	695	532	1'134		599
	Poland	34'957	2'758	1'635	1'641	111	520	68	
% p.a. 2002 - 2015		Germany	Sweden	Finland	Denmark	Estonia	Latvia	Lithuania	Poland
Import	Germany		3.1	4.6	4.0	6.3	5.0	5.3	6.1
	Sweden	4.5		3.9	5.0	6.8	6.7	8.6	7.1
	Finland	5.6	4.7		5.7	8.1	7.1	6.9	4.8
	Denmark	4.6	3.7	3.7		7.7	7.0	7.5	5.2
	Estonia	8.4	8.4	5.3	7.1		12.7	9.7	7.6
	Latvia	7.5	5.3	5.5	6.6	7.3		7.3	10.3
	Lithuania	8.7	8.3	7.6	7.3	5.4	6.0		5.5
	Poland	6.2	5.5	5.7	4.6	9.3	7.6	4.6	

Data Source: Eurostat prognos 2003

A further component of the Prognos contribution to this study is a forecast of the commodity flows between Germany, Denmark and Sweden, sorted according to categories of commodity groups. Ex-post statistics of foreign trade between the three countries by categories of commodities are present for 1996 and 2002. The exports and imports up to 2015 are already determined, equally the respective industry development is well-known in the three countries until 2015 from the Prognos World Report. In preparation of the forecast we opposed in each case the development of the foreign trade between 1996 and 2002 of one special group of goods to the appropriate industry development in the exporting country. In only very few cases a development moving in opposite directions is to be observed here, which are to due to special developments of unknown origin. Therefore we set the assumption, that the industry development in the respective exporting country is representing a substantial determinant for the commodity flow of the appropriate group of goods.

With having the initial values of foreign trade in 2002 and respective industry growth, we received a structure of the foreign trade in 2015 by categories of commodities. Since industry growth precipitates smaller than the growth of the entire foreign trade, in a second step the determined commodity flows are adapted proportionally by categories of commodities in such a way that they are identical in the sum to the entire foreign trade. In a last step, the foreign trade structures of the years 1996, 2002 and 2015 are compared with each other by categories of commodities and particularly the values in 2015 are partly corrected (this appears especially at absolutely small groups of goods).

Figure C.8 Exports between Germany, Denmark and Sweden, 2002 and 2015
(based on Table C.2)



prognos 2003

The forecast of foreign trade by categories of commodities shows partly clear structural differences (see Table C.3). Generally it can be held, that products with small value added are exported and/or imported less with increasing distance, for instance agriculture products. This is due to the rising proportion of transport costs, which becomes more clearly apparent with these goods. Prognos expects highest increases in categories of commodities with high creation of value added; this concerns above all machinery, electrical and transport equipment. The trade with chemicals and rubber and plastic products will increase also above-average.

Table C.3 Trade by commodities between Germany, Denmark and Sweden, 2002 and 2015, in Mill. Euro

	Exports from Germany to ...					
	Denmark			Sweden		
	2002	2015	% p.a.	2002	2015	% p.a.
1 Agriculture, Forestry and Fishing	192	294	3.3	108	164	3.3
2 Industry, including Energy	10'695	19'360	4.7	13'362	23'676	4.5
21 Mining and Quarrying	14	9	-3.5	43	38	-1.0
22 Manufacturing	10'626	19'255	4.7	13'318	23'637	4.5
22a Food, Beverages and Tobacco	866	1'437	4.0	480	790	3.9
22b Textiles and Leather	411	468	1.0	372	420	0.9
22c Wood and Wood Products	141	201	2.7	78	109	2.7
22d Paper and Paper Products	409	678	4.0	296	487	3.9
22e Coke, Petroleum, Nuclear Fuel	58	85	3.0	179	259	2.9
22f Chemicals	997	2'166	6.2	1'371	2'290	4.0
22g Rubber and Plastic Products	396	788	5.4	463	914	5.4
22h Non Metallic Mineral Products	186	287	3.4	167	256	3.3
22i Basic Metals, Metal Products	968	1'700	4.4	1'278	2'225	4.4
22j Machinery Equipment	1'459	2'933	5.5	2'000	3'986	5.4
22k Electrical Equipment	1'973	3'762	5.1	2'264	4'280	5.0
22l Transport Equipment	1'454	2'775	5.1	2'717	5'142	5.0
22m Manufacturing n.e.c.	1'307	1'975	3.2	1'654	2'480	3.2
23 Electricity, Gas and Water	55	96	4.4	-	-	-
Total	10'887	19'653	4.6	13'470	23'839	4.5
	Imports to Germany from ...					
	Denmark			Sweden		
	2002	2015	% p.a.	2002	2015	% p.a.
1 Agriculture, Forestry and Fishing	492	788	3.7	25	17	-2.8
2 Industry, including Energy	11'459	19'154	4.0	8'483	12'680	3.1
21 Mining and Quarrying	1'088	1'625	3.1	175	215	1.6
22 Manufacturing	10'233	17'319	4.1	8'308	12'465	3.2
22a Food, Beverages and Tobacco	1'933	3'001	3.4	91	128	2.7
22b Textiles and Leather	303	368	1.5	73	55	-2.1
22c Wood and Wood Products	191	346	4.7	171	253	3.1
22d Paper and Paper Products	222	366	3.9	2'006	2'936	3.0
22e Coke, Petroleum, Nuclear Fuel	35	26	-2.1	246	355	2.9
22f Chemicals	823	1'510	4.8	1'004	1'748	4.4
22g Rubber and Plastic Products	316	582	4.8	137	201	3.0
22h Non Metallic Mineral Products	131	214	3.8	27	15	-4.4
22i Basic Metals, Metal Products	546	955	4.4	1'055	1'394	2.2
22j Machinery Equipment	968	1'596	3.9	768	1'141	3.1
22k Electrical Equipment	2'087	3'830	4.8	650	1'039	3.7
22l Transport Equipment	442	746	4.1	668	1'055	3.6
22m Manufacturing n.e.c.	2'237	3'778	4.1	1'412	2'145	3.3
23 Electricity, Gas and Water	137	209	3.3	-	-	-
Total	11'950	19'941	4.0	8'508	12'697	3.1

Data Sources: Eurostat prognos 2003

Appendix D Quantification of the most important dynamic and strategic effects

This appendix documents the model we use to quantify the most important dynamic and strategic effects. Because of the complexity of the issues at hand we combine the results from a new economic geography model (The CENEG-model) build by Copenhagen Economics with a model build by Bröcker (1998a). The latter model is documented in Bröcker & Richter (1999).

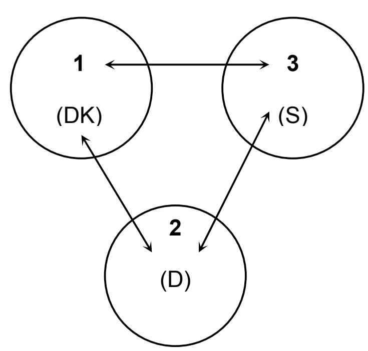
D.1. Economic geography effects (the CENEG-model)

We use the CENEG-model to analyse the dynamics of firm entry and relocation. In this section we document the model and its application to the analysis of the Fehmarn Belt fixed link. The documentation has three parts. First, we present the model and its theoretical foundations. Second, we document the calibration and the data employed. Finally, we define the policy scenarios and document the reporting of the results.

Model

The structure of the CENEG-model has originally been developed for SACTRA[12] in the UK by Venables & Gasiorek (1998). Here we limit the documentation to an overview of the main characteristics and the key mechanisms in the model. The CENEG-model structure follows Venables & Gasiorek's model very closely and we therefore refer interested readers to the SACTRA-study for technical details on functional forms, etc.

For the analysis of the Fehmarn Belt fixed link, we study a reduction in transport costs in a model with 3 regions: 1) Denmark (DK), 2) Germany (D) and 3) the rest of Scandinavia (S). A transport network through which goods and services can be traded links the regions. We can therefore think of the regions as a triangular economy, where we analyse reduction in transport costs between regions 1 and 2 (i.e. the link between DK and D regions).[13]



[12] SACTRA is an abbreviation for Standing Advisory Committee on Trunk Road Assessment.

Each of the regions has a representative consumer and 14 production sectors. Table D.1 lists the production sectors and Figure D.1 gives an overview of the markets, and the flows of goods, services and factors in the model.

Figure D.1 Overview of the CENEG model

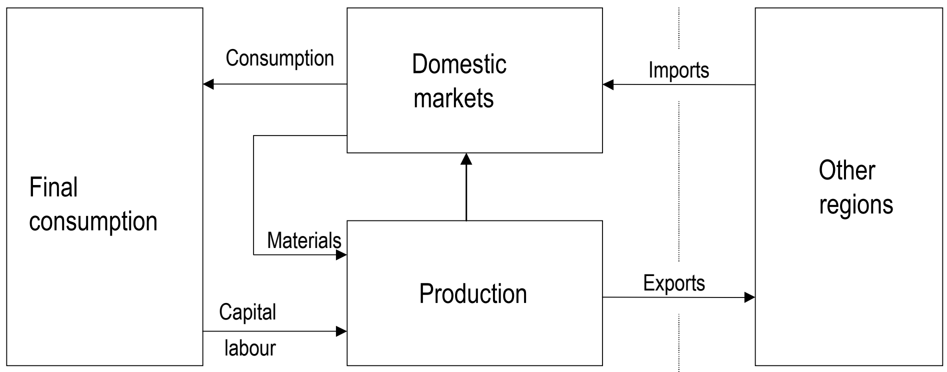


Table D.1 Production sectors and their key economic characteristics

		Sectors	Value-added	Price-cost margins: Central case	Lower bound	Upper bound
Traded	Perfectly competitive	Agriculture	2,2%	-	-	-
		Other energy	1,4%			
		Traded services	38,3%			
	Imperfectly competitive	Refined oil	0,1%	1,15	1,10	1,20
		Food	3,3%	1,15	1,05	1,25
		Textiles	0,8%	1,13	1,10	1,15
		Wood	0,8%	1,15	1,10	1,20
		Paper	1,8%	1,15	1,05	1,25
		Chemical	2,9%	1,13	1,05	1,20
		Minerals	1,2%	1,25	1,20	1,30
		Metals	2,4%	1,18	1,05	1,30
		Transport equipment	5,3%	1,20	1,10	1,30
		Other manufacturing	5,3%	1,15	1,10	1,25
Non-traded	Perfectly competitive	Domestic services	34,2%	-	-	-
	Imperfectly competitive	None	-	-	-	-
		TOTAL	100%	-	-	-

Source: Own calculations based on the GTAP5 database and Martins et al. (1996)

Table D.2 Relative size of the economies

	Denmark	Germany	Rest of Nordic	Total
Value added	5%	76%	18%	100%

[13] In addition to the three regional trading partners, the model also includes a region representing all other external trading partners, including the rest of the EU. The model incorporates this region via horizontal import supply and export demand functions. That is, trade outside the three regions take place at exogenous world market prices.

The representative consumer represents final consumption. He is endowed with labour and capital, which are exogenously supplied and perfectly mobile across sectors within a given region, but immobile across regions. He finances his consumption with income from sales of capital and labour services plus any pure profits.

Firms producing goods and services represent the supply side of the model. All goods and services are being produced with materials and primary factors capital and labour, and output may be sold domestically or abroad. Output competes with imports in domestic markets, and exports compete with foreign production in export markets.

All firms are assumed to maximize profits, but we divide the production sectors into perfectly competitive and imperfectly competitive sectors. Firms in the perfectly competitive sectors set prices equal to marginal costs, and instant entry or exit implies that pure profits never arise in these sectors.

Prices exceed marginal costs in the imperfectly competitive sectors. Following the literature on the “New Economic Geography”, the sectors feature increasing returns to scale in production, imperfect competition, and differentiated product markets. Specifically, each firm is assumed to produce its own distinct variety of output, which is a close, but imperfect substitute for other varieties of the same good or service within the sector. Entry and exit of firms thus help explain the pattern of industrial location across regions. Since a significant portion of firms’ sales are intermediate inputs to other firms, the model further more allows for industrial agglomeration, also known as industrial clusters. That is, firms locate close to each other to benefit from the backward and forward linkages that arise, when firms are important suppliers to some (downstream) firms and customers with other (upstream) firms.

The model does not include a separate transport sector. Transportation services are instead a derived demand from interregional trade with goods. Specifically, interregional trade flows require transportation services in terms of additional inputs of goods and services. Transport costs therefore correspond to the costs of these inputs.

The input requirement of transportation services therefore influences interregional trade directly. We use this feature to capture the effects of an investment in transport infrastructure and the key mechanism in the model is as follows. First, the infrastructure project reduces the required inputs of transportation services and therefore lowers transport costs. The lower transport costs directly affect the prices of goods in the different regions, and this in turn changes firm sales and profits. Second, entry and exit of firms may occur as a reaction to the changes in profits, which generates a second round of effects. Third, firm entry increases competition, which lowers profits and increases factor prices, which again lower profits. Fourth, firm entry also increases the demand for intermediate inputs, which increases the profits of the firms supplying the intermediate inputs. Higher profits may in turn stimulate further entry by firms supplying these goods and services. Thus, the initial reduction in transport costs changes the structure of multiple production sectors through a series of forward and backward linkages between the different sectors in all regions. The model captures all these effects simultaneously and translates them into resulting impacts on each sector in each region.

Calibration and data sources

The model presented above is based on specific functional forms for the production technologies and consumer preferences (see Venables & Gasiorek (1998) for details). We calibrate the parameters of the functional forms to represent a benchmark data set, assuming that the data set represents a snapshot of the economies, in which they all in equilibrium.

In other words, we calibrate all the model parameters such that the data set represents an equilibrium solution of the model. This also implies that the model specification cannot be tested statistically as all parameters are calculated deterministically. Instead, we acknowledge the uncertainty underlying the model parameter by performing systematic sensitivity analysis of key parameters in the model.

Our main data source is an aggregation of the GTAP5 database from 1997. This dataset contains data for both the production sectors and the consumer demands in all the regions. The dataset furthermore contains consistent data on bilateral trade flows of both goods and services as well as data on bilateral transportation costs by production sector. Table D.1 shows the contribution of value-added by production sector as a weighted average across all 3 regions (Table D.2 shows the regional share in total value added).

We combine the dataset with data on price-cost margins from an OECD-study (see Martins et al. (1996). The data shows price-cost margins by production sector and this represents an extension of the model by Venables & Gasiorek, which assume uniform price-cost margins across sectors. Table D.1 reports the average estimate of the price-cost margin by production sector.

With one exception, all elasticities of substitution in the model are identical to the SACTRA-study by Venables & Gasiorek. The exception relates to the so-called Armington trade elasticity, which determines the degree of substitution between domestic and imported goods (or services) within a given production sector. We are not aware of any thorough estimations of this elasticity based on European data, but we employ a value of 3 as our central estimate based on the survey by McDaniel and Balistreri (2002).

We fully acknowledge both the importance of these parameter values for the results and the uncertainty surrounding the empirical estimates. Consequently, we perform systematic sensitivity analysis on these model parameters when reporting the results (explain below).

A final step in the calibration of the model involves the calculation of a reference equilibrium for the year 2015, which will serve as the reference point for the evaluation of the policy scenarios. The reference equilibrium employs two additional assumptions. First, to account for economic development between 1997 and 2015, we assume that all the economies in the model grow uniformly along a steady-state equilibrium path at an average rate of 1.8 percent per year. Second, no taxes apply in the reference equilibrium. This assumption serves several purposes.

One purpose is to remain consistent with the corresponding, traditional cost-benefit analysis, which employs factor prices, i.e., prices net of taxes. The assumption is furthermore consistent with the corresponding theoretical model by Venables & Gasiorek, which brings us to the second purpose: We want to focus on the effects of lower transportation costs. That is, if the model includes other distortions, for example taxes, the results would include not only the effects of lower transportation costs, but also of changes in for example tax revenues and of interactions between transportation costs and tax distortions. In summary, the assumption about no taxes in the reference equilibrium implies both consistency with other studies and makes the results easier to interpret as a direct consequence of the infrastructure project.

Policy scenarios and reporting

The theoretical model has now been specified and the model parameters have been calibrated to a real dataset covering production, consumption, trade and transportation in the regions around the Fehmarn Belt. With this completed, we can now use the model to analyse counterfactual equilibria, i.e., new equilibria under alternative policy scenarios. By comparing the counterfactual equilibria with the reference equilibrium, we can infer the effects of the policy change, in this case a reduction in transportation costs.

In our core policy scenario we assume that the Fehmarn Belt fixed link implies a uniform percentage reduction in the transportation costs per unit of output traded across the Fehmarn Belt. We analyse this scenario in two stages corresponding to the short run and the long run. We define the short run as the equilibrium where the location of firms are held fixed, but all other variables, such as output and prices, change in response to lower transportation costs. In other words, the short run effects ignore the possibility that firms may exit or enter the different production sectors in the different regions and thereby cause industrial relocation. Consequently, the short run equilibrium contains changes in the level of pure profits in the production sectors.

We then define the long run as the equilibrium where the location of firms is allowed to change. The location of firms will change in response to the short run changes in the level of pure profits. Firms will enter in the production sectors where incumbent firms make positive profits until the level of pure profits is driven to zero. Conversely, firms will exit the production sectors where the level of pure profits is negative until the profits are driven back up to zero.

We can compute the sectoral, the regional and the aggregate effects of our policy scenario. A distinctive feature of the approach is the incorporation of spill over effects between production sectors both within regions and across regions. The model thus allows insights on the overall effects of the infrastructure in addition to those developed by standard cost-benefit analysis.

We specifically summarise our results in a total benefit multiplier to establish a direct correspondence with the corresponding cost-benefit analysis of the infrastructure project. We define the multiplier as the ratio of the total change in welfare to total direct benefits. The total direct benefits correspond, in principle, to the result of the cost-benefit analysis, whereas the total change in welfare includes all both direct and indirect benefits.[14]

A final point regarding reporting is that we do not report the total benefit multiplier as a point estimate, but rather as a range reflecting the uncertainty surrounding the estimates of some of the key model parameters. Specifically, the analysis reports the results of systematic sensitivity analysis, where the price-cost margins and the Armington-elasticity is chosen randomly within given ranges assuming a uniform distribution of estimates between the lower and the upper bounds for the estimates. Table D.1 shows the bounds for the price-cost margins in the sensitivity analysis and the bounds for the Armington elasticity is set a 2 and 4, respectively.

D.2. Transport cost reductions

The reductions of transport costs in the Fehmarn Belt fixed link scenario is deducted from the latest forecast by FTC (2003). We calculate the direct cost savings from a fixed link by multiplying the predicted number of vehicles by the average distance for each combination of origin, destination, transport mode, route and commodity type.

We use the valuation of time and distance savings that are use in the cost benefit analysis by Cowi (2004). For lorries the direct gain is a combination of a time-component and a distance-component. First we show the calculation of the distance component (i.e. the kilometre savings from country *I* to country *J*):

[14] We use the equivalent variation to measure the total welfare change. An alternative measure is the compensating variation, which also measures the total welfare change. Both are theoretically consistent with the model and both take into account all changes in prices and income. They only differ with respect to the choice of the reference price level. In the present analysis, the difference between the two welfare measures is negligible.

$$Km-savings(I,J)=\left[\sum_{i\in I}\sum_{j\in J}\sum_{m}\sum_{r}\sum_{g}(nbveh^{FL}_{ijmrg}\times avgkm^{FL}_{ijmrg})\right]$$
$$-\left[\sum_{i\in I}\sum_{j\in J}\sum_{m}\sum_{r}\sum_{g}(nbveh^{WC}_{ijmrg}\times avgkm^{WC}_{ijmrg})\right]$$

where

- *nbveh* is 'Number of vehicles'
- *avgkm* is 'Average transport distance in km'
- *i* is region of 'origin' (and I and J are countries)
- *j* is region of 'destination'
- *m* is 'mode'
- *r* is 'route'
- *g* is 'type of good'

Furthermore:

- *WC* stands for the scenario 'without case' i.e. "before" the fixed link
- *FL* stands for the scenario 'fixed link' i.e. "after" the fixed link

Time-savings are calculated likewise by replacing "avgkm" with "avgtime" in the above formula. For rail transport we calculate the gain on basis of ton-kilometers. This is done by replacing "number of vehicles" with "number of tons" in the summation above and multiply with the corresponding average distance for trains. The savings in physical units are evaluated using the following unit prices.

Table D.3 Unit costs for transport

	km-component	Time-component	Value of time
	kr/km	kr/min	kr/tonkm pr minut
Road	2,75	304	5,7
	kr/tonkm		
Rail + combined	0,25		

Source: Cowi (2003)

The results are shown in Table D.4 in both monetary terms and in percentages. We use the monetary values to reduce the transport costs in the fixed link scenario.

Table D.4 Transport cost reductions (mio. Danish kroner from 'Without case')

Goods category	Denmark-Germany	Germany-Denmark	Other Nordic-Germany	Germany-Other Nordic	Total
0 Cereals, fruits and vegetables	0	1	0	6	7
1 Foodstuff and animal fodder	2	2	1	4	8
2 Wood and cork, textiles	1	18	12	9	40
3 Fuels	0	0	0	0	0
4 Ore, metals	6	2	13	19	40
5 Building materials	0	0	0	4	5
6 Fertilizers, chemicals	1	1	3	17	23
7 Transport equipment and machinery	0	3	4	14	21
8 Other manufactured articles	2	5	64	30	101
9 Paper pulp and waste paper	2	2	5	4	13
10 Miscellaneous articles	3	7	8	12	31
TOTAL	**17**	**41**	**112**	**118**	**288**

Table D.5 Transport cost reductions (pct-change from 'Without case')

Sectors in the model (pct change from 'Without case")	**Denmark-Germany**	**Germany-Denmark**	**Other Nordic-Germany**	**Germany-Other Nordic**
Refined oil products	0,0%	6,1%	0,0%	0,1%
Agriculture	0,0%	0,5%	0,0%	1,2%
Food products	0,4%	0,8%	0,4%	1,6%
Textiles	0,5%	14,2%	18,8%	5,1%
Wood products	0,2%	17,5%	1,0%	12,3%
Paper products - publishing	2,3%	2,2%	0,4%	3,3%
Chemical - rubber - plastic products	0,8%	0,6%	0,9%	1,7%
Mineral products nec	0,2%	0,7%	0,6%	1,7%
Metals	2,7%	1,3%	2,8%	3,4%
Transport equipment and other equipment	1,2%	3,5%	4,1%	3,2%
Other manufactures	1,5%	3,7%	25,2%	5,7%

Source: CENEG-model (own calculations)

Table D.6 Costs of supply including transport costs (pct-change from 'Without case')

Sectors in the model (pct change from 'Without case")	**Denmark-Germany**	**Germany-Denmark**	**Other Nordic-Germany**	**Germany-Other Nordic**
Refined oil products	0,00%	0,02%	0,00%	0,00%
Agriculture	0,00%	0,02%	0,00%	0,06%
Food products	0,01%	0,02%	0,01%	0,05%
Textiles	0,01%	0,21%	0,33%	0,08%
Wood products	0,00%	0,49%	0,03%	0,21%
Paper products - publishing	0,06%	0,06%	0,01%	0,08%
Chemical - rubber - plastic products	0,01%	0,02%	0,02%	0,05%
Mineral products nec	0,01%	0,03%	0,02%	0,08%
Metals	0,07%	0,03%	0,06%	0,08%
Transport equipment and other equipment	0,01%	0,03%	0,03%	0,03%
Other manufactures	0,01%	0,03%	0,24%	0,05%

Source: CENEG-model (own calculations)

D.3. The regional distribution

The regional distribution of the welfare gains has been studied carefully in a model built by Dr. Johannes Bröcker. The main results from this model are reported in Bröcker (1998a), Bröcker (1999) and Bröcker (2003). The Bröcker-model is very detailed with respect to the number of regions. It covers all of Europe divided into more than 800 regions. This is very useful in order to answer the question: *How far into Germany and how far into the Nordic countries would the growth effects of a Fehmarn Belt link spread?* The model deals with the economic gains from reduced costs for road transport with respect to trade. This is an important economic effect from the fixed link. The model is strategic in the sense that it includes a number of economy-wide effects of the lowering of transport costs. The model is the same type of model used in the previous sections, which means that trade flows between countries and the money flows between sectors and household are all included in the model. We therefore use the results from the Bröcker model to regionalise the effects analysed in the previous sections.

The results are confined to the regional economic effects resulting from the use of the new links for trading goods and we pay special attention to new road links. Simulating effects of transport distance reductions in a spatial computable general equilibrium model quantifies the economic implications of new links. We model a static equilibrium for two sectors (local goods and tradables) and a large number of regions. Firms in the tradables sector supply a large number of symmetrical product varieties under monopolistic competition. In the Bröcker-model trade between regions is costly with costs depending on transport distances through a given transport network as well as on national trade impediments. Numerical results are presented separately for the fixed link across the Fehmarn Belt. The application to the transport issue and to the Fehmarn Belt situation is explained in Bröcker (1998a) and Bröcker (1999).The reader is referred to these papers regarding details of model specification, calibration, and data.

Appendix E Calculation of net present value

In this appendix we calculate the socio-economic value of the main quantified effects. We use a common yardstick to compare the importance of the different dynamic effects to results of other studies by calculating net present value. We use the different scenarios and model runs to test sensitivity the broader regional effect of the fixed link.

We use the direct benefits accounted for in the cost benefit analysis as an input to estimating the net present value of the dynamic and strategic effects. We use this number in the calculation in order to ensure as much consistency between the two studies as possible. Indeed our methodology is developed to with special attention to avoid any double counting of the benefits. Therefore we use the total benefit multipliers that are consistently calculated by the use of the CENEG-model in combination with the direct benefits from the CBA.

The dynamic and strategic effects for a given year of operation are thus given by:

Dynamic and strategic effects$_{\text{year=t}}$ = (TBM $_{\text{year=t}}$ – 1)*direct benefits $_{\text{year=t}}$

Which we will shorten to: $B_t = (TBM_t - 1)D_t$

Since the dynamic and strategic effects are permanent effects during the entire operation of the fixed link (which set to 50 years like in the CBA) we shall discount future benefits. We also calculate TBM's for the short run (TBM^{short}) and for the long run (TBM^{long}). We assume that long run effects are fully encountered ten years after the opening of the link, and that short run effects last the first five years after the opening. In intermediate years we apply a TBM of the average of the short run and the long run value (i.e. for years 6-10). We use a calculation rate of r=6%. We use 2003-price level and discount the benefit flows to the expected opening year in 2015. The net present value under these circumstances is calculated as:

$$NPV = \sum_{t=1}^{5} \frac{(TBM_t^{short} - 1) \times D_t}{(1+r)^t} + \sum_{t=6}^{10} \frac{(½(TBM_t^{short} + TBM_t^{long}) - 1) \times D_t}{(1+r)^t} + \sum_{t=11}^{50} \frac{(TBM_t^{long} - 1) \times D_t}{(1+r)^t}$$

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