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Study of dynamic effects of the FBFL which has not been considered in the FTC study

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Client

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Content

1 BACKGROUND OF THE STUDY

In the FTC[1] study the main demand effects for the FBFL result from

- replacement of the existing ferry line between Rødby and Puttgarden by the FBFL: **traffic overtake**
- traffic from other routes, mainly Great Belt, Gedser – Rostock and other ferry lines to the route via FBFL: **route choice effects**
- traffic from other modes, for passenger traffic mainly air traffic between Hamburg and Copenhagen to land based traffic via FBFL, for goods traffic mainly from road to rail: **modal-split effects**

Apart from that an "induced traffic" has been calculated for passenger traffic only:

- additional trips respectively more frequent trips from the same origin to the same destinations (= **primary induced traffic**).

The number of **trip generators** (inhabitants, for freight: producers/shippers) or trip attractors (workplaces, inhabitants, tourist sites, for freight traffic: recipients/consumers) **was kept constant** between reference case (without FBFL) and planning case (with FBFL).

The Danish transport consultant COWI recommended 2015 in the external quality assurance[2] of the FTC study[3] among others an **assessment of *newly generated traffic* by the FBFL** by new opportunities for economy, trade, tourism and housing which was not covered by the FTC study due to the lack of effective tools for predicting the *potential dynamic effects* of the link.

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[1] Intraplan Consult GmbH and BVU Beratergruppe Verkehr + Umwelt GmbH: Fehmarnbelt Forecast 2014 - Update of the FTC-Study of 2002, on behalf of Femern A/S 2014

[2] COWI: Ekstern kvalitetssikring af den opdaterede trafijprognose of Femern Bælt-projektet, comissioned by the Ministry of Transport, November 2015

[3] see footnote 1

2 STUDY APPROACH

Infrastructure projects lead among others to "**induced traffic**". Induced traffic is defined as traffic which would not take place without the projects, neither on other routes, with other modes or to other destinations.

There are **two main categories** of "induced traffic:

(1) Additional or more frequent trips or transports **to existing destinations** resp. attractores and **from existing generators** (= induced traffic in the narrower sense or **primary induced traffic**) because travel times or travel costs ("resistance") are reduced by the project

(2) Additional trips or transports due to effects of the project on local/regional economy, housing, tourist sites, logistics sites, etc. that means due to **changes in the numbers of generators and/or attractors** (= indirect or **secondary induced traffic**)

In the FTC study only (1) has been considered in the passenger traffic part.[4]. In the freight traffic part no induced traffic has been calculated (because here there are doubts that this kind of effects, primary induced traffic without changes of the generators or attractors, is existing)[5]. But neither for passenger traffic nor goods traffic (2) the "secondary induced traffic" has been considered resp. calculated as COWI has stated in its review of the FTC-forecast.

Indeed, it is conventional wisdom that transport infrastructure in general and special transport projects have considerable effects on economy, employment, trade, tourism and settlement[6] in consequence to a better accessibility of the regions in the influence of the project. In the case on hand a better accessibility *between* the regions north and south of the FBFL should be relevant. These factors, again, would generate traffic, "secondary induced traffic" or (to make a difference to the term "induced traffic" as used in the FTC study) ***"generated traffic by economic effects from the project"***.

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4 Intraplan Consult GmbH and BVU Beratergruppe Verkehr + Umwelt GmbH: Fehmarnbelt Forecast 2014 – Update of the FTC-Study of 2002, on behalf of Femern A/S, 2014, S. 74, 118f

5 Intraplan Consult GmbH and BVU Beratergruppe Verkehr+Umwelt GmbH: Verkehrsverflechtungs-prognose 2030 Los 3: Erstellung der Prognose der deutschlandweiten Verkehrsverflechtungen unter Berücksichtigung des Luftverkehrs, Ergänzender Bericht zur Methodik, on behalf of the German Ministry of Transport and digital Infrastructure, 21.11.2014

6 Copenhagen Economics Aps and Prognos AG: Economy-wide benefits Dynamic and Strategic Effects of a Fehmarn Belt Fixed Link; Report prepared for the Ministry of Transport, Denmark, and the Federal Ministry of Transport, Building and Housing, Germany, June 2004

However, it is very difficult to measure these effects in terms of values and numbers. To measure economic effects of a single transport project and to estimate the effects on traffic by these economic effects is quite a challenge, because accessibility is obviously an important, but by far not the only location factor for business and settlement.

In all the available resp. substantial studies positive economic effects of important transport projects have been found and the effects are considerable:

- In the case of the **Channel tunnel** Ernest & Young[7] found a strong effect of this connection on trade and tourism.
- For the **Öresund Bridge** ex-post socio-economic assessments have been made[8], showing a strong effect on commuter traffic, settlement and economic growth in the neighbour regions Copenhagen and Malmö stimulated by the new connection.
- Also for the **Great Belt Bridge** strong "wider economic effects", here effects on commuting and other agglomeration effects, have been found.[9]
- For the **transalpine rail tunnels** in Switzerland considerable regional economic effects from better domestic and – even more important – better international accessibility caused by the tunnels have been found.[10]
- In a more general and less project specific way also in **Germany** considerable "wider economic effects" resp. stimulation of economic growth by investment in transport infrastructure have been found. [11]

The **results from these studies are highly significant but in our view far from being complete and comparable**

And, in none of these studies which give scarce indicators about the economic and settlement effects of the infrastructure project there are indicators about the **after-effects** of these **on traffic and transport,** which is the question here.

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7 Ernst & Young: Economic footprint of the Channel Tunnel fixed link – An analysis of the economic value of trade and passenger traffic travelling through the Channel Tunnel, October 2016;
less optimistic however sn the study of the University of Kent, Centre for European, Regional and Transport Economics (Alan Hay, Kate Meredith, Roger Vickerman): The impact of the Channel Tunnel on Kent and relationship with Nord-Pas de Calais, June 2004

8 M.Aa. Knudsen, J. Rich: Ex post socio-economic assessment of the Oresund-Bridge, 2012

9 Copenhagen Economics: Bredere økonomiske effekter af transport-investeringer, DEBATOPLÆG udarbeijdet for Transportministeriet, Maj 2014

10 Schips/Hartwig (KOF at the ETH Zurich): Wachstumswirkungen und Rentabilität von Verkehrsinfrastrukturinvestitionen – Stand der Forschung und wirtschaftspolitische Schlussfolgerungen, on behalf of Schweizerische Bau-, Planungs- und Umweltdirektorenkonferenz, 2005

11 See for example: RWI: Verkehrsinfrastrukturinvestitionen – Wachstumsaspekte im Rahmen einer gestaltenden Finanzpolitik, on behalf of German Ministry of Finance, 2010: Dependent from the economic lifetime an investment of 1 billion € leads to a macroeconomic effect of 0,8 to 4,2 billion €.

Given these double uncertainties, no clear or countable effects of the project on economy and settlement and no "rules" for after-effects of the latter on traffic and transport, **we decided to apply another approach**:

- To derive the dynamic effects by analogies from traffic and transport analyses with respect to the **correlation between accessibility** ("gravitation") **and traffic intensity** (transport science approach) (see figure 1)

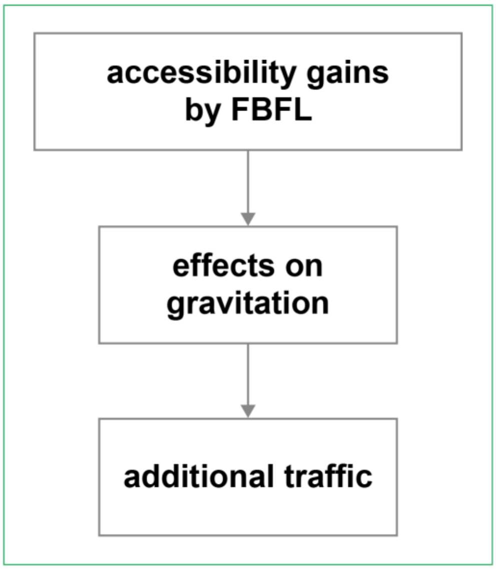

Fig. 1: Basic approach

The accessibility gains are calculated by a *gravitation model*: if travel distance and time are reduced gravitation is growing. This leads to more traffic.

In detail the approach is outlined in figure 2. The rules which are analyzed by the approach are applied using the FTC-model with regard to the base data, traffic and socio-economic drivers and with regard to the gains in travel time resp. reduction of Generalized Costs caused by the project FBFL.

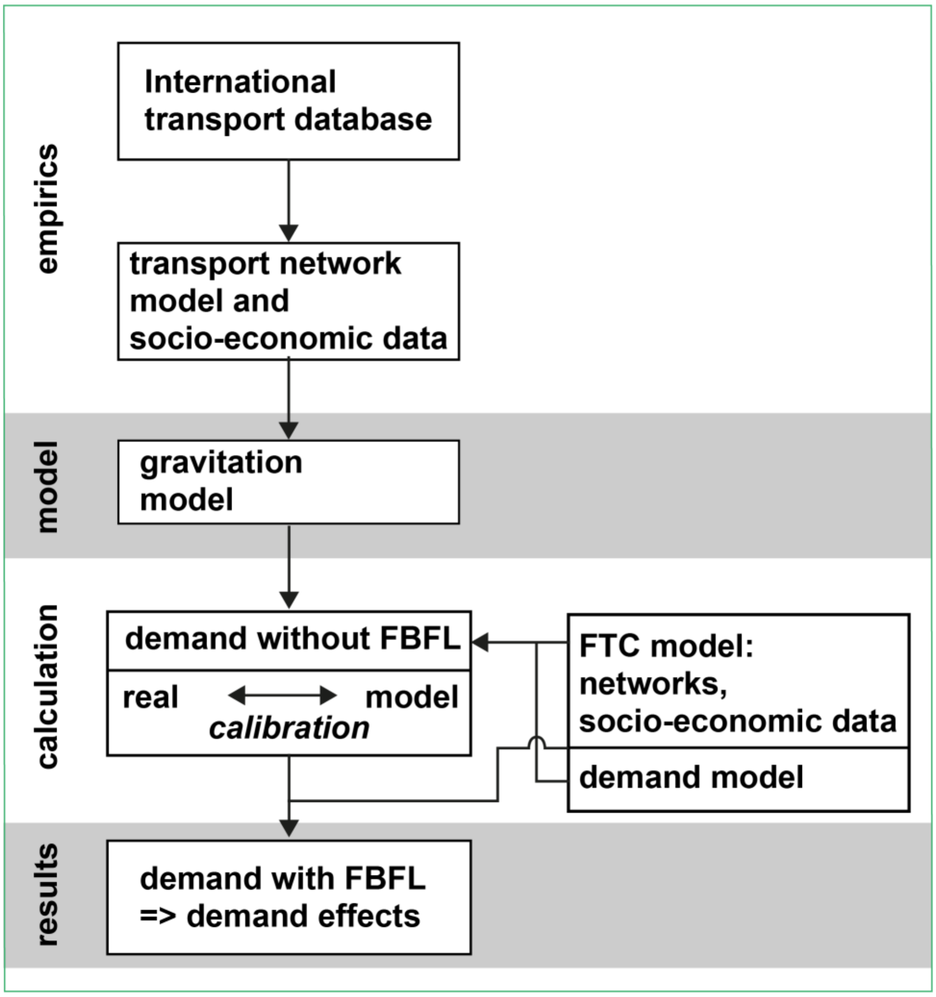

Fig. 2: Method to estimate additional traffic caused by the economic effects of the FBFL

This approach is more substantial than other methods if reasonable "benchmark" data are available. This is the case: There are well founded origin-destination matrices available for the Bundesverkehrswegeplanung for the international traffic and transport between the German regions and all foreign regions in Europe including for eight neighbouring countries.[12]

Combining these empirical based matrices with network models and zonal socio-economic data *gravitation functions* can be derived, for passenger traffic as well as for freight transport:

- gravitation model for international passenger traffic

[12] Intraplan has access to well-founded data for even more country-country-pairs: from Netherlands to Belgium/France/United Kingdom, from Austria to Italy/Czech Republic, Slovak Republic, Slovenia, Hungary, from Switzerland to France/Italy, from Denmark to Sweden, from United Kingdom to France.

- gravitation model for international freight transport
- gravitation model for total (domestic and international) passenger traffic (for comparison)
- gravitation model for total (domestic and international) freight traffic (for comparison)

The principle of such a gravitation function is shown in figure 3.

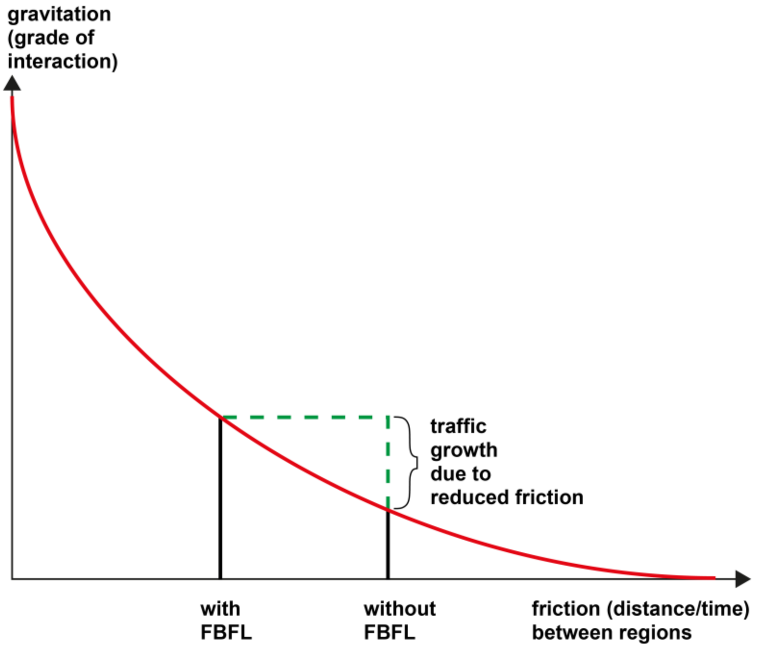

Fig. 3: Gravitation model: principle

Applying these functions for the FBFL project resp. the difference between reference case (without FBFL) and with case (with FBFL) the "theoretical" demand effects of a project can be calculated (see fig. 3). Two more working steps are necessary in this approach:

- calibration: if the existing traffic on Rødby – Puttgarden is not in line with the curve, the curve has to be adjusted (calibrated).

- deduction of the effects considered in the FTC study: in the FTC study among others (primary) induced traffic as described above is considered. This has to be subtracted from the results to avoid double counts.[13]

Apart from the (primary) induced traffic (formula see footnote 13) which was applied only for passenger traffic in the FTC study **no gravitation mo**del was applied due to the fact that it was a corridor study without reference to the overall traffic (complete OD-matrices for Europe).

3 ANALYSIS OF EXISTING TRAFFIC IN EUROPE

In the context of the German Bundesverkehrswegeplanung detailed origin-destination-matrices have been set-up for 2010, widely on the basis of empirical data:

- for the passenger traffic: OD matrices using traffic counts (among others on borders), surveys for national and international tourism on regional level, commuter statistics, surveys on business travel, etc.[14]
- for goods traffic: OD-matrices based on samples of transport flows per haulage firm[15]

The matrices for the base year 2010 are differentiated on NUTS 3 level and cover most of Europe due to the central location of Germany.

These matrices have been combined with network models and zonal data for population and GDP. By that analyses in the way as shown in fig. 3 were carried out.

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13 Formula in the FTC-model to calculate (primary induced traffic :

$$R_{ind} = \frac{GK_a - GK_p}{\max(GK_p; GK_a)} * \min(R_p; R_a) * AR$$

with

R_{ind}	induced trip per mode, purpose and OD-relation ij
GK_p	Generalized Costs (GK) in the planning case
GK_a	Generalized Costs (GK) in the reference case
R_p	trips in the planning case
R_a	trips in the reference case
AR	Share of Generalized Costs (GK) on the total activity costs of the journey (dependent on the trip purpose)

14 Intraplan Consult GmbH and BVU Beratergruppe Verkehr+Umwelt GmbH: Verkehrsverflechtungsprognose 2030 Los 3: Erstellung der Prognose der deutschlandweiten Verkehrsverflechtungen unter Berücksichtigung des Luftverkehrs, on behalf of the German Ministry of Transport and digital Infrastructure, June 2014;
for more detail see: the same: Ergänzender Bericht zur Methodik, 21.11.2014

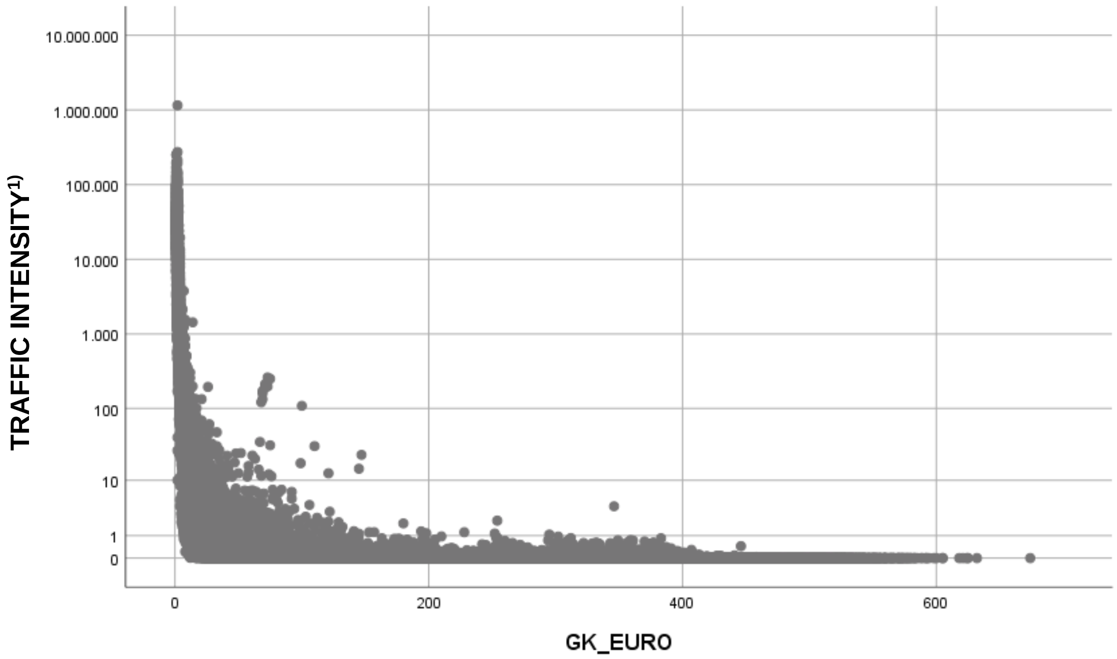
15 see footnote 14

For passenger traffic gravitation has been defined as a function of the population of the regions of origin and destination and the Generalized Costs as proxy for the "resistance" resp. costs to overcome the distance between the regions. For goods traffic the regional GDP has been chosen as "masses" in the gravitation model.

The generalized costs are specified for passenger and freight traffic and have been derived from the network models.

The following curves show the functional interrelationship between gravitation and traffic resp. transport intensity.

For **total passenger traffic** the curve is shown in figure 4.



1) passengers/year (per 1000 inhabitants $_{origin}$ x 1000 inhabitants $_{destination}$)

Fig. 4: Correlation between Generalised Costs (GK) and traffic intensity (here: passenger trips/year) – total passenger traffic

The gravitation model

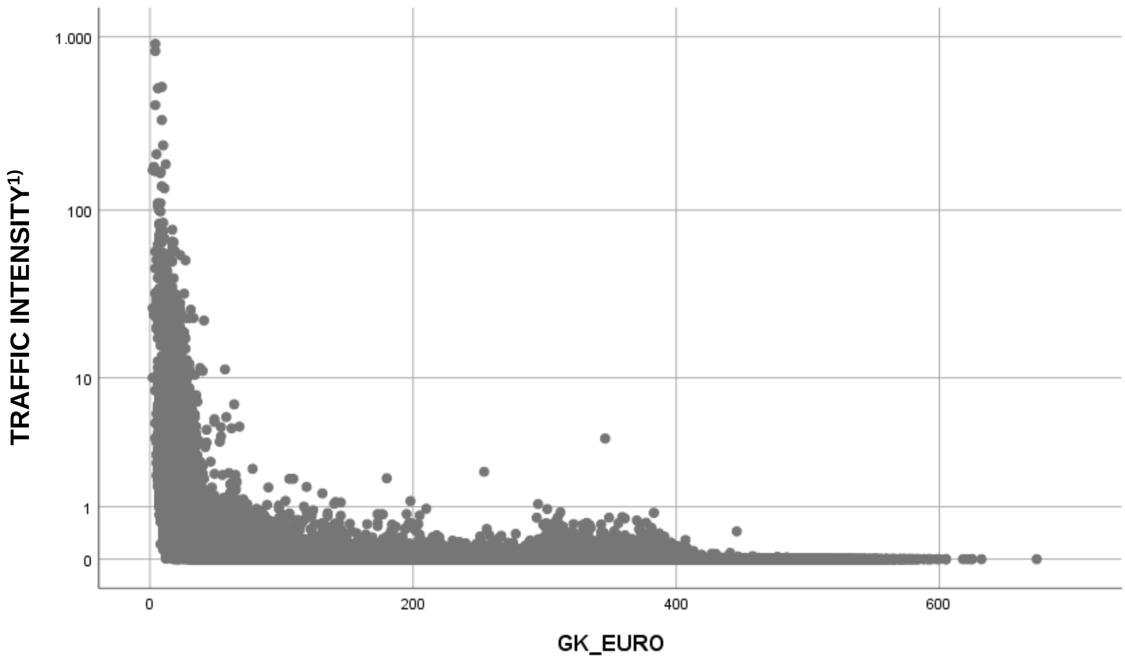
$$v_{OD} = (P_o * P_d) * c_{OD}^{\alpha}$$

with:

v_{OD}	traffic between origin and destination
P_o	population in the zone origin (in 1000)
P_d	population in the zone destination (in 1000)
c_{OD}	Generalized Costs between origin and destination (in €)
α	gravitation exponent

has a gravitation exponent of – 1,268 and a good regression coefficient r^2 with 0,87.

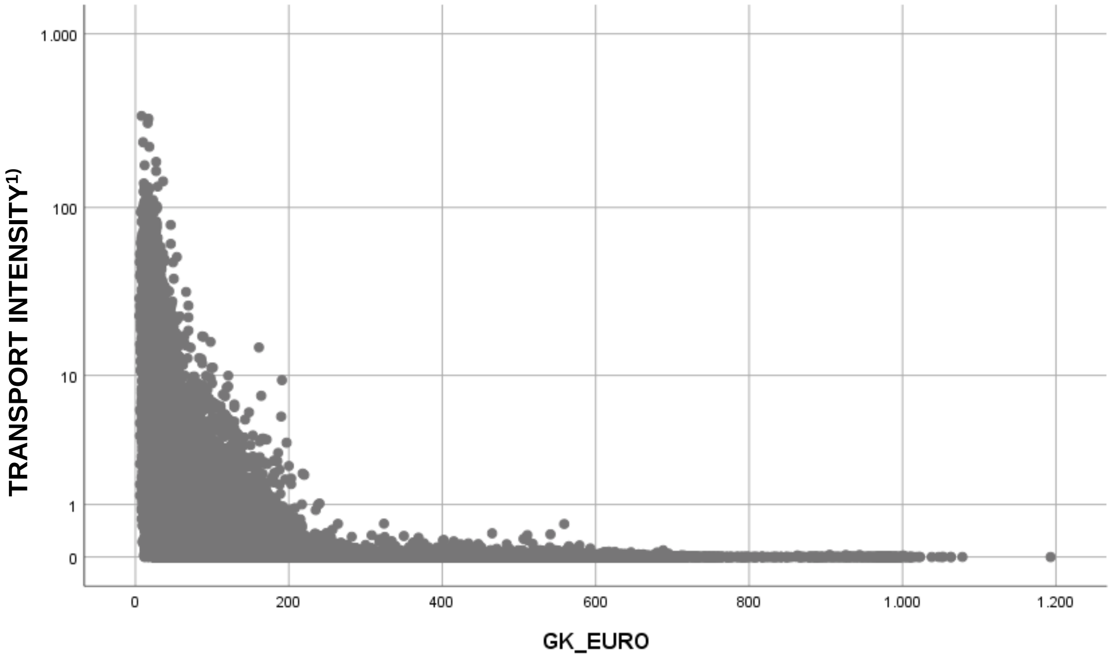
For **international passenger traffic** (see figure 5) the gravitation coefficient is at – 1,462 and the regression coefficient r^2 is even higher (0,95). The reason for that is the generally larger range of distances in international traffic in Europe and therefore a higher number of (very) small traffic intensity values compared with domestic traffic. This leads to an increase of statistical correlation in the international traffic part. At the same time international traffic intensity is more dependent on the transport "resistance" than domestic traffic.



1) passengers/year (per 1000 inhabitants origin x 1000 inhabitants destination)

Fig. 5: Correlation between Generalised Costs (GK) and traffic intensity (here: passenger trips/year) – international passenger traffic

For **road freight** traffic the results have a similar shape. In figure 6 the transport intensity for road transports (domestic and international) are shown.



1) here: 1000 tons road/year per (gross value added $_{origin}$ (in million €) x gross value added $_{destination}$ (in million €))

Fig. 6: Correlation between Generalised Costs (GK) and traffic intensity (here: tons/year) – total road transport

The model formula is the same as in passenger traffic, with different variables

$$t_{OD} = (e_o * e_d) * g_{OD}^{\beta}$$

with:

t_{OD} transport between origin and destination in 1000 tons

e_o gross value added in the zone origin (in million €)

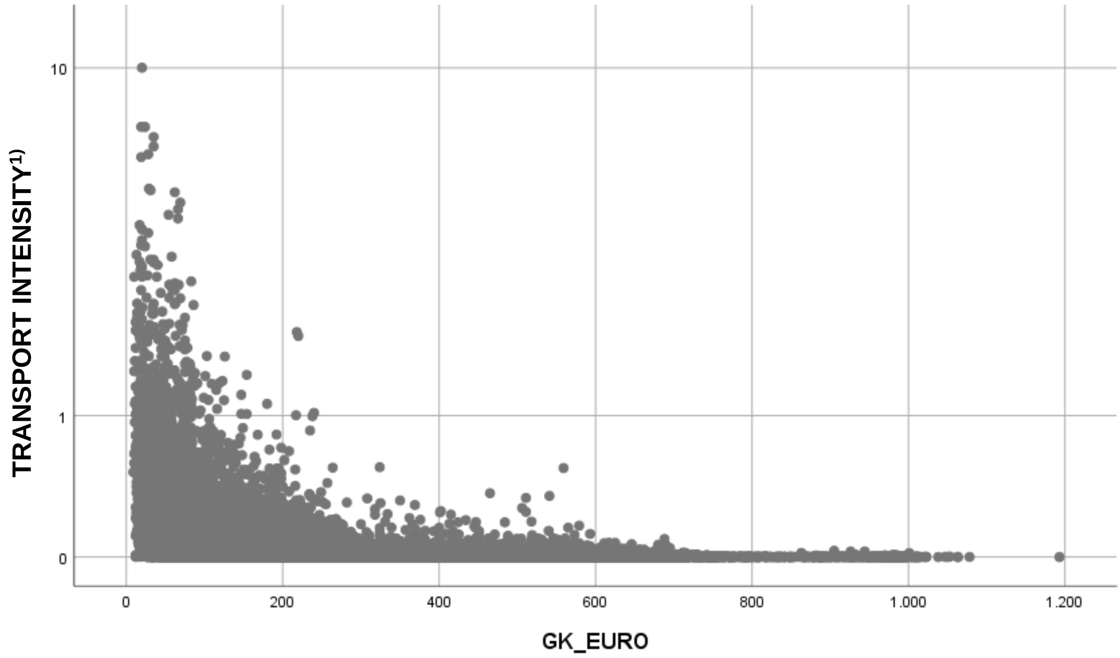
e_d gross value added in the zone destination (in million €)

g_{OD} Generalized Costs between origin and destination (lorry traffic, in €)

β gravitation exponent

The gravitation exponent is – 0,823 with a regression coefficient r^2 of 0,80.

For **international transports** (see figure 7) the gravitation exponent is – 1,077 with again as in passenger traffic a higher regression coefficient r^2 of 0,89 and a higher dependency on transport resistance compared to overall transports.



1) here: 1000 tons road/year per (gross value added $_{origin}$ (in million €) x gross value added $_{destination}$ (in million €))

Fig. 7: Correlation between Generalised Costs (GK) and traffic intensity (here: tons/year) – international road transport

4 APPLICATION OF THE MODEL

The model has been applied in the following way:

$$I_{OD} = \left(\frac{V_{OD,F}}{V_{OD,R}} - 1\right) * FTC_{OD}$$

with

I_{OD} generated traffic between origin and destination

$V_{OD,F}$ model transport intensity between origin and destination in the case with FBFL (same for freight with $t_{OD,F}$)

$V_{OD,R}$ model transport intensity between origin and destination in the reference case without FBFL (same for freight with $t_{OD,R}$)

FTC_{OD} traffic between origin and destination according to the FTC model (year 2030)

Applying this model for a reference year 2030[16] there is a generated **passenger traffic** of 2.398.000 trips (see table 7). From this figure 778.000 trips have to be subtracted which have been already considered in the FTC-study.[17] The remaining "secondary" induced traffic which was not considered in the FTC study would be 1.620.000 trips or **13,2 % related to the FTC-results**.

trip purpose	FTC study for 2030 (1000 trips)	generated trips (1000 trips)	thereof already in FTC-study	total trips FTC + generated	% increase to FTC results
Business	1.604	324	78	1.850	15,3
Day Commuter	775	701	274	1.202	55,1
Weekend Commuter	874	396	167	1.103	26,2
Shopping	1.372	54	12	1.414	3,1
Other daytrips	1.085	324	117	1.292	19,1
Visiting friends/ relatives	1.704	288	55	1.937	13,7
Short holidays	1.368	293	67	1.592	16,3
Holidays	3.227	18	8	3.237	0,3
Total	**12.009**	**2.398**	**778**	**13.629**	**13,2**

Tab. 7: Generated trips by intensified interaction

With regard to trip purposes the biggest effects are for day and weekend commuting followed by business and "other day trips". These results especially with regard to commuting are in line with empirical observations in recent decades in the context of the realized projects Öresund Bridge[18] and Great Belt Bridge[19].

16 Complete OD-matrices and network models are not available for a later year

17 In the FTC study 2014 an induced traffic of only 113 thousand trips have been shown (table 6-10 on page 140). However, this includes negative effects of walk-on-passengers due to the stop of ferry services (see tab. 6-8). Considering that induced traffic is at 530.000 trips in the FTC study. This figure is related to 2022, updated to 2030 (see Intraplan Consult GmbH and BVU Beratergruppe Verkehr+Umwelt GmbH: Verkehrsprognose für eine Feste Fehmarnbeltquerung 2014 – Aktualisierung der FTC-Studie von 2002, im Auftrag von Femern A/S, 2016, Tab. 6-2) this figure increases to 778.000 (336.000 + 424.000).

18 See: M.Aa. Knudsen, J. Rich: Ex post socio-economic assessment of the Oresund-Bridge, 2012

Altogether the highest effect would be for car trips (+ 1.226.000, see table 8) but there are also considerable effects for rail (309.000 trips). The additional generated traffic, calculated by this model, would lead to 772.000 additional car trips (2.115 per day) apart from around 3.000 buses per year.

trip purpose	rail (1000 trips)	bus (1000 trips)	car (1000 trips)	car (1000 veh.)
Business	55	0	191	164
Day Commuter	99	0	328	273
Weekend Commuter	73	21	135	83
Shopping	0	0	42	14
Other daytrips	12	23	173	81
Visiting friends/ relatives	44	15	175	88
Short holidays	26	26	172	66
Holidays	0	0	10	3
Total	**309**	**85**	**1.226**	**772**

Tab. 8 Assignment of the generated traffic not considered in the FTC study to modes

The number of additional car trips (772.000) in relation to the additional passenger trips for this mode is based on occupancy rate approx. of 1,6. The occupancy rate is much lower than the overall occupancy rate in the study area (around 2,5) due to the fact that the majority of the generated traffic is related to the trip purposes day commuter and business with relatively low occupancy rates compared to the overall traffic which is more dominated by private purposes including holidays.

For **freight traffic** we expect about 35.000 additional trucks on the FBFL apart from 41.000 tons of rail freight (see table 9). The effects for freight traffic are lower due to the fact that here the transports have much longer average distances and the time savings due to the FBFL are less relevant for the whole transport chain and partly are compensated due to the fact that parts of the ferry cruises could be used for the mandatory drivers rest times.

[19] See: Copenhagen Economics: Bredere økonomiske effekter af transport-investeringer, DEBATOPLÆG udarbeijdet for Transportministeriet, Maj 2014

mode	road (1000 trucks)	rail (1000 tons)
FTC study for 2030	634	9.464
generated traffic	35	41
total traffic	**669**	**9.505**
generated traffic in % of FTC traffic	6	0,4

Tab. 9: Generated traffic for freight traffic

It is unlikely that these "dynamic effects" will occur immediately after opening. It will take time to develop in full scale. Therefore, the reference to the 2030 results as shown here is only fictional. However, this is the **relationship between the "dynamic effects" not considered in the FTC study and the traffic forecasts considered there**.

5 SUMMARY AND CONCLUSION

The results for passenger traffic and freight traffic are summarized in table 10.

	additional trips/vehicles to the FTC study related to 2030 (in 1000)	additional trips in % of the FTC traffic
rail passengers	309	28,5
bus passengers	85	6,3
car passengers	1.226	12,8
total passengers	**1.620**	**13,5**
rail tons	**41**	**0,4**
cars	772	20,5
buses	3	8,2
lorries	35	5,5
total vehicles	**810**	**18,3**

Tab. 10: Overview of the results and synthesis (related to the year 2030)

Altogether the number of vehicles would increase with 18,3 % if considering the "dynamic effects" (induced traffic) in full scale compared to the FTC study, thereof with 20,5 % for passenger cars.

We would consider the outcome of the chosen transport science approach to calculate potential dynamic effects of FBFL as relevant and realistic.

The model described above is considering intensified interaction due to better accessibility. However, there is a certain inertia with settlement and social structures. The dynamic effects probably take some time to set in structures.

The FTC model did not consider these dynamic effects due to the fact that as stated in chapter 2 gravitation was not covered fully because not the whole traffic of the study area had been considered, but only the traffic between Scandinavia and the continent. Thus, the induced traffic of the FTC study did not cover the gravitational effects in full scale. The results would be the long term view of the "generated traffic" with a considerable "ramp-up-effect" of maybe 5 to 10 years or more.

But in any case the results are considerable: Given the calculated 810 thousand (see Table 10) additional vehicles related to the year 2030 (around 2.200 per day) and a growth rate of 2 % p.a. we would expect a number of around 2.500 vehicles per day ten years after opening of the FBFL.

And the results should also be a motivation for the regions along the axis Hamburg – Oresund region to push regional development of economy, tourism and social interaction. FBFL opens big chances to develop this axis to a centre of growth resp. an axis of growth between Central and Northern Europe.