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Revisiting financial uncertainty of the Fehmarn Belt business case

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Abstract

This work investigates the revised financial analyses of February 2016 as well as external quality assurance of traffic forecasts, building contracts, reserves and the German approval process. Particular emphasis is put on the credibility of financial risk and uncertainty analyses. Comparisons with financial calculations made since November 2014 are carried out. It turns out that the revised financial analysis does not substantially change the status of the Fehmarn Belt immersed tunnel project as a high risk business case already established by earlier analysis. It is pointed out that partial sensitivity analysis is a rudimentary approach to uncertainty profiling only revealing partial information compared to a multivariable approach.

Background and purpose

The financing of the fixed link across the Fehmarn Belt is based on a state guarantee model. This model entails financing of the project via loans guaranteed by the Danish Government and which are to be repaid via revenue from the users of the fixed link. Based on available information about base cases and uncertainties involved, it was recently documented that the Fehmarn Belt immersed tunnel, conditionally approved by the Danish Parliament in April 2015, is a high risk business case, [9]: The likelihood of a payback period less than or equal to 40 years required by the political parties behind the project was practically equal to zero. Subsequently, a revised financial analysis has been published, [10], [11], according to which it is allegedly demonstrated that the economics of the project are sound: The new financial analysis “is based on a comprehensive review of the key parts of the economics”, [10]. External quality assurance of the traffic figures, [8], as well as building contracts, risks, the German environmental approval process and project reserves, [12], has been completed. The purpose of this presentation is to identify critical but uncertain assumptions about project variables that may dramatically influence the financial uncertainty of the new project base case of February 2016 compared to earlier analyses.

Traffic forecasts

The financial analyses from November 2015 and onwards, [1], [3], [8], [9], are based on a passenger car traffic forecast summarized in Fig. 1, including a traffic jump of 66% by tunnel opening. In [10] and [11] a later opening date is assumed, which means that the forecasted tunnel traffic has a higher starting level due to extrapolation of the forecasted ferry traffic until tunnel opening. The overall assumption is that ferry operation will be discontinued by tunnel opening.

Passenger car traffic is the most important category accounting for a major share of the total traffic income. It is also by far the most controversial income issue for several reasons. Firstly, a forecasted traffic jump of 66% by tunnel opening including a ramp-up period of 3 years, see Fig. 1, has been seriously questioned [2], [7]. 40% of the traffic jump is made up of transferred traffic from other existing ferry services calculated by means of the same traffic model as was used in earlier forecast work. The remaining 60% of the traffic jump is transferred traffic from the Great Belt link and remains undocumented: The external quality assurance report, [8], explicitly states in the main conclusion that “especially the expected transfer of passenger car traffic from the Great Belt is

difficult to document due to lack of data of the present traffic pattern crossing the Great Belt link” and further investigations are recommended. The Ministry of Transport and Building chooses to ignore this serious reservation in the conclusion of the quality assurance report. Further, the forecasted traffic jump by tunnel opening seems not to be a central estimate, but rather a best case estimate. This conjecture is supported by the fact, that the partial sensitivity analyses carried out in [1] and [11] only are down sided, with traffic jumps of 40% and 25% only, compared to a base case average of passenger cars and trucks of 54%.

Secondly, today’s ferry traffic consists of two distinctly different passenger car segments. Approximately 34% of the total traffic is a border shopping segment of passenger cars developed since 2000 enjoying a substantial rate of reduction whereas 66% are long haul Europe travellers, mainly for holiday purposes, see Fig. 1. In the simplified traffic model calculations, however, an average rate has been used for the total traffic thereby introducing an uncertainty of unknown magnitude in the traffic forecasts. It is clear that by using a too low rate, i.e. the average rate, the forecasted tunnel traffic tends to be too large due to an overestimated relative preference in comparison with other competing connections. Furthermore, it is seen from Fig. 1 that the European traveller passenger car segment shows a decline since 2000 in contrast to the forecasted growth 2011-2021. Also shown in Fig. 1 is an alternative forecast of passenger car traffic with a reduced traffic level claimed to be more realistic, [7].

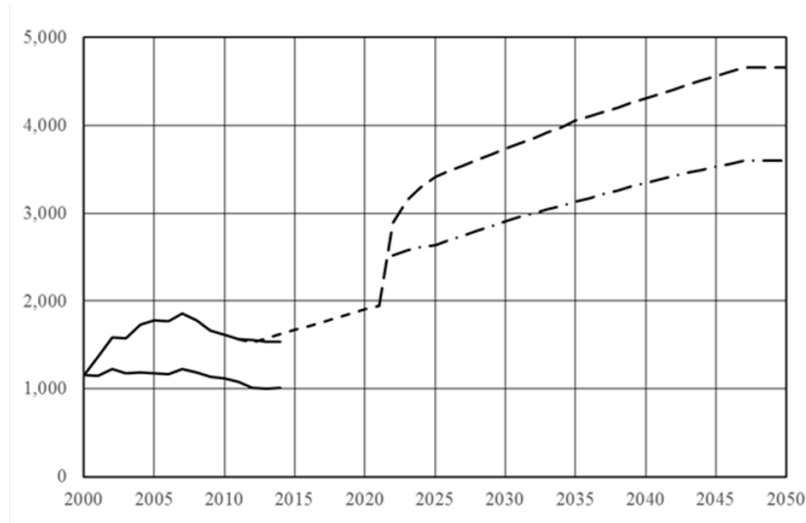


Fig. 1. Fehmarn Belt passenger car traffic (1000 one way cars pr. year). (Adapted from [9]).
 2000-2014, upper: Realized total cars by ferry [5].
 2000-2014, lower: Realized Europe travelling cars by ferry [4].
 2011-2021: Forecast total cars by ferry [1].
 2022-2050+, upper: Forecast total cars by tunnel [1].
 2022-2050+, lower: Forecast total cars by tunnel [7].

Thirdly, according to Scandlines, [6], the total road traffic income in 2014 from the existing Rødby-Puttgarden ferry services is 19% lower than forecasted by Femern A/S. The reason for this is a mix of too high estimations of passenger car volume and rate, too high estimation of truck rates and too low estimation of truck volume. As for the volume of passenger cars, consult with Fig. 1.

Construction costs and reserves

Since November 2014 the estimation of base case construction costs as well as reserves have undergone several changes, see Table 1, the most recent one from February 2016 is seen in the rightmost column. According to [11,

Table 4], the coast-to-coast construction costs excl. reserves has been reduced by DKK 6.9 billion compared to the assumptions behind the construction act L141. This reduction is due to re-negotiations with the building contractor about prolongation of the construction period, transfer of tasks and risks to the master builder and elimination of tasks. It is unclear to what extent the different categories contribute to the reduction and what is the precise content. Furthermore, reserves have been increased to DKK 7.3 billion compared to DKK 3.7 billion. It is unclear, however, to what extent stand-by costs due to delayed construction start up from 2015 to 2017/2019 because of lacking German environmental approval is included, thereby reducing ordinary reserves. It is mentioned in [11] that 112 risks were identified and included in the reserves using P80. Note, that a new cost category “project preparation and client organization 2009-2015/2017/2019” is introduced, [11, Table 4], by eliminating “reserve for contractor risk” and reducing “construction costs excl. reserves”.

| Base Case construction costs (DKK billion) | Nov. 2014 [1] Main Scenario | Nov. 2014 [1, Table 20] | Feb. 2015 [3] | L141 [11, Table 4] | Feb. 2016 ¹ [11, Table 4] |
|---|-----------------------------------|----------------------------|------------------|-----------------------|---|
| Price level | 2014 | 2014 | 2014 | 2015 | 2015 |
| Danish landworks | | | | | |
| Construct. excl. reserves | 7.3 | 7.3 | 7.3 | 7.3 | 7.3 |
| Correction allowance (10%) | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Reserves (20%) | 1.5 | 1.5 | 1.5 | 1.5 | 1.5 |
| Sum reserves | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 |
| Sum reserves (%) | 30% | 30% | 30% | 30% | 30% |
| Sum construct. costs incl. reserves | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| Coast-to-coast construction | | | | | |
| Construct. costs excl. reserves | 40.5 | 40.5 | 49.4 | 45.8 | 38.9 |
| Reserve for contractor risk | 1.8 | 1.8 | 1.8 | | |
| <i>Other reserves:</i> | | | | | |
| Client reserve | 3.7 | 3.7 | 3.7 | | |
| Extra reserves (16.4%) | | 6.7 | | | |
| <i>Total other reserves</i> | 3.7 | 10.5 | 3.7 | | |
| Sum reserves | 5.5 | 12.3 | 5.5 | 3.7 | 7.3 |
| Sum reserves (%) | 14% | 30% | 11% | 8% | 19% |
| Project preparation, organisation etc. | | | | 5.6 | 6.4 |
| Sum construct. costs incl. reserves | 46.0 | 52.7 | 54.9 | 55.1 | 52.6 |
| Total project | | | | | |
| Total construct. costs excl. reserves | 47.8 | 47.8 | 56.7 | 53.1 | 52.6 |
| Total reserves | 7.7 | 14.5 | 7.7 | 5.9 | 9.5 |
| Total reserves (%) | 16% | 30% | 14% | 11% | 18% |
| Total construct. costs incl. reserves | 55.5 | 62.2 | 64.4 | 64.6 | 62.1 |
| Payback period ² | 32 years | 37 years | 39 years | 39 years | 36 years |

Table 1. Base Case construction costs and payback periods.

Payback periods of base cases

The changing payback periods of the base cases ranging from 32 to 39 years are shown in Table 1. The improvement from 39 to 36 years in February 2016 is due to nine changes of assumptions of which three

¹ Construction start-up by 2020, tunnel opening by 2028.

² Calculated payback periods depend on other project input variables as well.

increase the payback period by 5.5 years and six decrease it by 8.5 years, [11, Table 13]. Most significant increase is 4 years due to reduced EU funding. Most significant decreases are 3 years due to decreased construction costs and 2 years due to a significant reduction of operation, maintenance and reinvestment cost. In reality the improvement of the payback period is only marginal taking into consideration the uncertainty connected with the base case input variables. It should be mentioned that these calculations of payback period and partial uncertainty assumptions and consequences have not been subject to external quality assurance.

Partial sensitivity and uncertainty analyses

Using the base case of February 2014 [1, Table 20] and [3] and realistic uncertainty assumptions on road traffic income, construction costs and reserves and EU funding it was recently demonstrated by Monte Carlo uncertainty analysis that the likelihood of a payback period less than or equal to 40 years was only 7.5%, [9], see Table 2 below. By realistic uncertainty assumptions on the passenger car volume the likelihood was 0%. This is remarkably worse than the results of partial sensitivity analyses carried out on the main scenario of November 2014, [1], where the changes of the payback period were all within the range [-4; +9] years in relation to the base case of 32 years. It is a major criticism of partial sensitivity analysis that it does not deliver an appropriate overall picture of the uncertainties involved because only one input variable is changed at a time and usually only with small amounts. Femern A/S has refused to acknowledge this fact and continues to rely exclusively on partial sensitivity analysis, [11]. Note that this approach has not been subject to external quality assurance.

| Base Case and Uncertainty Profile | Base Case from [1, Table 20] | Uncertainty Profile |
|--|------------------------------|--|
| Traffic income | Section 5.3 in [1] | Road traffic income factor Uniform distribution [0.85; 1.0] |
| Coast-to-coast construction costs | DKK 40.5 billion | Uniform distribution DKK [40.5; 49.4] billion |
| EU subsidies | DKK 10.3 billion | Uniform distribution DKK [4.4; 10.3] billion |
| Payback period (PBP) by Monte Carlo simulation | 37 years | Red: 36.6% |
| | | Yellow: 55.9% |
| | | Green: 7.5% |
| Total construction costs incl. reserves | DKK 62.2 billion | DKK [62.2; 64.4] billion |
| Total reserves | 30% | [14; 30]% |

Table 2. Uncertainty Profile based on base case from [1, Table 20]. (Adapted from [9]).
Green: PBP ≤ 40 years. Yellow: 40 years < PBP ≤ 50 years. Red: 50 years < PBP.

The partial sensitivity analysis of the main scenario of November 2014, [1], and recent financial analysis of February 2016, [11], are now compared. The range of changes of payback period in [11] of 14 different partial changes of input parameters is [-5; +12] years in relation to the base case of 36 years, including some pair-wise changes. This leads to an uncertain payback period in the range of [31; 48] years, which is worse than the range [28; 41] years from November 2014, [1]. It is interesting to note that the base case estimates in both cases seem not to be central estimates, since the downside uncertainty (payback period larger than base case) is more than twice the upside uncertainty (payback period smaller than base case). Most importantly, much more extreme

payback periods are envisioned when more input variables are deviating from the base case at the same time in a multivariable analysis, see Table 2 and [9].

The partial sensitivity analysis accounting for the extreme of +12 years is concerned with continued ferry service after tunnel opening, which is maintained by Scandlines. This is probably an under estimation of the consequences, but closer analysis is needed.

The stress tests in [1] and [11] are performed relative to an assumed maximum payback period of 50 years although this is a far longer period than accepted by the political parties supporting the project. For example, in [11] it is quoted that the road traffic income can be reduced by 16% per year before a payback period of 50 years is attained. Unfortunately, the road traffic income was already reduced by 19% in 2014, as mentioned earlier.

Conclusion

The revised assumptions and financial analyses from February 2016 do not constitute a mitigation of the high risk profile of the Fehmarn Belt immersed tunnel business case. Although a revised payback period of 36 years is within the green zone, partial sensitivity analyses do not provide an adequate analysis of the financial multivariable uncertainties connected with the project. By comparison with the November 2014 analysis it is shown that the range of payback period uncertainty has deteriorated and that the base cases presented are not necessarily central estimates.

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