"De ontbrekende spoorlink van het noorden" Vervoers- en optiewaarde studie voor de spoorlijn Heerenveen-Groningen

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Summary
In this thesis the transportation demand and option value is calculated for the new railway connection between Heerenveen and Groningen. The German transportation demand model the Standardisierte Bewertung is used for the calculation of the transportation demand of the railway line. The option value study is conducted by distributing questionnaires incorporating a choice experiment to determine the willingness to pay for the realization of the railway line.

Theoretical Framework:
In order to determine the transport value, a literature study is conducted to see which attributes should be included in a transportation demand model when it is necessary to determine the transportation demand of a public transport line. Normally, a transportation demand model concludes the four steps of the 4-step model. Because some models perform these step simultaneously, it is not possible to divide the different attributes among these steps. Also some transportation demand models only perform step three of the 4-step model: the modal split. Also some attributes influences the transportation directly or indirectly. Therefore the different attributes are divided into three different groups: filling related attributes, person-related attributes and transportation demand-related attributes. The model is tested against the third group showing whether these attributes are present and how. The distribution of the attributes among these groups looks like this:

Based on the traffic data three alternatives for training the neural network have been created. The pre-processing aims at finding an alternative which is able to predict travel times better and more rapidly. The basic alternative where all data of car traffic have been taken along without pre-processing, serves as a frame of reference. The second alternative has been built from a minimum amount of car traffic data. The last alternative has been derived from a travel time algorithm for the urban road network[1]. This alternative is based on"meetvak" travel times.

Attributes		
Group 1: Filling related attributes	*Group 2: Person-related attributes*	***Group 3: Transportation demand-related attributes***
Ageing	Income	Distance to the train station
Economic developments	Education	Frequency
Population (growth)	Family Size	Degree of comfort
Employment	Car ownership	Degree of safety
Current infrastructure	Trips by residents	Waiting time
Parking	Motif	Transferring time
Station characteristics		Travel Time / Distance
		Cost / price
		Congestion

Table A Attributes

WLO scenarios:
Because in this study a transportation demand value is calculated for a railway line which is operational in 2020, a transportation demand range is given. This has to do with the fact that it is unsure how external environmental factors will develop in the future. Therefore, two scenarios are used that takes into account these spatial factors. One scenario with high economical development (GE) and one with economical decline (RC). The scenario's which are used are de SEG WLO scenario's of Rijkswaterstaat. When the transportation demand is calculated for these two situations, a transportation demand range can be given which takes into account different spatial factors like population growth and employment. Because the theoretical framework shows that the frequency is designated as influential attribute on the total transportation demand, the transportation demand will be calculated for the GE and RC scenario with a frequency of one train per hour and four trains per hour.

Transportation demand module: "Standardisierte Bewertung":
To determine the transportation demand of new railway line between Heerenveen and Groningen, the German transportation demand model called the "Standardisierte Bewertug" is used. The basic idea of the model is that the transportation demand is determined for the current situation and for the future situations. For the future situation the model calculates the transportation demand for a situation in which the new railway is realized (m), and a situation in which the new railway is not realized (o). To calculate the transportation demand, the model determines the resistance for travelling from i to j by car or by public transport. The total resistance is determined by calculating the maximum utility to travel with a certain modality from i to j. The resistance is based on total travel time. The travel time of a trip is divided in pre and post transport, in-vehicle time, transfer time and waiting time. Also attributes like the availability of public transport and the comfort and safety of public transport is translate into resistance. The resistance for using the car is only based upon the total travel time from i to j and the availability of parking space in the city where the trip ends.

Standardisierte Bewertung versus the theoretical framework:
A comparison with the literature shows that most attributes are included in the Standardisierte Bewertung. The model only contains and calculates step three of the 4-step model, the model split. The strength of the 4-step model is the interaction between the different steps. Because the Standardisierte Bewertung only consists of step three, the interaction between the different steps is missing which leads to a lack in precision of the final transportation demand. Despite the model only calculates the modal split, most of the attributes which are included into the third group of table A are included. Only price and congestion are missing. The attributes which are present in group one and two are all present in the model because they are included in the O/D-matrix which is the basic input for the model. It should be noted that if an accurate transport value estimate should be obtained, the distance to and from the station should be entered for every individual trip from i to j. This is a very labour intensive process but gives the best result.

Despite this disadvantage it can be concluded that the transport module of the Standardisierte Bewertung can be well used to obtain an indication of the value of a public transport project. However, the reliability of the transport value outcome depends on the accuracy of the input attributes.

Sensitivity analyses:
The transportation demand module of the Standardisierte Bewertung is not digitally present. Therefore the transportation module is digitized with Excel. With this digital version of the Standardisierte Bewertung it is possible to calculate the transportation demand for different scenario's but also to perform a sensitivity analysis on the results the model generates. The results of an individual parameter variation study shows that the model is sensitive to changes in the input value. This can lead to a variation in the transportation demand by as much of 15 20%. This is a fairly normal range as several other studies performed with other transport value demand models also show variation in the number of transportation demand within these margins (Goudappel Coffeng, 2007). In table B the influence of every individual attribute is given upon the total transportation demand:

Attribute	Present?	Chances in transportation demand	Remark
Distance to the station	Yes	Tot 28%	Very labour intense process
Frequency	Yes	Tot 25%	Effect of frequency doubling in the transport value increase is modelled well.
Comfort/safety	Yes	Tot 20%	Standards are base don experience of DBI
Waiting time	Yes	Tot 19%	Same as in the theoretical framework
Transferring time	Yes	Tot 40%	Literature suggests that unlike the model, people with shorter travel times experience transferring as more problematic.
Travel time/distance	Yes	Tot 15%	Distance is based upon total travel time.
Cost/price	No	-	Not present in the model
Congestion	No	-	Not present in the model but not a problem for the investigation area

Table B The influence of the attributes upon the transportation demand

Trace variants and transportation demand calculations:
The transportation demand is determined for the trace which is proposed and developed by Railinfra Solutions in 2008. The transportation demand is determined for different scenario's where economical development changes and the frequency of the train service. Also the transportation demand is calculated for various changes in the proposed trace because of alternative location of the train stations. These changes are introduced to maximize the transportation demand value. Changes are proposed in the locations of the stations by Marum, Leek and Gorredijk.

According to the Standardisierte Bewertung, the transportation demand for the new railway line Heerenveen – Groningen in 2020 varies between 7.500 and 14.000 trips per day, depending on the economical developments and the frequency. When the calculated transportation demand is compared with similar regional railway lines the numbers match with each other. Therefore it can be concluded that the transportation demand is plausible. When the calculated transportation demand values from the different runs are compared it can be concluded that the frequency have more influence on the transportation demand than the difference in economical situations.

Situation	Proposed track by RIS			Proposed track by RIS		
WEG-scenario	GE2020			RC2020		
Frequency	1	2	4	1	2	4
Transportation demand	**8.500**	**11.500**	**14.000**	**7.500**	**10.000**	**11.500**
Modality choice-effect	3.500	4.900	6.000	3.200	4.500	5.000
Route choice-effect	3.800	5.200	6.300	3.500	4.700	5.200
Generation-effect	800	1.100	1.400	700	1.000	1.000

Table C Transportation demand results

The maximum transportation demand is generated when the station locations by Marum, Leek and Gorredijk are changed. This results in a transportation demand which varies between 13.800 and 15.100 trips per day, depending on the economical situation. However, this adoptions require a €12 million extra investment in the infrastructure. When the ratio between the extra amount of generated transportation value and the extra investment costs are calculated, the most effective variant is the one where the extra investment cost rise less and the extra transportation demand rise a lot. Looking at this ratio it appears that the station adjustment by Marum generates the most extra transportation demand and requires a low additional investment costs. This change results in approximately 2.500 additional trips, and requires an additional investment of €500.000. Every extra generated trip then cost €210,00 with a transportation demand which varies between 12.500 and 13.750 trips per day, depending on the economical situation. In the other trace variants the increase in transportation demand is less while the extra investment costs are very high and therefore they are not effective to realize. It is therefore advised to consider only the different station location by Marum.

Option value survey:

The option value and willingness to pay for the realization of the railway between Heerenveen and Groningen is determined by performing a survey in the places Drachten, Marum and Leek. In three months time, 1.450 surveys where distributed. 300 of them where completed and returned. This resulted in a response rate of around 20% which is good enough to draw a conclusion which is valid for the entire investigation region.

There are three types of users of a railway line which are identified as *users* (daily train travellers), *non-users* (people who never travel by train) and *option value-users*, people who use the presence of a railway line as a backup alternative when there first way of travelling is not at hand. By making use of screening questions in the survey, it is possible to determine what type of user the respondent is and how the answers of the respondent have to be implemented. The survey is composed of four parts and designed in such a way that the different users can fill in the questionnaire completely. Normally the different users will get different question, unfortunately that was not possible in this research. In the first part of the survey respondents are asked about there current way of travelling throughout the region, how they make these movement, with which kind of modality and how many times per day. Based on the answers it is determined what type of traveller the respondent is at this moment. In the second part of the survey the new railway line is introduced and the respondent is asked about his/her opinion about the realization and coming of the new railway line. Should it be realized or not?

Based on these questions it is determined whether the respondent is a user, not user or option-user of the railway line in the future. This information is used to implemented the results which are given in part three of the survey where a choice experiment is given. With this choice experiment, the willingness to pay for each individual user group can be determined and also the option value of the new railway line. In part four, some additional general question are asked.

Choice experiment:
Part three of the survey consist of a choice experiment. The choice experiment is designed in such a way that six choice-sets are presented to the respondent. In every choice-set the respondent can choice between four different options. The attributes travel time, frequency and amount of local taxes are implemented in the options and these attributes vary from each other. The cost attribute "municipal taxes" is chosen because every household in the Netherlands has to pay this tax and it is independent of the use of the railway line. The advantage of working with these three variables is that all types of users can identified themselves with the choice experiment and that is why everybody can fill in this part of the survey. In each choice the respondent can choose between the following four options with each option varied in the level of the attributes. Behind every choice the corresponding utility function is given:

Option:		Utility function:
1.	No railway line	$U_1 = \beta_1 * cost_1 + \beta_2 * spoor = 0$
2.	New railway line with a frequency of one train every hour	$U_2 = \beta_1 * cost_2 + \beta_2 * spoor + \beta_3 * freq_1$
3.	New railway line with a frequency of two trains every hour	$U_3 = \beta_1 * cost_3 + \beta_2 * spoor + \beta_4 * freq_2$
4.	New railway line with a frequency of four trains every hour	$U_4 = \beta_1 * cost_4 + \beta_2 * spoor + \beta_5 * freq_4$

Table D Choice options and utility functions

The willingness to pay for each user is determined by the béta values of the options where the new railway line is realized equivalent to those in which the railway line is not realized (option 1). The béta value indicates the importance of an attribute, compared with other attributes in the choice to maximize the total utility. De value of cost1 t/m cost4 is the same as the amount of municipality taxes in the different choices. The value of freq1 t/m freq4 is one when a certain frequency is present and zero when not. The willingness to pay for the realization of a new railway line with a frequency of one, two or four trains per hour can be determined as follows:

$$U_1 = \beta_1 * cost_1 + \beta_2 * railway$$
$$U_2 = \beta_1 * cost_2 + \beta_2 * railway + \beta_3 * freq_1$$
$$U_1 = U_2$$
$$\beta_1 * C_1 = \beta_1 * C_2 + \beta_2 + \beta_3$$
$$C_2 - C_1 = \frac{-\beta_2 - \beta_3}{\beta_1}$$

Waarbij:
U_1=Utility function for option without a new railway line
U_2=Utility function for option with the new railway and a certain frequency
C_1=The cost (municipality taxes) when no new railway line is realized
C_2=The cost (municipality taxes) when the new railway line is realized
β_1= Parameter for the costs
β_2= Parameter for the presence of the railway line
β_3= Parameter for the presence of the railway line with a frequency of one, two or four train per hour.

Willingness to pay:
Future users of the railway line are willing to pay an amount of €12,00 extra municipal taxes per household per month. Non-users are willing to pay €0,00 extra municipal taxes per household per month. The option value of the railway is €7.6 additional municipal taxes per household per month. Per person this means that the willingness to pay for users will be €5.4 extra municipal taxes per month. For non-users €0,00 extra municipal taxes per month and for option-users €3.5 extra municipal taxes per month.

When the weighted average willingness to pay for different user groups is calculated, this gives the average amount of extra municipality taxes inhabitants of the investigation area are willing to pay for the realization of the new railway line. This amount is determined at €3.5 extra municipal taxes per person per month.
The cost and the benefits for the realization of the new railway line are compared with each other. Three cost and three benefits are compared with each other which follows out the transportation demand and option value study:

Costs		Benefits	
Investment costs	€860.000.000,-	Willingness to pay	€9.900,- per/day
Operational costs	€3.115,- per/day	Travel time savings	€14.675,- per/day
Maintenance costs	€4.900,- per/day	Ticket price	€26.700,- per/day

Table E Cost and benefits of the realization of the new railway line between Heerenveen and Groningen

When the cost and benefits are compared with each other it can be concluded that it takes about 54 to 60 years before these two are equal. It can therefore be concluded that the inhabitants experience more benefits of the realization of the railway line in the short term, then the willingness to pay. When the results of this study are compared with the option value in other studies, it shows that the willingness to pay for the Heerenveen - Groningen railway line is lower. This may be due to that in other studies the line is already realized and inhabitants are asked how much they are willing to pay to keep it. Because respondents experience the usefulness of the railway line, they are willing to pay more for the presence of it. Therefore the results of the option value study for the Heerenveen - Groningen railway line are plausible.

Conclusion:
The transportation demand in 2020 for the new railway line is in between 7.500 and 14.000 trips per day, depending upon the economical situation and the frequency. The option value of the railway is €7.6 extra municipal taxes per household per month (€3.5 extra municipal taxes person per month), the average willingness to pay for the entire study area is €3.5,00 additional municipal tax per person per month. When the calculated cost and benefits of both studies are compared with each other it takes about 54 to 60 year before the cost and benefits are equal.

Based on the findings in this study and the way they are derived, it is not possible to conclude that the railway should be realized or not. This has to do with the fact that some important attributes are missing in the transportation demand model the *Standardisierte Bewertung.* For that reason the model is not complete which can result in unreliable transportation demands. It is therefore advisable to determine the transportation demand again with a more reliable model. The results of this study can be used in a social cost benefit analyses in which all the benefits and costs of the realisation of the new railway line can be compared with each other. With the results of that study the conclusion can be given if the railway line should be realized or not. Something that can be concluded from this study is that the transportation demand is the same as in other regional railway lines in the Netherlands, but that the investment cost are high. Therefore one of the recommendations is to investigate if with the available amount of money, the current bus network in de region can be improved or if other forms of light rail transport can be used. These variants should all be incorporated into a social cost-benefit analysis which should be executed so it can be determined if the new railway should be realized or not.