Bereidheid tot gebruik van de nachttrein voor langeafstandsreizen binnen Europa

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Samenvatting

Klimaatverandering en duurzaam reisgedrag: in tijden van #vliegschaamte en #treintrots een *'hot topic'*. Het beperken van de klimaatverandering dwingt ons om na te denken over een duurzamere mobiliteit. Reizen met de trein is, in vergelijking met het vliegtuig, aanzienlijk duurzamer. Nachttreinen zouden een oplossing kunnen zijn en bieden verschillende voordelen, zoals een hoger comfortniveau, en kunnen gedurende de nacht aanzienlijke afstanden afleggen. Tot nu toe is er een kennisleemte in wetenschappelijke literatuur over of mensen bereid zouden zijn de nachttrein te gebruiken.

Dit paper is het eerste onderzoek naar de bereidheid om de nachttrein te gebruiken, als alternatief voor het vliegtuig, voor Europese langeafstandsreizen. Hiervoor wordt gebruik gemaakt van twee Stated-Preference experimenten. Een 'comfort-rating experiment' waarin het comfortniveau de afhankelijke variabele is. Hierin wordt onderzocht hoe verschillende nachttrein kenmerken, zoals het type accommodatie of de mogelijkheid om te douchen, het 'verwacht comfortniveau' beïnvloeden. Vervolgens wordt in een 'mode choice experiment' onderzocht hoe dit comfortniveau wordt afgewogen tegen meer traditionele modaliteitskeuze attributen zoals reistijd, kosten en reizen per vliegtuig. Dit paper presenteert de resultaten van een lineair regressie en Panel Mixed Logit model, geschat op een dataset bestaande 804 Nederlanders welke buiten de Benelux hebben gereisd in 2018. Een 'latent class choice model' is geschat om inzicht te krijgen in de verschillende segmenten in de dataset en de bereidheid van deze segmenten tot het gebruiken van de nachttrein. Tenslotte is voor verschillende scenario's de bereidheid om de nachttrein te gebruiken onderzocht.

Resultaten laten zien dat het 'verwacht comfortniveau' het meeste wordt bepaald door het aantal passagiers waarmee men de coupé van de trein moet delen. Nederlandse reizigers hechten dus veel waarde aan privacy. Introductie van de nachttrein, zoals nu in dienst in landen als Duitsland en Oostenrijk, resulteert in een bereidheid tot gebruik van ongeveer 60%. De nachttrein positioneren als een alternatief voor 'low-cost carriers', waarin de ticketprijzen zelfs lager liggen dan die van het vliegtuig, leidt tot een aanzienlijke reductie in de bereidheid, dit als gevolg van het lage comfort niveau.

1. Introduction

Travelling by aeroplane is a major contributor to human-induced greenhouse gas emissions. To reduce the impact of climate change, a switch to more sustainable mobility is needed. Travelling by train is much more friendly for the environment, it can save up to five times the CO_2 emissions compared to an aeroplane (Álvarez, 2010). However, travelling by train is usually far slower making the number of possible destinations limited. This poses a question if people are willing to use night trains for European long-distance travel.

Scientifically, there is little to no knowledge about the Willingness to Use night trains for European long-distance trips. To the best of the authors' knowledge, no study has been done directly addressing this issue. However, mode choice, in general, is a widely studied topic in travel behaviour. Stated-Preference studies into mode choice typically include a variety of attributes, such as trip time, access/egress time, trip cost, waiting time, departure/arrival times, frequency and the number of transfers (e.g. Bhat, 1998; de Jong et al., 2003; Hensher & Rose, 2007; Morikawa, Ben-Akiva, & Mcfadden, 2002; Paulssen, Temme, Vij, & Walker, 2014; Román, Espino, & Martín, 2010). The comfort of the travel mode is not often taken into account. Román et al. (2010) used it in a mode choice study comparing aeroplane to High-Speed Train alternatives for the Madrid - Barcelona corridor, in which it is found to be a significant effect.

Based on these findings, it poses the question of how this relates to mode choice including the night train. One can argue that the comfort level of the night train is higher compared to an aeroplane. Comfort, in general, is expressed as a star rating (e.g. hotels). However, the level of comfort is very subjective, it differs between persons. This 'perceived comfort' level can be included in a traditional choice experiment. This would allow examining trade-offs with other included attributes, such as trip time or costs.

However, only including the 'perceived comfort' attribute in a mode choice experiment does not provide any information about how travellers arrive at this comfort rating. Therefore, it is proposed to construct an additional experiment, a comfort rating experiment, in which respondents are asked to rate different night train configurations. These night train configurations differ in various attributes such as the accommodation type, number of people in the compartment or the possibility to shower. The results of this experiment provide insight into which measures could be taken to improve the perception of the night train comfort level. The proposed approach is based on the Hierarchical Information Integration theory, originally introduced by Louviere (1984). This will be introduced in the next section.

Furthermore, it is highly interesting from a marketing perspective to identify certain segments who are most likely to use the night train for their travel. To answer this question, a latent class choice model is also estimated.

Summarising, this paper contributes to the scientific literature by being the first to study the Willingness to Use night trains, as an alternative for flying, for European long-distance travel. This will be studied with a mode choice experiment using Stated-Preference data. Additionally, using a rating experiment the determinants of the night trains' 'perceived comfort' will be studied. This approach is applied, and model results reported on data collected from a sample consisting of 804 (mostly) regular train travellers recruited in the Netherlands. At last, insights into segments that are most likely to use the night train is provided by the application of a latent class choice model.

The remainder of this paper is structured as follows. First, the methodology is explained in more detail. This is followed by a presentation and discussion of model estimation results. At first, for the comfort rating experiment, consisting of a regression model. Next, results for the estimated Panel Mixed Logit mode choice model are discussed and segments identified using a latent class choice model. This will be followed by scenario analysis in the model application. Finally, conclusions are drawn, as well as implications for society, limitations of the study and possibilities for future research are discussed.

2. Methodology

As mentioned in the Introduction, the applied main approach involves first determining the 'perceived comfort' rating of various combinations of night train attributes. It is assumed people trade-off this comfort attribute with other attributes, such as trip cost and trip time, in a mode choice experiment. This approach is inspired by the Hierarchical Information Integration theory, which is briefly discussed next.

2.1 Hierarchical Information Integration theory

The Hierarchical Information Integration theory was first introduced by Louviere (1984). It is meant as an approach for studying decisions in which many attributes might play a role. It assumes that decision-makers first group together attributes in sets, forming constructs. These constructs are each individually evaluated by the decision-makers. After that, these individual impressions for the decision-constructs are reviewed together and used to evaluate the alternatives in the choice set, resulting in a preference for one of them. The 'perceived comfort' level can be one of those decision constructs.

The traditional approach involves designing two different experiments, a sub-experiment and a bridging experiment. In the sub-experiment, it is explored how the attributes defining the target variable are traded-off. The bridging experiment is used to explore to what extent the decision-constructs itself trade-off against each other.

Variations of this traditional HII-approach exist. Bos et al. (2004); Molin and Van Gelder (2008) both adapt the bridging experiment. That approach directly included the decision-construct evaluation into the main choice experiment, showing it next to other attributes such as travel cost and travel time. The two experiments can be linked together if the same scale is used for attributes values. A similar approach is also applied in this study, although there is only one decision construct: 'perceived comfort'. This means the term bridging experiment is strictly speaking not correct, therefore it will be referred to as the mode choice experiment. The 'perceived comfort' is the dependent variable in the comfort rating experiment and one of the independent variables in the mode choice experiment. These experiments will be introduced next.

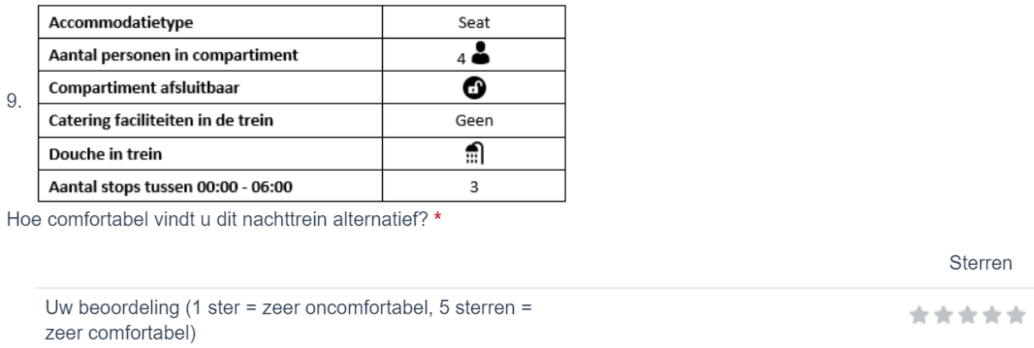
2.2 Comfort rating experiment

The comfort rating experiment aims to explore to which extent comfort determinants influence the comfort rating of a night train. To do so, potential passengers will be asked how they would rate their 'perceived comfort' for several night train configurations. This comfort rating may be influenced by several determinants.

However, currently, there is little to no knowledge about what determines the comfort level of a night train. Studying the current night train service levels offered by Austrian operator ÖBB, provided several attributes. Besides, focus groups were organised. During these focus groups, respondents were asked about what determines their comfort level for the night train. Combining these results, it is decided to use six different attributes:

- Accommodation type: this attribute reflects the type of accommodation aboard the night train. Mirroring the service levels by ÖBB attribute levels will be Sleeper, Couchette and Seat.
- Number of people in the compartment: was often mentioned by people taking part in the focus groups. The included attributes will be taken as 2, 4 or 6 people.
- Possibility to lock compartment: relates to the possibility to physically lock the compartment for other travellers. Only the traveller and fellow travellers in the compartment can enter. This is varied between yes and no.
- Catering facilities. This indicates possibilities for getting food or drinks on the train. Three different service levels are distinguished: none, kiosk and a restaurant car. In a kiosk, travellers can buy some snacks/sandwiches and other light meals. In a restaurant car, people have a place to sit down and have a more extensive diner.
- Possibility to shower: this is varied between yes and no.
- Number of stops during the night: this reflects the number of stops the night train makes between 00:00 and 06:00. Stopping, travellers boarding and alighting might disrupt sleep and therefore impact comfort levels. This is varied between 0, 3 and 6 stops.

The comfort rating experiment was designed using Ngene software. A fractional factorial design was constructed. This resulted in 36 different profiles. Because this would lead to respondent fatigue, it was chosen to block the design into 6 blocks. Therefore, each respondent was faced with 6 different night train compositions to rate. An example of a comfort rating question is illustrated in Figure 1.



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Accommodatietype	Seat
Aantal personen in compartiment	4
Compartiment afsluitbaar	
Catering faciliteiten in de trein	Geen
Douche in trein	
Aantal stops tussen 00:00 - 06:00	3

Hoe comfortabel vindt u dit nachttrein alternatief? *

Sterren

Uw beoordeling (1 ster = zeer oncomfortabel, 5 sterren = zeer comfortabel)

Figure 1: Example of a comfort rating question.

2.3 Mode choice experiment

The goal of the mode choice experiment is to examine how this 'perceived comfort' level is traded off against other attributes, such as travel cost or travel time in mode choice. This study will investigate trips of about 12-14 hours, using conventional train technology, this will be illustrated as trips as Amsterdam - Vienna or Milan. As the main goal of this research is to explore what the Willingness to Use the night train is, as an alternative for flying, it is decided to focus on these two modes. Therefore, the included modes in the mode choice experiment are Night Train (NT), Morning Plane (MP) and Evening Plane (EP). While both NT and MP alternatives arrive early in the morning, the EP alternative arrives the day before, which means a hotel stay is needed. Literature research was performed to identify often used attributes in mode choice. As no previous study on this topic has been conducted, participants of focus groups were asked what factors they would consider when deciding. This revealed no previously unknown attributes specifically for the night train that needed to be included. The resulting framework can be seen in Figure 2. The following list presents the chosen attributes and the included levels. The EP alternative is a base alternative and has fixed attribute levels.

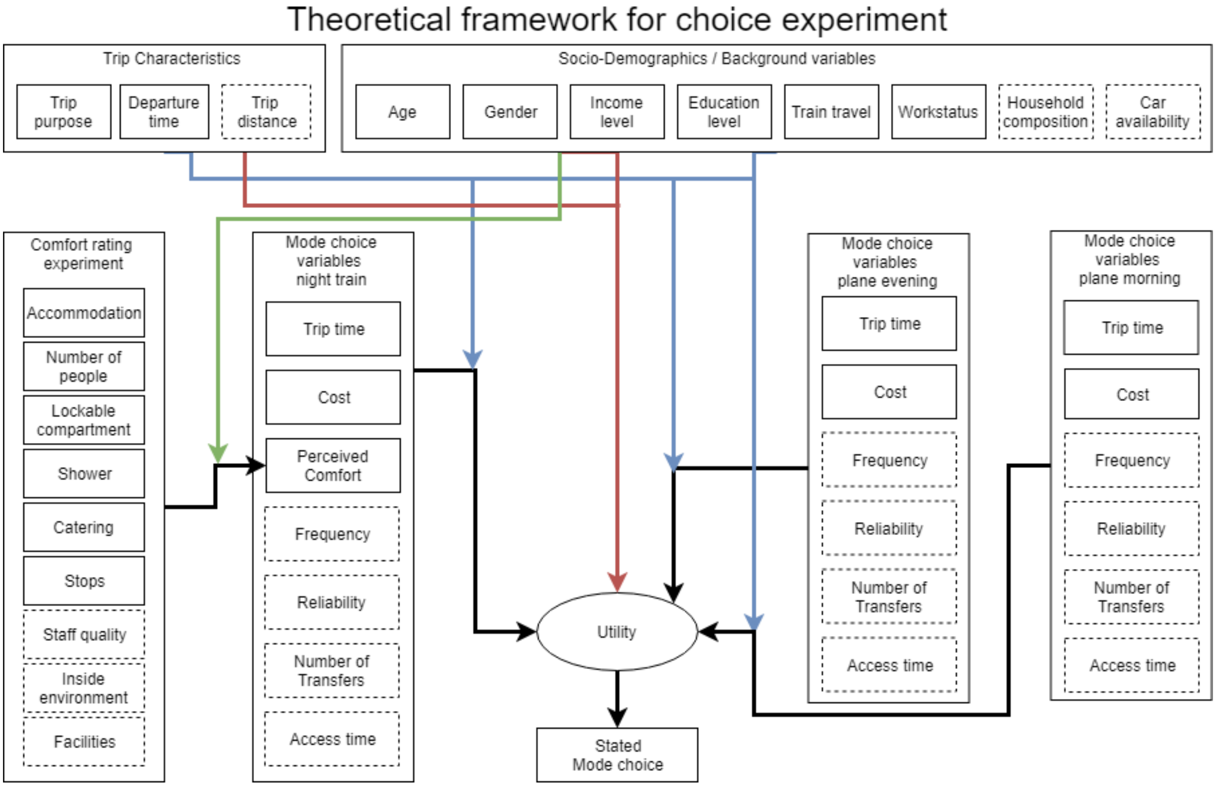

Figure 2: Graphic overview of the theoretic framework. Square boxes: observable variables, oval boxes: unobservable variables, dotted boxes: variables used in other studies, but excluded. Black lines: main effects, green line: sociodemographics/background variables and interactions on comfort rating, red lines: socio-demographics/background on mode choice, blue lines: interactions on mode choice.

- Travel time night train: this attribute is based on the average distance (by rail) between Amsterdam and Vienna/Milan, and the average speed of the night train service. This could be 80, 90 or 100 km/h. Resulting in attribute levels of 11:45, 13:00 and 14:15 hours.
- Travel time plane: reflects the total travel time from arrival at the airport until arrival at the destination's city centre. The attribute levels are 05:00 and 05:30 hours. The base alternative is fixed to 05:00 hours.
- Travel cost night train: the one-way trip cost for a night train ticket. Attribute levels are chosen to cover a wider range of prices: €40, €80, €120 and €160.
- Travel cost plane: the one-way cost for the aeroplane alternative. This includes the airport-city centre transfer. Attribute levels: €60, €110, €160. For the Evening Plane alternative, the middle price level is chosen and a hotel night has to be added. For the hotel, the average of €120 is taken (PWC, 2016, 2018). This results in a fixed price of €230.
- Perceived comfort: this is the comfort level of the night train. This is now an independent variable. The attribute levels are chosen as 1, 3 or 5 stars. This reflects a very uncomfortable to a very comfortable comfort level.

The attribute 'perceived comfort' in the mode choice experiment is an independent variable. It is explained to respondents that it is 'their comfort' level. By doing so, they use of the previously completed comfort rating experiment as a reference frame.

Additionally, a survey context was provided to limit respondents from making own assumptions. Based on previous answers to the introductory questions of the survey, respondents were told to be travelling for leisure or business and whether they are travelling alone or with someone else. Also, they were told that they can be on-time on the departure location and can ignore the access leg of the journey. It was also stated that respondents are travelling with hand-luggage only.

Including the arrival/departure time in a model is shown to improve the model (Bhat, 1998; de Jong et al., 2003). Therefore, it is chosen to include this in the context. To explore the arrival time effect on the Willingness to Use the night train, respondents are asked the same questions in two different settings. One with the desired arrival time at 08:30 and another where this is 10:30.

In total, an experiment with 36 choice sets was designed, which was also blocked in 6 blocks. Therefore, for each context-setting respondents had to answer 6 questions, multiplied by 2 arrival time contexts, results in a total of 12 questions. Figure 3 provides an example of a mode choice question.

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	Kenmerken	Nachttrein	Vliegtuig	Vliegtuig + Hotel
	Tijd aanwezig op station/luchthaven	17:45	02:30	17:30
	Aankomsttijd op treinstation bestemming	08:00	08:00	22:30
	Uw verwachte comfort niveau	★	Economy Class	Economy Class
	Totale reistijd, waarvan:	14:15	05:30	05:00
	- Tijd voor vertrek	00:10	02:00	02:00
	- In trein/vliegtuig	14:00	02:15	01:45
	- Uitstappen/overstap	00:05	00:45	00:45
	- Luchthaventransfer	-	00:30	00:30
	Totale kosten, waarvan:	€160	€110	€230
	- Ticket	€160	€100	€100
	- Luchthaventransfer	-	€10	€10
	- Hotel	-	-	€120

Figure 3: Example of a mode choice question.

2.4 Background variables

After completion of the choice experiments, respondents were asked some questions regarding socio-demographics and other background variables. This to improve model fit and possibly identify target markets for the night train. Data that was collected provided information on gender, age, education level, employment status, travel purpose, as well as information on their frequency of international train and aeroplane travel.

2.5 Data collection and sample characteristics

The intended population was defined as 'Dutch people who had travelled outside Benelux-countries in 2018', this was chosen so respondents would be familiar with travelling abroad and could imagine making such as trip. Data was collected in three ways: by distributing the survey link to members of the Dutch Railways (NS) customer panel, by handing out flyers at Schiphol Airport and by distributing the link on several social media platforms. This resulted in a total of 804 collected answers.

Table 1 provides more information on the collected background variables for the sample. It is shown that the sample consists of a high percentage of people who are highly educated. Additional variables are included in the model to check if a bias is significant. Furthermore, a lot of the respondents are regular train travellers. This is expected as by distributing the survey in the NS panel, loyal train users were approached. Additionally, by social media students were reached, who can travel by train for free in the Netherlands. Therefore, one must conclude that the sample representativity for Dutch people travelling abroad is questionable. The sample should be considered to be a convenience sample. However, this is not considered to be a (big) problem for the study, as it could be considered that regular train users comprise a primary market for the night train.

Table 1: Distribution of socio-demographics and background variables of the sample.

Background variable	**Category**	**Percentage**	**Background variable**	**Category**	**Percentage**
Gender	Female	43.9%	Train travel	Never	0.2%
	Male	56.1%		<1 day a year	1.0%
Education level	Preschool	0%		1 - 5 days a year	4.7%
	VMBO, HAVO, VWO, MBO1	2.9%		6 - 11 days a year	17.7%
	HAVO, VWO, MBO2-4	16.4%		1 - 3 days a month	28.7%
	HBO, WO Bachelor	39.8%		1-3 days a week	25.5%
	HBO, WO Master or higher	40.9%		4 or more days a week	22.1%
Age	0-19	1.1%	Employment status	Student/Scholar	11.9%
	20-39	24.6%		Parttime worker	18.9%
	40-64	43.2%		Fulltime worker	38.4%
	60-79	30.3%		Retired	28.6%
	80+	0.7%		Jobless	2.2%
Disposable income	<10.000	11.9%	Disposable income		
	10.000 - 20.000	9.6%		40.000 - 50.000	12.7%
	20.000 - 30.000	18.1%		50.000 - 100.000	19.7%
	30.000 - 40.000	24.7%		>100.000	3.3%

2.6 Model estimation

This subsection discusses the followed model estimation procedure. Two models were estimated, one for the comfort rating experiment and another for the mode choice experiment. As stated, in the comfort rating experiment the dependent variable is the 'perceived comfort'. Respondents were asked to rate their comfort on a 5-star rating scale. One could argue that this measurement scale is ordinal, which would mean an ordinal logit regression model should be estimated. However, it is chosen to make a simplification. In reality, people could also award scores on the full range between 1 and 5 stars, meaning the variable can also be interpreted continuously. That also provides the possibility for interpolation between the levels not measured. For these reasons, it is chosen to use a linear model for the comfort rating experiment.

In addition to the main attributes that were varied in the choice experiment, it is explored if including social-demographics and other background variables improve the model fit. This is indeed the case. The final model fit is $R^2 = 0.263$. For estimation, some of the attributes were effects coded and IBM SPSS 25.0 was used. The estimated coefficients and t-values are shown in Table 2.

For the mode choice experiment, 3 different alternatives were included: night train (NT), morning plane (MP) and evening plane (EP). The EP is the base alternative, its utility is fixed to 0. Several logit models were estimated. As with the comfort rating experiment, also socio-demographic and background variables were included. Backward elimination was used to remove insignificant parameters. Table 3 shows the parameter estimations for a base MNL model as well as the final Panel Mixed Logit model. Models were estimated with PandasBiogeme (Bierlaire, 2018). The Panel Mixed Logit model converged with 200 draws from a normal distribution. The comfort rating attribute is modelled as a linear + quadratic component. Reflecting that with increasing comfort levels the utility of upgrading to a higher-level drops (decreasing marginal utility). Furthermore, it was found that both the NT and MP alternatives share unobserved factors, resulting in a nest. This is modelled using an additional error component $\sigma_{morning}$ in the Panel Mixed Logit model.

2.7 Latent class choice model

To get insights into the segments of the population that are most willing to use the night train, a latent class choice model was estimated. This model was estimated using LatentGold Choice software. The model consisting of 7 classes performed best. It has a BIC score of 9941.05 points and R^2 = 0.625, compared to a 1 class model with a BIC score of 14741.90 and R^2 = 0.185. Due to a lack of flexibility in the used program, the interpretation or simulation of LC model is quite burdensome. This is why the latent class model was used solely to identify segments in the dataset.

3. Results

This section presents and discusses the results of model estimations. The results of the comfort rating experiment are presented first, followed by the results of the mode choice experiment. Finally, user groups most willing to use the night train are identified.

Table 2: Estimates for main attributes as well as included background variables for comfort rating experiment.

Parameter	Estimate	T-value	Parameter	Estimate	T-value
Constant	4.086	61.321	High Income	-0.110	-6.553
Sleeper	0.722	11.083	Frequent train traveller	-0.034	-2.104
Couchette	0.285	4.276	Age	-0.006	-2.845
Number of People	-0.253	-26.966	Sleeper * Age	-0.003	-5.506
Possibility to lock compartment	0.163	10.962	Couchette * Age	-0.003	-2.456
Restaurant car	0.148	6.810	Education * Number of People	-0.012	-2.934
Kiosk	0.116	5.532			
Possibility to shower	0.127	8.374			
Number of stops	-0.070	-11.560			

3.1 Comfort rating experiment

Table 2 presents the parameter estimations for the regression model. The dependent variable is the comfort rating, which is predicted by 6 different comfort attributes and several background variables. The estimations reflect the extent of the change in comfort rating when the attribute value is altered. Main observations:

- All main parameters have the expected sign. Meaning that attributes that are expected to contribute negatively to the comfort level, indeed have a negative sign and vice versa.

- Largest (absolute) parameter is for the 'Sleeper' parameter. The difference between 'Couchette' and 'Sleeper' is almost half a rating point. 'Seat' accommodation results in a penalty of almost a full rating point.
- The 'Number of people' has a strong effect on the comfort rating. It has an effect between -0.506 (2 people) and -1.518 (6 people). Reflecting that people have a strong dislike for sharing the accommodation.
- This 'Number of people' effect is higher if the person is highly educated (interaction), lower if one is not.
- With increasing age people give, on average, a lower rating to the night train (it reduces the constant). Furthermore, age has a negative effect on both accommodation type parameters. Note that the difference between accommodation types 'Sleeper' and 'Couchette' stays equal. However, the marginal utility difference between 'Seat' and 'Couchette' declines with age.
- The difference between catering parameters is rather small. Meaning that people associate utility with the possibility to get food or drinks on the train, but there is little difference between 'kiosk' and a 'restaurant car'.
- The background variable 'Frequent train traveller' appears to have a counter-intuitive sign. It was expected that people who travel regularly by train, award the night train a higher score (because in daily life the train is their mode of choice). However, the estimation is negative, meaning frequent train travellers give a lower score. Pinpointing a reason for this effect is not possible as that data was not collected.
- Combining all this information leads to the conclusion that a basic night train (no amenities) with 2-person accommodation has a higher comfort rating than a night train with all kinds of luxury facilities, but with shared 6-person accommodation.

Table 3: Estimates for base MNL and Panel Mixed Logit model.

Model:	Base MNL		Panel ML				
Parameter:	Estimation	T-value	Estimation	T-value	Parameter	Estimation	T-value
ASC_{Train}	1.68	5.66	2.06	5	β_{Gender_Plane}	0.121	4.08
ASC_{Plane}	1.85	3.39	3.1	4.8	$\beta_{HighEdu\_Plane}$	-0.874	-5.07
β_{Com}	0.518	7.49	0.648	8.09	$\beta_{HighEdu\_Train}$	-0.578	-3.37
β_{Com_Q}	-0.0294	-2.58	-0.0322	-2.43	$\beta_{HighIncome\_Train}$	-0.117	-3.36
$\beta_{TCPlane}$	-0.972	-15	-1.12	-15.9	$\beta_{Purpose\_Plane}$	-1.11	-6.92
$\beta_{TCTrain}$	-0.774	-15.8	-0.939	-13.7	$\beta_{Purpose\_Train}$	-1.35	-7.81
$\beta_{TTPlane}$	-1.72	-1.67	-1.27	-2.26	$\beta_{Student\_Train}$	-0.209	-3.98
$\beta_{TTTrain}$	-0.93	-4.8	-1.21	-4.84	$\beta_{FreqTrain\_Plane}$	-0.729	-4.91
β_{AT}			-0.0776	-2.1	β_{Age_Train}	0.017	8.15
β_{AT_Plane}			0.0869	2.11	$\beta_{CostPurpose}$	0.184	2.7
					$\sigma_{Morning\_std}$	3.32	21.5
Parameters	8		21				
Final loglikelihood	-8955.28		-6815.64				
Rho squared	0.155		0.355				

Table 3 presents the estimations for two logit models. One is a base MNL model with only main attributes, the other is extended Panel Mixed Logit model including several background variables. Main observations:

- All main parameters have the expected sign.
- Both alternative specific constants are positive, meaning that compared to the base alternate both MP and NT alternatives are more preferred.
- The comfort attribute has a positive linear component and negative quadratic component, reflecting a decreasing marginal utility with higher comfort levels.
- Note that the travel time and travel cost parameters for both modes are scaled. However, for the time the scaling differs between modes. Therefore, these cannot be compared 1 to 1. Travel time for the train is scaled by a factor 10, for the plane a factor 5. Travel cost is scaled by a factor 100.
- Taking this into account, it is noted that a minute onboard the night train causes less disutility than a minute onboard an aeroplane.
- The travel cost parameter for the night train interacts with travel purpose (CostPurpose). Meaning that if travelling for business, the cost parameter is higher (less negative).
- With increasing age, people associate a positive utility with the night train (compared to both aeroplane modes).
- Travel purpose has a strong influence on utility for both NT and MP alternatives. In other words, if travelling for business, there is a preference for travelling the day before and staying in a hotel.
- People who are highly educated, have a preference for travelling by EP.
- Frequent train users have a disutility for the morning plane alternative. Resulting in a higher chance of choosing the night train.
- The AT parameters, reflecting the arrival time scenario (which was modelled as an interaction effect on the constant), show that there is a slight preference for the night train when the desired arrival time is 08:30, and a slight disutility for the morning plane.
- Other socio-demographics (such as being a student or the gender) do influence the utility of the modes, but the effect is limited.

3.2 Latent class choice model

A 7-class latent choice model is used to identify segments that are most willing to use the night train. The cumulative probability of belonging to the first three classes is 79.1%, illustrated in Figure 4. The remainder is split among the other 4 classes.

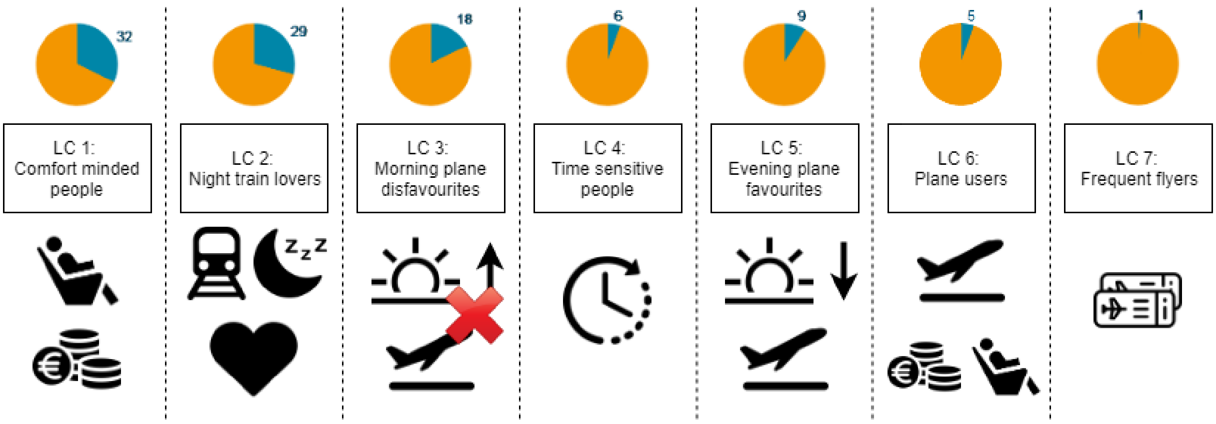

Figure 4: Overview of the identified latent classes.

Using the included socio-demographics and background variables each segment can be described as follows:

- ‘Comfort minded people’: the probability of belonging to this class is 32.3%. In this class most attention is put on the comfort level of the night train. The relative importance (RI) of the comfort attributes is more than 60%. People in this group choose for the night train in 52% of the cases, followed by the morning plane (39%). One is most likely to be between 20 and 39 years old (42%), have a low income (36%) and have not travelled by international train before (43%).
- ‘Night train lovers’: one has a probability of belonging to this class of 29.1%. Most attention is paid to the cost of the ticket (RI: 38%) and night train comfort. Due to this fact, the night train is chosen almost every time (98%). People in this class are most likely to be older than 65 (49%), have an average income and hold a university master (41%).
- ‘Morning plane disfavoured’: 17.8% of the sample belongs to this class. Cost of the morning plane is most important (RI: 63%). Because this is a disutility, that means this mode is little used (3%). People in this group are more likely to be male (67%), have a university master (63%), are middle aged (48% between 40 and 64) and have a high income (33% more than €50.000).
- ‘Time sensitive people’: this group represents only 5.5% of the sample. Only attention is paid to travel time and arrival time. The arrival time context variable for the night train is most important (RI: 90%). For the morning plane option, they only consider the travel time and that has low importance (RI: 3%). Therefore, that is the favourite travel option (89%). In this group, there is a high probability one never travelled by international train (69%).
- ‘Evening plane favoured’: probability of being in this class is 8.8%. People in this class pay a lot of attention to the cost of the morning plane (RI: 76%). The travel time of the night train (RI: 7%) and comfort (RI: 16%) play a smaller role. This results in a preference for the evening plane (96%). There is equal probability (50%) to travel for business or leisure, compared to other classes in which the leisure purpose varied between 61-88\%. People are most likely to be male (78%), earn a high income (44%) and hold a university masters degree (56%).
- ‘Plane users’: 5.4% of the sample belongs to this group. People mostly choose for the aeroplane options (79%). They are cost sensitive towards the morning plane (RI: 51%) and pay attention to night train comfort (RI: 36%). In that sense, this group is similar to class 3. However, the difference is in the covariates. People in this class are young (44% between 20-39), and likely to earn a low income (35%) or high income (28%).
- ‘Frequent flyers’: the probability of belonging to this class is only 1.2%. People in this class do not opt for the night train (only 2%). Their choice behaviour is only described by the arrival time variables. 42% chooses the evening plane, 56% the morning plane. People in this class are middle aged (62% between 40 and 64), hold a university degree (49%) and are frequent flyers (38% more than 6 times in the past 2 years).

Based on choice behaviour it is possible to identify the classes that are most likely to use the night train. Those are the ‘comfort minded people’, ‘night train lovers’ and ‘morning plane disfavoured’. To a lesser extent ‘plane users’ should also be considered, because they are price sensitive and pay attention to comfort.

4. Application

The estimated mode choice model is applied to investigate the potential modal shares for several scenarios. The investigated scenarios are shown in Table 4.

Table 4: Different scenarios with according attribute levels for the mode choice experiment.

Scenario:	1. Reference	2. Upgraded trains	3. Fast, luxury trains, upgraded infrastructure	4. Current trains, optimised timetable	5. Luxury trains, optimised timetable	6. Low-cost competitor
Travel time train [hh:mm]	14:15	14:15	11:45	13:00	13:00	14:15
Travel cost train	80	120	160	80	120	40
'Perceived comfort'	3 stars	4 stars	5 stars	3 stars	5 stars	1 star
Travel time plane [hh:mm]	05:00	05:00	05:00	05:00	05:00	05:00
Travel cost plane	110	110	110	110	110	60

When the night train is introduced as-is, meaning the line between Dusseldorf and Vienna gets extended, it reflects the reference scenario. Simulations show that upgrading the night train comfort level would have more influence on the night train market share than drastically reducing the travel time by investing in high-speed infrastructure. Positioning the night train as an alternative for low-cost flights with low comfort and low-price levels do not benefit the market share, it would drop around 20%. Meanwhile optimising the timetable should be possible.

The timetable can be optimised by reducing the buffer time or the coupling/decoupling time required for splitting the night trains at intermediate stops. Furthermore, often night trains need to share the tracks with freight trains. In that case, better coordination can result in a reduction in travel time. Therefore, scenarios '4. Current trains, optimised timetable' and '5. Luxury trains, optimised timetable' are further considered.

To provide some estimates about how many passengers one could expect for a night train service, some assumptions had to be made. The number of aeroplane passengers between Amsterdam and Milan/Vienna is about 750.000 each. When assuming return trips, this results in 375.000 one-way passengers. To both these destinations around 11 to 14 flights depart daily, of which 2 or 3 in the early morning. This results in a percentage of about 20% if demand is uniformly distributed (and the night train only captures those early morning passengers). Both leisure and business purposes are considered. Data analysis showed that 22% of the respondents travelled for business. This is used to calculate a 'combined potential market share'. Figure 5 shows the potential number of night train passengers one could expect for the scenarios.

The number of daily passengers is estimated to be roughly between 120 and 140. The maximum capacity of the current train from Dusseldorf is 246 passengers (vagonWEB, 2019). This would mean occupancy rates would be about 50%. This seems low; however, one should consider that the night train also serves other markets in Germany and the train composition can relatively easily be adapted.

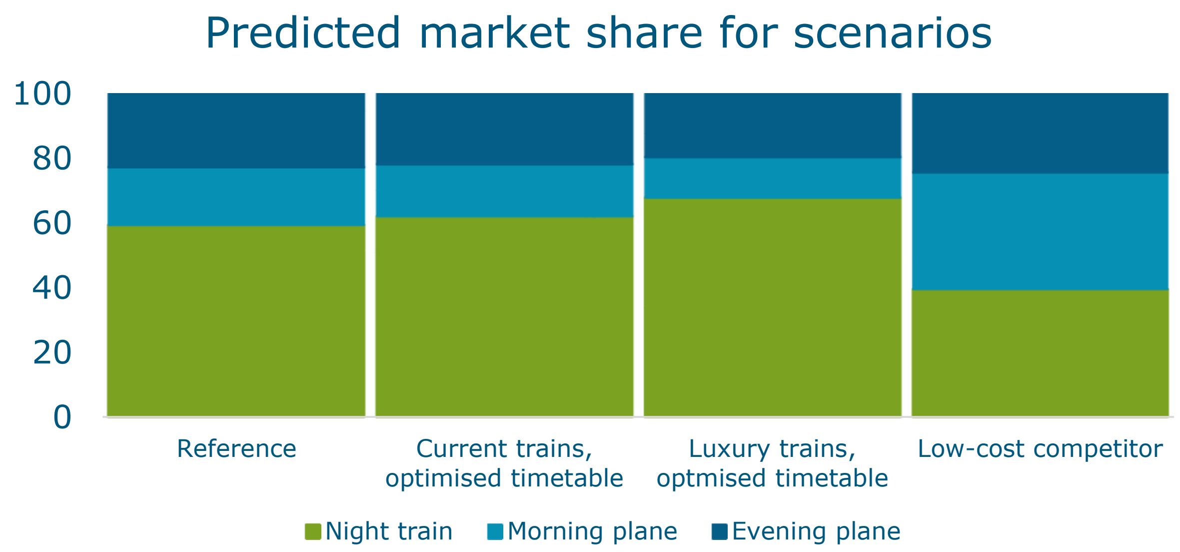

Figure 5: Graph showing the predicated market share for 4 different scenarios.

5. Conclusion

5.1 Key findings

This paper aimed to explore what the Willingness to Use night trains, as an alternative for flying, for long-distance European travel is. The approach is based on the assumption that travelling by night train has several advantages and comes with a higher comfort level. To investigate this, two experiments were developed, a comfort rating experiment and a mode choice experiment. In the first experiment, the 'perceived comfort' level was the dependent variable, it was predicted by a set of night train characteristics (& background variables). During the second experiment, the 'perceived comfort' level was included as an independent variable, this to assess how it is traded-off to the more conventional mode choice attributes such as trip time. Additionally, a latent class choice model was estimated to gain insights on market segments.

It has been shown that the 'perceived comfort' rating is heavily influenced by the number of people in the shared accommodation. A non-stop night train with shared accommodation for 6 people with lockable compartments, showers, a restaurant car etc. would score lower than a basic night train that lacks all these 'luxury facilities', but does offer 2 people shared accommodation. With increasing age, people put less weight on the accommodation type (i.e. seat, couchette or sleeper).

Using focus groups, it was determined that people do not take previously unknown attributes into account when considering the night train travel option. Travel time and cost, together with comfort for the night train were proved to be significant explanatory variables for mode choice. It has been shown that the marginal utility contribution decreases with increasing comfort levels. People value one minute of travel time onboard the night train less than one minute onboard an aeroplane in the early morning. The arrival time does influence the mode choice. When people want to arrive in the early morning (08:30) there is a preference for the night train. Most important background variable is the travel purpose. If travelling for business one has a strong preference for taking the aeroplane the evening before and staying in a hotel.

Application of a latent class choice model revealed that 'comfort-minded people', 'night train lovers' and 'morning plane disfavoured' are the most likely segments to choose for the night train. To a lesser extent 'plane users' is found to be interested into using the night train. The ‘comfort-minded people’ find the comfort factor of the night train highly important and are mostly young. The ‘night train lovers’ are people who are older than 65, retired and have a high education level. In the ‘morning plane disfavoured’ segment, people are middle-aged, highly educated and earn a high income.

When the night train is introduced as-is, the combined market share for both leisure and business travel purposes could be around 60%. With improvements to the rolling stock and the timetable, it is predicted to increase to 67%. Positioning the night train as a low-cost alternative is not a good option, the market share suffers from the low comfort level. Using airline passenger numbers, it is expected daily passengers could be between 120 - 140. One can, therefore, conclude that people do indeed seem willing to use the night train as an alternative for flying for long-distance trips in Europe.

5.2 Limitations

This study considered a set context, i.e. a trip within Europe taking 12-14 hours, with a desired arrival time in the (early) morning. This means that conclusions regarding services that fall outside of this scope cannot be made.

A second limitation is the distribution of the survey through the NS panel. It resulted in a large number of responses. However, data analysis showed it is likely to be a 'convenience sample' as it consists of a substantial amount of regular train users. Variables accounting for being a frequent train traveller or highly educated were significant. Therefore, a bias might be present in the sample.

As always with any Stated-Preference study, it remains to be seen if people opt for the night train in reality. It might have been hard for people to imagine the full travel experience for a non-existing mode. This, for example, showed in the low parameter estimate for the number of stops during the night. Their decisions could also be influenced by a single negative experience. Something that is currently ignored.

Social-desirability might have played a role when answering the questions. During the study period, there was a public debate about climate change and 'shame of flying'. At last, for some people the choice set would not offer a 'real choice', i.e. people who are in principle against flying or have a fear of flying would opt for the night train by default, while in reality, they might also use another travel mode.

5.3 Further research

Suggestions for further research include repeating the study with a more representative sample, to reduce the possible effects of bias.

Repeating the study in a country where the night train is already operating would allow combing Revealed-Preference data with Stated-Preference data to calibrate the choice model.

Further research is also needed into the mode choice for night trains outside the defined scope of this study, e.g. a preferred arrival in the afternoon. This would allow for more accurately determining the potential market share.

One could develop more advanced latent class choice models. This would allow to further explore the segments in the dataset and related covariates. As a follow-up, these models can be used to investigate how the specific segments would react to different scenarios.

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