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Understanding preferences for night trains and their potential to replace flights in Europe. The case of Sweden

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A R T I C L E I N F O

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A B S T R A C T

Possible strategies to mitigate the climate impact of tourism transport include encouraging tourism to closer destinations and supporting more sustainable modes of transport, including trains. Today international trips by railways only have a small market share but night trains are considered an important part of a future green Europe. However, little is known about travelers' preferences for night trains for long-distance travel in Europe. The results of an integrated choice and latent variable model (ICLV) applied to stated preference (SP) data collected from 1691 residents of Sweden show that, depending on place of origin in Sweden, in response to a set of innovations, including reduced travel time emanating from ongoing infrastructure investments, and the introduction of new, more comfortable trains, the share of plane users willing to switch to night trains to Central Europe could reach 20–30% and to Southern Europe, 6–10%.

1. Introduction

To meet the climate goals of the Paris Agreement in terms of reaching net zero emissions by 2050, a reduction in CO_2 emissions from many sectors is needed, including tourism. In the tourism sector, the airline industry alone generates around 3.5% of total global anthropogenic climate impact (Lee et al., 2021). The climate impact of air travel may be mitigated by technological improvements in aviation, such as low carbon fuels, improvements in energy efficiency, and the optimization of air traffic management (Larsson, Elofsson, Sterner, & Åkerman, 2019). However, these measures are unlikely to contribute enough to achieve a substantial reduction in greenhouse gas (GHG) emissions in the mid-term perspective (Åkerman, Kamb, Larsson, & Nässén, 2021). A considerable part of the remaining environmental impact from long-distance travel can be reduced through the substitution of flights with more environmentally sustainable modes of transport (Peeters, Gössling, & Becken, 2006). The magnitude of the environmental benefits depends on the mode of transport displacing flights. The European Environmental Agency finds that, in terms of CO_2 emissions per passenger-kilometer (pkm), flights have the largest emissions, while train travel remains overall the most environmentally friendly mode (European Environment Agency, 2021).

1.1. Background

In Europe and the United States trains represent a niche, constituting respectively 2% and 1% of travel demand for trips longer than 1000 km. This share is higher in other contexts; rising for example up to 10% in Japan (Hall, Le-Klähn, & Ram, 2017). This evidence indicates that developing a more sustainable tourism mobility is possible (Hall et al., 2017). In recent years there has been a large increase in demand of high-speed (HS) trains, which often is the time efficient solution to connect destinations up to 800 km (Yin, Bertolini, & Duan, 2015). For more remote destinations, the potential of HS trains is more limited.

In Europe, for origins/destinations such as the Scandinavian countries, the Iberian Peninsula, the south of Italy, the UK, the Baltic countries and Eastern Europe, HS trains are not a very competitive alternative since the travel time would still be relatively long. For those travel ranges there is however optimism about the potential for night trains to fill this gap in the near future (Lena Donat et al., 2021). The year 2021 has been named the "European Year of Rail" by the European Commission and rail transportation is considered to be a key driver of the European Green Deal, which is boosting expectations of a night train renaissance in Europe (Lena Donat et al., 2021).

Trains with so-called bed-carriage were developed as early as in the

Abbreviations: DT, Direct train; DPE, direct price elasticity; CPE, cross price elasticity; GHG, greenhouse gas; HS, high-speed; SP, stated preference; ICLV, integrated choice and latent variable; MMNL, mixed multinomial logit; PEPN, pro-environmental personal norm; FOF, fear of flying.

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1830s and remained the premium mode of long-distance travel within Europe until at least the second world war, then gradually lost market shares compared to cars and planes (Bird et al., 2017). Higher speed and flexibility, together with the desire of escaping from the bureaucratic mentality of the state-owned rail monopoly had a positive impact on car ownership and use (Bird et al., 2017; Prideaux, 1999). At the same time, the introduction of new generations of aircrafts and the falling cost of air travel boosted the demand for flights (Prideaux, 1999). The growth of commercial aviation has been particularly steady in the last decades, when, in response to airline liberalization, low-cost airlines flourished, increasing even more the appeal of flights over trains (Bird et al., 2017). As a result, night trains have not managed to grow beyond a small niche (Bird et al., 2017). Moreover, even though the main railway infrastructure is already there, train services in Europe suffer from weak international cooperation, administrative hurdles, the lack of trains which are technologically possible to use in different countries, the absence of easy international booking and the lack of a legal framework that guarantees passengers' arrival times (Lena Donat et al., 2021). Nowadays, night trains have started to attract the attention of policymakers, with the "Pilot Project on the Revitalisation of Cross-border Night Trains" launched by the European Commission (TED, 2020). Service operators, such as the Austrian company ÖBB, has also introduced new connections and new trains that will link several major cities by night train.[1]

To extend the connections between Scandinavia and European continental cities, the construction of railway infrastructure with the Fehmarn Belt Fixed Link (FBFL), an underwater tunnel that will connect the Danish island of Lolland with the German island of Fehmarn by 2029, has begun (BMVI, 2021). Its potential to connect Scandinavian countries with the rest of Europe and reduce travel time connections by train could contribute to a reduction of total environmental impact from tourism. It is estimated that if all intra-European flights were replaced by train travel, the total global climate impact of Swedish residents' long-distance travel could be reduced by 26% (Kamb, Lundberg, Larsson, & Nilsson, 2020). Expectations are high, but there is still little evidence of a behavioral response from travelers, which is crucial, given that technology innovation alone is not sufficient to spur a more sustainable transport behavior (Cohen, Higham, Gössling, Peeters, & Eijgelaar, 2016).

1.2. Related studies

To reduce the GHG emissions of long-distance travel, it is important to identify alternative solutions to air travel. Among those, excluding the radical option to avoid travelling, travelling to closer destinations and changing transport mode are the most relevant (Peeters et al., 2006). The shift to greener transport solutions is possible, but hard to achieve. Often, people have a higher preference for greener options, but a lack of alternative modes of transport contributes to a vast gap between preferences and behaviors (Árnadóttir, Czepkiewicz, & Heinonen, 2021). Many studies have investigated awareness-attitude and attitude-behavior gap, of which Cohen et al. (2016) provide a comprehensive overview. A common conclusion seems to be that government, tourism and transport industries need to take actions to fill those gaps since voluntary behavioral change is often insufficient (Cohen et al., 2016; Higham, Cohen, Cavaliere, Reis, & Finkler, 2016). To help governments adopt adequate policy designs, it is crucial to understand the determinants of long-distance travel mode choice, which range from attributes of the mode of transport and socio-demographic characteristics, to previous use experiences, habits and other psychological factors (Hess, Spitz, Bradley, & Coogan, 2018; Lanzini & Khan, 2017).

Regarding the attributes of means of transport, the most important determinants of mode choice are considered to be travel cost and travel time (Gunn, 2001). Other relevant comparing factors, especially when choosing between a flight, train or bus, are comfort level and the number of transfers (Creemers et al., 2012; Heufke Kantelaar, Molin, Cats, Donners, & van Wee, 2022; Román, Espino, & Martín, 2010). As for the effect of travel time on choosing train, thanks to the diffusion of high-speed (HS) trains across Europe, travel times between major cities are decreasing, making HS trains an increasingly viable alternative to long-distance flights. Also, the propagation of HS connections has both environmental benefits, by decreasing the pkm associated emissions, and tourism-related benefits, by increasing the number of visitors of cities connected by HS (Hall et al., 2017; Yin et al., 2015). Where available, HS trains are a particularly attractive solution for medium-distance trips[2] (below 1000 km), in Central Europe 8% of passenger transport demand is currently served by railway services (Lena Donat et al., 2021). For more remote destinations, the travel time for trains compared to flights is much longer, so that, even with HS trains, day trains present a less viable alternative. The use of night trains might increase their attractiveness (Heufke Kantelaar et al., 2022). Night trains are generally slower than day trains in order to provide enough time for sleep, to allow splitting to serve several destinations, and to give priority to freight trains (Bird et al., 2017). However, given that the perception of travel time varies across transport modes (Juschten & Hössinger, 2020) and depends also on the activity that travelers are doing while travelling, on night trains it might be perceived as shorter given the possibility of sleeping during part of the trip.

Train companies have less incentives to operate night trains due to a lower profitability, affected by higher costs (linen services, higher wages for staff working during the night and far from home) and lower revenues (lower numbers of passengers per carriage) (Bird et al., 2017; von Arx, Thao, Wegelin, Maarfield, & Frölicher, 2018). Comfort is a relevant variable that affects travel experience and mode choice (Creemers et al., 2012; Román et al., 2010). Travelers are less willing to travel by modes that are perceived uncomfortable (Creemers et al., 2012) and willing to pay for higher comfort (Heufke Kantelaar et al., 2022), which has also the benefit of affecting the perception of travel time (Román et al., 2010). Despite all these challenges, night trains have more recently been considered a concrete and important alternative to reduce the GHG emissions of long-distance travel due to the continuous reduction of travel time and the increasing comfort (Lena Donat et al., 2021).

Socio-demographics are significant determinants of mode choice (De Palma & Rochat, 2000; Gross & Grimm, 2018; Reichert & Holz-Rau, 2015; Soltanzadeh & Masoumi, 2014; Sovacool, Kester, Noel, & de Rubens, 2018) All else being equal, higher education is often associated with the choice of a mode of transport that has a lower environmental impact (Sovacool et al., 2018). However, higher education is often also correlated with higher total travel volumes, even when income is considered (Reichert & Holz-Rau, 2015). Travel companionship and household size is another relevant factor for travel mode choice (Gross & Grimm, 2018; Soltanzadeh & Masoumi, 2014), with larger group size often associated with a higher preference for cars (De Palma & Rochat, 2000).

Psychological aspects play a role in determining transport mode choice (Árnadóttir et al., 2021; Fleischer, Tchetchik, & Toledo, 2012; Kamb et al., 2020; Lanzini & Khan, 2017;Osterhus, 1997 ; Schwartz, 1977). For example, an environmentally friendly attitude is often associated with a higher intention to use sustainable solutions. Environmental variables, however, are often more strongly correlated with intention than with actual behavior (Lanzini & Khan, 2017) and a high preference for sustainable solutions does not lead concretely to actual use, partly due to the lack of viable alternative transport modes, causing a preference-behavior gap (Árnadóttir et al., 2021). An extensively used psychological variable to understand pro-environmental behavior,

[1] https://www.nightjet.com/en/reiseziele

[2] We use medium and long distance just as convenient labels to differentiate between the two scenarios in the experiment presented in Section 2.2.

which has been shown to be a relevant factor affecting tourism choices (Kamb et al., 2020), is the pro-environmental personal norm from the Value-Belief-Norm Theory (Osterhus, 1997; Schwartz, 1977). Another relevant psychological factor for long-distance travel mode choice is the fear of flying (FOF - Fleischer et al., 2012). It is a common phenomenon among airline passengers and affects the value attached to flight itineraries to the extent that higher FOF is associated with a higher willingness to pay for fear-alleviating attributes (Fleischer et al., 2012).

1.3. Research objectives and structure of the paper

To investigate the potential of night trains to replace flights for long-distance travel, we aimed to investigate the behavioral intentions of Swedish travelers, the reasons for conducting the study in Sweden are explained in section 2.1. Our study is aimed to: 1) understand the profile of current train users for long-distance travel to Europe; 2) identify the socio-demographic and psychological characteristics of new potential night train travelers; and 3) provide an overview of existing policy instruments that can increase the attractiveness of night trains compared to flights. We focused on leisure travel. Business travel has been excluded due to (i) a minor share (20%) of the passenger-kilometers flown by Swedes (Kamb et al., 2019), (ii) the expectation of a low level of business travel in the future due to the increasing use of online meetings, (iii) different time and budget constraints between leisure and business travels. The structure of the article is as follows: Section 2 introduces the methods and materials used to conduct the study, Section 3 presents the main results, and Section 4 discusses the results in relation to the extant literature and describes implications for policymakers and rail operators' managements. Finally, Section 5 summarizes the conclusions.

2. Research methods and materials

In this section, we describe the methods and materials used to conduct our study. We present the research context, describe the design of the survey and the data collection and characteristics of the sample. Finally, we explain the model specification and the associated econometrics.

2.1. Research context

As introduced in section 1.1, day trains on HS railway networks are insufficient to connect the Scandinavian countries with most European destinations. Therefore, night trains would probably be necessary. The research was conducted in Sweden, as a case study for Scandinavian countries, within the project "On track to climate neutral long-distance travel 2045 - technology, travel patterns, high-altitude impact". The context of Sweden is particularly interesting for a threefold reason: 1) investments in railway infrastructure will drastically reduce the travel time between Sweden and the rest of Europe in the coming years; 2) high potential of comfort level improvement through replacement of existing old night trains; 3) environmental movements put a strong pressure to choose more sustainable travel solutions.

The FBFL is not the only ongoing infrastructure development in Sweden. HS railways are not fully developed yet and there is an increasing interest in trains for long-distance travel due to investments in the HS railway system, which will be built in stages in Sweden. At the time of writing, three new HS corridors are planned with the aim of connecting the three main cities of Stockholm, Gothenburg and Malmö (Swedish Transport Administration, 2020). The travel time reduction from Sweden to the main cities in Europe could be reduced up to 2 h 30 min thanks to the FBFL, and additional 2 h 45 min thanks to the HS infrastructure (Greater Copenhagen, 2019; Nelldal, 2019).

Sweden is one of the countries registering the longest average distance travelled on national railways (Hall et al., 2017) and two environmental movements are pushing towards more sustainable travel solutions. The *flygskam* (flight shame in English, and the associated idea of train bragging), and the *skolstrejk för klimatet* (school strike for climate) movements that started spreading among the population in 2018 have contributed to break the strong and consistent increase in air travel into a reduction. The international air travel volumes among the Swedish population were 5–10% lower 2019 compared to 2017 (Ekvall, Larsson, & Nässén, 2022).

2.2. Survey

We investigated travelers' preferences for night trains through a web-based survey, designed using Qualtrics software. The survey was composed of three parts. In the first part, we collected relevant socio-demographic characteristics such as gender, age, education level, income, residence location and travel companionship. Information about travel habits were also collected through questions about current travel mode choice for long-distance travel and previous experiences with night trains. In the second part, we performed a stated preference (SP) choice experiment (Moshe Ben-Akiva, McFadden, & Train, 2019) to investigate the appeal of night trains as an alternative solution to flights for holidays of at least one week at different destinations. Regarding travel attributes, we used total travel time (including departure and arrival time), comfort level, number of changes (i.e. transfers) and travel costs. We created a choice task requiring the consideration of two alternatives: 1) night train; 2) morning flight on the following day compared to the train departure. An example of a choice task is shown in Fig. 1.

To include realistic levels for the attributes, we adapted the design of the experiment to every respondent depending on their origin location and destination. To cover a wide range of trips, we opted for including cities at a medium distance (<1000 km) or long distance (>1000 km) from the geographical center of the selected counties in Sweden. We selected two different groups of origins (named A and B), and two different groups of destinations (named medium distance and long distance). For the origins, we grouped together the counties closer to the border with Denmark (group A), i.e., those with a significantly lower travel time to Europe compared to Sweden's northern counties. The aim is to measure the changes in preference in response to a change in destination distance. However, presenting different destinations in terms of distance, bear the risk of being a too abstract task. To simplify the process for respondents, we selected a small set of popular destinations (i.e. destinations with the highest number of visitors from Sweden) within the range of the distances of interest. Medium-distance cities

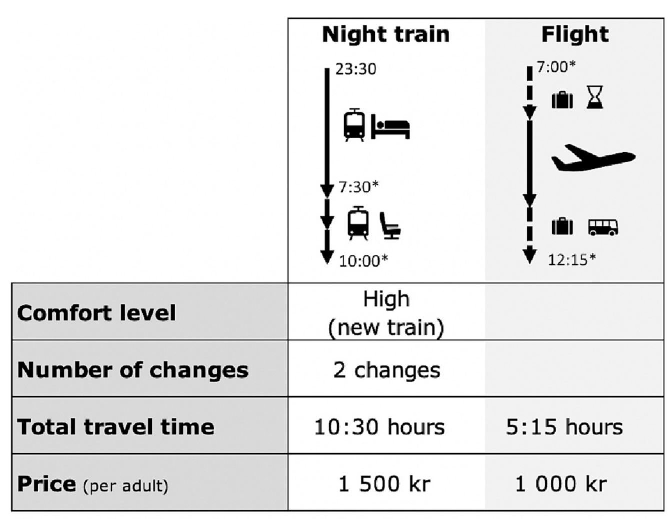

Fig. 1. Example of a choice task card in the SP experiment (translated version). Note: kr = Swedish krona, at the time of data collection, 1000kr = 100€.

from Sweden included cities in the distance range of Amsterdam or Prague, while long-distance cities referred to cities in the distance range of Barcelona or Venice. Origins and destinations are shown in Table 1.1.

With two origins and two destinations, four different experiments can be designed. In each experiment, we considered specific travel times, travel costs and the number of changes for the alternatives. We generated four D-efficient designs of the experiment, obtained by minimizing the determinant of the asymptotic variance-covariance matrix of the standard errors of the parameters (Rose & Bliemer, 2007), with resulting D-errors lower than 0.30 and a minimum sample size required of 206 respondents. The specific levels of the attributes of the four experiments are shown in Table 1.2.

To measure sensitivity to changes in attributes, we presented several choice tasks to the respondents, varying the levels of the attributes in each choice task. We included four choice tasks for medium distance for those who selected plane as their current mode of transport for medium distance. The same applied to those who selected plane for their current long-distance trips. Therefore, for those who selected plane as their current mode of transport for both medium- and long-distance travels, we analyzed eight choice tasks (four for medium distance and four for long distance).

In the third part, we collected responses to Likert scale questions (Albaum, 1997) to measure psychological factors whose effects on mode choice can be estimated using integrated choice and latent variable (ICLV) models (Moshe Ben-Akiva et al., 2002). We collected information about the two psychological variables, pro-environmental personal norm (PEPN) and fear of flying (FOF). For both variables, we presented a list of statements to which respondents expressed their level of agreement from 1 = completely disagree to 5 = completely agree. The statements were adapted from previously validated scales. In particular, PEPN was from the Value-Belief-Norm theory (Kamb et al., 2020; Osterhus, 1997; Schwartz, 1977). The statements regarding FOF were adapted from Fleischer et al. (2012), which is, to the best of our knowledge, the only study using FOF in a choice experiment. The list of statements is shown in Table 2.

The two z of travelers' choices. The econometric method used to integrate them in the choice experiment is explained in subsection 2.4.

2.3. Data collection and sample characteristics

The survey was administrated in the 13 southernmost of Sweden's 21 counties by the market research company Norstat[3] during May 2021. An internal pre-test with a total of 450 choice tasks had been conducted to colleagues in the research division to refine the design of the experiment. In the national survey, northern counties were excluded due to low population density and remoteness. Before participating in the SP experiment, respondents received information about possible changes in the future due to improvements in trains and investments in HS railway infrastructure. A soft launch to 50 respondents was conducted, as a risk mitigating strategy, for a preliminary testing of the model. Quota-adjustment was applied after 1000 and 1500 respondents; the final sample is composed of 1691 respondents (Table 3).

The structure of the sample resembles the distribution of age, gender and population living in the selected counties, with small deviations in some categories. The sample is slightly over-representative of highly educated people and is on average wealthier than the reference population. The results can be considered as indicative of preferences for the population living in the selected counties of southern Sweden.

Table 1.1
Design of the experiment: origins and destinations.

Origin (county)		*Destination*	
A	*B*	*Medium distance*	*Long distance*
Close to the border with Denmark: Blekinge, Halland, Kronoberg, Skåne	Far from the border with Denmark: Jönköping, Kalmar, Örebro, Östergötland, Södermanland, Stockholm, Uppsala, Västmanland, Västra Götaland	<1000 km from the geographical center of selected counties (e.g., Amsterdam or Prague)	>1000 km from the geographical center of selected counties (e.g., Barcelona or Venice)

Table 1.2
Design of the experiment: Alternatives, attributes, and levels of the attributes.

Alternative	Attribute	Level			
		A to medium	A to long	B to medium	B to long
Night train	Departure time	23:30			
	Comfort level	Low (current train)			
		High (new train)			
	Number of changes	Direct	1 change	1 change	1 change
		1 change	2 changes	2 changes	2 changes
	Total travel time	8:00	11:30	10:30	14:00
		9:30	14:00	12:00	16:30
		11:00	16:30	13:30	19:00
	Travel time on night train	6:00	8:00	8:00	8:00
		8:00	11:30	10:30	14:00
		9:30	14:00	12:00	16:30
		11:00			
	Time of change after night train	Departure time + Travel time on night train			
	Travel cost	100 €	150 €	150 €	200 €
		200 €	250 €	250 €	300 €
		300 €	350 €	350 €	400 €
Plane	Departure time	7:00*			
	Total travel time	4:30	5:30	5:15	6:15
		5:15	6:15	6:00	7:00
	Travel cost	100 €			
		200 €			
		300 €			
	Arrival time	Departure time + Total travel time			

* The day following the train departure day. Note that prices have been reported in euro (€) in the Table, but respondents received the experiment in their local currency (kr).

Table 2
Constructs and statements for the latent variables.

Construct		Source
Pro-environmental personal norm (PEPN)		
PEPN1	I feel that I should protect the environment.	[Kamb et al., 2020; Osterhus, 1997; Schwartz, 1977]
PEPN2	I feel it is important that people in general protect the environment.	
PEPN3	Because of my own values/principles, I feel an obligation to behave in an environmentally friendly way.	
PEPN4	I should do what I can to conserve natural resources.	
Fear of flying (FOF)		
FOF1	I am afraid during take-off and landing.	[Fleischer et al., 2012]
FOF2	I feel insecure in the air.	
FOF3	Air pockets make me nervous.	

2.4. Model specification

Respondents' preferences regarding night trains were investigated through an integrated choice and latent variables (ICLV) model (Moshe Ben-Akiva et al., 2002). The theoretical framework is based on random

[3] https://norstat.se/

Table 3
Sample characteristics (n = 1691).

Variables		Sample	Population[a]
Gender	Female	48.3%	50.3%
	Male	51.7%	49.7%
Age	15–24 years	7.1%	9.8%
	25–34 years	20.3%	17.8%
	35–44 years	17.6%	15.8%
	45–54 years	16.9%	16.3%
	55–64 years	13.2%	14.8%
	65–74 years	15.0%	13.3%
	>74 years old	9.9%	12.2%
Education	No university degree	69.3%	76.6%
	University degree	30.7%	23.4%
Income before tax	Mean	36,540 €	30,990 €
Counties*	Group A	24.7%	24.4%
	Group B	75.3%	75.6%
Municipality	Stockholm, Gothenburg, Malmö	14.4%	18.4%
	Other municipalities	85.6%	81.6%
Most common travel companionship	Solo or with friends	22.2%	–
	Couple	41.5%	–
	Family	36.3%	–
Airport distance	<1 h	52.6%	–
	>1 h	47.4%	–
Previous experience with night trains	No	49.8%	–
	Yes, negative	18.0%	–
	Yes, neutral or positive	32.2%	–
Expected hours of sleep on the night train	Mean	5:40 h	–

[a] Data from official statistics of Sweden: https://www.scb.se/en/About-us/official-statistics-of-sweden/

* Counties belonging to group A and B are listed in Table 1.1. Note: Prices in euro (€) have been reported in the Table, but respondents received the experiment in their local currency (SEK).

utility maximization (RUM) theory (McFadden, 1973). The model relies on the assumption of respondents being rational agents aiming to maximize utility (U) through their choices. The respondents' choices are predicted by the attributes of the alternatives in the choice tasks, the socio-demographic characteristics of the respondents, and the psychological variables. A schematic representation of the conceptual model is shown in Fig. 2.

The econometric specification of the model follows. The utility U_{njt} is estimated for each respondent $n = (1, \ldots, N)$ choosing alternative $j = (1, \ldots, J)$ in choice situation $t = (1, \ldots, T)$. $N = 1691$ is the number of respondents, $J = 2$ is the number of alternatives in each choice task and $T = (4 \text{ or } 8)$ is the number of choice tasks presented to every respondent. The functional form of utility is set out in Eq. (1)

$$U_{njt} = \boldsymbol{\mu} V_{njt} + \epsilon_{njt} \quad (1)$$

where V_{njt} is the deterministic part of the utility function, while ϵ_{njt} is the extreme value distributed stochastic part of the utility. The scale parameter $\boldsymbol{\mu} = \mu_B \mu_{LD}$ captures differences in the variance of respondents in group B (μ_B), and for choices in the long-distance sub-experiments (μ_{LD}). The deterministic part of the utility function for the two different alternatives is defined in Eq. (2) and (3)

$$V_{n,plane,t} = \beta X_{n,plane,t} \quad (2)$$

$$V_{n,train,t} = ASC_{train} + \beta X_{n,train,t} + \psi Z_n + \sigma \xi_{n,train,t} \quad (3)$$

where ASC_{train} is the alternative-specific constant capturing the baseline preference for trains; $X_{n,\ plane,\ t}$ and $X_{n,\ train,\ t}$ are the vectors of attributes of the plane and night train, respectively; $Z_n = (SD_n, LV_n)$ is the vector containing idiosyncratic characteristics of the respondents (i.e. socio-demographic characteristics and latent variables); β and ψ are the corresponding vectors of coefficients; $\xi_{n,\ train,\ t}$ is the normally distributed error component part, with mean 0 and variance σ^2, capturing the unexplained heterogeneity of preferences. The probability of observing the choices for each respondent n, and the estimation procedure used to include the latent variables in the choice experiment are reported in Appendix A1.

We calculated the demand elasticity of the night train in response to a change in its ticket price (direct elasticity) and to a change in the flight ticket price (cross-elasticity). The direct elasticities ($E^{train}_{price,\ train}$) and cross elasticities ($E^{train}_{price,\ plane}$) were calculated as shown in Eq. (4) and (5), respectively (M. Ben-Akiva & Lerman, 1985).

$$E^{train}_{price,train} = (1 - P_{train}) x_{price,train} \beta_{TC,train} \quad (4)$$

$$E^{train}_{price,plane} = - P_{train} x_{price,plane} \beta_{TC,plane} \quad (5)$$

where x_{price} and β_{TC} represent the mode of transport's specific price and travel cost sensitivity. P is the probability of choosing the specific alternative.

3. Results

In this section, we show the main results of our analysis. Firstly, we present the most important factors for long-distance travel mode choice and the determinants of current travel mode choices for the whole sample. Then, for current air travelers, we analyze SP with regard to switching from plane to night trains after the introduction of innovations supporting the night train option. An overview of the most important factors when booking long-distance travel is reported in Fig. 3.

In line with the expectations, cost and travel time were the two most important factors for long-distance travel mode choice. The number of changes (i.e., transfers) was considered one of the most important factors by more than half of the sample, indicating the relevance of offering direct connections. Easy booking was also seen as an important aspect. At the time of writing, it was not possible to book international train tickets on a single website from Sweden. This barrier could partially explain the current low preference for trains. The arrival time was judged to be slightly more important than the departure time. Comfort level, risk of delay, the environmental impact of the mode of transport, the possibility of using travel time in satisfying ways, and the connection time were also considered as important by a substantial proportion of respondents. Other factors were considered important by <20% of the sample. Seven of the most important factors were included in the proposed experiment, indicating a low risk of relevant attributes having been omitted in our study.

In Section 3.1 we included the determinants of current travel mode choice, while in Section 3.2 we investigated the preferences for airline passengers. With this approach, we can present a comprehensive picture of the current preferences in the population, and then investigate in more detail the preferences of the target group of interest.

3.1. Current travel mode choice

The drivers of current preferences have been estimated using an ICLV model applied to choice data for medium and long distances. The results of the structural model of the latent variables and the choice model are presented below. Socio-demographic characteristics associated with the psychological constructs are shown in Table 4.1.

Age was found to be negatively associated with FOF and PEPN with a non-linear effect. Below the median age, there was no difference in FOF, while it started decreasing above that threshold. The youngest age groups had the highest PEPN, decreasing up until the median age level. Then, no difference is found between respondents older than the median. Higher PEPN is associated with female gender, university degree and lower income, while higher FOF is associated with female gender and lower income. The measurement model and the reliability of the

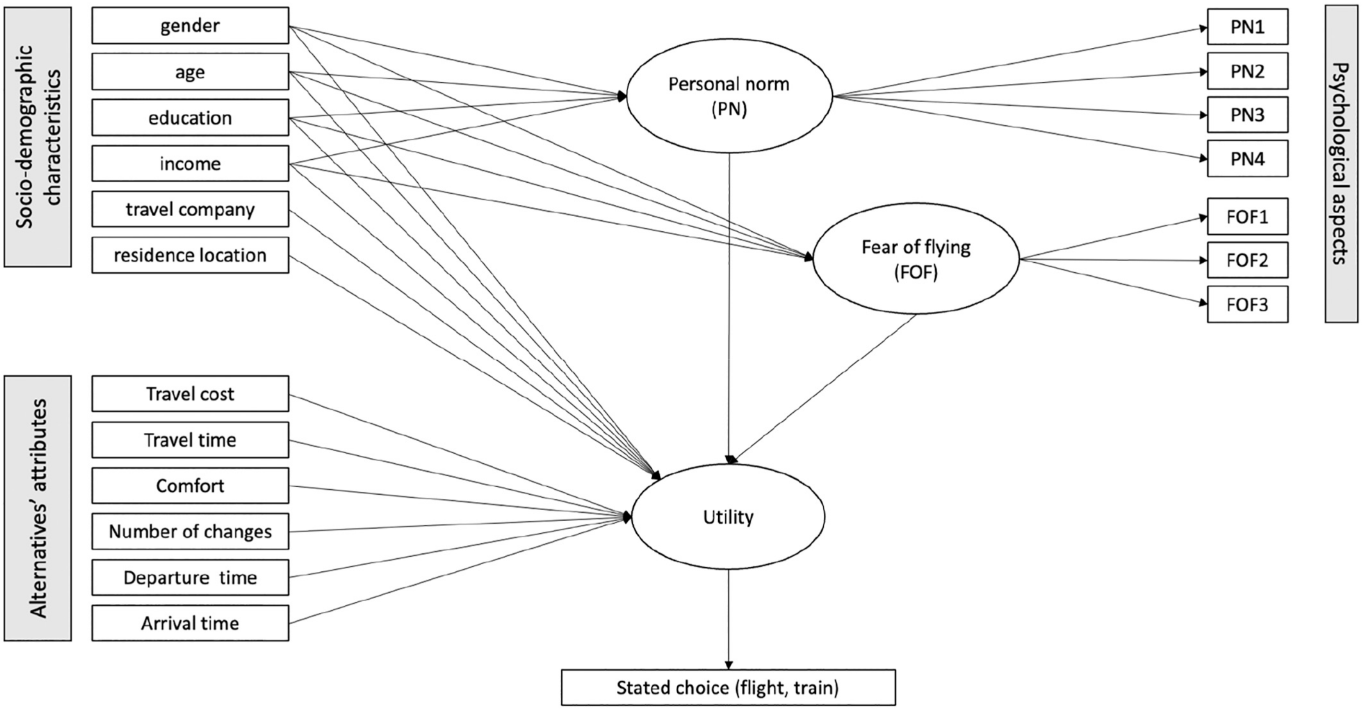

Fig. 2. Conceptual model.

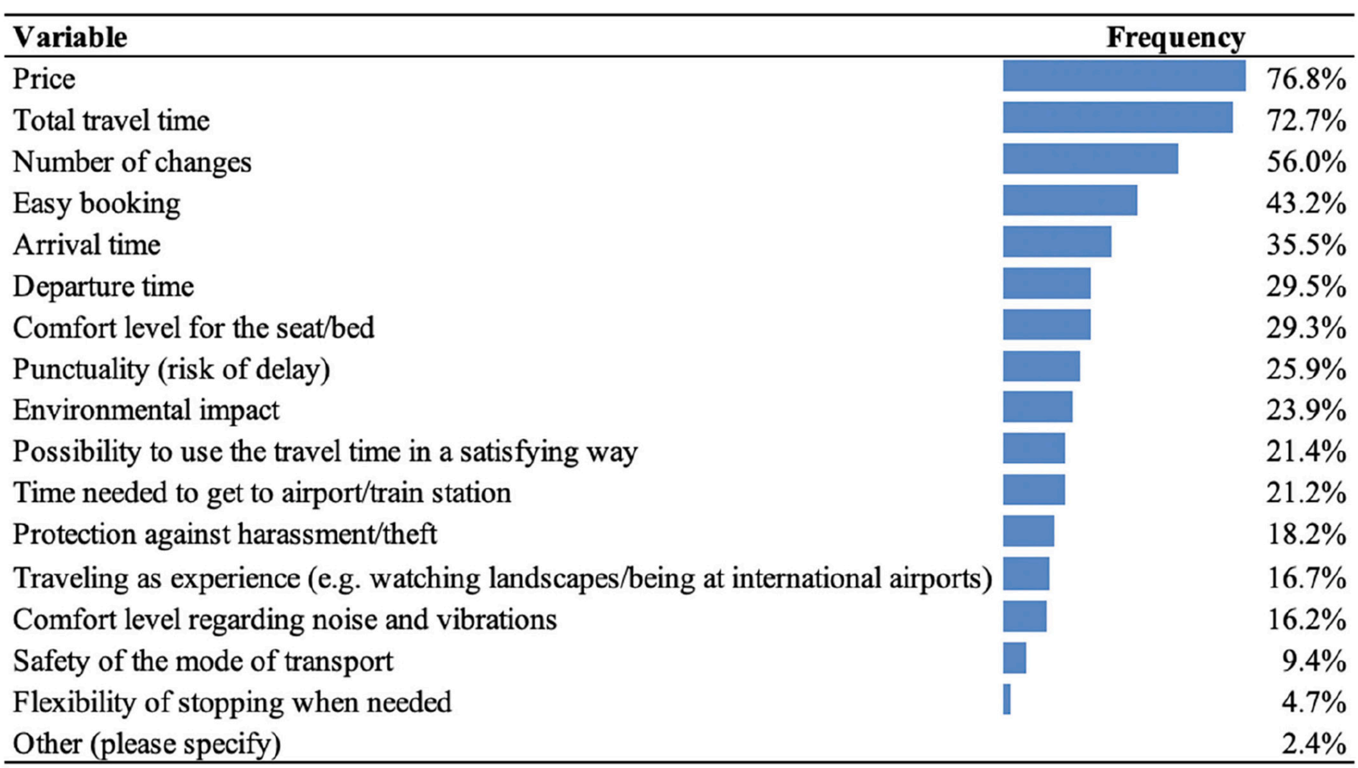

Fig. 3. Reported importance of factors for long-distance travel mode choice.

construct are set out in Appendix A2. The results of current preferences are presented in Table 4.2 with plane is the reference category.

The model presents a high goodness of fit ($\rho^2 = 0.636$), indicating that the current variables are relevant to explain travel mode choice. The significant negative parameters for the alternative specific constants (ASCs) of train, car and bus indicate that plane has the highest intrinsic preference. The negative parameters for long distance travel indicate that the relative preference for plane increases with increasing distance of the trip. Respondents from counties in group B had a lower preference for cars and buses compared to those living in counties in group A (i.e., counties closer to the national border with Denmark). The impact of age was investigated through a two-piece piecewise linear function to

Table 4.1
Estimation results of the ICLV model for current choices, structural model.

Variables	Fear of flying (FOF)		Pro-environmental personal norm (PEPN)	
	Est.	SE	Est.	SE
Age (below median)	0.002	(0.002)	−0.006***	(0.002)
Age (above median)	−0.006***	(0.003)	−0.002	(0.003)
Female	0.527***	(0.059)	0.276***	(0.054)
Education (university degree holder)	−0.073	(0.063)	0.251***	(0.068)
Income	−0.038***	(0.008)	−0.020**	(0.008)

*** $p<0.01$.
** $p < 0.05$.
* $p < 0.1$.

capture non-linear effects. This means that the slope of the continuous impact of age changes above the median level. There was no age effect for respondents below the median age, while age was a determinant variable for older respondents. Above the median age, preference for cars and buses were found to increase with age. There was a gender effect through higher PEPN and FOF. Women's preferences for train and car were found to be lower than men's, but compensated by a higher PEPN and FOF, which on average offsetted this effect (Table 4.2). University degree holders had a higher preference for trains, while increasing income was associated with lower preference for trains and buses. Travel companionship had a strong impact, with couples showing a lower preference for trains and a higher preference for cars, while families had a strong preference for cars, probably due to economies of scale reducing the travel cost per person. Respondents from the three largest cities in Sweden had a higher preference for cars, while those living more than one hour away from the closest airport had a higher preference for buses. FOF increased the probability of choosing train or car, while higher PEPN was associated with a higher preference for trains.

3.2. Stated preference experiment results

To investigate the potential of night trains replacing flights in the future, we conducted the stated preference (SP) experiment to current plane users for holidays to Europe. The estimates of the models are shown in Table 5, while the economic interpretations of the results concerning willingness to shift from flights to night trains and price elasticities are reported in Subsection 3.3. The results of three models are reported in Table 5. The mixed multinomial logit (MMNL) model (1) includes the attributes of the SP experiment and an error component capturing the heterogeneity in preferences. Socio-demographic variables were added in the MMNL (2), while the integrated choice and latent variable (ICLV) model (3) also included the psychological variables.

The ρ^2 indicates a slightly better fit for the ICLV model. We controlled for the alternative specific constant of train (ASC_{train}), which indicates a lower baseline preference compared to plane; and for differences in scales (μ_{LD} and μ_B) and preferences (ASC_{ld} and ASC_B) for the sub-experiments of long distances and respondents in group B. The significant parameter for the error component (σ_{train}) indicates that there is heterogeneity in preferences. Lower values of σ_{train} in Models 2 and 3 indicate that part of the heterogeneity is explained by socio-demographic and psychological characteristics.

Regarding the attributes, as expected, a higher comfort level significantly increased the preference for night trains. Direct connections were preferred over solutions with one or more changes, with the marginal disutility of the number of changes decreasing less than proportionally. Thus, the first change seems to cause the highest perceived inconvenience. As expected, increases in travel times and travel costs had a negative effect on the utility of the modes of transport. The sensitivity of travel time was different depending on the mode of transport, with travel time perceived more negatively while travelling by plane. The result is in line with that of the Swedish Transport Administration (2020). Socio-demographic characteristics, place of residence, travel habits and psychological factors were associated with significant differences in preferences for night trains. Higher education, living more than an hour away from the airport, a previous positive experience of night trains, and expectations of longer sleeping time were positively associated with a preference for night trains. FOF and PEPN had a positive impact on preference for night trains. The effect of travel companionship is captured in the ICLV model, in which families' preferences for night train is significantly lower than single travelers. We did not find any significant gender nor income effects there. Estimates of the shares of airline passengers who could consider switching to night trains, and price elasticities depending on different innovations, are

Table 4.2
Estimation results of the ICLV model for current choices, choice model (plain is the reference category).

Variables	Train		Car		Bus	
	Est.	(SE)	Est.	(SE)	Est.	(SE)
Choice model						
Alternative specific constant (ref = plane)	−1.441***	(0.396)	−2.496***	(0.428)	−2.425***	(0.611)
Long distance (ref = medium distance)	−0.515***	(0.155)	−0.526***	(0.177)	−0.664***	(0.201)
Origin B (ref = origin A)	−0.153	(0.198)	−0.333*	(0.187)	−0.940***	(0.246)
Age (below median)	−0.010	(0.007)	−0.003	(0.007)	−0.013	(0.017)
Age (above median)	−0.008	(0.012)	0.029***	(0.011)	0.079***	(0.014)
Female	−0.355*	(0.199)	−0.386*	(0.213)	0.049	(0.281)
Education (university degree holder)	0.649***	(0.199)	−0.133	(0.200)	0.386	(0.279)
Income	−0.102**	(0.040)	−0.049	(0.037)	−0.201***	(0.062)
Travel companionship (couple vs solo)	−0.675***	(0.230)	0.492*	(0.278)	−0.283	(0.302)
Travel companionship (family vs solo)	−0.304	(0.228)	1.200***	(0.279)	−0.369	(0.381)
Municipality (STO, GTB, MAL)	0.038	(0.254)	0.790***	(0.203)	0.509	(0.323)
Airport distance (more than one hour)	0.251	(0.183)	0.150	(0.170)	0.442*	(0.249)
Fear of flying (FOF)	0.308***	(0.104)	0.203*	(0.105)	0.079	(0.147)
Pro-environmental personal norm (PEPN)	0.937***	(0.164)	−0.045	(0.114)	0.157	(0.174)
Model statistics						
Number of individuals	1691					
Number of observations	3382					
Number of draws	500					
Model fit (ρ^2)	0.636					

*** $p<0.01$.
** $p < 0.05$.
* $p < 0.1$.

Table 5
Estimation results SP experiment, choice model.

Variables	MMNL (1)		MMNL (2)		ICLV (3)	
	Est.	(SE)	Est.	(SE)	Est.	(SE)
Choice model						
ASC_{train} (ref = plane)	−0.696	(0.651)	−4.721***	(0.897)	−3.827***	(0.893)
ASC_{ld}	−0.201	(0.210)	−0.205	(0.208)	−0.17	(0.211)
ASC_{B}	0.617**	(0.274)	0.474*	(0.268)	0.287	(0.277)
μ_{ld}	−0.219***	(0.069)	−0.21***	(0.070)	−0.196***	(0.071)
μ_{B}	0.174*	(0.104)	0.175*	(0.105)	0.129	(0.099)
σ_{train}	3.276***	(0.295)	2.986***	(0.280)	2.682***	(0.290)
Comfort level	1.451***	(0.147)	1.443***	(0.149)	1.441***	(0.142)
One change (ref = direct train)	−1.699***	(0.233)	−1.694***	(0.231)	−1.623***	(0.224)
Two changes (ref = direct train)	−2.459***	(0.281)	−2.449***	(0.279)	−2.371***	(0.272)
Travel time (night train)	−0.262***	(0.037)	−0.258***	(0.038)	−0.264***	(0.037)
Travel time (day train)	−0.229***	(0.040)	−0.227***	(0.040)	−0.229***	(0.039)
Travel time (plane)	−0.299**	(0.117)	−0.292**	(0.117)	−0.291**	(0.118)
Travel cost	−0.002***	(<0.001)	−0.001***	(<0.001)	−0.001***	(<0.001)
Age (below median)			−0.002	(0.008)	−0.005	(0.008)
Age (above median)			0.030**	(0.013)	0.026	(0.016)
Female			0.300	(0.212)	−0.341	(0.235)
Education (university degree holder)			0.538**	(0.236)	0.491*	(0.252)
Income			0.029	(0.039)	0.063	(0.041)
Travel companionship (couple vs solo)			−0.284	(0.259)	−0.339	(0.248)
Travel companionship (family vs solo)			−0.356	(0.281)	−0.673**	(0.284)
Municipality (STO, GTB, MAL)			0.332	(0.309)	0.300	(0.386)
Airport distance (more than one hour)			0.482**	(0.208)	0.417*	(0.221)
Previous positive experience			1.331***	(0.259)	1.278***	(0.279)
Previous negative experience			0.101	(0.272)	0.169	(0.345)
Expected sleeping time			0.517***	(0.079)	0.454***	(0.075)
Fear of flying					0.355***	(0.132)
Pro-environmental personal norm					1.204***	(0.144)
Model statistics						
Number of individuals	1571		1571		1571	
Number of observations	11,440		11,440		11,440	
Number of draws	500		500		500	
BIC	6403.97		6344.23		31,908.34	
Model fit (ρ^2)	0.604		0.615		0.616	

*** $p<0.01$.
** $p < 0.05$.
* $p < 0.1$.

reported in subsection 3.3.

3.3. Percentage who could switch to night trains and price elasticity

With the results of the first MMNL model, we estimated the market share of night trains for different scenarios including proposed innovations. We used the MMNL to obtain a generic overview of the population, but we did not consider specific socio-demographic characteristics. Given the representativeness of the sample, results can be extrapolated to the Swedish population. The scenarios consider the average costs in the experiment. In the easy booking (EB) scenario, we estimated how many current airline passengers would travel by night train if booking were as easy as expressing their preference in the SP experiment. This preference-behavior gap may be interpreted as the cost of the booking inconvenience. Starting from the EB scenario, we additively measured the impact of introducing new comfortable trains (NCT), a reduction in travel time due to the FBFL (FBFL), HS day-train connections from the rest of Sweden to Malmö (HS), and direct connections (DT) instead of having train changes. The percentages of airline passengers willing to switch to night trains in these scenarios are shown in Table 6.

For medium-distance destinations, easy booking would influence up to 6% of current airline passengers to shift to night trains, while the introduction of all the innovations would influence up to 30.3%, with a massive effect provided by direct trains. Air passengers are more loyal to air travel for long-distance destinations, where easy booking would influence up to 1.5% of current airline passengers, and the introduction of all the innovations would influence up to 9.7%.

Additional changes in travel demand might be stimulated through changes in travel costs. Examples of price strategies to stimulate night train demand are discounted train tickets and increasing the price of flight tickets with a flight tax.[4] The effects of changes in travel cost on night train demand, calculated through the direct and cross price elasticities, are shown in Table 7.

The direct price elasticity (DPE) of the night train was higher than the cross price elasticity (CPE) of night train demand in response to a change in flight cost. The estimated CPE effect on train demand of altering flight cost is similar to that found in a recent article applying a meta-analysis to evidence from 97 studies conducted in 19 countries (0.28) (Wardman, Toner, Fearnley, Flügel, & Killi, 2018). The DPE of trains, when higher than one, reflects an elastic demand, confirming the results of other studies conducted in the US (−1.06)(Gama, 2017), China (from −1.04 to −1.09 depending on the season) (Zeng, Ran, Zhang, & Yang, 2021), and the UK (from −1.02 to −1.47)(Wardman, 2014). The weaker effect of CPE from plane to night train comes as no surprise given air travel's dominant position in the long-distance travel market and the relative niche of trains. For dominant alternatives, CPE is generally low (Wardman et al., 2018) and the DPE tends to be higher for niche markets (Neiman & Vavra, 2019). A higher DPE compared to CPE indicates that, to increase night train demand, discounted prices for night trains would

[4] By flight tax we mean here a general flight tax that might be a combination of a passenger tax and a carbon tax.

Table 6
Percentage of airplane travelers switching to night train depending on innovation.

Scenarios	Distance	
	Medium	Long
EB		
Malmö	6.0%	1.5%
Gothenburg	2.7%	0.7%
Stockholm	2.3%	0.6%
EB + NCT		
Malmö	12.9%	3.5%
Gothenburg	6.0%	1.5%
Stockholm	5.2%	1.3%
EB + NCT + FBFL		
Malmö	16.5%	4.6%
Gothenburg	7.8%	2.0%
Stockholm	6.8%	1.8%
EB + NCT + FBFL + HS		
Malmö	16.5%	4.6%
Gothenburg	10.1%	2.7%
Stockholm	8.8%	2.3%
EB + NCT + FBFL + DT		
Malmö	30.3%	9.7%
Gothenburg	22.8%	6.8%
Stockholm	20.4%	5.9%

Note: EB = Easy booking, NCT = New comfortable trains, FBFL = Fehmarn Belt Fixed Link, HS=High speed trains for daily connections, DT = Direct train.

Table 7
Direct and cross price elasticities of night train demand.

Scenarios	Medium distance		Long distance	
	DPE	CPE	DPE	CPE
EB				
Malmö	−1.69	0.11	−2.22	0.03
Gothenburg	−2.19	0.05	−2.68	0.01
Stockholm	−2.20	0.04	−2.68	0.01
EB + NCT				
Malmö	−1.57	0.23	−2.17	0.06
Gothenburg	−2.12	0.11	−2.66	0.03
Stockholm	−2.13	0.09	−2.66	0.02
EB + NCT + FBFL				
Malmö	−1.50	0.30	−2.15	0.08
Gothenburg	−2.08	0.14	−2.65	0.04
Stockholm	−2.10	0.12	−2.65	0.03
EB + NCT + FBFL + HS				
Malmö	−1.50	0.30	−2.15	0.08
Gothenburg	−2.02	0.18	−2.63	0.05
Stockholm	−2.05	0.16	−2.64	0.04
EB + NCT + FBFL + DT				
Malmö	−1.25	0.55	−2.03	0.17
Gothenburg	−1.74	0.41	−2.52	0.12
Stockholm	−1.79	0.37	−2.54	0.11

Note: EB = Easy booking, NCT = New comfortable trains, FBFL = Fehmarn Belt Fixed Link, HS=High speed trains for daily connections, DT = Direct train, DPE = direct price elasticity, CPE = cross price elasticity.

be more effective than increasing the price of the flight ticket. While there is evidence in the literature that increasing the passenger tax is an effective tool to reduce travel demand by plane (Markham, Young, Reis, & Higham, 2018; Tol, 2007), our results seem to indicate that a higher flight tax would have a limited impact on night train demand. A combined effect of increasing a flight tax and providing discounted fares for night trains could have a much stronger effect compared to applying only an increase in flight tax. Therefore, if properly manipulated, an air-rail integrated flight tax (in line with existing bonus-malus taxes on cars depending on their CO_2 emissions) could be an effective tool for traffic level adjustments, as theoretically shown by Jiang (2021). The results show that when more innovations for night trains are involved, a higher percentage of airline passengers are willing to switch to night trains (Table 6), and direct price elasticity to stimulate night train demand becomes weaker and cross price elasticity stronger (Table 7). This seems to indicate that as long as a few innovations are introduced, discounted tickets for night trains might be more effective than a flight tax, the effects of which are strengthened when night trains become a more appealing alternative as a result of innovations.

4. Discussion

Currently, technological, economic and operational limitations contribute to making international night train trips a niche rather than broad market (Lena Donat et al., 2021). If night trains are to contribute to reducing GHG emissions from tourism, government intervention is needed to increase their appeal relative to air travel. In this paper, we aimed to understand the potential of night trains as a viable alternative to flights by exploring travelers' preferences, and by estimating the potential impact of some night train innovations and measures. We identified the socio-demographic characteristics and the interventions needed to make night trains more appealing. Our results indicate that lower travel time and travel cost and fewer changes/transfers increase the appeal of night trains. We found mode-specific travel time sensitivity, indicating that the same additional amount of travel time would have stronger negative impact on the flight alternative. Results show that through a reduction of travel time, altered price relations with effective pricing policies and an increase in comfort level of night trains, a significant number of airline passengers might shift to night trains. However, considering the seasonality of tourism and the additional inbound tourism demand, high pressure on the railway system and bottlenecks are likely. Further research is needed to investigate if the current infrastructure can satisfy this future demand or if investments are needed to avoid delays due to such bottlenecks.

With respect to the characteristics of night train travelers, we investigated the profiles of current train users as well as of those with a higher probability of switching from plane to night train in response to innovations. Education level is one of the most important predictors for current and future night train users. This result is in line with other studies identifying education as one of the most relevant characteristics for long-distance travel choices (Reichert & Holz-Rau, 2015) and higher education associated with pro-environmental behavior, all else being equal (Sovacool et al., 2018). Another important socio-demographic variable is the respondent's age, with older travelers being more attracted by the night train alternative. With respect to travel habits and psychological determinants, our results show that past use experiences and a pro-environmental norm have significant impacts on long-distance travel preferences. Some interventions are needed to facilitate the shift from planes to night trains, such as making it easier to book night trains, and ensuring the same rights for night train travelers as airline passengers in terms of arrival guarantees (Lena Donat et al., 2021). The impact of FOF indicates that across current airline passengers, there is a latent segment of travelers with a certain degree of concern about flying who are interested in night trains as an alternative solution. This is noteworthy for service operators given that travelers with high FOF seem to be less price sensitive and less intervention might be needed to shift them to night trains (Fleischer et al., 2012).

In subsections 4.1 and 4.2, we provide recommendations to public institutions and private companies wanting to facilitate the transition from flights to night trains.

4.1. Policy implications

The relative attractiveness of flights compared to night trains is, in absence of interventions, likely to remain in the future. However, several government policies could and should intervene to reduce the gap between the two, given that voluntary behavior change is often insufficient (Cohen et al., 2016; Higham et al., 2016). We identify four main aspects that can substantially influence travelers' choices: 1) travel time, 2) travel cost, 3) comfort level, and 4) easy booking.

In terms of travel time, it is important to note that the travel time is perceived differently depending on the mode of transport. Travel time sensitivity is lower for trains than flights. This means that the disutility of an hour of travel time by train is lower compared to that by plane. This is explained by the possibility of performing other activities and by a lower idle time compared to plane travel. However, a long travel time is still perceived as negative in travel mode choice, and therefore interventions to reduce travel time by trains will be effective to increase their appeal. Our estimates indicate that investments in train infrastructure will likely move market share from flights to night trains. For example, the FBFL is estimated to shift up to 3.7% of airline passengers to trains, and further investments in HS railways for connecting Swedish day trains might contribute an additional 2.3%.

Regarding travel costs, a range of policy interventions could be used to increase the relative appeal of night trains compared to flights. A flight tax is expected to reduce the number of airline passengers, confirming the results of previous studies showing its potential (Seetaram, Song, & Page, 2014; Tol, 2007). However, DPE for flights seems to be quite inelastic (Seetaram et al., 2014). Therefore, to provide a substantial shift to night trains, a very high flight tax would be needed to trigger a consistent demand change at the present time. Such an intervention could be more effective if integrated with policies aimed at making night trains more appealing and if pro-environmental attitudes become more widespread.

The comfort level represents a relevant attribute for travelling by night train, confirming the results of (Heufke Kantelaar et al., 2022). An increase in comfort level is estimated to drive the market share up by 6.9%. Granted that rail operators should be responsible for renewing their rolling stock, if their financial situations impose constraints, the government could consider subsidies. In fact, the low profitability of night train trips (Bird et al., 2017; von Arx et al., 2018) could be a barrier for this means of increasing the appeal of night trains. Government intervention is needed and could be seen as an environmental investment for governments.

Enacting easy booking can also be an effective tool. The EU Regulation on rail passengers' rights and obligations (EUR-LEX, 2021) is a move in the right direction, but its entry into force in 2030 is far away and this will likely delay the increase in international train traffic.

To summarize, in order to make night trains more appealing, the government could: 1) invest in infrastructure that can reduce travel time for night trains; 2) provide incentives for night train operators to invest in comfortable night trains; 3) consider a range of governance models to overcome the low profitability of running night trains for companies, such as state ownership of night trains and outsourcing their operation and management through public procurement; 4) push national rail operators and EU regulations that enable efficient booking systems for international travel and arrival rights for travelers.

4.2. Implications for rail operators' and destination management organizations

Results of this study might be useful to both companies offering night train services, and destination management organizations (DMOs). Three main implications arise from our results for rail operators' managements regarding investments, operations, and marketing campaigns.

It is worth noting that comfort level is one of the most important factors influencing travelers' preferences. Therefore, investments in new rolling stock might attract new users. Additionally, older carriages can still be used to offer beds at a lower price to attract more cost-sensitive travelers.

At a logistical level, night trains offering direct connections seems to be much more appealing than those including train changes. It is important to gather data which can be used by international rail operators to identify origin-destination pairs with the highest demand and provide direct connections. In this way, a split and recombination of night train carriages might be organized more efficiently during the night, minimizing the number of locomotives required to connect to several destinations. Establishing a few very attractive direct destinations could help demonstrate the positive aspects of night trains, enabling further growth from niche to more mainstream.

Marketing strategies in the form of offering vouchers and targeted marketing communications could be effective measures. The potential demand for night trains from current airline passengers seems to be quite elastic at discounted prices, e.g., price campaigns with targeted banners on webpages for flight bookings could attract new users. It is interesting to note that respondents with a negative experience do not seem to have a lower preference for night trains compared to those having no experience, while a positive experience increases the likelihood of choosing night trains in the future. Offering deals and discounted tickets is a promising promotional idea to attract new users. For example, last-minute/standby free vouchers could be offered to users when there are free places left. A positive experience for users who take advantage of this promotion will likely increase future use, while a negative one would not decrease it. This tool could be effective, as in the transportation setting it seems that a previous experience triggers the development of a positive attitude, which eventually leads to loyal behavior (Kroesen, Handy, & Chorus, 2017). The positive impacts of PEPN and FOF indicate that there is room for leveraging psychological aspects to attract airline passengers who are sensitive to environmental issues and those who have a fear of flying.

Finally, an active cooperation between different stakeholders, such as railway operators, local governments and DMOs seems to be important for both an effective transport development (Taczanowski, 2015) and to achieve a successful sustainable tourism (Kunjuraman & Hussin, 2017). Partnerships between DMOs and railway companies can be beneficial in creating integrated, coherent, and effective touristic products (Taczanowski, 2015; Thao, von Arx, & Frölicher, 2020). Similar partnerships are already implemented with day trains for example in Switzerland (Thao et al., 2020), and at Italian destinations like the National park of Cinque Terre (TTG, 2014), the regions Friuli Venezia Giulia, in the form of free train tickets (TTG, 2022), and Tuscany, through discounted accommodation prices (Qualitytravel, 2020). Besides, there is an untapped potential for the collaboration between DMOs and railway operators offering night train services. Therefore, from a DMO's perspective, the creation of specific packages for holiday experiences jointly proposed by rail operators and accommodation sites might further increase the attractiveness of both the destination and night train services, fostering the development of an effective and sustainable transport system.

4.3. Limitations and future research

The study presents some limitations that will be addressed in future research. Firstly, the study has been conducted in a single country and for outbound tourism only. New research is needed to investigate outbound and inbound tourism in other countries, especially from and to those destinations where connection by train would require >8 h, or where the deployment of HS trains would be problematic. Secondly, already existing modes of transport, such as cars and buses, or new transportation services that might be introduced into the market when new technologies are fully developed, such as autonomous vehicles or travel pods in low pressure tubes (e.g., hyperloop), could be considered as greener alternatives to flight. New research is needed to investigate travelers' preferences for those modes of transport. Thirdly, the disutility of travel time is influenced by the possibility of performing other activities, above all sleeping. Investigating the value of travel time while sleeping might be of interest for developing an efficient pricing strategy and will be the subject of a future study. Fourth, this research was conducted during the COVID-19 pandemic, which might have biased the results. In fact, in the short term, travel restrictions, quarantine policies, and higher levels of travel anxiety have completely changed travel behavior and had a huge impact in the form of a reduction in international tourism (Bratić et al., 2021; OECD, 2020). One relevant consequence of this is a higher preference among travelers for shorter distance and domestic trips, and the associated uncertainty surrounding the recovery of long-distance travel in the next few years. A lack of investigation, especially about the impact of COVID-19 on travel behavior, is an additional limitation, for which more research is needed in less exceptional times to verify the consistency of the results. Finally, there are of course intrinsic survey-related limitations, such as: (i) self-selection bias, (ii) the lack of accessibility of certain target groups, (iii) the lack of opportunity for queries from participants, (iv) lower traceability and control of the survey process, the identity and contextual situation of the participant, (v) technology resistance among participants, (vi) concerns about anonymity and data protection and the lack of non-verbal recordings, (vii) the limitation in terms of representativeness, given that even the representativeness of certain socio-demographic characteristics is not a sufficient criterion to ensure representativeness of preferences.

5. Conclusions

In this paper, we investigated the potential of a change in mode of transport from flights to night trains to achieve reductions in GHG emissions from long-distance travel. We shed light on travelers' preferences about changes in night train offers. The introduction of new comfortable trains, shorter travel times and relatively lower prices compared to flights would positively impact the demand for night train travel to an extent that requires international collaboration to satisfy the demand from the market. We list some practical implications for policymakers and rail operators to stimulate a substantial shift from planes to night trains.

CRediT authorship contribution statement

Riccardo Curtale: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Jörgen Larsson:** Conceptualization, Funding acquisition, Project administration, Supervision, Writing – review & editing. **Jonas Nässén:** Conceptualization, Funding acquisition, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare no conflict of interests.

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Appendix A

The probability of observing the choices of every respondent n is given by Eq. (A.1)

$$P_n(C) = \prod_t \frac{exp(\boldsymbol{\mu} V_{njt})}{\sum_{m \in J} exp(\boldsymbol{\mu} V_{nmt})} \tag{A.1}$$

where j indicates the chosen alternative, m denotes a generic alternative over the set of J = 2 alternatives. The inclusion of psychological factors requires two additional components: the measurement part and the structural part of the latent variables. The latent variables are measured through the items' scores, as given by Eq. (A.2)

$$P_n(I_{rk}) = z_{rk} LV_{kn} + \sigma_{rk} \xi_{rkn} \tag{A.2}$$

where $r = (1, \ldots, R_k)$ is the generic item of the latent variable k = (FOF, PEPN). For FOF there are 3 items ($R_{FOF} = 3$) while for PEPN there are 4 ($R_{PEPN} = 4$), as shown in Table 2 and Fig. 2. LV_{kn} is the generic estimated latent variable; z_{rk} is the factor loading of the latent variable k on the item r; ξ_{rkn} is a randomly generated draw from a standard normal distribution and σ_{rk} is the variance. The structural part, indicating the relationship between latent variables and socio-demographic characteristics, is given in Eq. (A.3)

$$LV_{kn} = \gamma_k X_n + \psi_{kn} \tag{A.3}$$

where X_n is the vector of socio-demographic variables of respondent n, γ_k is the vector of parameters capturing the impact of socio-demographics on the latent variable and ψ_{kn} is the standard normally distributed error term. The probability of observing respondents' choices is given by Eq. (9)

$$P_n = \int_{\xi_{PN}} \int_{\xi_{FOF}} \int_{\xi} P_n(C|\xi, \xi_{FOF}, \xi_{PN}) P_n(I|\xi_{FOF}) P_n(I|\xi_{PN}) f(\xi) f(\xi_{FOF}) f(\xi_{PN}) d\xi d\xi_{FOF} d\xi_{PN} \tag{9}$$

where $f(\xi)$, $f(\xi_{FOF})$ and $f(\xi_{PN})$ are the density function of the error component and the errors of the latent variables. The final log-likelihood (LL) is given by Eq. (A.4).

$$LL = \sum_n log(P_n) \tag{A.4}$$

Due to the computational complexity of integral calculations, the method of maximum simulated likelihood (MSL) estimations was applied (Train, 2009; Walker, 2001), using a Monte Carlo simulation with 500 Modified Latin Hypercube Sampling (MLHS) draws to simulate the normal distribution of the random variables.

Table A.1
Mean, standard deviation, skewness and kurtosis.

Variables	Average	Standard deviation	Skewness	Kurtosis
FOF1	2.14	1.33	0.80	2.30
FOF2	1.78	1.08	1.33	3.88
FOF3	2.58	1.33	0.27	1.79
PEPN1	3.69	0.91	−0.6	3.45
PEPN2	4.13	0.80	−0.9	4.20
PEPN3	3.62	0.93	−0.5	3.14
PEPN4	4.02	0.83	−0.8	3.98

Table A.2
Measurement model of the ICLV.

Variables	Zeta		Sigma		Cronbach's alpha
	Est.	SE	Est.	SE	
FOF1	1.174***	(0.028)	0.615***	(0.025)	0.89
FOF2	0.903***	(0.028)	0.631***	(0.023)	
FOF3	1.078***	(0.024)	0.771***	(0.021)	
PEPN1	0.800***	(0.025)	0.520***	(0.019)	0.88
PEPN2	0.671***	(0.025)	0.497***	(0.017)	
PEPN3	0.807***	(0.026)	0.538***	(0.017)	
PEPN4	0.662***	(0.026)	0.546***	(0.017)	

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.tmp.2023.101115.

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