



Factors influencing the perceived value of travel time in European urban areas

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Abstract

This research aims at expanding the scope of travel satisfaction by incorporating subjective elements in the evaluation of worthwhileness of travel time proposed by the H2020 MoTiV project, using a European-wide mobility dataset collected in 2019. Trip characteristics, mood, socio-demographic characteristics, experience factors, travel activities and weather were analysed to explore their influence on travellers' perception of worthwhileness of travel time. The analysis was performed separately for five different transport mode categories using Structural Equation Models. The empirical analysis of this research indicates the high significance of enjoyment in terms of making a trip worthwhile for all transport modes. The results also revealed mode-specific experience factors that play an important role in shaping travel experience which could be addressed to improve the quality of travel time. It is expected that these results can support a shift towards a more human-centric approach in urban mobility plans as well as pave the way for more inclusive transport policies.

Keywords Value of travel time · Worthwhileness of travel time · Perceived travel experience · Travel satisfaction · Structural equation modelling

Introduction

One of the major challenges in transport and mobility planning is figuring out the complexity of the variables involved in people's travel choices. Usually, individuals make decisions to maximise their utility, and researchers attempt to identify the key factors influencing people's behaviour. Regarding the travel mode choice and individuals' satisfaction with travel, the perceived value of mobility as a part of the subjective theory of value plays a significant role in the traveller's decision, which does not always rely on the trip purpose

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at destination and travel cost or individuals' time budget. As such, travellers' perception of travel time value can impact the level of satisfaction, which varies across different transport modes based on the perceived quality of travel time in different situations, reflecting individuals' subjective well-being (Mogilner and Norton 2016). Even though scholars have discussed the perceived travel experience impact in positive and negative valuations of travel time, these factors have not been applied in the Value of Travel Time (VTT) studies in regard to users' satisfaction with travel per se.

In the last decade, researchers were also extensively investigating the links between specific forms of travel satisfaction and subjective well-being employing cognitive and affective evaluation measures (Ettema et al. 2011; De Vos et al. 2013). The wealth of evidence of literature review on travel satisfaction makes it possible to state that most researchers limited their studies to commuters' travel satisfaction by comparing the use of private car and public transport or active modes with respect to affective evaluation or cognitive satisfaction assessments, and with a limited target group (e.g., university students or employees) through stated preference surveys. These studies mostly focused on travel experience by asking travellers to assess specific attributes of regular work or leisure trips (Eriksson et al. 2013; Carreira et al. 2014; De Vos et al. 2019; De Vos 2019).

However, travellers' satisfaction can be influenced by different events experienced while on the move. For instance, previous studies show a discrepancy between public transport users' travel experience and their preferences, and attitudes towards public transport modes most likely impact on their evaluation of quality of public transport service and level of satisfaction respectively (Ettema et al. 2011; Bergstad et al. 2011). Gatersleben and Uzzell (2007) studied the affective experience of daily commuters by comparing perceptions of private car users, public transport users, cyclists, and walkers, and found out that private car and public transport modes are perceived as more stressful means of transport due to the affective factors related to the transport infrastructure and quality of service. It has also been argued that cognitive evaluation of travel satisfaction is primarily related to cost, reliability of travel time and travel experience with different transport modes. While independent of the chosen transport mode, worthwhileness of travel may also be influenced by the affective evaluation of the experienced utility of a trip.

Despite a substantial share of research on travel satisfaction, most studies have focused on general impacts of subjective well-being either by rating travel satisfaction (Abou-Zeid 2009) or by measuring the subjective evaluation of transport performance (Gao et al. 2017). Yet, little attention has been paid in exploring the influence of the perceived travel experience on users' level of satisfaction with travel time in terms of worthwhileness of travel time (WTT), considered as a subjective, qualitative judgment of the value of travel time (Cornet et al. 2021). In this study, WTT across various transport modes available in European urban areas is explored.

To address the above-mentioned shortcomings, the present study examines the travellers' genuine experience while on the move captured through smartphone data collection. For doing so, firstly, this paper expands the scope of travel satisfaction considering travellers' perception of WTT and perceived mood. In this research, the perceived mood is defined as the overall feeling of the door-to-door trip (i.e. feeling of traveller from the trip at its end) while WTT represents subjective perception of travel time for a specific trip leg. Secondly, the research will explore how individuals' travel experience is associated with the quality of transport infrastructure and services for short trips (i.e., less than 30 km) together with trip and socio-demographic characteristics of travellers as well as external factors such as weather conditions. It will also be investigated how these factors impact users' perception of WTT and mood when travelling

on different transport modes. In this study, travel satisfaction reflects the users' travel experience in terms of the perceived WTT for a particular trip in different transport modes as reported by users of the Woorti app in 8 European countries.

To summarise, the current study aims at addressing the following research questions:

1. Does the perceived mood derived from travel experience affect travellers' evaluation of WTT?
2. How the perceived WTT and mood are influenced by the type of activities on the move, experience factors associated with quality of transport infrastructure and provision of services, and the three associated values of WTT (proposed worthwhileness elements)?
3. How do trip attributes impact individuals' evaluation of WTT and mood across different transport modes?
4. Which socio-demographic characteristics have significant influence on travellers' experienced mood and perceived WTT?
5. How do different weather conditions impact travellers' level of satisfaction based on the perceived WTT and experienced mood?

The above-mentioned research questions are explored in the following 5 sections of the paper. "[Conceptual Model](#)" section presents an overview of state-of-the-art literature related to travel satisfaction and conceptual model. "[Methodology](#)" section provides the applied research methodology, the data collection method, sample description and data modelling procedure. "[Results](#)" section provides statistical descriptions of the of perceived WTT for empirical investigation and model development. Hereafter, the results of the model estimation within the scope of the structural equations modelling analysis are demonstrated and discussed. Finally, "[Conclusions](#)" section summarises the outcomes of the research, its contribution, and potential implications for future studies.

Conceptual model

The role and importance of subjective well-being related to daily travel are well recognised in the literature and has been applied by scholars to identify significant determinants for measuring users' satisfaction with daily travel.

Figure 1 presents a holistic conceptual model that explores the importance of worthwhileness elements (productivity, enjoyment and fitness), trip characteristics, socio-demographic characteristics, experience factors, travel activities and weather conditions on the perceived WTT and mood of the traveller. In addition, the effect of mood on the perceived WTT is examined. This model's novelty lies in the determination of causal relationships in a simultaneous modelling system through the parallel linking of exogenous and endogenous variables to reveal which of the investigated elements have a significant impact on shaping WTT and travellers' mood. The conceptual model will be applied separately on five transport mode categories: private motorised—driver, private motorised—passenger, public transport, cycling and emerging micro-mobility and walking.

The sections that follow present all variables included in the model and a summary of the up-to-date research for each of them.

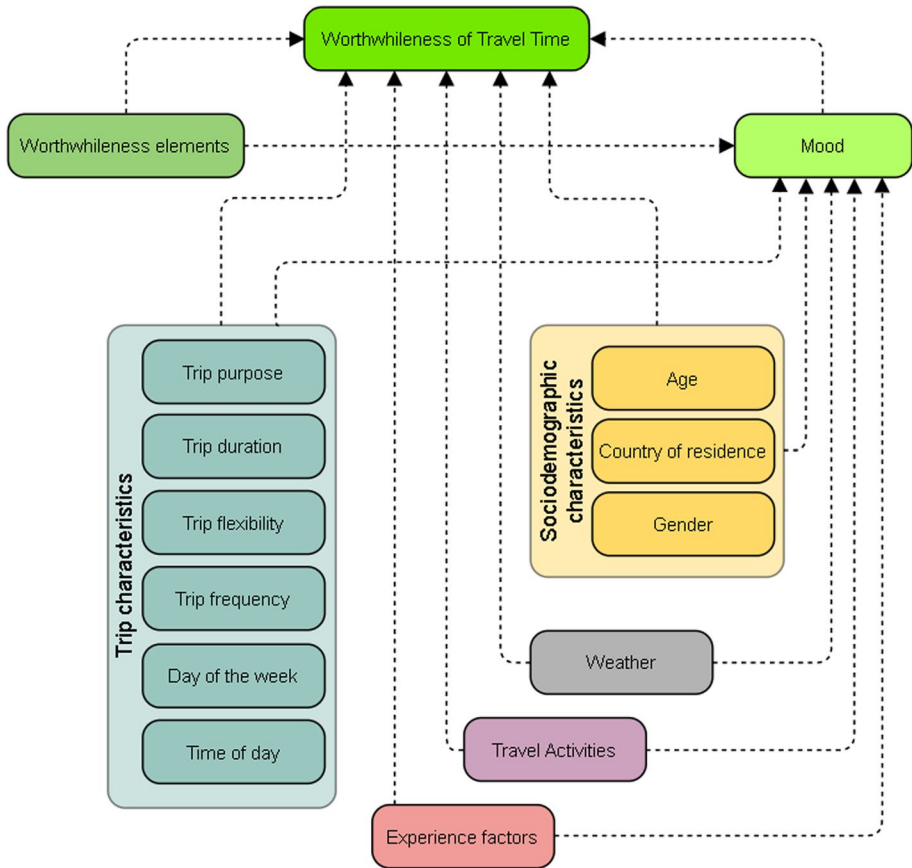


Fig. 1 Proposed conceptual model for testing WTT across 5 transport categories

Transport modes

A growing number of research papers on travel and subjective well-being have investigated the relation between individuals' travel satisfaction and transport modes (Lades et al. 2020; Chatterjee et al. 2020; De Vos et al. 2016; Handy and Thigpen 2019; Legrain et al. 2015; Mokhtarian et al. 2015; Friman et al. 2013; Ettema et al. 2011; Páez and Whalen 2010) and argued that different modes of transport have specific attributes that make them more or less satisfying for users.

For instance, Legrain et al. (2015) stated that walking and public transport negatively affect the levels of stress compared to driving in the American context, while Gatersleben and Uzzell (2007) found active modes to be less stressful compared to driving and public transport in the UK context. Findings from Ye and Titherige (2017) study are similar, showing that commuters who travel by bike or walk are more satisfied with their travel time than commuters travelling by car and train.

In the travel satisfaction context, there has not been yet a study focusing on the impact of travel modes on the perceived WTT. The conceptual model presented in Fig. 1

aims to reveal any significant impact of the different elements presented above to WTT and mood of the traveller across five different transport mode categories.

Worthwhileness of travel time (WTT) and worthwhileness elements

The concept of worthwhile use of travel time has been discussed in several VTT studies from two different perspectives. On one hand, there is a view that emphasises the importance of time savings in the valuation of travel time for business and non-business trips (Wardman and Lyons 2016). On the other hand, it is argued that travel time should be treated as a gift that can be enjoyed by travellers who turn their travel time into a fruitful event, gaining non-monetary value derived by their experience while travelling (Jain and Lyons 2008).

The perceived WTT experienced by a traveller across different travel modes can be measured according to three main types of value, which we refer to as worthwhileness elements: productivity, enjoyment, and fitness (Cornet et al. 2021; Basile et al. 2020). Productivity is related to the possibility of utilising time during travel to complete personal or work-related tasks. Enjoyment is related to how travellers can use their travel time for pleasure (listening to music, browsing the Internet, watching videos, etc.) or relaxing. Fitness is related to how much an individual appreciates the way they can exercise during travel.

Mood

The mood of a traveller certainly has an impact on the perceived VTT (Gao et al. 2017); depending on how happy or sad a traveller is when starting a trip, it may result in assigning different weights on the travel time value or the emotional effort required to perform the same trip over different days. Abou-Zeid (2009) also confirmed the effect of mood as a part of context effect on travel satisfaction rating.

In the present study, the mood was assessed by asking travellers to rate how they felt about the trip they performed. The mood was reflected as the happiness or sadness perceived by a traveller following the completion of a trip. It is acknowledged that the mood may have resulted in assigning different weights on the travel time value or the emotional effort required to perform the same trip over different days. However, in this research, the mood is assessed as the overall feeling that travellers had from their trip.

Travel activities

Traditional approaches to evaluation of VTT consider travel time as unproductive, segregating the value entailed in “activity time” from “travel time” (Kováčiková et al. 2017). As stated by Mokhtarian and Salomon (2011), travel should be considered as an activity itself. Therefore, the emerging VTT and subjective travel satisfaction evaluation should explore both the activities carried out by travellers on the move and travel as an activity itself.

Performing activities while travelling is considered a significant determinant contributing to a more positive assessment of WTT (Kouwenhoven and de Jong 2018; Banerjee and Kanafani 2008; Mokhtarian and Salomon 2011). Activities are typically divided into work-related and non-work-related or based on their benefit for the traveller (e.g., useful and pleasant) (Hagen et al. 2017). Travel activities can also be divided into activities that require equipment (active)

or not (passive) or based on the use of ICT (ICT related, non-ICT related) (Molin et al. 2020). The massive adoption and use of portable ICT devices have emphasised the impact of the type of activities on travel time perception. In addition to the significant effect on WTT (Connolly et al. 2012), ICT and the availability of Internet connection have provided an opportunity to carry out several activities and multitask during travel (Nathan et al. 2019).

Experience factors

The travel experience and the perceived quality of transport infrastructure and services have been studied most often in relation to the cognitive evaluation of public transport users in terms of comfort, safety, and reliability (Carreira et al. 2014; de Oña et al. 2013). The perceived travel experience is also influenced by different factors such as convenience, frequency, reliability, comfort, and the potential of gaining utility from spending time on other activities. The experience factors or journey conditions can enable the participation in activities while travelling, therefore, contributing to different levels of travel time utilisation. Given that a journey involves positive and negative experiences, travel time evaluations should account for both effects while making sure that the value of activities and travel conditions are not double-counted (ITF 2019). The importance travellers assign to experience factors can change depending on the transport mode, stage of the journey (on-board time vs transfers) and individual preferences (Hagen et al. 2017).

Trip characteristics

One of the fundamental factors influencing people's travel time perception is trip duration. Extended trip duration can cause changes in traveller's mood and negatively affect the perceived VTT due to increased levels of stress, fatigue, painfulness (in some transport modes) and sadness on long trips (Zhu and Fan 2018; Morris and Guerra 2015). The trip duration is closely associated with travel time reliability, defined as "the consistency of a trip's travel time" (Lyman and Bertini 2008). It means that the expected travel time should be equal to the actual travel time at the destination. Reliability of travel time is the most valued factor for passengers in public transport (Allen et al. 2018). People who experience a delay on their trip are less satisfied than others. Other travel characteristics such as trip flexibility, frequency and trip time also affect travel time perception and overall subjective well-being. In the case of trip frequency, if a traveller makes the same trip more times, the enjoyment decreases (Ettema et al. 2013).

Trip purpose is another significant factor potentially affecting the perceived experience of a journey. However, it is difficult to determine its direct impact, as it is closely related to other factors influencing travel time perception. Ettema et al. (2013) in their research confirmed that travellers who travel for recreation purposes present higher trip satisfaction levels compared to other trip purposes. At the same time, it is found out that the most fatiguing and less pleasant trips are those that have a work purpose. These trips also have a negative effect on travellers' mood (Mokhtarian et al. 2015).

Socio-demographic characteristics

Socio-demographic characteristics such as age, gender, country, or even educational level play a significant role in shaping travel choices (Singleton 2018; Lades et al. 2020) and

influence the individual perceived travel experience. Pronello and Camusso (2011) demonstrated that geographical location of individuals affects their travel behaviour. Age and gender have been extensively referenced in the travel behaviour literature and associated with differences in travel choices. However, there is little evidence on how different socio-demographic attributes interfere with the value travellers assign to travel time and their experience.

Weather

Another important element affecting the user's perception of travel time value is weather conditions. Weather can significantly influence the choice of transport mode, which is related to the travel experience and the subsequent user's perception of travel time. Previous research has shown that active transport modes' usage boosts when temperatures are higher without precipitation and wind. On the other hand, bad weather (increased precipitation, higher wind speed) increases usage of the private motorised mode of transport and public transport (Böcker et al. 2016; Creemers et al. 2015; Zhao et al. 2019). However, other research confirms that the influence of weather variability on the choice is mostly contextual and general assumption of the effect of weather may not apply to all transport modes (Zhao et al. 2019; Tao et al. 2018). With modern forecast techniques and technology, people have learned to adjust their habits according to the weather to fit their maximum convenience.

Methodology

Data collection

The data analysed in this paper were obtained within the MoTiV (Mobility and Time Value—Horizon 2020) project. The project's main objective was to investigate VTT from the perspective of an individual person, emphasising the end users' travel experience. In 2019, data collection campaigns were implemented in 8 European countries (Belgium, Finland, France, Italy, Norway, Portugal, Slovakia, and Spain). The purpose was to gather data related to everyday travel and a subjective assessment of travel time and its value by travellers. The data collection focused on people aged 16 and over. Each campaign manager in the data collection countries was commissioned to recruit at least 700 people, the composition of which considered the whole country's age and gender structure in line with the national census. The potential respondents were directly approached through the MoTiV social media channels, outreach events, popularising articles, off-line dissemination activities such as printed advertising and indirectly through the engaged stakeholders (Hudák and Cornet 2019).

Data were collected using Woorti mobile application developed within the project. Respondents were asked to use the application for at least seven consecutive days. The application automatically recorded data on users' trips and their individual parts (trip legs). It recorded data such as date, travel time, travel distance, speed, and transport mode for every transport leg in the trip. In addition, the application requested users to enter information about the trip purpose, overall evaluation of the trip (travellers' mood) and information related to trip legs such as: WTT (if the travel time was wasted or worthwhile), type of value derived from a trip leg (elements of worthwhileness;

productivity: paid work and personal task, enjoyment and fitness), activities performed while travelling (Cornet et al. 2019) and experience factors (factors influencing the quality of travel time). Users were also able to provide their socio-demographic information, such as age, gender, residence, education, marital status, occupation, years of residence and number of household persons (Lugano and Cornet 2018; Veiga and Bernardino 2019). The questions from the Woorti mobile application are shown in table S1 in a supplementary file (SF).

The worthwhileness evaluation of travel time was measured by a five-item scale (Pavot and Diener 1993; Ettema et al. 2011) referring to general quality and efficiency of travel time while on the move. However, for the research purpose and for having a clear vision of the level of satisfaction with travel, trip legs were modelled in the format of wasted travel time (rating from 1 to 3) and worthwhile travel time (rating of 4 and 5).

Such a division was determined based on the initial data analysis and response style identification. Only 10% of the responses were evaluated as 1 and 2, 25–30% as 3 and 60–70% as 4–5. Hence, we decided to merge the categories into two. By dividing the scale into two options, we wanted to make a strong distinction between whether someone considers their travel time wasted or worthwhile and focus only on that comparison and not degrees of difference in the comparison.

Sample description

The MoTiV campaign involved 3,330 users who performed 67,178 door-to-door trips with 120,713 legs. As the evaluation of WTT, factors influencing travel experience and activities during travel were reported by users for at least one trip leg in the trip, all trip legs, which did not contain a comprehensive assessment (worthwhileness, experience factors, activities, and mood) were removed. To eliminate the dependency of the observations, i.e., legs, in the trips that contain more evaluated legs, only legs with the longest duration were kept. The current study focused on short distance legs, which are performed solely in urban areas. Therefore, only the legs with starting and ending points in urban areas were extracted. These legs represent 69.5% of all legs. To explore difference of users' evaluation of WTT in European urban areas among various transport modes, only trip legs up to 30 kms long were selected, which are considered short-distance trips (Ramjerdi et al. 1997). These represent trip legs performed between two nearby cities or trips within a city.

After applying the defined filters, 8,463 trip legs were used for further analysis and modelling. As shown in Table 1, 3,826 trip legs were performed by females. Respondents aged between 30 and 49 years performed 5,111 trip legs. Regarding the country of residence, analysed trip legs were performed by residents of eight European countries, mainly from Slovakia, Portugal, and Belgium.

All trip legs were divided according to their transport mode into five transport categories. Two categories (private motorised passenger, private motorised driver) have been assigned to private motorised transport modes (cars, mopeds, motorcycles) which differ in whether the user travelled as a passenger or as a driver. Another category includes all legs performed by public transport modes (buses, trains, subways, and trams). The cycling and emerging micro-mobility category consists of legs in which users travelled by bike, e-bike, bike-sharing services, and micro-scooter. The last category is walking. The detailed structure of the sample is shown in Table S2 in SF.

Table 1 Socio-demographic characteristics of the trip legs ($N=8,463$)

Socio-demographic characteristics	<i>n</i>	%	Socio-demographic characteristics	<i>n</i>	%
<i>Gender</i>			<i>Country of residence</i>		
Female	3826	45.2	Belgium	1445	17.1
Male	4637	54.8	Finland	707	8.4
<i>Age</i>			France	184	2.2
16–19	264	3.1	Italy	242	2.9
20–24	995	11.8	Norway	1137	13.4
25–29	723	8.5	Portugal	1716	20.3
30–39	2741	32.4	Slovakia	1894	22.4
40–49	2370	28.0	Spain	1138	13.4
50+	1370	16.2			

Structural equation model

For revealing the influence of defined factors on mood and WTT, a structural equation model (SEM) was used. The SEM has been a popular data analysis method over the last 25 years in numerous areas of the social sciences research areas such as sociology, psychology, business, and economics, thanks to its flexibility for analysis of the complex causal relationship between a great number of exogenous and endogenous variables. A typical structural equation model with observed endogenous variables can be formulated as (Bollen 1989; Golob 2001).

$$\mathbf{y} = \mathbf{B}\mathbf{y} + \mathbf{\Gamma}\mathbf{x} + \boldsymbol{\zeta}, \quad (1)$$

where \mathbf{y} is a column vector of p endogenous variables, \mathbf{B} is the matrix ($p \times p$) of direct effects between pairs of p endogenous variables, \mathbf{x} is a column vector of q exogenous variables, $\mathbf{\Gamma}$ is the matrix of regression effects of the q exogenous variables, $\boldsymbol{\zeta}$ is a column vector of error terms (Bollen 1989). Path analysis is a special case of SEM, which has been applied in this study. Path analysis is restricted only to observed variables, assuming that all variables are measured without error (Golob 2001).

To investigate simultaneously the causal relation between traveller self-assessment of mood and perception of WTT as endogenous variables and endogenous as described earlier, five separate models were created using SEM for each transport category. The endogenous variables in this study are referring to WTT and mood. WTT is an ordinal variable where is worthwhile encoded by 1 and wasted encoded by 0. Similarly, mood is an ordinal variable that contains values from 1 to 5 (i.e., 5-point Likert scale), where 1 means lousy, and 5 means great. Among exogenous variables, the duration is also treated as an ordinal variable. Trip frequency, trip flexibility, working day, gender, age, and time of the day are categorical variables. The trip purpose, travel activities, experience factors, weather, and worthwhileness factors are encoded by several categorical binary variables as one trip can have multiple travel activities.

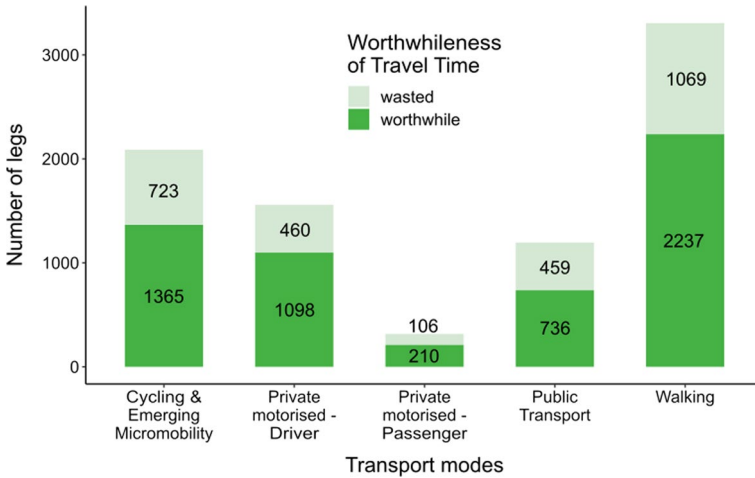


Fig. 2 WTT in trip legs based on transport mode category. The numbers inside the bars represent the number of legs

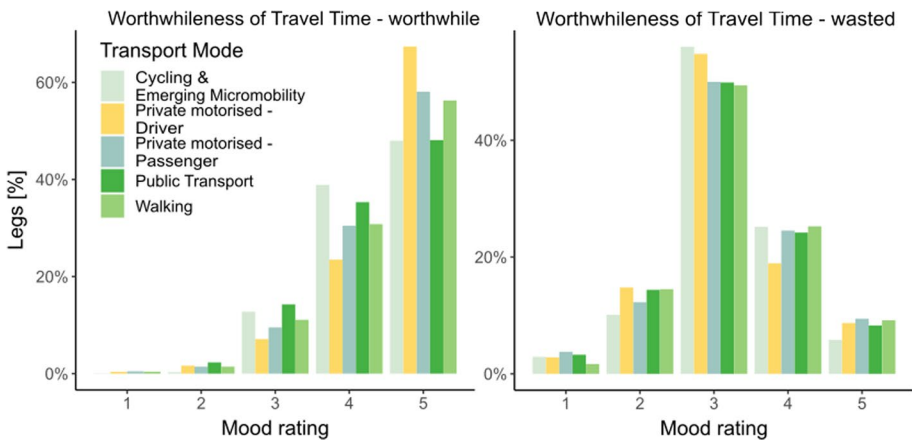


Fig. 3 Distribution of mood rating on worthwhile and wasted trip legs among transport mode categories

Results

Data analysis of the factors influencing the perceived WTT

Based on the conceptual model, our research addresses satisfaction of travel time in terms of perceived worthwhileness. As can be seen (Fig. 2), in every transport mode category, trip legs with perceived worthwhile travel time represent more than 60% of the sample. Most worthwhile legs were identified in the private motorised—driver category (70%), while the largest proportion of wasted legs was identified in the public transport category.

Regarding the perceived mood derived from the travel experience, results indicate the correlation between people’s experienced mood and WTT. As shown in Fig. 3, in the legs

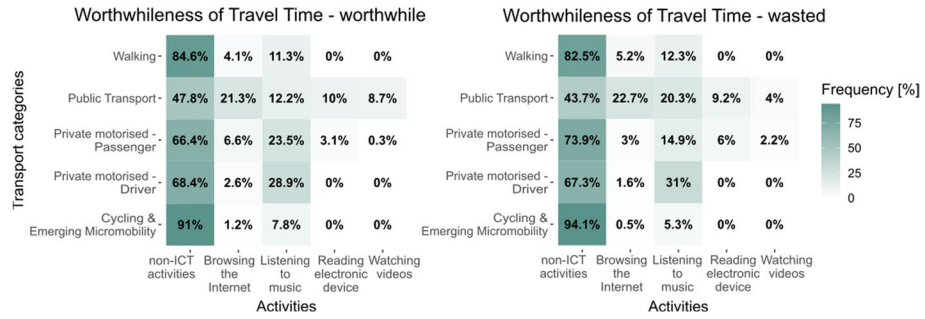


Fig. 4 Frequency of activities by transport mode category in worthwhile and wasted legs

Table 2 Values of goodness-of-fit measures for each of the models

Goodness of Fit index	Private Motorised Driver	Private motorised Passenger	Public transport	Cycling & emerging micro-mobility	Walking
RMSEA	0.001	0.059	0.001	0.042	0.035
CFI	0.996	0.966	0.998	0.970	0.982
TLI	0.990	0.966	0.998	0.993	0.994
GFI	0.990	0.994	0.999	0.982	0.996

evaluated as worthwhile, the perceived mood has a rating mostly 4 or 5, while for trip legs perceived as wasted, the distribution of mood rating shows the highest share for rating 3. Regarding the transport category, more than 72% of legs in the private motorised driver category reached the best mood rating (values 4 or 5). The lowest share with such a rating was in the public transport category (63% of legs).

Figure 4 demonstrates the frequency of travel activities by transport mode for worthwhile and wasted legs. Across all transport categories, non-ICT activities were the most performed. In the case of ICT activities, users mostly browse the Internet or listen to music. For the other categories, the most performed activity was listening to music. Results also show that the frequencies in worthwhile and wasted legs are remarkably similar. The difference is in the private motorised—passenger category, in which users more listen to music in worthwhile legs than the wasted legs. On the contrary, in the public transport legs, listening to music had a higher frequency in wasted legs.

Models results

Model estimation results

The base model as specified in Fig. 1 was estimated by using diagonally weighted least squares method with NLMINB optimisation within the R Software *lavaan* package (Rosseel 2012).

To assess the model fit, the tested goodness-of-fit measures are listed in Table 2. for each model. Root Mean Square Error of Approximation (RMSEA) is the significant criterion in covariance structure modelling (Arbuckle 2011), with cut-off value 0.06 or lower. The rest of applied measures, namely Comparative Fit Index (CFI), Tucker Lewis index

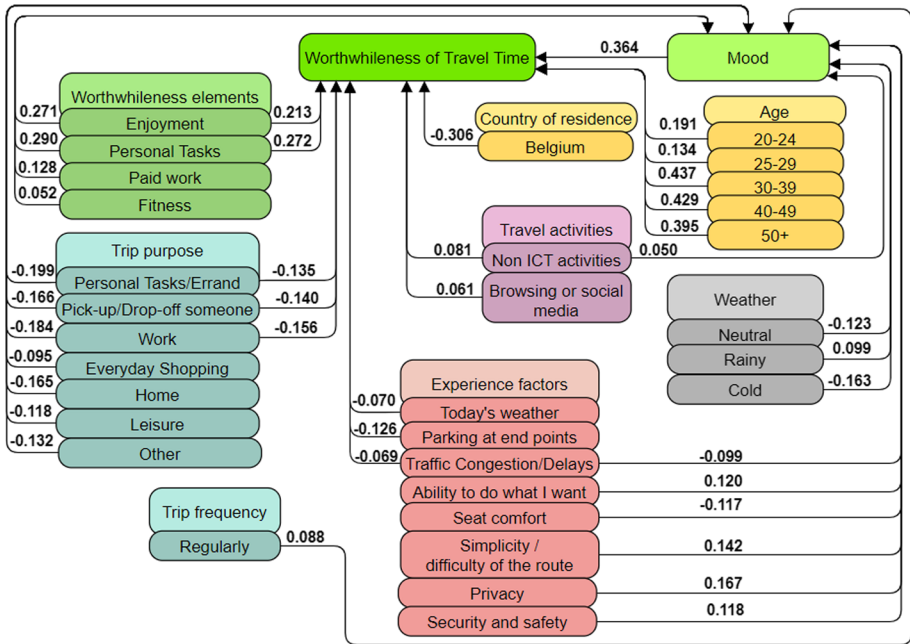


Fig. 5 Model results for private motorised—driver

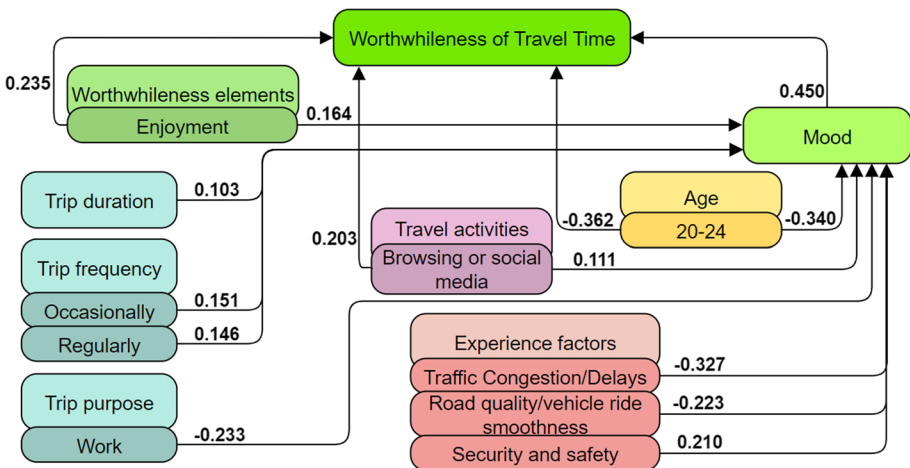


Fig. 6 Model results for private motorised—passenger

(TLI), Goodness-of-Fit-Index (GFI) have a cut-off value 0.95 or higher (Cangur and Ercan 2015). According to the cut-off criteriums and the goodness-of-fit measures displayed in Table 2 all models can be accepted.

The model results are shown below in Figs. 5, 6, 7, 8 and 9 for all five transport mode categories. The graphs illustrate only those relationships that were found to be significant, i.e., p -value < 0.05 with standardised coefficient presented for each significant relationship.

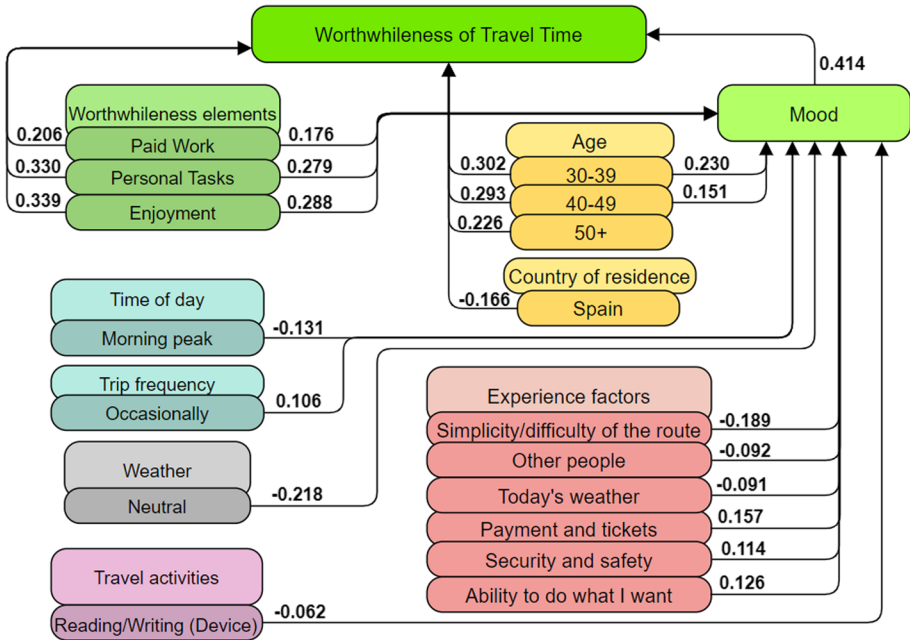


Fig. 7 Model results for public transport

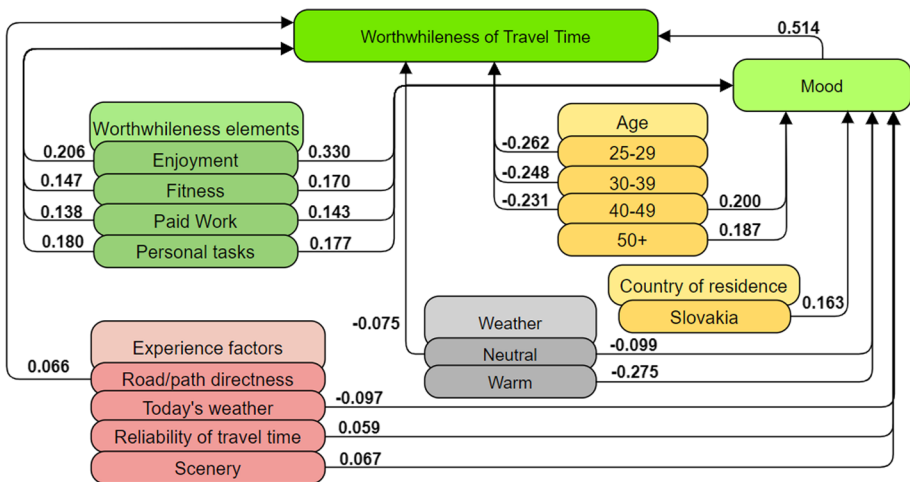


Fig. 8 Model results for cycling and emerging micro-mobility

The subsequent analysis is based on seven variable groups examined in the model in relation to their importance on shaping WTT and mood, performing a comparative analysis of each variable both within the same transport mode category and across different transport mode categories. For a better presentation of the results, each standardised coefficient value is put in brackets, followed by the p -value encoded by three categories ($p < 0.05$, $p < 0.01$, $p < 0.001$).

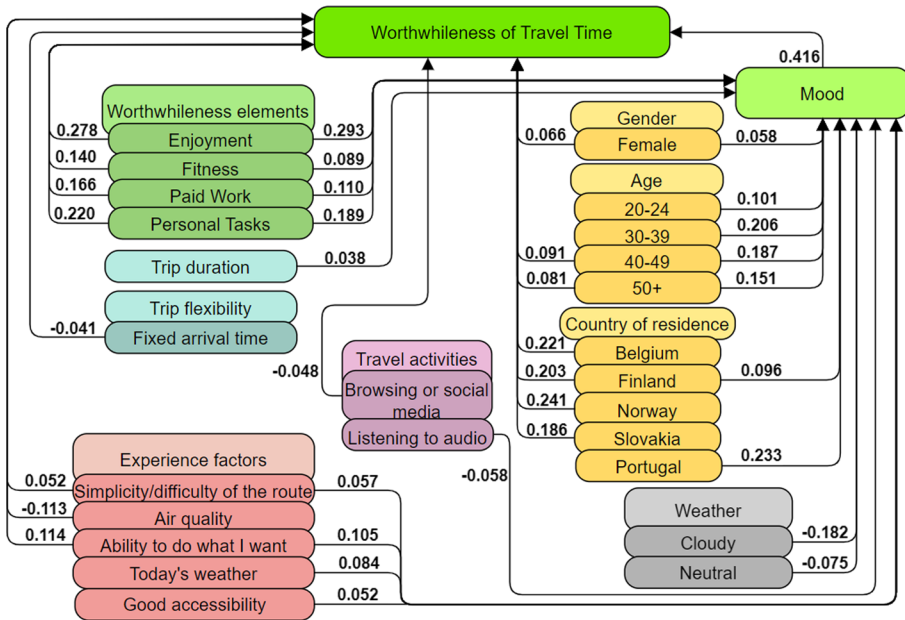


Fig. 9 Model results for walking

Effect of mood on WTT

The estimated results reveal the significant and positive effect of individuals' mood level (i.e., rating) on WTT rating across all travel modes. As shown in Fig. 9, it can be interpreted that people who are using bike/e-bike and micro-mobility systems (e.g., e-scooter) with higher mood evaluation also have higher travel satisfaction in terms of WTT (0.514, $p < 0.001$). This also applies to people who travelled in a private motorised vehicle as driver (0.364, $p < 0.001$), passenger (0.450, $p < 0.001$) or used public transport (0.414, $p < 0.001$). The results also demonstrate a positive association between mood and level of WTT evaluation for walking (0.416, $p < 0.001$), which is in line with other studies (Morris and Guerra 2015; Ye and Titheridge 2017; Lades et al. 2020), which report high levels of travel satisfaction with walking.

Effects of travel activities on WTT and mood

The effects of travel activities performed during travel and mood shown in Fig. 6 point out that the non-ICT activities (e.g., accompanying, talking, thinking) positively affect the perceived WTT and mood among those people who used private motorised vehicle as a driver (0.081, $p < 0.001$). As shown in Fig. 6, the self-assessment of mood (0.111, $p < 0.05$) and WTT (0.203, $p < 0.05$) among passengers of private motorised vehicles is positively affected by the ICT related activity of browsing the Internet. This reflects that the passenger connectivity to the Internet and use of ICT devices can likely increase their perception of travel satisfaction in terms of WTT. Also, it was found that reading electronic device

(-0.062 , $p < 0.05$) negatively influences self-assessment of mood while travelling by public transport, and listening to music (-0.057 , $p < 0.01$) negatively affects mood in the walking category. In addition, the negative impact of Internet browsing (-0.049 , $p < 0.01$) on individuals' perception of WTT was found in this category.

Effects of experience factors on WTT and mood

Regarding the influence of people's experience of transport infrastructure and services on WTT and mood, the results show that finding parking at the end of a trip (-0.126 , $p < 0.001$) is a significant negative factor influencing the WTT of private motorised vehicles drivers. Moreover, traffic congestion yields as a significant negative factor affecting mood of private motorised vehicles passengers (-0.327 , $p < 0.001$) and mood and WTT of private motorised vehicles drivers (mood: -0.099 , $p < 0.001$; WTT: -0.069 , $p < 0.05$). Those factors significantly decrease individuals' travel satisfaction in terms of perception of waste of time for WTT, which is in line with Gatersleben and Uzzell (2007). Results also demonstrate that the privacy (0.167 , $p < 0.001$) and simplicity of the route (0.142 , $p < 0.001$) impact the private motorised vehicle drivers' mood positively in terms of being great in a European context that is consistent with Ettema et al. (2013) findings. Based on the selected experience factors by public transport users, the findings indicate that the difficulty of the route (-0.189 , $p < 0.001$) together with the weather condition on the day of travel (-0.091 , $p < 0.01$) and other passengers (0.092 , $p < 0.01$) are the most negative experience factors for public transport riders that affect the self-evaluation of mood negatively; meanwhile the ability to do what I wanted (0.126 , $p < 0.001$), the ease of payment and tickets (0.157 , $p < 0.001$), security and safety (0.114 , $p < 0.01$) are the most significant ones influencing drivers for public transport rider to have a higher positive evaluation of users' mood. Regarding cyclists, results indicate that the road path directness (0.066 , $p < 0.05$) is the most effective factor for having a higher perception of WTT. For the walking travel mode, ability to do what I wanted (WTT: 0.114 , $p < 0.001$; mood: 0.106 , $p < 0.001$) and simplicity of the route (WTT: 0.052 , $p < 0.05$; mood: 0.056 , $p < 0.01$) showed as the most significant factors that positively affect the people's higher evaluation of WTT and the mood while travelling.

Effects of worthwhileness elements on WTT and mood

According to estimated results (Figs. 5, 6, 7, 8 and 9) for evaluation of impact of the worthwhileness factors on WTT and mood, it can be seen the enjoyment has got significant positive value for all travellers across the transport modes compared to two dimensions related to productivity and fitness. The highest impact of enjoyment on WTT can be seen in the category public transport (0.339 , $p < 0.001$) and walking (0.290 , $p < 0.001$). These results are consistent with the findings of Eriksson et al. (2013). As expected, fitness has a significant positive impact on WTT and mood in cycling or emerging micro-mobility (WTT: 0.147 , $p < 0.001$; mood: 0.170 , $p < 0.001$) and walking (WTT: 0.140 , $p < 0.001$; mood: 0.090 , $p < 0.001$) trips. Meanwhile, in the case of private motorised drivers, the outcomes reflect the positive effect of productivity (mood: 0.290 , $p < 0.001$; WTT: 0.272 , $p < 0.001$) in terms of being more flexible to do personal tasks, general good feeling of their trips and WTT. However, a high significant positive impact of productivity (personal tasks) on WTT can also be seen when traveling by public transport (0.330 , $p < 0.001$) and walking (0.220 , $p < 0.001$).

Effects of trip characteristics on WTT and mood

The importance of trip characteristics varies across different transport mode categories. In all models except cycling and emerging micro-mobility, at least one element of trip characteristics was significant in shaping WTT and mood ratings.

Trip duration was found to positively affect the mood of travellers in both categories: private motorised—passenger (0.103, $p < 0.05$) and walking (0.038, $p < 0.05$) considering that walking trips are more often shorter in terms of travel time compared to motorised trip (De Vos et al. 2022; Lades et al. 2020). Trip frequency is another element that positively affects travellers' mood when travelling by private motorised vehicle as passenger (trip frequency: regularly: 0.146, $p < 0.05$; trip frequency: occasionally: 0.151, $p < 0.05$) and public transport (trip frequency: occasionally: 0.106, $p < 0.05$). Interestingly, when travelling during morning peak hours, the mood of public transport users was affected negatively (-0.131 , $p < 0.05$). The WTT was only found to be negatively affected in two transport mode categories. In particular, trip purposes of work (-0.156 , $p < 0.05$), personal tasks (-0.135 , $p < 0.05$), when picking-up/dropping-off someone (-0.140 , $p < 0.05$) in the private motorised—driver model, and fixed arrival time (-0.041 , $p < 0.05$) in the walking model negatively affect the perceived WTT.

Effects of sociodemographic characteristics on WTT and mood

The direct influence of sociodemographic characteristics on WTT and mood evaluation across 5 different transport modes are shown in Figs. 5, 6, 7, 8 and 9 above. The results demonstrate the significant impact of socio-demographics on individuals' evaluation of WTT and mood. The age has significant positive impacts on WTT evaluation for those using private motorised vehicles as drivers, public transport and bike/e-bike and micro-mobility commuters and walk, while it has a significant negative effect on private motorised vehicles passengers (see Fig. 6). As illustrated in Figs. 5, 6, 7, 8 and 9, the association between age and trip mood evaluation was not significant for commuters by private motorised vehicles either as drivers or passengers. On the other hand, the results indicate a positive influence of age on mood evaluation for people in age range of 40–49 using bike and emerging micro-mobility, and a higher positive significance on walking commuters in age range of 30–49 being in line with other previous studies (De Vos et al. 2016; Ye and Titheridge 2017; Lades et al. 2020). Regarding WTT, age has a high negative effect (age 25–29: -0.262 , $p < 0.001$; age 30–39: -0.248 , $p < 0.05$; age 40–49: -0.231 , $p < 0.05$) in the case of travelling by bike and emerging micro-mobility. Furthermore, as shown in Figs. 5 and 9, a country of residence has a negative impact on perception of WTT for the private motorised drivers in Belgium ($c = -0.306$, $p < 0.005$) compared to walking as a commuting mode, which has a positive impact on a traveller in Belgium, Finland, Norway, and Slovakia. As models result point out, we can argue that women (0.066, $p < 0.001$) 40 years old and above (age 40–49: 0.091, $p < 0.05$; age 50 and more: 0.081, $p < 0.05$) in these countries have a higher evaluation of travel worthwhileness for walking compared to other age groups for daily commuting.

Effects of weather conditions on WTT and mood

Model results demonstrated that weather conditions negatively affect the mood of travellers in all transport mode categories apart from the private motorised—passenger. Neutral weather condition was found to negatively affect WTT and mood of cycling and emerging micro-mobility users (-0.099 , $p < 0.001$), while the same weather scenario negatively affects the mood of those walking (-0.075 , $p < 0.05$) or using public transport (-0.155 , $p < 0.05$). Within the cycling and emerging micro-mobility transport mode category, the warm weather condition was found as the one which negatively affects the mood (-0.218 , $p < 0.001$) of bike and micro-mobility users. Cloudy weather condition seems to negatively affect the mood (-0.182 , $p < 0.001$) of those walking.

Conclusions

The current research further expands the concept of “worthwhile travel time”, based on its main components (i.e., enjoyment, productivity, and fitness), activities carried during travelling, experience factors referring to travel circumstances, and other external factors such as weather conditions. Gaining a deeper understanding of how satisfaction levels in terms of WTT differ across transport modes can guide mobility policies and regulations towards the use of more sustainable modes of transport (Georgouli and Malichova 2020).

The research findings demonstrate that (1) Enjoyment has the strongest influence on positive evaluation of WTT and mood across different travel modes; (2) The self-assessment of mood (for the whole trip) is strongly correlated with mode-specific WTT assessments across all travel modes, however further research is needed to establish a potential causal effect and its direction, and whether mood could be used as a proxy to WTT in all circumstances; (3) Passengers’ connectivity to the Internet and use of ICT devices can likely increase their perception of travel satisfaction in terms of WTT; (4) ICT related activities such as watching videos, reading electronic devices, listening to music and browsing the Internet positively influence individuals’ perception of WTT and self-assessment of mood while travelling by public transport and on foot; (5) Trip duration was also found to be a positive factor influencing the mood of travellers in both private motorised vehicles as passenger and walking trips; (6) Interestingly, travelling during morning peak hours negatively affects the mood of public transport users. The largest proportion of wasted trip legs was identified in the public transport category; (7) Results also indicate that the trip purposes related to work, personal tasks, picking-up/dropping-off someone in the private motorised as driver model and fixed arrival time in the walking model negatively affect WTT; (8) Modes of transport in cycling and emerging micro-mobility category received the highest positive impact on mood evaluation for people aged 40–49. This finding provides interesting insights for the bike-sharing and micro-mobility service providers who can offer attractive solutions as intermodal alternatives, safer and high-quality infrastructure to bring a higher level of the perceived WTT and mood for users of emerging micro-mobility systems.

Like other previous studies, this research has data limitations in modelling users’ socio-demographic information such as marital status, level of education, occupation, years of residence and number of household persons due to making those questions optional for respondents. Therefore, we included only obligatory socio-demographic questions asked

during the registration in the Woorti app. A second limitation of data collection resides in predominant use of mobile applications by younger people reflected by our users' age sample. Consequently, our results primarily reveal the perception of travel time by people aged 16 to 50. Another limitation is that the data used in the research are self-reported and therefore cannot be independently verified. Postponed trip evaluations might modify users' perception of the travel time too, although the application requested trip evaluation right after it finished. Hence, we are aware that identified limitations could impact research results on individuals' perception of WTT.

The results show that mobility planning needs to be reconsidered in favour of travellers' travel experience. Maximising the perceived value of WTT as a part of the subjective theory of value should also be considered as a crucial driver for a paradigm shift on transport planning and policies striving for travellers' satisfaction beyond the time and cost-saving and overemphasis of the travel speed (Banister et al. 2019). Incorporating people's well-being perspectives in current urban mobility planning practice can support the identification of gaps and requirements for future transport models and develop decision support tools. The research findings also have implications for many stakeholders, such as urban and transport planners and EU policymakers, supporting the implementation of a more human-centric approach in urban mobility plans. This requires incorporating people's subjective well-being perspective and values, such as WTT in EU legislation and policies on inclusiveness, to reinvent the conventional cost–benefit analysis method in favour of social welfare functions (SWF) in the economy context for improvement of the quality of existing transport services and appraisal of future mobility services and transport infrastructure.

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Data availability The datasets generated by the MoTiV project and analysed during the current study are available on the project website (<https://motivproject.eu/project-results/deliverables.html>) and the EU open access repository (<https://doi.org/10.5281/zenodo.4027465>) and interested research communities can use it for the further studies of value of travel time.

Declarations

Conflicts of Interest The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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