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Abstract. Sustainable urban mobility planning (SUMP) plays a significant role as an integrated strategic management tool in enabling, among others, a participatory approach in urban transport development. A relevant aspect of the transition towards sustainable and smart mobility planning concerns the reconsideration of concepts such as Value of Travel Time (VTT). Rather than "cost of time spent in transport", new perspectives on VTT aim at conceptualizing and measuring VTT based on individual needs, expectations and perceptions. Among others, attention is paid to individual experience in using transport infrastructure, services and systems while on the move. The ongoing shift towards a broader view of VTT gives importance to subjective "well-being" (SWB) and describes, in quantitative and qualitative terms, the individual value proposition of mobility (VPM). The opportunity to collect mobility and behavioral data via smartphones, to be processed with advanced analytical and modelling techniques, represents a pillar of such shift, since it allows identifying patterns embedded in individual daily activities and mobility choices. These patterns can be visualized to increase self-awareness and better understand one's own value proposition of mobility.

Keywords: Sustainable Urban Mobility Planning; Value of Travel Time (VTT); Value Proposition of Mobility (VPM); Quantified Self (QS); Individual preferences; Mobility and Behavior Data collection.

1 Introduction

In a seminal paper from 2008, David Banister presented the sustainable mobility paradigm as an alternative approach to transport and mobility to meet the needs of contemporary societies facing both local and global challenges [1]. In Banister's view, two fundamental pillars of the conventional transport planning approach should be reconsidered: the first pillar to question is the consideration of travel as "a derived demand and not an activity that people wish to undertake for its own sake". The second pillar to reconsider is the assumption that "people minimise their generalised costs of travel,

mainly operationalised through a combination of the costs of travel and the time taken for travel". There is an increasing body of research supporting the view that there can be value, not necessarily just of hedonic nature, associated to the travel experience [2,3,4,5,6] and that additional factors than cost and time when play a role in travel and mobility decisions [7,8,9]. This paper builds on Banister's approach to sustainable mobility (Table 1) and it focuses on value of travel time (VTT). In this respect, our aim is to introduce the concept of Value Proposition of Mobility (VPM), the subjective, dynamic and contextual valuation of available (or preferred) mobility options. Adopting a VPM perspective is timely and relevant not only because this is compatible Banister's view of sustainable mobility but especially to support the ongoing shift from an economic-centered VTT valuation to a broader and more complex process that puts the individual at the center of the stage.

Table 1. Banister contrasting approaches to transport planning – selected dimensions [1]

The conventional approach—transport planning and engineering	An alternative approach—sustainable mobility
Physical dimensions	Social dimensions
Mobility	Accessibility
Traffic focus, particularly on the car	People focus, either in (or on) a vehicle or on foot
Large in scale	Local in scale
Motorised transport	All modes of transport often in a hierarchy with pedestrian and cyclist at the top and car users at the bottom
Modelling approaches	Scenario development and modelling
Economic evaluation	Multicriteria analysis to take account of environmental and social concerns
Travel as a derived demand	Travel as a valued activity as well as a derived demand
Demand based	Management based
Speeding up traffic	Slowing movement down
Travel time minimisation	Reasonable travel times and travel time reliability

The "behavioral shift" of research on VTT is supported by two important parallel trends affecting its conceptual and methodological underpinnings: the first one, of conceptual nature, concerns the ongoing efforts in economics research to move from merely economic indicators to "utility functions" incorporating the notions of happiness and subjective well-being (SWB) [10,11]. As underlined by Duarte et al. [10], "*existing behavioural travel choice models should be enhanced with regards to their behavioural validity incorporating the impacts of travelling happiness/satisfaction*". The second trend, of methodological nature, is about the possibility to "quantify the self" [12] by voluntarily collecting, processing and interpreting personal data (e.g. manually or with the support of advanced AI techniques). The data collection, also known

as personal life-logging [13] or self-tracking [14], is carried out via smartphones or wearables (e.g. smart watches). The notion of quantified self (QS) was unofficially introduced in a 2007 by Wired editors Gary Wolf and Kevin Kelly [15], who later promoted the QS movement to use self-tracking technologies for better understanding oneself through indicators, trends and statistics. It is assumed that a person can use this knowledge to optimize decisions and improve aspects of his/her daily life. Another underlying assumption is that human behavior is, to a certain extent, rather predictable [16]. It follows that personalized recommendations are optimized for routines and ordinary behaviors, although there are efforts to support serendipity [17].

The assessment of SWB via a QS approach is an area of increasing academic interest, with relevant applications [18,19]. In the context of travel behavior, the concept of quantified traveler [12] was introduced to promote sustainable travel behavior and smart tourism [20]. This approach does not only make use of contextual information related to a specific travel (e.g. routes, mobility choices, mood and feelings), but it also crosses this information with personal historical data generated in other life situations. The QS approach is part of a broader interdisciplinary research and application area that has emerged in last fifteen years and it is known as computational social science [21,22]. Together, the possibility to assess individual behavior based on a computational social science approach and the adoption of hedonistic approaches to value estimation have the potential to advance the field of VTT research and applications [23]. In the long-term, it is expected that knowledge in this area will generate significant opportunities for public and private actors, as well as the civil society, involved in the transition towards sustainable mobility. As an example, if the full door-to-door traveler's experience was considered, decisions on transport infrastructure planning may pay more attention to travel quality rather than speed [6]. In other words, it might be a more efficient, also from a cost viewpoint, to invest in enhancing the overall travel experience – in and between transport modes - rather than attempting to increase time gains on single points and links of the transport infrastructure.

In the following sections, the relevant trends reviewed in this introduction in the context of VTT will be used to introduce the notion of VPM. Next, we will describe how VPM will be developed and applied in the recently granted H2020 project "Mobility and Time Value" (MoTiV), which aims at advancing VTT research and related sustainable mobility applications. Since the theoretical concepts introduced in this paper will be tested in the MoTiV project, at this stage there are no results yet allowing an initial assessment of the notion of VPM. Nevertheless, we believe it is relevant to introduce this concept to stimulate debate and potentially considering useful feedback from the research community into the MoTiV project.

2 Conceptualizing the Value Proposition of Mobility

The "behavioral shift" of studies on VTT calls for an integration of models and frameworks of individual needs, motivations and preferences adapted to the mobility context. In this respect, which personal values and expectations should be generally

fulfilled and addressed by mobility solutions? The conception, development and deployment of mobility infrastructure, services and solutions adapting to individual needs and expectations defines and shapes a VPM. This represents a promise of value to be delivered, communicated, and acknowledged to the individual traveler. Time and costs savings will continue to play a key role in individual travel and mobility decisions. However, other relevant factors affecting travel experience such as comfort [24] should be acknowledged and included into an enlarged conceptual framework for VTT estimation. Each transport mode, or a travel option based on a combination of transport modes, provides a different value proposition to the traveler in a specific mobility situation. Time and cost savings represent only one of these factors, not necessarily the one contributing the most to VTT. Depending on the situation, other factors such as increased safety or well-being may influence traveler's choice more than time and cost, hence considered more valuable.

As individual valuation of available (or preferred) mobility options, the VPM can be regarded as the value embedded in individual mobility choices. As such, the VPM is focused on the individual traveler and his/her perceived travel experience. Knowledge on barriers and factors playing a role in the traveler's choice is therefore key to align expectations and actual experience. Previous research on behavioral factors influencing mode choice underlined the importance of habits [25, 26, 27]: hence, information on traveler's routines is very useful to quantify the subjective view of the VPM, based on the appreciation of its different dimensions. The adoption of the VPM to assess VTT implies the consideration of a range of aspects of mobility behavior, which are tightly connected to motivational factors. The VPM cannot be reduced only to the value proposition of a single product, technology, and brand (e.g. the Tesla Model S car), but it must be referred to a set of products, services and technologies used within activities and mobility situations. This is particularly relevant with current trends of digitalization and diversification of transport: integrated mobility solutions such as Internet-based travel planners, peer-to-peer real-time mobility services (e.g. ride-sharing, Uber), and, Mobility as a Service (MaaS), are shaping and redefining the value of technologies, products, and services. A common aspect of these efforts is the aim to enable a smooth door-to-door, multimodal experience for the traveler. However, being a complex ecosystem, there is no single actor in charge of shaping travelers' VPM. It is rather a joint outcome of actors, including end users, co-creating meaning and value to transport and mobility options through policy, implementation, deployment, and participation.

As a starting point to understand the expected determinants of individual happiness and subjective well-being linked to transport and mobility choices, we refer to a classic model proposed by Sheth [26] to analyze motivational factors influencing travel choices. In line with Sheth's approach, multiple decision factors contributing to shape the individual value proposition of mobility should be considered (Table 2). Other studies presented similar models: for example, Johansson et al. [28] proposed a model including safety, comfort, convenience, flexibility and environmental preferences (which in Table 2 are considered as part of the "well-being" dimension). This and other related studies demonstrated the importance of considering not only socio-economic factors, but also socio-psychological variables in the study of transport and mobility preferences and decisions. Sheth's model allows accounting for travel as a valued activity in itself

[2] and also for assessing the value of activities within mobilities, and the value of mobilities within activities. From this viewpoint, VTT is not only about the value of the activity at destination but it should also capture the value of activities carried out while on the move, as well as the value of travelling for the sake of it.

Table 2. Dimensions of the Value Proposition of Mobility

Decision Factor	Objective
Time	To be minimized to reach destination rapidly.
Cost	To be minimized (as personal expenditure) to reach destination at the lowest cost, or to be maximized in case personal mobility plans are compatible with possibility of earning by transporting people or goods.
Comfort	To be maximized in line with travel service expectations.
Safety	To be maximized to reach destination safely.
Curiosity	To be maximized in line with travel experience expectations.
Prestige	To be maximized in line with social status aspirations.
Pro social	To be maximized to maintain and/or extend personal social relationships (e.g. it may involve volunteering/charity activities).
Well-being	To be maximized in line with health and well-being aspirations and objectives. This includes also commitment to reduce environmental impact of transport (in terms of CO_2 emissions).

The notion of VPM allows developing a conceptual framework for estimating VTT from a broader perspective that goes beyond the conventional optimization of travel time and cost savings. It is a multi-dimensional construction that, in line with the theory of self-determination [29], includes both intrinsic and extrinsic motivations contributing to VTT. To our knowledge, there is currently no conceptual framework for VTT estimation that captures the individual value proposition of mobility by accounting all the soft factors described in Table 2 (e.g. cost, curiosity, comfort, safety). Each of the dimensions, especially those who are under-researched (e.g. prestige, curiosity), would deserve a more detailed and elaborated described, which is out of the scope of this paper but certainly of relevance for future research.

The acknowledgement of the soft factors illustrated in Table 2 goes beyond academic interest and has practical applications. As a matter of fact, the design of public and commercial transport services already embeds such knowledge: journey planners query results include information on trip itinerary, duration and cost as well as some additional details supporting the user travel decision (e.g. environmental impact, available services such as 1st or 2nd class, Wi-Fi availability). In the future, such services should be able to incorporate all soft factors that play a relevant role in the traveler's experience, making personal mobility more flexible and customizable. To achieve this objective, a prerequisite is the ability to deliver a personalized range of travel options

matching personal expectations and contextual needs (e.g. daily commute to work, long-distance business trip, week-end leisure trip).

Recent technological advances allowing continuous self-tracking of mobility and activity behaviors (e.g., via smartphones or wearables), combined with the potential of real-time personal data analytics, are expected to open up a wide range of personal door-to-door multi-modal mobility solutions enhancing one's travel experience.

3 Modelling the Value Proposition of Mobility: the MoTiV approach to VTT

Smartphones are ubiquitous and, as an extension of the self, they are endlessly recording our life. Until now, digital content (e.g. photos, videos, audio-recordings) has been used either as digital memories or as part of conversations with our social circles. Other digital logs (e.g. our information searches, movements and activities) are collected and used by virtual agents and assistants such as Siri or Cortana to anticipate and fulfil our personal needs [30], including travel and mobility. With the emergence of computational social science, researchers collected mobility and behavioral data to better understand human mobility patterns and behaviors [1], as well as our use of time, including travel time [31]. Based on the idea that the "smartphone knows ourselves better than we do" [32], the QS approach allows going beyond the traditional travel survey and to measure the travelers' evolving view of their VPM. Defining and validating such a methodology for VTT estimation based on the VPM is one of the key objectives of the recently granted research project on Mobility and Time Value (MoTiV), which is funded under the EC Horizon 2020 framework program [33]. The project started in November 2017 and will end in April 2020, for a total duration of 30 months. In the MoTiV project, value of travel time is conceived as the individual happiness/satisfaction for the time spent on transport. As such, VTT is conceptualized as a multi-dimensional entity consisting of several relevant indicators aligned with the VPM.

The MoTiV conceptual framework will be validated by carrying out a European wide data collection campaign, enabling identification and comparison of behavioral patterns across gender, generations, and socio-cultural contexts. Data will be collected via the MoTiV smartphone app developed within the project. The app will combine features of personal mobility/time tracker, travel/activity diary and journey planner supporting a qualitative and quantitative description of the traveler. It is expected that the campaign will involve at least 5,000 participants from at least 10 EU countries, who will actively use the app for at least two weeks. To collect sufficient and high-quality data, particular care will be devoted to address user engagement while addressing privacy concerns through usability, gamification and privacy-by-design.

Similarly, to the "quantified traveler", the MoTiV app aims at enhancing self-awareness and contributing to a better understanding of one's own VPM. These goals will be supported by visual representations of personal mobility and behavioral patterns, trends and statistics. An open mobility and behavioral dataset is planned to be released at the end of the MoTiV project. This dataset, representative of travel behaviors at a EU level, will stimulate further research on VTT and will also serve as a reference for analysis

and assessment of the measures connected to SUMP and other EU key policy indicators on citizens' quality of life.

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