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School commuting: the influence of soft and hard factors to shift to public transport

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Abstract

School commuting is critical for modern societies considering its potential and long-lasting impacts in travel behaviour of younger generations, today and in the future. Besides positive health impacts, it is crucial to expose students to more sustainable modes (e.g., walking, cycling, public transport) to form future adults with more sustainable mobility decisions. Despite the vast research on school commuting, scrutinizing the foremost factors that determine the modal choice of households when students commute to school is still challenging.

Here, we carry out an analysis of the main factors that impact the willingness to shift to public transport (PT) for school commuting, in the Lisbon Metropolitan Area. Also, we analyse the potential of hard and soft factors to change the households' perception towards PT and their willingness to shift away from private car. While hard factors relate to interventions in the transport operation characteristics, soft measures act on the users' behaviour. Based on a survey of 1640 households whose children attend primary, middle and high schools, our results suggest that in order to achieve a modal shift towards PT, we should focus both on Hard factors *Frequency* and *Schedules*, Soft Factors and considering the Context of the school.

Keywords: Barriers; School Public Transport; Soft factors; Hard factors

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1. Introduction

One of societies´ major contemporary concerns is to simplify daily processes and routines including family mobility planning, especially for households with students. In many cities worldwide, and more prominently in Europe, students are frequently driven by car to school and leisure activities (Macket, 2002, Hjorthol and Fyhri,, 2009), thus increasing the overall family car-dependence and the corresponding modal share. On the other hand, school commuting is a critical topic for debate in modern societies considering its potential and long-lasting impacts, regarding travel behaviour. It is crucial to expose students to more sustainable mobility options (such as walking, cycling and public transport) in order to, potentially, form future adults with more sustainable mobility decisions.

It is commonly accepted that children mimic their parents' behaviour by following their choices and attitudes. As such, a child who is driven everywhere is expected to become an adult who will prefer the car to other modes and will also drive his/her offspring more often, thus perpetuating this travel behaviour cycle as studied by Morris et al. (1998) and Davison et al. (2007).

Despite the vast literature on school commuting, scrutinizing the foremost factors that determine the final modal choice of households when students commute to school is still challenging and prone to further research, as car is still the main transport mode in many situations. Such factors are often categorized into “hard” and “soft”. Although the literature has not yet clarified the concepts of “hard” versus “soft” factors or measures, there is a general consensus that the former are more related to indicators and interventions on the supply side of the transport system, while the latter are more related to the demand side, which includes voluntary change measures, psychological and behavioural strategies (Bamberg et al., 2011, Möser, 2008, Juhász, 2013).

In Fig. 1 we seek to stylize the relationship of “supply” and “demand” sides with “hard” and “soft” factors and measures. On the supply side of the system, the authors include infrastructure (IF) and, on the demand side, the characteristics of the users (i.e. users´ profile – UP; and travel behaviour - TB). PT operation and services (OP) mediate the relationship between the infrastructure and the users. As such, it is unclear where to include transport operations and services, i.e. whether these should be considered soft or hard factors. Here, we opted for addressing attributes related to the operation of transport services as hard factors or measures. For example, “driver´s attitude” determines the performance of the transport services. As such, it was classified as a hard factor. Conversely, psychological or environmental consciousness attributes were classified as “soft factors” as they are determinant for the users´ behaviour, that is, on the demand side of the equation.

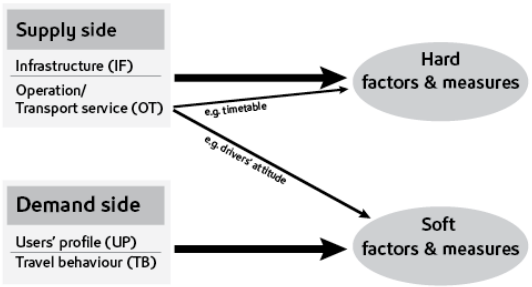

Fig. 1 Classification of hard and soft factors

The main goal of this research is to understand the relative impact of “hard” (i.e., infrastructure; operations) and “soft” (profile; travel behavior) factors on the willingness to shift to PT instead of using the private car. The remainder sections of the paper are organized as follows: section 2 provides an overview of the existing literature on behavioural aspects. Section 3 describes the data and the methodology proposed aiming to analyse the factors that favour travel behaviour change. Section 4 discusses the model results and finally Section 5 reports the conclusions, limitations and further research.

2. Literature review

Many studies on students´ commuting to school have hypothesized that the characteristics of youth, households, schools, and neighbourhoods exogenously affect their travel mode to school, as studied by Heath and Gifford (2006), Schlossberg et al. (2006), Wong et al. (2011), among others. Other studies discuss if it is children's school commuting that determines the household overall modal options or the other way around, i.e., parents' mobility planning and modal options that determine the way students commute to school, as proposed by Deka (2013).

In psychology, the theory of planned behaviour (TPB) links one's beliefs and behaviour. The concept was proposed by Icek Ajzen (1991), to improve the predictive power of the theory of reasoned action by including perceived behavioural control. The central factor in the TPB is the individual's intention to perform a particular behaviour. This intention holds the motivational factors that influence that behaviour. Intentions are thus indications of how strongly people are willing to try and how much effort they are planning to invest and perform the behaviour (Ajzen, 1991).

The overarching ambition of this research is to contribute to foster the adoption of PT by more citizens of all ages living in urban areas. Currently, and in the longer term, acting on today's younger generations (i.e., students) will influence future lifestyles, striving towards a more sustainable urban mobility, as a whole. Hence, to capture new PT users among students, we need to identify the existing latent demand of school transport. Considering that a chief topic addressed in this research is the modal shift to public transport, it is necessary to discuss the concept of latent demand to attract new passengers and consequently how to influence their planned behaviour (Clifton and Moura, 2017).

Despite the majority of the more recent research focusing on the importance of active modes in children's youth health, they are however focused on modes such as bicycles and walkability and fewer paying little attention to school public transport to and from school, as explored by McMillan (2005), Mitra (2013), among others. Related with this background, the present study, is an attempt to understand which factors determine the preference for one mode over another, when families plan their commutes to school. Different authors approached this topic from diverse perspectives: socio-demographic by Susilo and Liu, (2015), socio-economic by Shokoohi et al. (2012), barriers to the use of public transport to school investigated by Kotoula et al.(2017), Loitz and Spencer-Cavaliere, (2013), Mitra and Buliung (2014), personality profiles by Haustein et al. (2018), Yazdanpanah et al. (2017), and environmental awareness investigated by Onwezen et al. (2013), among others, all of which emphasize the complexity of the topic.

In addition to the identification of these conditioning factors and psychological profiles, it is important to assess the willingness to shift between modes. There are some studies that evaluate this cognitive availability to change habits (e.g. Yazdanpanah et al. (2017), Meloni et al. (2013), Prochaska (2013), among others).

Lastly, it is also important to bear in mind that there is a gap between the propensity to change and the effectiveness of the change in mobility. This decision process involves a variety of issues such as, the quality of transport service, how it is perceived by the users and also the commuter´s behaviour consistency as studied by the following researchers: Chen and Chao (2011), Meloni et al. (2013), Kassirer and Lagarde (2010).

3. Data and methodology

This study is structured in two parts. First, we identify the willingness to shift to PT, the transport barriers to modal change (infrastructural and operational barriers related to hard factors that can potentially be changed with hard measures), and characterize the personality and environmental profiles of the respondents (related to soft factors that can potentially be influenced by soft measures). Secondly, we modelled the modal choice of school commuting, using a Bivariate Logit Model to estimate the binary response-variable *Willingness to shift to PT (Yes/No)*. The model includes a set of independent variables, related to both soft and hard factors, aiming to jointly simulate the stated preferences of respondents on whether they would be willing to shift to PT in face of a set of technical attributes (see section below). The joint probability of each outcome is quantified with three components: calibration parameters, marginal probabilities and odds ratio; in order to compare the marginal impact of each factor on the respondents' choices, when compared to all other factors included. The independent variables include both alternative specific attributes and socioeconomic attributes from the respondents.

3.1. Data

To this aim, a survey was conducted in 10 pre-university schools (6-18 years range) of three municipalities of the

Lisbon Metropolitan Area, Portugal. One of the goals of the survey was to gather high quality data and, as such, the surveys were designed to be paper-based, following the schools' board advice that, based on their past experiences, the paper method would be more effective. The dissemination and delivery of the survey was carried out by the school boards and teachers.

The 10-pages survey was divided in the following sections (in parenthesis, it is indicated whether the section was include in the questionnaire for parents and/or students):

- Socio-demographic information (parents and students)
- Mobility routines (parents and students)
- Transport assessment (parents)
- Personality type (parents only) and
- Environmental awareness and attitudes (parents only).

The National Data Protection Commission approved the survey´s procedures and design. The response rate was significant (57%; n=1640) and completed in a short timeframe (2 weeks in February 2018). After the data cleaning and mining, 1201 responses were validated and used.

52% of the respondents of the survey are aged between 35-44 years, while 34% range between 45and 54 years. 68,5% of the respondents are women. The majority of respondents (70,9%) have a full-time job and 7,4% are unemployed. With regards to the level of education, 38,4% have a graduate level of education and 36,8% a secondary grade level. From the sample of respondents, 55% parents escort students by car, while 15% of the students walk to school. Of the total number of surveys, 21%, 13% and 36%, are from primary (6-10 years), intermediate (11-12 years) and secondary (13-18 years) schools, respectively.

The sample studied here, eliminated the students that already commute to and from school by public transport, which represent approximately 13% of the total survey respondents. On the other hand, considering the range of ages involved in this study (6 to 18 years) and in order to assess students' autonomy in their trips to school, the following variables related to type of School (Context) were added: School1, related to the primary (6 - 10 years), School2 related to the intermediate type (11 - 12 years) and School3 to the secondary (13 - 18 years).

The physical barriers (hard factors), resulted from an open question in the survey where respondents were asked: "*Would you be available to have your children travel to School by PT if the barriers were eliminated?*".

Furthermore, the respondents were asked to rank the chosen barriers in a decreasing order of importance, from "the most important", to "the second most important" and "the third most important". Due to this fact, it was essential to classify into generic groups and not aggregate these barriers to better analyse them in detail and then propose improvements with specific and better targeted measures. The barriers grouped into types of barriers are presented in Table 1 as well as the corresponding descriptive statistics of these variables. Table 1 suggests that the "most important barrier" to shift to PT identified by the majority of respondents (32%) was "13 - Security". The "second most important" barrier chosen more often (26%) was "8 - Lack of buses connecting school/home/school". Finally, the "third most important barrier" to shift to PT selected by respondents was "6 – Cost".

On the other hand, regarding the type of personality, respondents were asked to rate their own personality according to the following eighteen personality traits: 1- optimist , 2- adventurous, 3- like routines,4- spontenous, 5- like being outdoor, 6- risk taking, 7- like to stay close to home, 8- efficient, 9- variety seeking, 10- punctual, 11- like to be alone, 12- independent, 13- creative, 14- calm, 15- anxious, 16-like being in charge, 17- participative, 18-lazy. These traits were placed in a three-factor scale: "Yes, that is me", "Somewhat", "No, not all", as studied in two suburban neighbourhoods in the San Francisco Bay Area, by Redmond (1996).

Moreover, the environmental awareness evaluation contained 15 statements related to environmental concerns that respondents rated on a five-level Likert psychometric scale: from "1- Completely disagree" up to "5- Completely agree", following the methodology proposed by Redmond (1996), as well.

Table 1. Type of Barriers

		BARRIERS BY LEVEL OF IMPORTANCE								
			MOST IMPORTANT		SECOND MOST IMPORTANT		THIRD MOST IMPORTANT		TOTAL	
		BARRIERS	N	%	N	%	N	%	N	%
HARD	IF	1- TRANSFERS Transfer	101	11%					101	6%
		2- STOP- Bus stop conditions	1	0%	18	3%	5	8%	24	2%
		3- WALK- Sidewalk conditions			1		1	2%	2	0%
	OT	4- ATDRIV- Drivers´attitude			2				2	0%
		5- CONF- Comfort			10	2%	5	8%	15	1%
		6- COST- Cost	13	2%	81	14%	20	35%	114	7%
		7- TRIPDURATION- Journey time	21	2%	60	11%	6	10%	87	6%
		8- LACKOF_BUS- Lack of buses	83	9%	149	26%	10	18%	242	16%
		9- FREQUENCY- Frequency	62	7%	59	10%	2	4%	123	8%
		10- SCHEDULE- Incompatible schedules	66	7%	34	6%			100	6%
		11- ONTIME- Bus punctuality	20	2%	7	1%			27	2%
		12- BUSNETWORK- Bus network	17	2%	8	1%			25	2%
		13- SECURITY-Safety and Security	299	32%	21	4%			320	20%
		14- INF- Lack of information	9	1%					9	1%
SOFT	TB	15- CHILDRENAGE- Children´s age	61	7%	22	4%	2	4%	85	5%
		16- NO_NEEDPT- No need to go by bus	46	5%	16	3%	1	2%	63	4%
		17- DISLK- Not liking Public Transport	2	0%	3	1%			5	0%
		18- CAR Owning a car	11	1%					11	1%
		19- DISTANC- distance home/school	114	12%	79	14%	5	9%	198	13%
		Total	**926**	**100%**	**570**	**100%**	**57**	**100%**	**1553**	**100%**

Note: IF – Transport Infrastructure; OT - PT Operations and Services; TB – Travel Behaviour

The fifteen statements related to environmental concerns are the following: **1**- We are getting the limit of population on earth; **2**- Human beings can modify the environment when they need; **3**- The interference of human beings in nature frequently results in disasters; **4**- Human skills will prevent earth to become uninhabitable; **5**- Humans are using excessively environmental resources; **6**- Earth has many natural resources as far as we learn how to exploit them; **7**- Plants and animals have the same right to exist as human beings ; **8**- Nature equilibrium is strong enough to cope with the impacts of the modern industrial societies; **9**- In spite of our special skills, human beings are vulnerable to laws of nature; **10**- The "ecologic crisis" our humanity faces has been exaggerated; **11**- Earth has limited space and resources; **12**- Human beings should dominate the rest of nature; **13**- Nature equilibrium is delicate and easily disturbed; **14**- Human beings will learn enough how nature works so as to control it; **15**- If current behavioural and consumption patterns remain as until today, an ecologic catastrophe will occur.

3.2. Methodology

In terms of modelling, the willingness to change (WTC) to PT (i.e., based on the question related to the level of intention to use PT for daily travel to school) was defined as the dependent variable and coded zero to affirmative (i.e., if the decision is to shift to PT) and one for negative answers (i.e., if the decision is to avoid PT). From the total of answers, 84% were affirmative and 16% negative, suggesting an overall willingness to change to PT (and, possibly, showing some bias towards the socially-desirable options of choosing PT, instead of the private car).

As independent variables, the following were considered: identified soft and hard barriers (Table 1), personality type and environmental awareness of the household (that are included as soft factors as revealed by respondents and to which we can related soft measures to change behaviour, potentially), and type of school. The reduction of variables related to personality analysis and environmental awareness was performed with a Principal Component Analyses (PCA). The obtained scores were then cross-tabled with the remaining descriptive variables and the willingness to shift to PT, in order to infer the corresponding impact. All the soft variables (psychology and environment types) were tested for reliability using the Cronbach´s alpha with a conventional value above 0,70 indicating satisfactory reliability as considered by Hair et al. (2006).

This regression model is based on the transformation of the binary dependent variable, i.e., it does not estimate the probability of an event but rather the logarithmic ratio between this probability and the probability that the event does

not occur (Log-Odds), as considered by Long (1997), which can be expressed with the following formula:

$$\boldsymbol{L(pi) = \ln\left(\frac{pi}{1-pi}\right) = \alpha + \sum_{j=1}^{k} \beta j x} \quad (1)$$

Where $L(pi)$, represents the logarithm of the Odds-Ratio ratio;
p_i represents the probability of modal choice (affirmative WTC - 0, negative WTC - 1);
α, β_j represents calibration parameters of the utility function; and
x_j represents the independent variables collected from the survey.

If α, βj calibration parameters are negative, then the probability to shift to PT increases. Conversely, when α, βj are positive, then the probability of continuing to commute by car to school increases.

4. Results and discussion

The modelling approach presented above aims to understand the relative impact of "hard" (i.e., IF and OT),"soft" (UP and TB) and "context" factors on the willingness to shift to PT instead of using the private car. For the UP variables, a PCA was performed to the data collected regarding personality types revealing the existence of 5 personality factors. The respective results are presented in Table 2Table 2. As such, the initial 18 constructs gave rise to the following personality types: "Adventure seeker" (P1), "Organizer" (P2), "Bossy" (P3), "Loner" (P4) and "Peaceful" (P5).

Table 2 PCA Personality types

Personality Constructs	Adventure Seeker P1	Organizer P2	Bossy P3	Loner P4	Peaceful P5
1-Optimist	0.485	0.154	0.211	-0.337	0.056
2-Adventurous	0.727	-0.132	0.068	-0.051	-0.074
4- Spontaneous	0.502	0.076	0.264	0.068	0.041
5- Like being outdoor	0.523	0.392	-0.181	0.015	-0.020
6- Risk taking	0.683	-0.100	0.129	0.109	-0.124
9- Variety seeking	0.513	0.249	0.041	0.219	-0.210
13- Creative	0.432	0.111	0.322	-0.126	0.263
8- Efficient	0.106	0.572	0.160	0.045	0.263
10- Punctual	-0.036	0.606	-0.081	-0.054	0.119
12- Independent	0.128	0.605	0.276	-0.084	-0.074
16- Like being in charge	0.081	0.042	0.761	0.120	-0.041
17- Participative	0.315	0.165	0.667	-0.113	0.102
11- Like to be alone	-0.011	0.336	-0.107	0.644	0.088
15- Anxious	0.080	-0.174	0.357	0.555	-0.004
18- Lazy	0.144	-0.396	-0.063	0.571	0.124
3-Like routines	-0,239	-0,004	0,060	0,025	0,678
7-Like to stay close to home	-0,036	0,170	0,042	0,180	0,640
14-Calm	0,295	0,098	-0,179	-0,372	0,490

Table 3 PCA Environmental awareness

Environmental Constructs	Environmentally concerned E1	Environmentally relaxed E2	Environmentally aware E3
Environmt7	0,696	-0,195	-0,134
Environmt5	0,680	-0,159	0,247
Environmt15	0,624	-0,051	0,303
Environmt3	0,606	-0,078	0,192
Environmt9	0,568	-0,068	0,080
Environmt6	0,551	0,246	-0,405
Environmt13	0,551	-0,140	0,341
Environmt8	-0,190	0,715	-0,088
Environmt14	-0,069	0,690	-0,023
Environmt12	-0,311	0,682	0,187
Environmt10	-0,030	0,670	-0,170
Environmt2	-0,135	0,569	0,042
Environmt4	0,287	0,471	-0,038
Environmt1	0,130	0,016	0,723
Environmt11	0,267	-0,012	0,655

A similar approach was used for environment awareness (Table 3). Three attitudinal dimensions were discerned and labelled as "Environmentally concerned" (E1); "Environmentally relaxed" (E2); and "Environmentally aware" (E3).

In order to model the willingness to shift to PT when commuting to school, the initial model included all variables (hard and soft factors) and the *school level* the students attended. After running different models, the results from the final Logit model are presented in Table 4, Table 4and a number of factors revealed to be statistically significant: Hard Factors (*Number of Transfers, Security, Frequency, Schedule, Bus Suppression*); Soft Factors (*Users´ Profile 3 – "Bossy", and Child Age*); and Context factors (*School*1 – Primary school, and *School2* – Intermediate school). The selected variables improved the quality of the model and avoided multicollinearity without reducing model-data fit

(chi-square=99,346; df =15:p<0,001; McFadden Pseudo R-squared = 0,105).

As referred previously, decision to shift to PT was coded with "0", while keep commuting by car was coded "1". As such, negative parameters (and respective Odds Ratio (OR) lower than 1), indicate an increase in the probability of shifting to PT, while positive parameters (and respective OR bigger than 1), increase the propensity to keep on commuting by car. Table 4 includes two sets of factors: on the top, we include the factors that favour to remaining with the car; while on the bottom, we include the factors that favour shifting to PT. Each factor is organized according to being "hard", "soft", or "context" factors.

All factors that presented negative parameters are related to the identified barriers to shift to PT, by the respondents. Also, these are "Hard" factors as they are related to PT infrastructures or operations. As referred previously, if they are negative, this means that shifting to PT is preferred. This is consistent with the question asked, i.e., if they would shift to PT, provided that these barriers were dismissed. As such, *Frequency* and *Schedules* factors have the biggest impact on the willingness to shift to PT (i.e., the lowest OR), since they have the highest negative parameters. Interestingly, *Cost* has also a negative parameter, i.e. it impacts positively the propensity to shift to PT. This means that if PT cost is relieved (or minimized), than respondents are more prone to shift to PT. Still, the factor *Cost* has a lower impact than *Frequency* or *Schedule*. On the other end of the spectrum, the factor *Security* had the lowest impact on the propensity to shift to PT.

On the "Soft" side factors, we conclude that the Children Age (*Child Age*) has the biggest impact on keep on school commuting by car, i.e., younger children are more prone to be driven to school by their caregivers. Aligned with what was concluded by Haustein et al. (2018) and Yazdanpanah et al. (2017) some psychographic types were significant in determining future modal choice, as well as in our model. According to our results, Profile *P3* respondents (named after "Bossy", as these revealed to be more prone to be in charge) prefer to remain with car than shifting to PT.

Finally, to compare the impact of both negative and positive parameters, we calculated the inverse of OR of the former (1/OR). We conclude that the impact of the four top "Hard" factors is bigger than the impact of "Soft" factors. This result suggests that intervening with "Hard" measures can potentially be more effective than soft measures. Still, we believe that these should be implemented together.

Table 4 *Logit model estimation model results*

Variables	Type of factor	Symbol	Coefficient	Std. Error	z value	Pr(>|z|)	p-value	OR	1/OR
(Intercept)			-1.551	0.170	-9.109	0.000	***	0.211	4.718
								Remain with car	
Children´s age	Soft	ST_ChildAge2	1.156	0.476	2.425	0.015	*	3.178	0.314
Primary school	Context	s1	0.751	0.200	3.748	0.000	***	2.119	0.471
Owning a car	Soft	ST_Car1	0.709	0.650	1.090	0.275		2.032	0.492
Profile P3	Soft	SU_P3	0.629	0.230	2.726	0.006	**	1.876	0.532
Distance home/school/home	Soft	ST_HSHDist1	0.453	0.250	1.810	0.070	.	1.572	0.635
Intemediate school	Context	s2	0.356	0.252	1.413	0.157		1.428	0.700
								Shift to PT	
Frequency	Hard	HO_Freq1	-2.908	1.023	-2.843	0.004	**	0.054	18.322
Schedule	Hard	HO_Sch1	-1.841	0.614	-2.998	0.002	**	0.158	6.303
Transfers	Hard	HI_Transf1	-1.672	0.450	-3.710	0.000	***	0.187	5.326
Bus network	Hard	HO_BusNet1	-1.572	1.043	-1.506	0.131		0.207	4.818
Cost	Hard	HO_Cost1	-0.995	1.055	-0.943	0.345		0.369	2.705
Lack of buses connecting home/school	Hard	HO_LckBus1	-0.912	0.388	-2.351	0.018	*	0.401	2.491
Bus punctuality	Hard	HO_OnTim1	-0.840	0.768	-1.093	0.274		0.431	2.317
Bus network	Hard	HO_BusNet1	-1.572	1.043	-1.506	0.131		0.207	4.818
Security	Hard	HO_Sec1	-0.816	0.226	-3.605	0.000	***	0.442	2.261

5. Conclusions, limitations and further research

These results should be a good indicator of the work that must be carried out in areas where the quality of PT supply is not satisfying, in order to make the public aware of the benefits of the PT modal choice or for a social awakening to their contribution to the sustainable mobility in the city. The most impactful variables on the willingness

to shift to PT (i.e., *Frequency* and *Schedules*) highlighted a latent concern, specifically related to the "operation services" (i.e., Hard factors). Children's age is intimately linked to the school level, but also to the parent's willingness to trust their children to travel alone in PT and trusting the operation/transport service. It is up to the PT operator to provide/offer solutions to mitigate this barrier, through direct control measures, i.e. transport tracking, elimination of modal transfers and ensuring security, not only inside the transport mode, but also in terms of the accessibility to transport modes. In the latter case, a good coordination with other entities such as the police, the school and the community in general, is essential. It is important to know their profiles to segment the target population, allowing for identifying the needs, barriers and willingness to shift and consequently influence mobility behaviour (Esztergár, 2019). For future research, the authors advocate that the focus should be placed on improving these hard factors and analyse *ex- post* the behaviour changes, so as to evaluate the effectiveness of the measures.

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