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Assessing passenger preferences for Bus Rapid Transit characteristics: A discrete choice experiment among current and potential Dutch passengers

René Borsje [a,*], Suzanne Hiemstra-van Mastrigt [b], Wijnand Veeneman [a]

[a] Delft University of Technology, Faculty of Technology, Policy and Management, Jaffalaan 5, 2628 BX, Delft, the Netherlands
[b] Delft University of Technology, Faculty of Industrial Design Engineering, Landbergstraat 15, 2628 CE, Delft, the Netherlands

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ABSTRACT

To gain ridership, bus services need to offer more than just high frequencies. An attractive system design for Bus Rapid Transit (BRT) is a result of various configurational choices concerning infrastructure, rolling stock and operations. To find out which configurations are preferred by potential and current passengers, a Discrete Choice Experiment was carried out in The Netherlands. For this study, eight BRT characteristics were included. Results (n = 1019) show that four characteristics are valued the most: frequency, service hours, reliability and stop spacing. The attractiveness of three different service formulas or configurations is evaluated. The more conventional bus configuration is preferred by the majority of the respondents. However, a considerable amount (25%) of respondents that prefer this configuration does not consider using this service formula. Configurations that either address offering more passenger comfort or higher capacity, do seem to be attractive to distinct passenger segments who are more likely to actually use the service. These appealing BRT configurations address different types of passenger segments and therefore could coexist on certain routes.

1. Introduction

Accessibility and an attractive, healthy and sustainable environment are issues high on the agenda of regional and local governments. One of the instruments used to fulfil their policy ambitions is offering public transport. Bus systems have been developing in the last decade as a high-quality alternative for expensive rail systems. These Bus Rapid Transit (BRT) systems have demonstrated their ability to offer favourable outcomes like travel time saving, high-capacity transport, and emission reduction (Deng & Nelson, 2011). BRT systems have been emerging in a wide variety of appearances to fit various goals, budgets, and contexts (Hidalgo & Graftieaux, 2008). In this wide variety, some continental differences can be distinguished. In Latin America and Asia for example, BRT systems tend to focus on supplying high-capacity mass transport. In Europe on the other hand, BRT addresses the quality of service differently, from a wider perspective than their non-European counterparts. In Europe this form is also known as Buses with a Higher Level of Service (BHLS). Roughly speaking, the European BRT puts more emphasis on comfort and image next to speed, frequency, and reliability (López-Lambas & Valdés, 2010). Instead of a focus on supplying high-capacity mass transport, European BRT services are based on improving passenger experience (Nikitas & Karlsson, 2015, p. 14). With this, European BRT services are related to the North American BRT-Lite concept, for commuters between spread out residential areas and busy downtown locations (Heddebaut et al., 2010). This also applies to the related concept Branded Bus Services (Devney, 2011). In all, BRT and other higher quality bus concepts are applied to a wide range of bus services that can focus on offering high-capacity mass transport and on improving passenger experience.

This wide range of bus services is a result of a combinations of various design and implementation choices that are made, in line with the specific desired performance levels, policy goals and budgets. In designing a bus service, various choices can be made concerning the elements running ways, stations, rolling stock, intelligent transport

* Corresponding author.
E-mail addresses: r.b.borsje-1@tudelft.nl (R. Borsje), S.Hiemstra-vanMastrigt@tudelft.nl (S. Hiemstra-van Mastrigt), w.w.veeneman@tudelft.nl (W. Veeneman).

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systems, ticketing, branding and time table characteristics. The combination of choices concerning these elements make up, what the authors refer to as a configuration. Previous empirical research (Borsje et al., 2022) based on a wide variety of configurations, found two clearly distinguishable types of higher quality bus concepts that seem to be successful in generating relatively many boardings at the one hand, and a higher average trip occupancy on the other hand. It goes too far in this paper to describe all effective configurations in detail. Simply put, however, the first type includes configurations with articulated buses that are equipped to transport many passengers, whereas the second type includes configurations with (mostly) coaches, with a peak headway of 10 min or shorter during rush hour. As the analysis by Borsje et al. (2022) was based on actual use of higher quality bus concepts in the Netherlands, the question remains to what extent these successful configurations can be explained by passenger preferences.

The vast majority of transport mode choice models are based on random utility theory and use discrete choice models to predict the probability that a certain transport mode is chosen (Rasouli & Timmermans, 2014). This paper puts focus on the preferences of potential and current passengers concerning a set of BRT design dimensions (one transport mode in various forms) and sets out to answer the following two research questions:

(1) Which configurational elements are attractive to passengers when it comes to transport mode choice, and;
(2) Which passenger types are most likely to consider three basic configurations as a serious option to actually use them?

So far, no studies have been found that focus on the attractiveness of various combinations of design elements. Insights in what design and system performance aspects are valued by (potential) passengers can be relevant on one hand for system design, gaining ridership and developing incentive and penalty regimes, and on the other hand, for product positioning and market communication. This paper is directed to find out what general lessons can be learned, after evaluating the importance of various design elements and how these are valued. The article wants to contribute to a shift in the literature from defining BRT systems, and the running controversy in the literature on tram and light rail versus bus and higher quality bus services, to a focus on understanding the key design factors driving success, once the choice for BRT has been made.

2. Attracting passengers

This paper follows the premise that behavioural intention to use - and retain using - a certain mode of transport, is a major prerequisite to gain ridership. Other prerequisites are having sufficient means (time and money) at their disposal, and the presence of a favourable physical environment. This physical environment affects actual travel behaviour through the given transportation infrastructure (including travel speeds, congestion and quality of public transport) on the one hand, and the spatial and temporal distribution of activity opportunities on the other hand (Spears, 2013; Spears et al., 2013).

If more passengers use a BRT system, the performance will be affected. In many, or most cases, increasing ridership affects the ticket sales, yet increasing ridership can also lead to longer dwell times, queuing, overcrowding and possibly unfavourable social safety issues. Therefore the expected usage of the BRT system, should be considered.

2.1. Configurational design choices

Configurations can be seen as the combination of various design choices that are made concerning a (BRT) bus service, in line with the specific desired performance levels and policy goals. Performance levels can for instance be reliability, travel time savings, system capacity, accessibility and comfort (Rabuel, 2009; Diaz et al., 2004). Design choices include choices concerning various aspects, such as service hours, frequency, type of vehicle (including capacity), infrastructural choices (busways, stop type). As stated earlier on, BRT and other higher quality bus concepts are applied to a wide range of bus services. The authors created a typology for BRT which consists of four ideal types.[1] Ideal types are constructs that are meant to create order and assistance in analysing complex phenomena (Weber, 1925, pp. 20–22).

Capacity BRT is the first ideal type. This type typically corresponds with high ridership corridors. With a relatively short – but not too short – stop spacing. This type maintains a balance between offering a high operation speed and stopping nearby the most important origins and destinations. Capacity BRT is effective in high density areas with major social and economic activities. Capacity BRT is, however, more than offering vehicle (boarding) capacity and high-frequency services. Off-board fare collection and offering adequate capacity at stations, platforms and running ways is necessary for the free flow of passengers and vehicles. This metro resembling type can be found in cities like Guadalajara (Mexico), Curitiba (Brazil) and Guangzhou (China).

The second type is *Comfort BRT*. This form is directed at offering comfortable and pleasant travelling. This type distinguishes itself from the other types by offering significantly higher operational speeds, facilitated by a long stop spacing and limiting the number of stops. A lower frequency of service – apart from peak hours – is optional. Some might consider this type as a Branded Bus Service, others might regard this manifestation as an express service. Examples of this intercity type of service are Flixbus (long distance, country borders crossing inside the EU) and RedCoach (USA). Although it can be argued whether these examples are in practice “true” BRT systems, they do intend to improve passenger experience. Crucial for a reliable rapid service are bypassing lanes and or granted permission to bypass on the emergency lanes in case of traffic congestion.

Tacit BRT is offered to enable network reliability. Because regular vehicles and regular stops are used next to resembling conventional bus services, this third, BRT type is unbranded and stays under the radar. High frequencies and segregated bus ways enable a reliable and rapid service within a public transport network. Examples can be found in Pittsburgh (Pennsylvania, USA), Seoul (South Korea) and Twente region (Netherlands).

The fourth type is hybrid since it is budget dominated. Every design parameter is assessed carefully for costs and profits. This may result in fragmentary chosen bus and passing lanes. This so-called *Value-for-Money BRT* is offered in high frequencies of service and is (sub-) branded as BRT. BRT systems that score lower points at the BRT Standard Scorecard (Li & Hensher, 2020).[2] as a result of budgetary restrictions can be seen as a manifestation of this type. BRT Creep, a phenomenon of downgrading the initially intended higher quality due to budgetary pressures during project implementation, is related to this type.

2.2. Behavioural intention

A BRT configuration is a result of design choices in order to achieve certain levels of performance, such as reliability, operational speed and ridership numbers. For the latter, passengers need to choose to make use of the operational BRT system. Behavioural intention is, as being stated before, a prerequisite for actual choice to use a certain means of transport. Behavioural intention is studied in a wide range of disciplines and many factors can be taken into account. To illustrate: psychological (attitude, lifestyle), sensory (scent, seating comfort) and marketing (perception of price and quality) factors can play a role at the individual

[1] An ideal type is a systematic characterisation which is used for understanding and analysis of complex situations. Ideal types introduced by sociologist Max Weber (1925) can be used as conceptual tool to guide and structure comparative research.

[2] For more on the itdp BRT standard see itdp.org and for potential contributors to BRT performance, see Li & Hensher (2020).

level, but also on group or regional level. For developing the questionnaire in this study, the focus is on gathering information on preferences concerning a set of BRT design factors that seem to matter for generating ridership. These factors are: frequency, service hours, stop spacing, reliability, vehicle type, infrastructural issues and branding (Borsje et al., 2022). To identify passenger groups, additional population characteristics are necessary to collect. These aspects matter for market segmentation.

2.3. Population characteristics

For market segmentation, a heterogenous market is regarded as a collection of smaller homogeneous markets. Market segmentation can be seen as an adjustment of a product (or service) and the marketing effort to user requirements (Smith, 1956). And an effective market segmentation strategy can lead to increasing ridership (Elmore-Yalch, 1998). Markets can be segmented in various ways. Most common ways of market segmentation are based on demographics, geographics, psychographics and behaviouristics (Beane & Ennis, 1987). Demographic (such as gender, age, education, and occupation) and geographic segmentation (location, degree of urbanisation) are easy to collect, yet these characteristics do not take into account the needs and wants of individual passengers. Psychographics, the third base for segmentation, include general attitudes, values, opinions, interests, needs, lifestyles, and so on. These psychological characteristics are less clearly definable. Although psychographics might be more difficult to collect, this segmentation possibility is often regarded as more powerful to identify markets and to find explanations for consumer behaviour (Beane & Ennis, 1987; Barry & Weinstein, 2009). The fourth segmentation option, is based on behaviouristics and includes attitudes, knowledge, usage and responses *regarding a certain product or service*. In transit industry, segmenting on usage is synonymous to segmenting based on (frequency of) ridership (Elmore-Yalch, 1998). Additionally, knowledge about, and attitude towards a certain service are other aspects that can be part of this form of segmentation. For BRT, or public transport in general, groups of passengers are identified, that have similarities in characteristics or in needs, and who are likely to exhibit similar travel behaviour and/or responses to changes in marketing efforts. The users – or in the case of BRT, passengers – are grouped in commonalities and shared characteristics, in order to be more effective in offering the service to the right persons, at the right place and time. Earlier research (Outwater et al., 2003) demonstrated six dimensions for mode choice and market segmentation: (1) desire to help the environment, (2) need for time-saving, (3) need for flexibility, (4) sensitivity to travel stress, (5) insensitivity to transportation cost, and (6) sensitivity to personal travel experience. These behavioural patterns are shaped by underlying (psychographic) opinions and orientations, including beliefs, interests and attitudes.

3. Methodology

A Discrete Choice Experiment (DCE) is a research method that determines how people make trade-offs and choices among presented products or services. Respondents are asked to choose between hypothetical alternatives. All presented alternatives have multiple attributes (Ben-Akiva & Lerman, 1985; Louviere et al., 2000). The DCE has been performed to find out what attributes or features are valued above others in order to understand the decision-making process when choosing a transport mode for commuting or other purposes during weekdays. The selection of the included attributes is based on an international literature review and prior research (Borsje et al., 2022). The list of selected attributes and their corresponding levels are presented in Table 1. The attribute levels are based in general on variations that are present in the Netherlands. Although enclosed bus stations are not present, metro stations are. No monetary attribute has been included. Instead, respondents were asked whether they were prepared to pay

Table 1
Attributes and levels for discrete choice experiment.

Attribute	Level 1	Level 2	Level 3	Level 4	Level 5
Running Ways	separated running ways	mix traffic with passing lanes			
Stop type	enclosed stations, like metro	stops with amenities	regular stops without amenities		
Vehicle type	luxurious bus with comfortable seating	regular bus with seating and standing options	extended bus with many doors		
Operating hours	7 days a week: 8:00–0:00	Weekdays 5:30–21:30	Weekdays 6:30–9:30 & 15:00–19:00		
Stop spacing	far (3–15 km), stops infrequently	between 1 and 2.5 km, at important stops	close (400–600m), stops frequently		
Frequency p/h	10	6	4	2	1
Reliability on Arrival	90% or more on time	85–90% on time	75–85% on time		
Branding - colour palette	strongly distinctive	slightly distinctive	regular colouring		

more, if more quality is offered and whether they receive a travel allowance or not.

The DCE questionnaire was programmed in Sawtooth software, using the adaptive choice base variant, the variant that can be applied for studies with five or more attributes. To avoid multicollinearity a randomised choice design has been used. The questionnaire was tested and which led to the shortening of some the initial attribute levels to make them more respondent friendly. The fieldwork has been carried out during December 2019,[3] and in total 1019 Dutch civilians from an extensive research panel, completed the online submitted questionnaire consisting ofthe following sections:

- The questionnaire contained questions on socio-demographic and travel characteristics: gender, age, education, employment, travel behaviour (see Table 2).
- Questions were asked concerning the ownership of vehicles, their opinion on travelling, and their attitude towards public transport (see Table 2).
- To measure user preference, respondents were asked to state their (1) preference concerning individual attribute levels; whether they would (2) consider using in total at least 24 presented configurations (6 × 4) or not; and to (3) choose one of three (or sometimes two) presented configurations that are considered (see Appendix A for examples). Respondents continued to choose until eventually one preferred (winning) configuration was determined. Based on given answers, the utility scores (parameter estimates) were calculated.

The data were weighted on the demographic characteristics age, gender and education to reflect the Dutch population for these characteristics (weight value minimum = 0.94 and maximum 1.57). For the weighted results, see Appendix B.

The use likelihood represents the likelihood the respondent actually going to choose a presented option. This variable is based on given answers to presented alternatives. For data analysis, the use likelihood is coded into five symmetric categories ranging from 'most likely use' to

[3] The fieldwork period took place, two months before the first COVID-19 case was reported in the Netherlands.

Table 2
Explanatory variables used for analysis.

Variable	Abbreviation	Segmentation
Gender (a1)	A1	demographic
Age (a2)	A2_1	demographic
Education level (ha3)	HA3	demographic
Province	provinc	geographic
Regions (=big 3 cities + suburbs + 4 greater regions)	region	geographic
Degree of Urbanisation (address ˆkm)	urban	geographic
Employment (a8)	A8	demographic
Driver's license (q1)	Q1	demographic
Ownership motorised vehicle	HQ2	demographic
Travel distance work/education (q3)	Q3	geographic
Mode usage (q4)	Q4	behaviouristic
Train station at residence (q6)	Q6	geographic
Usage bus, tram and/or metro (q7-1)	Q7_1	behaviouristic
Usage train (q7-2)	Q7_2	behaviouristic
Travel allowance (n2)	N2	demographic
Willing to pay 10% more for a better quality bus (1_1)	N1_1	behaviouristic
Better check in & out at stop to reduce dwelling time (1_2)	N1_2	behaviouristic
An environmental friendly bus is very important to me (1_3)	N1_3	behaviouristic
I prefer to wait a little longer for a more rapid bus (1_4)	N1_4	behaviouristic
I prefer to board a slower bus than to waiting (1_5)	N1_5	behaviouristic
I would like more room in a bus, so I can work on a laptop (1_6)	N1_6	behaviouristic
Travelling by bus is complicated (1_7)	N1_7	behaviouristic
Attitude towards PT (q14)	Q14	behaviouristic
Use likelihood (based on constant alternative).	None	

'most likely not use'.

4. Results

This section presents the estimated Discrete Choice model and the most promising segmentation variables to adjust the service formula and communication efforts to meet passenger preferences.

4.1. Values and preferred attribute levels

A standard Multinomial Logit (MNL) model was estimated. Table 3 presents the model result. The table starts with the constant alternative or the 'none' option. The higher this parameter estimate value, the more difficult it will be to convince respondents, to choose to use a configuration. The parameter estimate of 0.07 indicates that the probability to choose to use a configuration is a little bit lower than not to choose. However, this parameter estimate is not significant (p value 0.3, see Table 3).

All other presented parameter estimates, correspond with individual attribute levels. Based on the range of preference of each attribute, it is possible to calculate the relative importance of each measured attribute. The higher the range within each attribute, the more important the attribute will be. With a range of 3 (i.e. −2.0551 to 1.0357), *frequency* turns out to be the most important attribute in this model. The relative importance of an attribute can be calculated by dividing the range of an attribute, by the sum of the ranges of all attributes. Next to Frequency (39.8%), the three other most important attributes are *Availability* or service hours (20.6%), *Stop spacing* (17.8%) and *Reliability on arrival* (13.8%). The importance found applies to this model only. If other attributes are added or other attribute levels are chosen, the relative importance likely will alter.

The parameter estimates for the attribute *Frequency* indicates that with increasing frequency, the probability to choose to use a configuration increases as well. According to Table 3, the probability to choose to use a configurations also increases when: (1) more service hours are offered (availability), (2) the stop distance is shortened, and (3) the reliability on arrival is improved.

Table 3
Model result.

Attribute [relative importance]	Attribute level	Parameter estimate[a]	p-value
None		0.0714	0.315
Frequency [39.8%]	every 6 min	1.0357	**0.000**
	every 10 min	0.8725	**0.000**
	every 15 min	0.6543	**0.000**
	every 30 min	−0.5073	**0.000**
	every 60 min	−2.0551	**0.000**
Availability: [20.6%]	7 days a week between 6:00–0:00 h	0.7606	**0.000**
	Weekdays between 5:30–21:30 h	0.0784	**0.000**
	Weekdays during rush hours 6:30–9:30 & 15:00–19:00	−0.8390	**0.000**
Stop spacing [17.8%]	distance 3–15 km	−0.8310	**0.000**
	1–2.5 km	0.2815	**0.000**
	400–600 m	0.5495	**0.000**
Reliability on arrival [13.8%]	90% or more in time	0.4687	**0.000**
	between 85 and 90% in time	0.1349	**0.000**
	between 75 and 85% in time	−0.6036	**0.000**
Stop type [3.0%]	Enclosed bus stations	−0.1383	**0.000**
	Stops with amenities	0.0924	**0.000**
	Regular stops without amenities	0.0459	**0.000**
Running ways [2.7%]	busways (dedicated)	0.1049	**0.000**
	mixed traffic and passing lanes	−0.1049	**0.000**
Vehicle type [1.9%]	luxurious bus	0.0705	**0.000**
	regular bus	0.0031	0.762
	articulated bus	−0.0737	**0.000**
Colour palette [0.4%]	very distinctive	−0.0197	**0.001**
	slightly distinctive	0.0095	0.056
	non distinctive	0.0102	0.056

[a] root likelihood (RLH) = 0.681.

The root likelihood (RLH) is a measure of fit between the parameter estimates and the choices made by respondents, to a choice based conjoint questionnaire. A RLH of 1 implies a perfect fit, the worst model would result into a value of 1 divided by the number of alternatives in the choice sets (in this study: 4). The RLH value of 0.681 for this model can be regarded as satisfactory as it is much higher than 0.25.

The four least important attributes according to this model are: Stop type (3.0%), Running ways (2.7%), Vehicle type (1.9%) and the preferred Colour palette (0.4%). The colour palette does not contribute much to the model. Combining the levels of the remaining three attributes with the highest probability to choose to use a bus configuration would imply a service with luxurious buses, making use of busways and stops with amenities. However, the preferred stop spacing of 400–600 m in combination of preferred levels will lead to a seemingly suboptimal service. A frequently stopping luxurious (high floor) bus, at stops with amenities would not only be inconvenient to most passenger, it will also be expensive for the authority.

A high parameter estimate value does not necessarily mean that this level is preferred by all respondents. Table 4 shows a distribution of the most preferred attribute level by respondents. The luxurious bus with the highest parameter estimate is preferred by 21.6% of the respondents; the articulated bus with a negative parameter estimate is most preferred by 12.7%. However, the largest group (48.9%) regards vehicle type as less important.

As described in the introduction, configurations can be capacity oriented (mass transit) or comfort oriented (passenger experience). Another orientation can be the integration of the service into a broader public transport network (see section 2). For this orientation, regular stops and vehicles are part of the service. Table 5 aligns the attribute levels to these orientations. Stop distance and ideal typical frequencies

Table 4
Most preferred attribute level.

Attribute	Attribute level	n = 1019
Frequency	every 6 min	42.0%
	every 10 min	18,0%
	every 15 min	16,9%
	every 30 min	7,7%
	every 60 min	3,8%
	less important	11.6%
Availability	7 days a week between 6:00–0:00 h	56,5%
	Weekdays between 5:30–21:30 h	18,9%
	Weekdays during rush hours 6:30–9:30 &	12,0%
	15:00–19:00 less important	12.6%
Stop spacing	3–15 km	16,4%
	1–2.5 km	25,2%
	400–600m	44,6%
	less important	13.8%
Reliability on arrival	90% or more in time	64,0%
	between 85 and 90% in time	18,8%
	between 75 and 85% in time	8,2%
	less important	8.9%
Stop type	Enclosed bus stations	12,9%
	Stops with amenities	29,5%
	Regular stops without amenities	22,0%
	less important	35.6%
Running ways	busways (dedicated)	41,9%
	mixed traffic and passing lanes	17,4%
	less important	40.7%
Vehicle type	luxurious bus	21,6%
	regular bus	16,8%
	articulated bus	12,7%
	less important	48.9%
Colour palette	very distinctive	7,7%
	slightly distinctive	9,4%
	non distinctive	9,4%
	less important	73.5%

Table 5
Attribute levels and service formula.

Attribute	Comfort	Conventional	Capacity
Vehicle type	Luxurious	Regular	Articulated
Frequency	Every 15 min	Every 10 min	Every 6 min
Stop Spacing	Long (3–15 km)	Short (400–600m)	Medium (1–2.5 km)
Stop type	Amenities	Regular	Stations

are also included in this table.

To identify preferences regarding these configurations, the parameter estimates are combined for each respondent. For these three service orientations, additional choices need to be made concerning service hours, offered reliability and infrastructure.

4.2. *Passenger characteristics and service formulas*

The conventional orientation for a configuration is most preferred: for 47.8% of the respondents, the sum of the corresponding parameter estimates is higher than the other two orientations, which are preferred by respectively 22.8% (comfortable) and 29.5% (capacity) of the respondents. To determine which passenger types are most likely to consider these configurations as a means of transport, the decision tree technique 'CHAID' has been used (Althuwaynee et al., 2014). CHAID stands for chi-square automatic interaction detection. It is a technique that splits a sample into nodes. It can handle a mixture of categorical and quantitative predictors (Vicente et al., 2020). The output is a visual: a tree with branches which represent the predictors and discriminate groups. It presents the most important segmentation variable(s). If a tree becomes too big, interpretation is more difficult.Nodes are separate, distinct segments form which the variation of the response variable is minimised within the segments and maximised among the segments (Althuwaynee et al., 2014).

To perform this procedure, all variables mentioned in Table 2 were used for the analysis to identify passenger types who are most likely to consider one of these three orientations. Of all entered variables, the likelihood to choose a configuration turns out to be the most important variable that predicts the user preference for a service formula. As can be seen in Fig. 1a, two thirds of the respondents (68.3%) that most likely are not going to use an offered service formula (node 3 on the right) prefer the conventional service formula. This segment represents 17.7% of all respondents. The preference for the conventional service formula is much lower among the respondents who are likely to choose a configuration (38.6% and 47.1%, respectively).

The results have been cross validated. The data have been split into 25 random sample folds (or groups) to validate the result (Groot, 2018). The decision tree as presented explains 53.7 percent of the variance after cross validation.

Fig. 1a visualises the top of the decision tree only. Among the respondents who are probably or most likely to choose a configuration are some subsegments to pinpoint. Those who prefer more room to work in a bus prefer either a capacity (41.2%) or a comfortable (31.4%) to a conventional service formula (see Fig. 1b). And those who do not prefer this room can be split into those with and without a car. The comfortable formula seems more popular in the first group, and the capacity variant in the latter group (see Fig. 1b).

The comfortable service formula seems more popular among male respondents in node 2, especially under respondents living 5 km or more from their work (see Fig. 1c).

For female respondents who might or are probably not going to choose a configuration, the degree of urbanisation is a factor. Women living in denser communities (>1500 addresses per square kilometre) prefer a capacity service formula, and those in less denser communities prefer the comfortable formula (see Fig. 1c).

Fig. 1c splits the respondents who probably not going to use a configuration (node 3), based on gender in two. The conventional service formula turns out to be more popular among women. Over 80% of the women, who are most likely not going to choose a configuration, prefers a conventional service formula. A gender difference in preference occurs also among respondents who might use or probably not use a configuration.

A separate CHAID analysis is performed with two adaptions. The first adaption is excluding the likelihood to choose variable, and the second, is a forcing a variable to be in the first nodes. This first variable contains four types of respondents: those who travel by public transport (1) without and (2) with a motorised vehicle (mv); those who do not travel by public transport who have a (3) positive and a (4) negative attitude towards public transport.

Based on their profiles, the decision tree automatically merges groups 2 and 3 into one group. In other words, public transport passengers with a motorised vehicle and non-public transport passengers that have a positive attitude towards PT are treated as one group. The decision tree (for visualisation, see Appendix C) gives the following results:

- Two thirds of the antagonists (travellers with a negative attitude towards public transport and who do not use it) prefer the conventional service formula. This group represents 6.8% of the population.
- Gender differences are found in those who use public transport and who do not own a motorised vehicle. Men more often prefer the capacity formula (38.0%; conventional: 39.2%) and women more often prefer the conventional (56.9%) and less often prefer the comfortable formula (10.6%).
- For the merged group (type 2 and 3), the educational level is an important factor. The medium and higher educated less often prefer

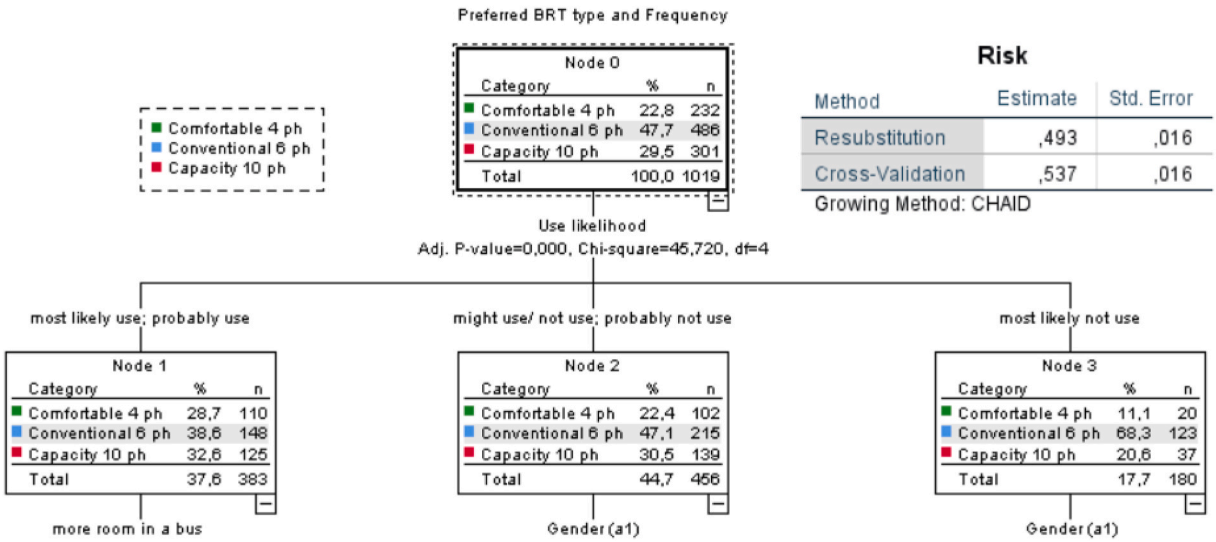

Fig. 1a. Decision tree preferred service formula (part 1 of 3).

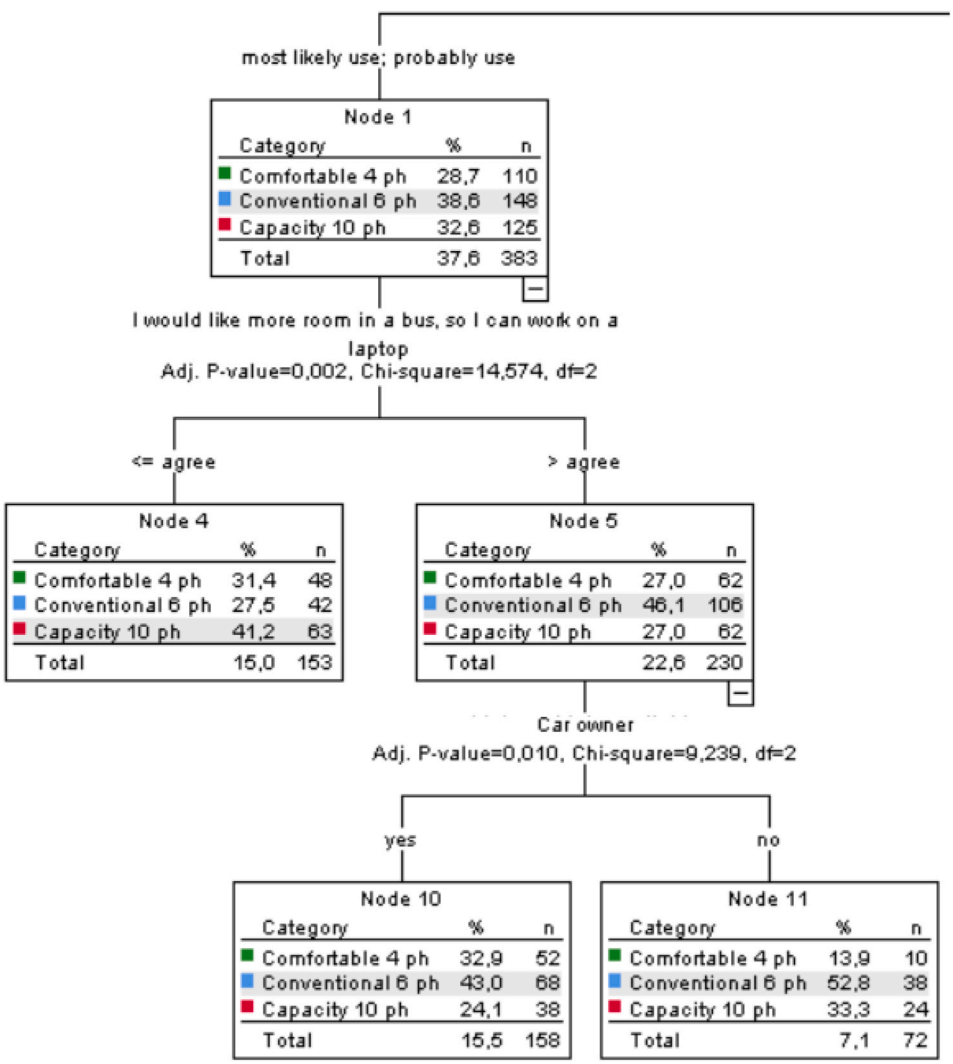

Fig. 1b. Decision tree preferred service orientation (part 2 of 3).

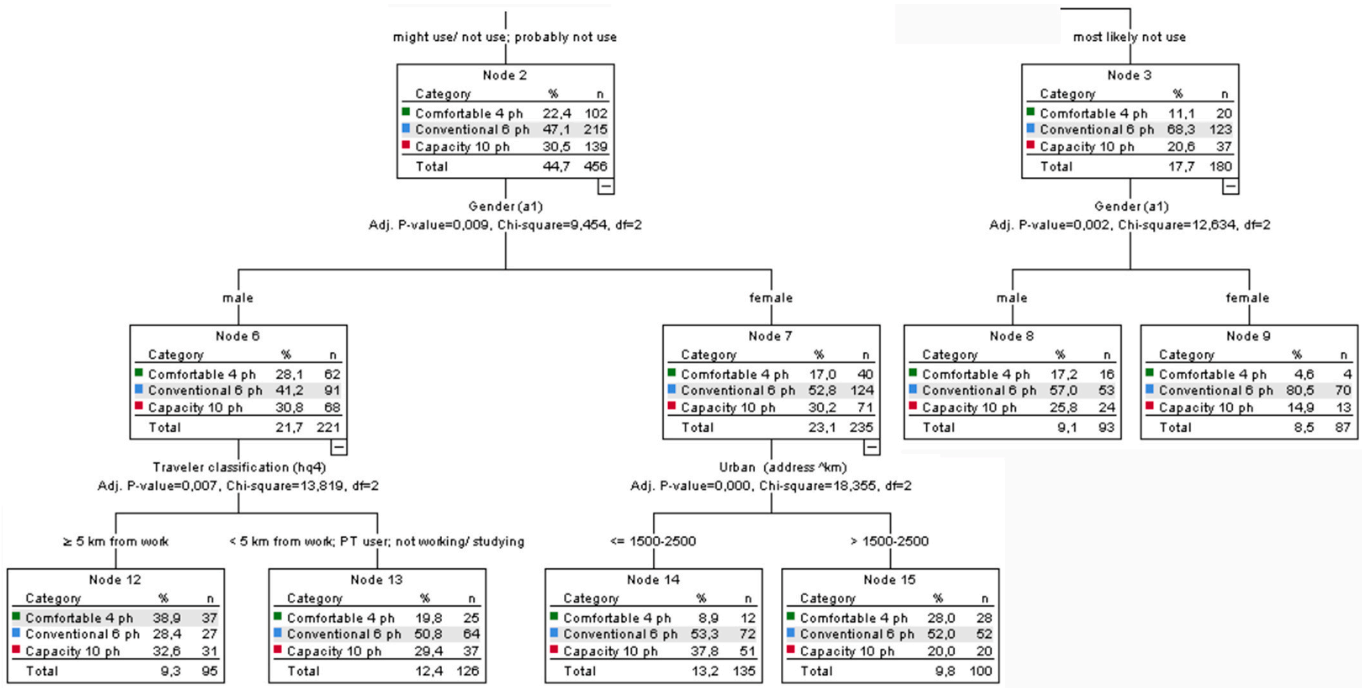

Fig. 1c. Decision tree preferred service orientation (part 3 of 3).

the conventional type (41.5% and 55.7%, respectively). This preference decreases for those in favour of more room to work in a vehicle (34.0%). Those who do not opt for more room can be split in those who find public transport complicated and not. Those who find it complicated prefer the comfortable service formula; the preferences for those who do not find travelling by PT complicated are similar to the entire population (=node 0 in Fig. 1a and the top box in Appendix C).

5. Discussion

The results of the performed discrete choice experiment underline the importance of frequency, service hours, stop spacing and reliability to (potential) passengers. Apart from stop spacing, all of these design dimensions are generic and generally important for any mode of public transport. Higher frequencies, more service hours and more reliable service will generally be appreciated from the passenger perspective. At the same time, offering these more favourable characteristics will lead to higher costs. Stop spacing distinguishes itself from the other three: one cannot say the shorter the stop spacing the better. Although the model results support this statement, the chosen stop locations need to make sense. In practice, the situation at hand will determine the design choices for a BRT or bus service.

The model result suggests one best configuration, but the market for public transport services turns out to be heterogeneous. This study demonstrates this market consists of different segments with each their own preferences. This is demonstrated to compare the preferences regarding comfortable, conventional and capacity service formulas. In this stage, the segments found are based on characteristics like gender, education, urbanisation and car ownership. Some segments are formed by preferences for more room to work or by the perception that travelling with public transport is complicated. More research is needed to find psychographic characteristics that help to predict and understand these preferences.

Based on this study, potential passengers prefer different product formulas. This suggests that different service formulas might be offered on the same corridor. On board comfort seems to be increasingly more important with longer travel times (Hansson et al., 2019). Additional research is needed to confirm or reject this presumption. Since this study is based on a written questionnaire, it might be difficult for (some) respondents to visualise the various options. An appealing luxurious bus for one respondent might not be attractive to the other. Future research should preferably done with visuals of vehicles, interior and stops.Pilot testing before quantitative research should be considered.

More conventional service formulas seem to be more appealing to women, and comfortable formulas to persons (mainly men) that favour more room in a vehicle to work. A higher frequency capacity formula is more preferred by men living at least 5-km from their work location and by women living in a less urbanised area.

6. Conclusions and policy implications

This paper presents various preferences of (potential) passengers concerning a set of BRT design dimensions. Frequency, service hours, stop spacing and reliability turn out to be the four most important attributes in the presented discrete choice model. The attributes vehicle type, stop type, running ways and colour palette are perceived as (far) less important. A selection of attribute level combinations was made, to measure preferences concerning three distinctive service formulas: Comfort, Capacity and Conventional BRT. These three service formulas turn out to attract different types of passengers. The findings can either be used to develop service formulas which are attractive to different market segments, or be used to communicate more effectively about existing service formulas to attract (more) passengers. Characteristics such as gender, urbanisation, travel distance to work, education and car ownership, can be used to identify promising market segments. Additionally, the preference for more room in the vehicle to work and the experienced complexity to travel with public transport can be used to determine market segments. Applying the presently gained insights might improve the effectiveness in marketing communication, and aid in prescribing certain service formulas for tender documents.

CRediT authorship contribution statement

René Borsje: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft. **Suzanne Hiemstra-van

Mastrigt: Writing – review & editing, Supervision. **Wijnand Veeneman:** Conceptualization, Supervision, Project administration.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: R. B. Borsje reports financial support was provided by Kennisplatform CROW. The online research has been funded without any conditions or interference by Kennisplatform CROW, the Dutch national Expertise Platform for Traffic and Transport.

Data availability

Data will be made available on request.

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Appendix A

Examples of the questions in this Discrete Choice Experiment

Screening section. At least 24 configurations (6 × 4) are presented to the respondent with the question whether they would consider to use the configuration or not.

Example of 1 of the screening (with i-text)

Which of the following bus services would you consider or not?

Bus uses	Busways	mixed traffic with passing lanes	busways	mixed traffic with passing lanes
With a stop distance of	1–2.5 km	400–600 m	3–15 km	400–600 m
Vehicle departs every	10 min	10 min	15 min	30 min
Transport is offered	weekdays from 6:30–9:30 & 15:00–19:00	weekdays from 5:30–21:30 u	7 days a week from 6:00–0:00	weekdays from 6:30–9:30 & 15:00–19:00
Punctuality at arrival	90% or more	between 85 and 90%	between 75 and 85%	between 75 and 85%
	○ would consider	○ would consider	○ would consider	○ would consider
	○ would not consider	○ would not consider	○ would not consider	○ would not consider

Choice tasks. In the next step the respondents who do consider more than one configuration, have to choose one of three (or possibly two) presented configurations. The respondents continue to choose until eventually one preferred configuration has been determined.]

Example of choice procedure.

Which of the following bus services do you prefer?

Bus uses	mixed traffic with passing lanes	Mixed traffic with passing lanes	mixed traffic with passing lanes
With a stop distance of	400–600 m	1–2.5 km	400–600 m
Vehicle departs every	30 min	30 min	15 min
Transport is offered	7 days a week from 6:00–0:00	7 days a week from 6:00–0:00	weekdays from 6:30–9:30 & 15:00–19:00
Punctuality at arrival	90% or more	between 85 and 90%	between 75 and 85%
	○	○	○

Appendix B

Table B.1
Compiled results questionnaire (explanatory variables)

Gender (0.1)	male	49.3	female		50.7
Age (0.2)	Mean (48.6)	Min. (18.0)		Max. (86.0)	Median (50.0)
Education (0.3)	Lower (29.1)		Medium (42.8)		Higher (28.1)
Location (0.6)	Groningen	4.5			
	Friesland	3.7			
	Drenthe	3.0		North	11.1
	Overijssel	5.4			
	Gelderland	10.9			
	Flevoland	3.4		East	19.7
	Utrecht	5.9	suburbs		3.9
	Noord-Holland	16.1	3 major cities		12.5
	Zuid-Holland	22.7	West (excl. major 3 and suburbs)		28.3
	Zeeland	2.0			24.4
	Noord-Brabant	13.9			
	Limburg	8.5		South	

(*continued on next page*)

Table B.1 (*continued*)

Urbanisation (0.7)	>2500 (25.9)	1500-2500 (32.0)	1000-1500 (14.3)	500-1000 (19.2)	<500 (8.7)
Daily activity (0.8)	entrepreneur	7.7		unemployed	3.9
	on payroll	44.2		retired	18.7
	civil servant	4.2		unfit for work	8.4
	student	5.4		homemaker/other	7.4
Drivers license (q1)	yes	83.9		no	16.1
Available means of transport (q2)	car	78.8		motor	6.4
	bicycle	73.7		moped	5.6
	e-bike/e-scooter	26.7		mobility scooter	1.6
	scooter	8.9		other	0.6
Distance to work/study (q3)	no work/study	38.5		25–35 km	5.2
	<5 km	16.1		35–50 km	4.4
	5–15 km	21.3		50–100 km	2.8
	15–25 km	11.0		>100 km	0.8
Mode usage to work/study (q4)	mostly PT (OV)	10.4		mostly other vehicle	1.7
	mostly car/motor	28.7		mostly work from home	1.1
	mostly (e) bike	16.8		other	0.3
	mostly walking	2.5		no work/study	38.5
Explanation mode choice (q5)	most rapid	24.5		healthiest	8.5
	easy	20.5		environment friendly	8.1
	more comfortable	11.6		cosier/more fun	1.9
	used to it	11.4		safer	1.9
	inexpensive	10.5		more prestige	1.1
Train @ dest (q6)	two or more (23.0)		one (21.1)	none (17.5)	no work/study (38.5)
Usage PT (q7)	daily (11.5)	weekly (14.6)	monthly 21.0)		less often (34.9) never (18.0)
-bus,tram, metro	daily (8.8)	weekly (13.1)	monthly 18.3)	yearly (23.6)	less often (13.6) never (23.5)
- train	daily (6.7)	weekly (9.6)	monthly 17.8)	yearly (28.2)	less often (14.8) never (23.0)
Trav allwnce (q8)	from government (4.9)		from employer (27.8)	no allowance (23.5)	no work/study (38.5)

Table B.2
Response to statements and attitude

Statements (q13)	strongly agree	agree	disagree	strongly disagree
I am willing to pay 10% more for a better quality bus	7.1	32.2	44.4	16.3
In favour of checking in & out at stop to reduce dwelling time	16.3	64.7	16.3	2.7
An environmental friendly bus is very important to me	17.3	56.2	20.7	5.8
I prefer to wait a little longer for a more rapid bus	7.3	46.4	42.7	3.6
I prefer boarding a slower bus to waiting	10.5	55.8	30.1	3.7
I would like more room in a bus, so I can work on a laptop	8.4	30.9	47.1	13.6
Travelling by bus is complicated	10.1	33.3	44.1	12.5
Attitude towards PT in the Netherlands (q14) — very positive	5.9	negative		9.6
positive	41.3	very negative		3.8
neutral	36.5	dont know		2.9

Table B.3
Preferred configurational elements by respondent type

Preferred level of service	Traveler classification (hq4)	not working/studying (n = 392)	PT user for work/study (n = 106)	non PT user for work/std. (n = 521)	Total (n = 2019)
Type running ways (q21)	Busway	70.9	67.9	61.6	65.8
	mixed traffic and passing lanes	29.1	32.1	38.4	34.2
Stop type (q22)	enclosed stations with metro like access	13.0	17.9	15.9	15.0
	stops with amenities	51.3	48.1	44.1	47.3
	regular stops without amenities	35.7	34.0	39.9	37.7
Stop spacing (q23)	large (3–15 km)	12.5	27.1	26.3	21.1
	medium (1–2,5 km)	53.3	47.7	54.7	53.4
	short (400–600 m)	34.2	25.2	19.0	25.5
Vehicle type (q24)	luxurious with seat comfort	31.3	34.9	30.7	31.4
	regular bus with seats and standing room	49.9	49.1	54.7	52.3
	articulated bus with many doors	18.8	16.0	14.6	16.4
Branding (q25)	own branding and distinctive colour	41.1	26.4	40.1	39.1
	sub branding, slighty distinctive colour	30.4	49.1	33.8	34.1
	no branding, non distinctive color	28.6	24.5	26.1	26.9
Frequency (q26)	6 min (10x/h)	15.3	25.7	15.2	16.3
	10 min (6x/h)	31.6	40.0	33.0	33.2
	15 min (4x/h)	36.9	25.7	40.3	37.5
	30 min (2x/h)	13.7	7.6	9.6	11.0

(*continued on next page*)

Table B.3 (*continued*)

Preferred level of service	Traveler classification (hq4)	not working/studying (n = 392)	PT user for work/study (n = 106)	non PT user for work/std. (n = 521)	Total (n = 2019)
	60 min (1x/h)	2.5	1.0	1.9	2.1
Availability (q27)	7 days a week (6:00–0:00)	63.0	57.5	53.6	57.6
	working days (5:30–21:30)	26.8	26.4	31.7	29.2
	working days (6:30–9:30 & 15:00–19:00)	10.2	16.0	14.8	13.2
Reliability on arrival (q28)	90% or more on time	65.6	67.9	64.5	65.3
	85–90% on time	31.8	28.3	30.9	31.0
	75–85% on time	2.5	3.8	4.6	3.7

Table B.4
Least important characteristics by respondent type

Traveler classification (hq4) Least important characteristics (q9)	not working/studying (n = 392)	PT user for work/study (n = 106)	non PT user for work/study (n = 521)	Total (n = 2019)
Branding and colour palette	77,0	72,6	71,0	73,5
Vehicle type	47,2	52,8	49,3	48,9
Type of running ways	41,6	43,4	39,3	40,6
Stop type	37,2	35,8	34,5	35,7
Stop spacing	15,1	12,3	13,2	13,8
Availability (service hours)	12,0	16,0	12,3	12,6
Frequency	11,2	10,4	12,1	11,6
Reliability on arrival	8,4	9,4	9,2	8,9

Table B.5
Statistics for part-worth utilities

	Mean	Minimum	Maximum	Median
Root likelihood	0,6810	0,4302	0,9704	0,6865
Choice likelihood (constant alternative)	0,0714	−5,8059	5,9367	0,0738
Number of Parameters	26	26	26	26
Busways	0,1049	−1,2556	1,7337	0,0000
Mixed and passing lanes	−0,1049	−1,7337	1,2556	0,0000
Enclosed stations	−0,1383	−1,9537	1,1795	0,0000
Stops with amenities	0,0924	−1,0248	1,2513	0,0000
Stops without amenities	0,0459	−1,0452	1,2210	0,0000
3–15 km	−0,8310	−5,2981	4,2338	−0,4313
1–25 km	0,2815	−2,0526	3,3487	0,1316
400–600m	0,5495	−4,9887	6,1088	0,2010
10x p/h	1,0357	−2,3224	5,0312	0,8417
6x p/h	0,8725	−1,8467	3,6523	0,7696
4x p/h	0,6543	−1,6314	3,0816	0,5575
2x p/h	−0,5073	−3,4343	2,6248	−0,3434
1x p/h	−2,0551	−6,6977	2,4115	−1,7158
Luxurious	0,0705	−1,3405	1,8764	0,0000
Regular	0,0031	−1,6338	1,8084	0,0000
Articulated	−0,0737	−1,7064	1,1401	0,0000
Own branding	−0,0197	−1,1624	0,8849	0,0000
Sub branding	0,0095	−1,0087	0,8749	0,0000
No branding	0,0102	−1,0302	1,0107	0,0000
7 days a week	0,7606	−3,1829	4,9133	0,5029
weekdays	0,0784	−1,8458	2,0038	0,0000
rush hours	−0,8390	−4,5218	2,6535	−0,5691
90% or more on time	0,4687	−1,6748	2,7038	0,3889
85–90% on time	0,1349	−0,8468	1,3320	0,1046
75–85% on time	−0,6036	−3,0661	1,5691	−0,5203

Appendix C

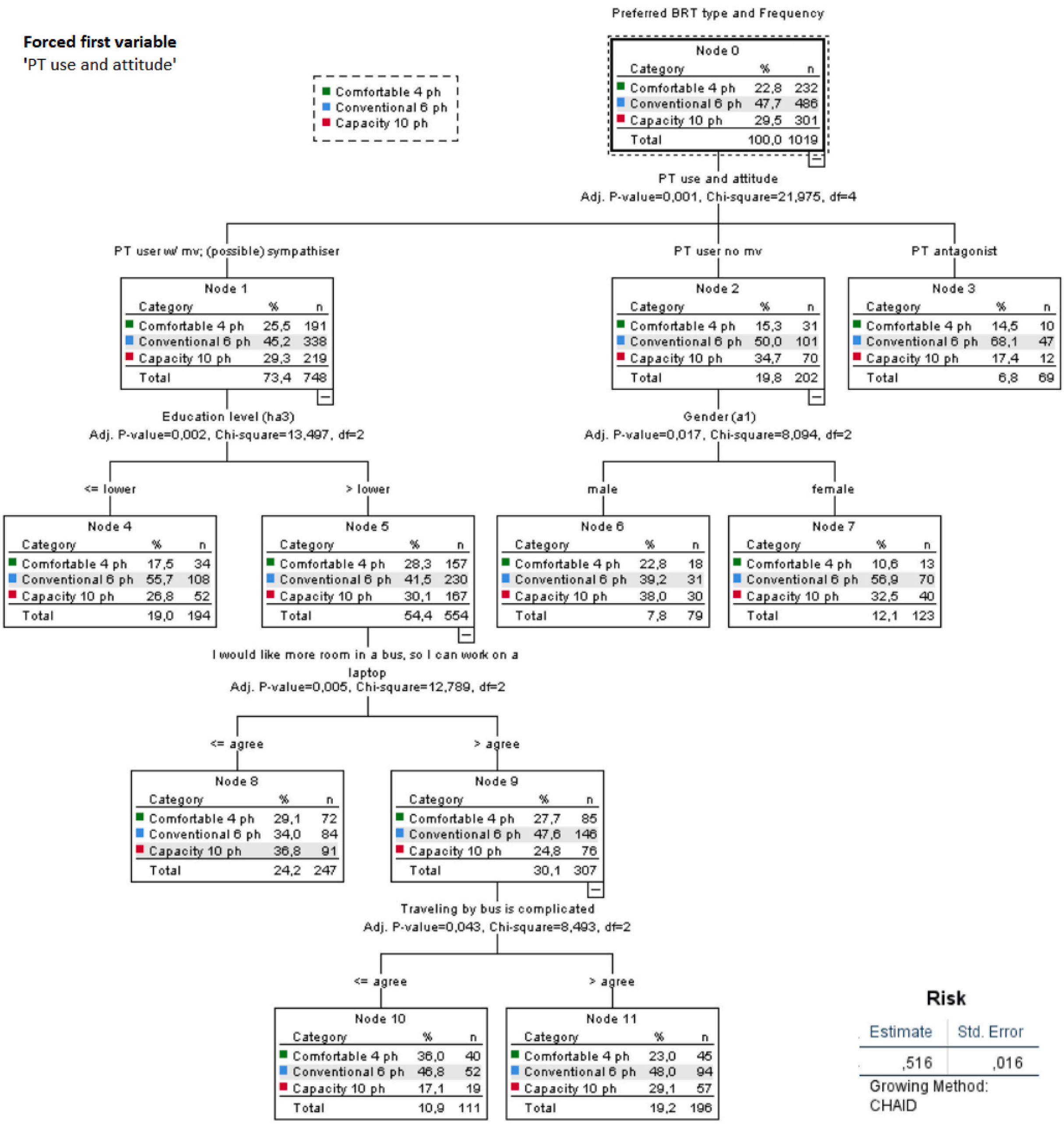

Fig. C.1. Decision tree with forced first variable
Cross validation is not available, when a first variable is forced.

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