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Mobility surveys and sustainable policies in universities

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The obligatory mobility patterns of the university community are analysed, in this case for the University of Burgos (Spain). The study is based on a survey that gathered data of a personal nature and data on daily journeys made by the university community. The mobility survey was conducted with over 2500 interviewees at the University of Burgos (students, teachers and other personnel). Outgoing and incoming journeys to each study centre and the modal split are analysed. The motives for using each transport mode that were given by the university population in reply to the questionnaire are also studied. Various discrete choice models are calibrated to determine how to improve demand for sustainable modes of public transport, in the search for a new scenario that would offer a better quality of life. On that basis, different action plans are proposed, comparing the reduction of carbon dioxide emissions, energy consumption and occupation of the urban area, among other points. The results will be useful for urban public transport planners and for the implementation of strategies to incentivise more sustainable modes of transport.

1. Introduction

The aim of the present paper is to analyse the obligatory mobility patterns of a university community, in this case the University of Burgos (Spain). The journeys made by the university community, which represent a high percentage of total daily journeys in the city of Burgos, are the principal motivation for the study. One relevant characteristic is that they all have points of departure and destinations in common, hence the importance of identifying and studying them in a detailed way.

The context of this case study involves around 9000 people who travel every day to and from the University of Burgos; this figure includes students, teachers and administrative staff, who together represent almost 10% of the active population of the city. The university population, workers and students, travel daily to their respective places of work/study, generating a large number of trips that add to the rest of the daily urban journeys in the city of Burgos.

Burgos University has eight centres that are located on two campuses, as described below; this also influences the mobility patterns under investigation.

- The Río Vena campus is located in the city centre and comprises the university school of tourism and some of the buildings of the higher polytechnic school.
- The San Amaro campus is situated on the western periphery of the city and comprises the faculties of law, humanities and education, sciences, business and economic sciences, the remainder of the buildings of the higher polytechnic school, and the university schools of labour relations and nursing.

A clear assessment must be made of present-day mobility patterns and possible future demand, with a view to understanding the impact arising from journeys made by university students and staff, as well as the adoption of measures to improve the present situation.

The methodology is based on a survey that gathered data of a personal nature and data on the journeys made by the university community. The mobility survey was conducted with over 2500 interviewees at the University of Burgos (students, teachers and other personnel). Outgoing and incoming journeys to each study centre and the modal split were both analysed. The questionnaire was also designed to

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elicit the motives of the university population for using each transport mode.

Various discrete choice models were calibrated to determine how to improve demand for sustainable modes of public transport, in the search for a new scenario offering a better quality of life. On that basis, different action plans were proposed, comparing the reduction of carbon dioxide (CO_2) emissions, energy consumption and occupation of the urban area, among other points. The contribution of the study relates to the utility of its results for urban public transport planning and for the implementation of strategies to incentivise more sustainable modes of transport.

2. Methodology

Alternative modes of travel to private motor vehicles, such as public transport, the bicycle and car-pooling, and their promotion are needed in practically all cities with a significant mass of students. Trial projects have been proposed to lower fares on public transport for students (Boyd *et al.*, 2003), and to issue special transport service passes (Myers *et al.*, 2006). The need to promote modes of transport by bike and on foot through specific training imparted at universities has also been analysed (Dill and Weigand, 2010).

The promotion of car-pooling, in all of its variant forms, is an aspect that has often been studied. Zheng *et al.* (2009) described a method for the estimation of car-pooling at the university of Wisconsin–Madison. Novel proposals have even arisen, such as the introduction of automated people movers, through the use of personal rapid transit (PRT) systems (Young *et al.*, 2004).

Other types of studies focusing on university mobility are based on mobility surveys conducted with students and staff. Thus, Marzoughi (2011) asked first-year students at the University of Toronto about their habitual travel patterns, and Galdames *et al.* (2011) consulted teaching and research staff. Alemu and Tsutsumi (2011) analysed factors that influence the decisions of high school students in Okinawa on how to travel to school. Among Spanish studies on the same theme, Bilbao and Fernández (2004) may be cited; they employed hierarchical logit type models for the simulation of modal choices at the University of the Basque Country and the University of Deusto.

As pointed out above, the university community represents about 10% of the working population of Burgos that travel to work/study daily. Accurate estimation of their transport behaviour is therefore necessary for any planning study that seeks to incentivise public transport and the bicycle at the expense of private motor vehicles.

To do so, three phases were followed, as explained below. In the first place, data collection was carried out through personal surveys of revealed preferences (RPs) and stated preferences (SPs). Then, using the data gathered from these surveys, the mobility patterns of the university community were identified and the influence of the different transport service variables on interviewee modal choice was analysed. Different discrete choice models were tested, from which those with the best results were selected. Lastly, the estimated transport model splits were calculated through fitted models, by applying the sample enumeration method.

2.1 Data collection

In the present case, the data collection stage was the first phase of the study, involving an exhaustive mobility survey of all staff and students at the University of Burgos. Its laborious design finally resulted in an extensive questionnaire covering three pages, to gather the largest possible amount of data.

The first page gathered information on the survey respondents, as well as the habitual characteristics of their journeys, through RP questions. These contributed data on the habitual behaviour of individuals with regard to their journey decisions, and their motives for making regular use of private motor vehicles, the bus and the bicycle in their journeys to and from the university.

The SP questions in this experiment appear on the second page. The survey respondents were asked about the transport mode they would use in certain hypothetical situations or scenarios that were described to them. Three distinct scenarios were prepared, comparing the private motor vehicle with another more sustainable option. They were all completed by choice procedures, a useful tool that is rapid and simple for interviewees.

Three variables were introduced into the experiment for the private motor vehicle, common to all the survey questions: cost and journey duration and extra cost for parking. Moreover, each sustainable mode under consideration was defined by its specific attributes (the same but with different values for car-pooling; access, waiting and travel times, and bus fares; and journey time, length of bike lanes, type of bike park, hire systems and possible discounts for the bicycle). By means of fractional factorial design (Kocur *et al.*, 1982), 27 scenarios were proposed to include in each of the three surveys, which would then be divided into blocks of nine situations to present to each respondent. In total, three blocks were prepared for each survey in the experiment, so as to obtain 27 different survey versions. These were distributed correlatively and at random, to ensure their even and homogeneous distribution throughout the sample.

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Finally, the third and last page covers an exhaustive survey of the travel diary type. Here inquiry was made into the daily journeys either to or from the university during a working week, specifying the chosen mode of transport, the departure point/destination and the range of travel times. Thus, information was gathered on the mobility patterns of all working days in the week instead of on one single day, with the resulting advantages as indicated by Stopher *et al.* (2008).

The surveys were conducted at the University of Burgos during the months of November and December 2008, and January 2009. In total, 2380 surveys were conducted with the student community and a further 339 with members of teaching and research staff and administrative and services personnel. At the time of the survey, there were a total of 7900 students and 1002 administrative and services personnel and teaching and research staff, which gave sampling errors of 1·7% and 4·3%, respectively.

Considering the specific distributions at each centre and even though the errors arising in some of them may be considered inadmissible when total data is employed, it may be confirmed that a practically imperceptible error emerges. Table 1 shows the list of surveys at each study centre, in comparison with their population.

2.2 Discrete choice modelling techniques

The choice of one or another transport mode by the user depends on different convergent factors: the personal circumstances of each individual, together with the specific characteristics or attributes of the available alternatives. Reviewing the existing literature, it is possible to find studies that apply what is commonly known as the 'theory of planned behaviour' (Bamberg *et al.*, 2003; Fuji and Kitamura, 2003) to estimate the effect of certain actions to incentivise public transport.

The most abundant studies over recent years, however, are those based on discrete choice techniques. There are examples that have employed hierarchical logit type (Ortúzar, 1983) or even probit type models (Kim *et al.*, 2003), to model the choice of mode in obligatory mobility. Finally, the study by Hensher and Reyes (2000) is also highlighted; they conceived of a useful method to employ multinomial, hierarchical and mixed logit models with random parameters, to model the impedance associated with modal interchange. Also, Rojo *et al.* (2011) employed ordered logit and probit models to analyse how users evaluate quality in bus services.

Models of user modal choice have conventionally used discrete choice techniques, including the multinomial logit (MNL) model, owing to its simplicity and promising results. The present study followed this methodology, using linear type utility functions from the data on both RPs and SPs. Thus, the functions that represent the utility of alternative i for a particular individual q, U_{iq}, are composed of two parts: a systematic V_{iq}, composed of k monomials resulting from the product of the parameters θ_{ikq} multiplied by attributes x_{ikq}, and another random ε_{iq}, which includes the errors of the model (Ortúzar and Willumsen, 2008; Train, 2003). Users will choose the alternative that offers greater utility (Domencich and McFadden, 1975).

School/Faculty	Students			Admin. services/teaching staff		
	Population	Sample	% error	Population	Sample	% error
Sciences	251	114	6·8%	110	45	11·2%
Economics	1027	309	4·7%	210	78	8·8%
Law	486	159	6·4%	99	14	24·3%
Humanities	2022	591	3·4%	173	42	13·2%
Higher polytechnic school Vena	1294	352	4·5%	159	42	13·0%
Higher polytechnic school San Amaro	2399	699	3·1%	202	79	8·6%
Nursing	217	86	8·2%	22	19	8·3%
Labour relations	133	35	14·2%	16	11	16·5%
Tourism	71	35	11·8%	11	9	13·9%
Total	7900	2380	1·7%	1002	339	4·3%
Total (students + administration services/ teaching staff)	8902	2719	1·6%			

Table 1. List of surveys at each study centre

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1.
$$U_{iq}=V_{iq}+\varepsilon_{iq};\quad V_{iq}=\sum_{k}\left(\theta_{ik}\;x_{ikq}\right);\quad P_{iq}=\frac{e^{\lambda V_{iq}}}{\sum_{A_i\in A(q)} e^{\lambda V_{iq}}}$$

3. Application and results

In this section, the mobility patterns in the sample are studied. Subsequently, the principal calibrated models on the basis of the survey data will be presented, on which basis the future transport modal splits may be estimated under various improvement scenarios. Finally, the estimated values of the impacts on the sustainability of the proposed actions will be shown.

3.1 Statistical analysis

Analysis was carried out of the responses from students and other personnel interviewed in the survey to the questions on personal data in the first part of the questionnaire. There are slightly more male than female respondents among both students and other personnel. With regard to age, the most common segments are students below 20 years old and teaching staff and administration and services personnel between 41 and 55 years.

Family units with four or more members constituted the most common family size, with two private motor vehicles. 70% of students and 95% of all personnel held a driver's license, but only 40% of the former can habitually use a private motor vehicle, as against 87% of the latter. With regard to the availability of bicycles, 70% of students and 55% of workers affirm that they have one. Finally, the most frequent travel time to the university was between 11 and 20 min, the population in general being uniformly distributed across the different areas of the city.

Subsequently, an analysis of the hourly and daily distribution of journeys to and from the university was completed. Figure 1 depicts that distribution for incoming (travelling to study centres) and outgoing (starting from the centres) journeys.

It can be seen that any day may be considered typical except Friday, which has fewer journeys than the other working days. This difference between Fridays and the other working days is much higher in the case of students.

Furthermore, a model of travel emerges with four peak periods. There are two peaks in the morning period, one incoming between 8:00 and 10:00 hours and another, outgoing travel, between 12:00 and 14:00 hours. Incoming travel constitutes the afternoon peaks between 14:00 and 16:00 hours and outgoing between 20:00 and 22:00 hours. Breaking down the analysis by centres, the distributions continue to show the aforementioned peaks, but they are not homogeneous between each other, as they are governed by their own hours.

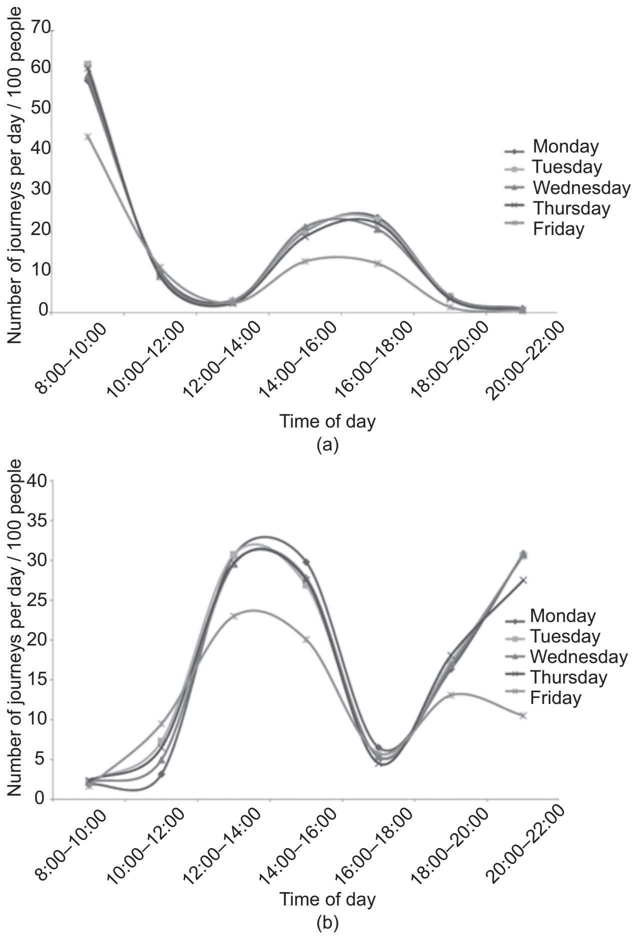

Figure 1. Temporal distribution of trips: (a) to the university; (b) from the university

Moreover, analysing the modal transport split of trips to and from the university, it may be noted that, for the students, the bus is the majority mode (34·0%), followed by the private motor vehicle (grouping those that travel alone with those that share cars yields 32·6%), journeys on foot (28·6%), and finally bicycle trips (4·1%). By contrast, the predominant mode for teaching, administration and services personnel is very clearly the private motor vehicle (63·3%), followed by journeys on foot (21·8%), and to a lesser extent by bus (6·1%) and by bicycle (5·5%).

Respondents that do not use the car to travel to the university affirm that they do not because they do not own one, because of parking problems, and because of ecological questions. Contrarily, those that drive point out that the car is a rapid, comfortable and flexible mode of transport.

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Among the motives indicated for using the bus are convenience, an acceptable route and, for students alone, the economy, whereas the principal dissuasive reasons for not using the bus are excessive travel time and inflexible timetables.

Lastly, with regard to the bicycle, the most common motive for its use is that it is a pleasant and healthy mode of transport, whereas adverse weather and insecurity on the road stand out as negative factors.

3.2 Modal choice modelling

Considering the linear utility functions described in the earlier chapter, the estimators of the parameters were obtained with the maximum likelihood method (Ortúzar and Willumsen, 2008), yielding the values shown in Table 2. Furthermore, the values of the t-statistic associated with each attribute are also shown, related to their level of confidence (values of over 1·96 indicate a confidence level above 95%).

In the model fitted with RP data, the available modes of transport were car, bus, bicycle and on foot, whereas the SP model had private motor vehicle (car), car-pooling, bus and bicycle. With regard to the dummy variables reflecting the personal data of the respondent, these include: the availability of a car (1 if affirmative and 0 if negative); whether the interviewee works or studies (1 if a student and 0 if a worker); income levels (1 for families with monthly income below €3500 and 0 for above €3500); and gender (1 if male and 0 if female). The other variables are related to each transport mode: travel time expressed in minutes, the cost (€), the existence of bicycle lanes as a percentage with respect to the total distance of the journey, and the hire system as a dummy variable (1 for the present system and 0 for improved ones). Both models are of the MNL type and use linear utility functions.

Basically, prediction success rates were employed in order to choose which model to use for the estimation of the effects of the improvement actions. Thus, according to the first preference recovery (FPR) test (Ortúzar and Willumsen, 2008), the RP and SP models were fitted to observed reality at 62·1% and 61·2%, respectively. If the normalised indices of success are considered (Ortúzar, 2000), values of 0·394 for the RPs and 0·413 for the SPs model may be given.

Thus, given the great similarity between both models, a priori any of them could be selected. However, with regard to the normalised indices, the SP model shows a better fit than the RP model. It also contributes a greater number of variables with which to explore possible proposed actions. This model would therefore be chosen to obtain the results of the estimated modal transport split when acting on the transport system.

3.3 Proposed actions

Applying the discrete choice model calibrated earlier on the basis of the SP data, the effects of various possible actions were determined on the actual modal split. The results for some of the proposals under analysis are shown in Figure 2, excluding trips on foot.

Variable	Parameter	t-test	Variable	Parameter	t-test	Statistic	Value
RP model:							
Time_{car}	−0·0118	−1·101	Gender_{bike}	0·7529	3·483	$l\ (\theta)$	−1027
$\text{Time}_{foot\&bike}$	−0·0871	−13·967	Student_{car}	−0·5189	2·434	l (const.)	−3208
Time_{bus}	−0·0324	−4·537	Student_{foot}	3·6730	14·058	ρ^2	0·680
Timeacces_{bus}	−0·0238	−0·870	Income_{car}	−0·7666	−3·594		
$\text{Cost}_{all\ modes}$	−0·0789	−1·160	Constant_{bus}	1·4480	5·972		
Available_{car}	3·0204	20·839					
SP model:							
Time_{car}	−0·0631	−8·657	Costpark_{car}	−0·4938	−14·767	$l\ (\theta)$	−7562
$\text{Time}_{car\text{-}pooling}$	−0·0575	−10·226	Available_{car}	0·6564	16·151	l (const.)	−13480
Time_{bus}	−0·0791	−21·248	Hiresys_{bike}	−0·3113	−4·244	ρ^2	0·439
Time_{bike}	−0·0884	−22·896	Bikepath_{bike}	0·0025	1·641		
Timeacces_{bus}	−0·0729	−8·373	Gender_{bike}	0·2205	2·695		
Interval_{bus}	−0·0166	−6·432	Student_{car}	−0·1257	−0·600		
Cost_{bus}	−0·3139	−1·733	Income_{car}	−0·0587	−0·655		
Cost_{car}	−0·4866	−8·579	Income_{bus}	1·1161	7·746		
Cost*Gender_{car}	0·0528	1·941	$\text{Income}_{car\text{-}pooling}$	0·2270	2·536		

Table 2. Modal choice models

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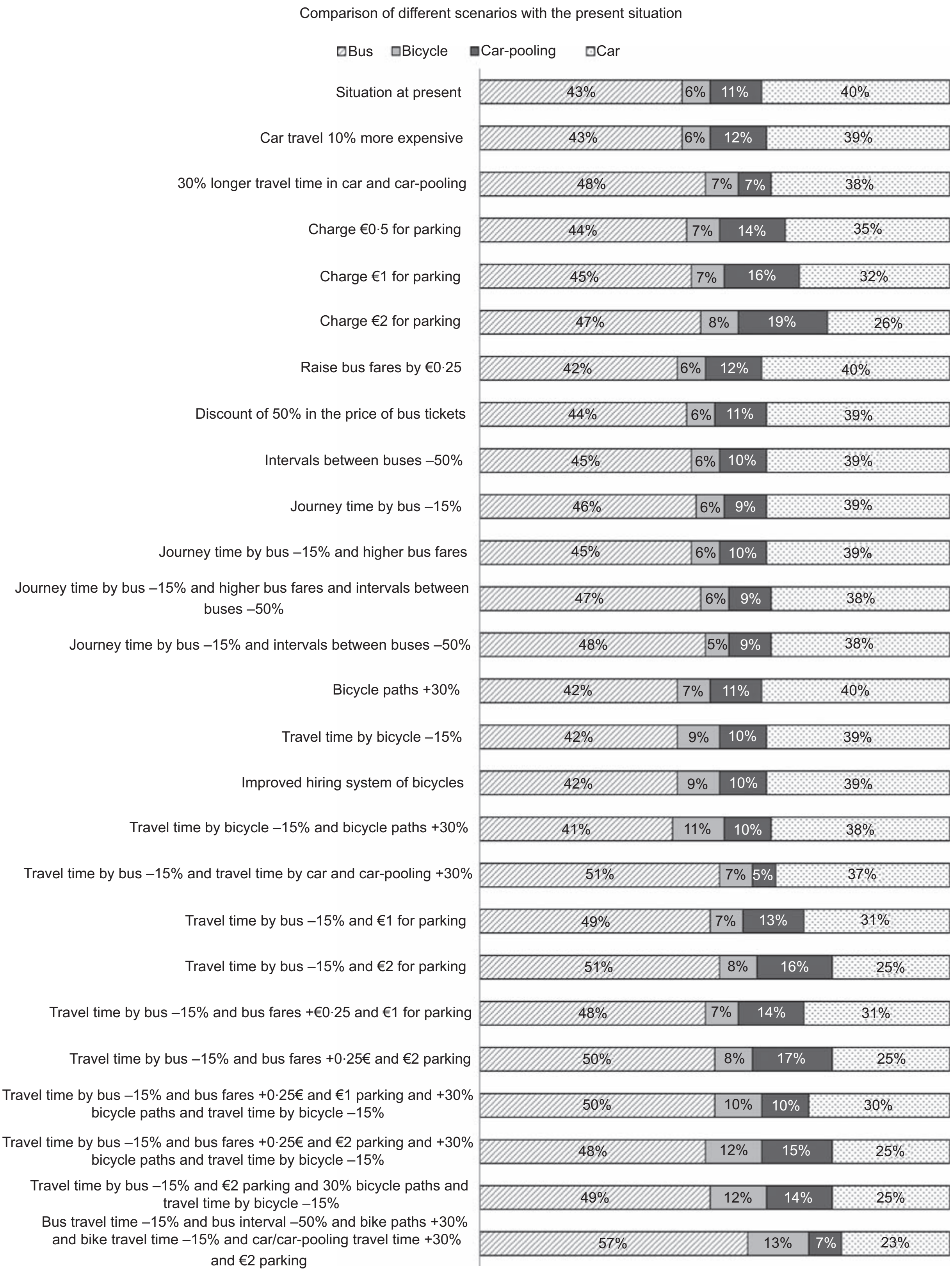

Figure 2. Effect of the proposed actions on modal split

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The sample enumeration method (Ortúzar, 2000) was employed for its preparation, which calculates the utilities and probabilities of the choice of each alternative for each interviewee. Their average value may be considered representative of the estimated modal split. This method is more appropriate than other aggregative approaches when a wide sample representative of the total population is considered, which is the case here.

Among the possible actions to stem private motor vehicle use through its penalisation, the most effective ones are to increase travel time by car (for example by restrictions on circulation in certain streets in the centre of the urban area) and to introduce parking charges on vehicles carrying less than three users.

With regard to actions to improve bus travel, changes to bus fares hardly have any influence on its demand. On the contrary, the most effective action is the reduction in bus travel time. In fact, this action, combined with a reduction in the intervals between buses, brings important benefits, even though fares rise. The scenarios with variations in bus travel time apply a reduction of 15% to this value. This reduction could be obtained through the introduction and/or improvement of reserved lanes for buses (or buses/taxis), together with priority at particular signalised junctions. Taking into account the time spent slowing down, accelerating and remaining stationary at bus stops and at junctions, an increase in rolling speed of 25–30% would be needed.

However, if the objective were to promote individual use of the bicycle, the hire system should be improved, or total travel time should be reduced, through an increase in the networks of bicycle lanes or routes and more optimal locations for bike parks.

Finally, among the combined actions to incentivise sustainable transport modes and penalise private motor vehicle use, the results are especially notable when action is taken on travel time, through reducing travel time by bus and increasing travel time by car. If, in addition, with a more aggressive strategy, improvements are added for the bicycle and a daily parking charge is imposed, an authentic turnaround in the modal share takes place. Thus, in the extreme scenario (the last one in Figure 2), the use of sustainable means of transport is extended to 69·6%, meaning that 41·9% of actual car users opt for other modes of transport. Nevertheless, a more 'achievable' scenario is the penultimate one in Figure 2; in which 49·4% of the university population travel by bus, 11·6% by bicycle and the rest in private motor vehicles (14·5% sharing and 24·5% alone).

Given that the routes considered in the study are all of obligatory mobility (to/from the university), it should be noted that the expected effects on the generation of traffic, because of changes to the operating conditions of the service, will be relatively small. However, it is important to take the existence of these effects into account, being aware that the results will to a certain degree be inexact, even though they would remain perfectly valid as an approximation of the real situation. Moreover, changes to the generation of journeys for the remaining users in the city can indeed acquire important values; this is a circumstance to consider if the scope of the study was to be expanded.

3.4 Sustainability impacts

The ecological impact of the selected scenarios for improvement was also studied. These were compared with the present situation, by evaluating emissions of carbon dioxide, energy consumption and daily traffic congestion generated throughout the year by the university community. Nepal (2006) and Pitt and Jones (2006) studied the impact of transport strategies on these parameters.

The 'achievable' scenario (the penultimate one in Figure 2) and a second 'achievable' option (maintaining the bus fleet) were selected for that purpose. The first is the result of applying a 15% reduction to travel time by bus, an increase of 30% to the length of bicycle lanes (also reducing travel time by 15%), and a parking charge of €2 on private motor vehicles carrying less than three users. In this situation, about 49% of the university population would travel by bus, 12% by bicycle, and the rest in private motor vehicles (14% sharing and 25% alone). The second 'achievable' situation was based on the previous one (with the same actions and modal split), but the occupancy rates of urban buses increased to 18·7 passengers (rather than the present-day scenario of 15 passengers) and the number of necessary buses remained practically constant. These occupancy values are derived from the analysis of the real circulation conditions of urban buses in the city of Burgos, assuming an average of almost 30 persons and allowing for a near empty return journey.

These scenarios were selected because they offer important changes in modal split, through actions that are relatively easy to implement. So, with some simple improvements, significant reductions could be achieved in emissions of carbon dioxide, energy consumption and daily traffic congestion.

To do so, an average journey distance was estimated at 5 km, from the location of the interviewees' homes. Moreover, the assumption is a total of 30 teaching weeks per year, and the average data on emissions and consumption that are found in Table 3. The energy consumption of each mode of transport as indicated comprises two parts: one attributable to fuel consumption (proportional, therefore, to those rates of consumption) and another due to the energy consumed in

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Transport mode	Initial occupation	Type of fuel	Fuel consumption: l/100 km	Carbon dioxide emissions: kg CO_2/l)	Energy consumption: MJ/passenger km
Bus	15	Diesel	54·0	2·60	0·58
Bicycle	1	—	0·0	0·00	0·06
Car	1·3	Petrol	9·2	2·35	4·56
		Diesel	7·0	2·60	3·56
Car-pooling	3·2	Petrol	9·2	2·35	2·88
		Diesel	7·0	2·60	2·16

Table 3. Estimated parameters for the analysis (source: authors' own work prepared from IDAE (2006), Ajuntament de Barcelona (2004) and Potter (2003))

the production processes of the vehicle. The results are presented in Figure 3.

First, the variation that takes place in annual carbon dioxide emissions under the proposed scenarios was studied. Thus, private motor vehicle carbon dioxide emissions were strongly reduced, thanks to the proposed measures. The other modes in the achievable scenarios slightly increased the emissions owing to greater use by users. In global calculations, under the achievable scenario, the carbon dioxide emissions would be reduced by approximately 14%. This would mean that 225 t of carbon dioxide would no longer be released annually, by applying only a few viable measures.

Second, looking at traffic congestion, daily congestion is a problem that worsens at peak times, affects the whole city and occasions numerous negative effects for the inhabitants of the city (insecurity, environmental and acoustic contamination, and so on). Under the achievable scenarios, it is possible to achieve large reductions in the space taken up by cars on the road. In order to interpret the graphs correctly, the bus should be considered equivalent to three typical vehicles and the bicycle to 0·25. Jointly, in the achievable scenario, the number of motorised equivalent vehicles on the road would be reduced by 22% and the number of bicycles would be increased by 93% with respect to the present modal split. This means that around the equivalent of 1950 motorised vehicles would no longer be in circulation daily, thereby improving mobility throughout Burgos.

Finally, an evaluation of annual energy consumption was conducted. Once again, annual energy consumption of the bus and car-pooling was maintained almost constant, although its use in future scenarios increased considerably. In this case, no more than two scenarios were presented, as data on vehicle occupancy was not required to estimate energy consumption per vehicle (Table 3). It is worth highlighting how energy consumption was globally reduced by 23%, implying an annual reduction of 7290 GJ, when introducing the proposed measures.

It should be noted, in any case, that extending car travel times imposes a dead loss on the economy, and can also increase fuel consumption and emissions if this is imposed through circuitous routing (restrictions on circulation) and forced delays. Accordingly, the results must be analysed while bearing in mind that there will be an opposite effect (not included) that may decrease the benefits of the proposed actions.

4. Discussion of results

The typical interviewee profile is a first-year student of 19 years old. There are four members in the home with two motor vehicles. Although owning a bicycle, the survey respondent holds a driver's license but has no car. The student takes an average of 15 min to travel from home to the university.

The majority of teaching staff and other personnel hold a driver's license and own a private motor vehicle, which they often use to travel to their places of work.

Daily trips to and from the university show a travel model with four peak periods: two outgoing and two incoming peak points. A typical day may be any day from Monday to Thursday, as hourly distributions are almost identical. Friday, however, covers fewer journeys than the other working days of the week.

The modal transport split suggests that the most widely used mode of transport by students is the bus. The second most frequently used means of transport are the private motor vehicle (cars) and by foot, there being few students that travel to the campuses by bicycle. With regard to teaching staff and administration and services personnel, the car (not shared) is the predominant mode, followed by travel on foot. Journeys by bus and by bicycle remain in a minority.

The effects on the modal share of certain actions have been estimated by means of modelling user modal choice. The most effective actions would be improvements in public transport

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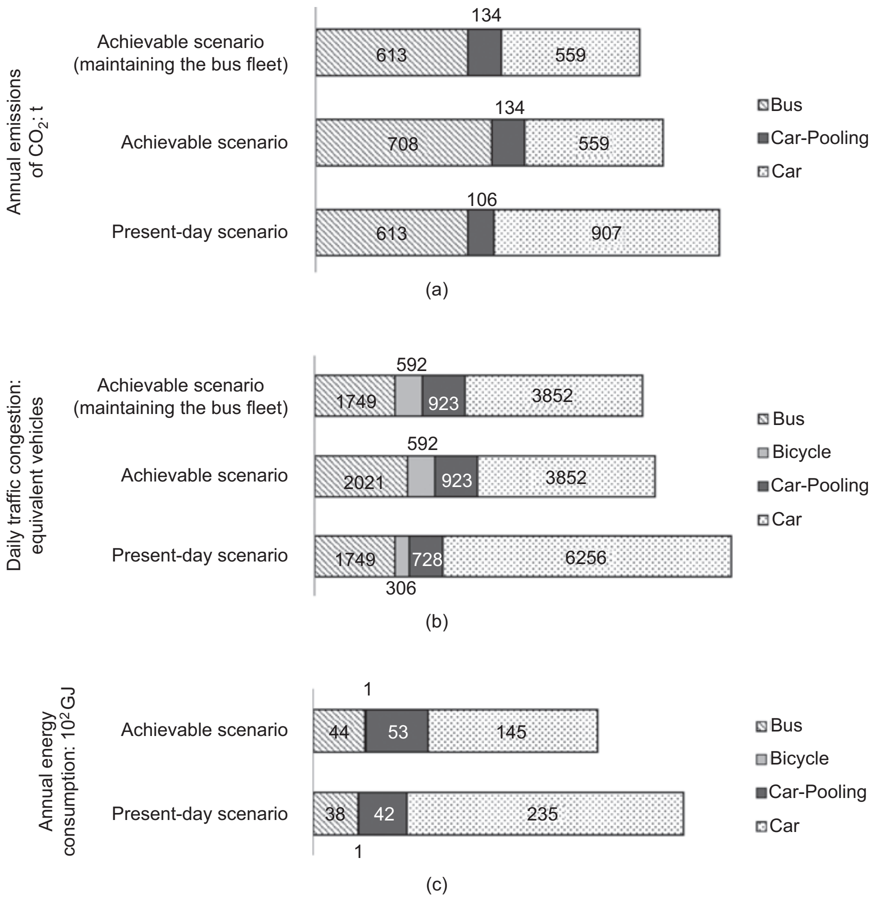

Figure 3. Sustainability impact of the scenarios under consideration: (a) annual emissions of carbon dioxide (t); (b) daily traffic congestion (equivalent vehicles); (c) annual energy consumption (10^2 GJ)

travel time and in cycle routes. With regard to the restrictions on car use, applying a daily parking charge and increasing travel time would give the best results.

By following a 'smooth' line of action, a 14% reduction in annual carbon dioxide emissions would be achieved and the consumption of energy used for travel back and forth from the university would fall by 23%. With regard to daily traffic, the motorised vehicles that at present block up the city, owing to the journeys of the university population, could be reduced by 23%, and a 93% increase in bicycle travel in the city could be achieved by encouraging more daily users in urban areas.

5. Conclusions

This research has presented the principal results of a mobility survey conducted with students and other personnel of the University of Burgos (Spain) that also examined their travel patterns. Using discrete choice techniques, the modal choice of the university community and the effects of different policy measures on modal transport split and sustainability have been modelled.

The study concludes that it is possible to influence the modal split of particular collectives, the university community in this case, in order to incentivise the use of more sustainable modes of transport, as opposed to private motor vehicles, thereby reducing emissions and fuel consumption, and leaving more urban road space available for more sustainable modes.

In view of the results, certain municipal policies may be proposed, which directly target increased use of more sustainable modes of transport than the private motor vehicle. In the first place, improvements in the travel time of the bus may be obtained through the provision of platforms and

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reserved lanes and the assignation of priority at signalised junctions or on certain routes. Subsequently, improvements should be introduced to cycle routes.

Another 'harsher' line of action, which is also very effective, concerns measures that restrict the use of the private motor vehicle. In fact, the best results would arise from the application of a daily parking charge, and even from increased travel time, through restrictions on circulation in certain roads in the centre of the urban area. However, it is evident that these measures are not easy to enforce, as they do not always enjoy public support.

In any case, these policy actions should not be short-lived or isolated, but have to be included within a global mobility plan, including education campaigns, awareness raising and training. The only way for these measures to be successful is to integrate them fully into a municipal policy that supports sustainable modes, in which both the municipal public authorities and the university are involved (with the representation of students, teachers and staff).

By doing so, cities presently overshadowed by the culture of the automobile may be transformed into 'greener' and safer ones. A better quality of life may also be achieved for cities, alongside raising awareness of the principles of sustainability and environmental protection among students (the employees and entrepreneurs of the future).

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