Students commuting choices: Carbon footprint and environmental identity

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Introduction

Environmental issues increasingly concern society; however, consumption patterns do not seem to evolve accordingly. Decisions on consumption are taken based on education, habits, cost and a number of other variables, and they are not easily modified. We focus on this issue by analysing transport decisions for students, and searching for a link between individual environmental identity and transport choices.

We do so by carrying out a survey questionnaire to University students that pursues a twofold objective. In a first stage, by asking about their actual transport decisions and pulling the information on a Multi-Regional Input-Output model, we can calculate the anthropogenic environmental impact in terms of carbon footprint. In a second stage, our questionnaire also analyses to what extend environmental identity determines real everyday commuting decisions. The questionnaire considers the environmental identity of the students, and by comparing them to the actual transport choices, and their receptivity to change, it is possible to appreciate whether they are coherent with their environmental self-dimension. This also allows creating a range of potential scenarios, where infrastructure or normative changes could encourage environmentally friendly decisions' making. The environmental impact of the proposed scenarios can also be measured, so potential benefits of a range of possible environmental policies can be foreseen.

The previous analysis pretends to identify the best option to prompt changes in the individual choices. Clear and straightforward information on environmental impact of consumption decisions is a powerful tool to change habits; otherwise, economic penalties can be considered when information on "Wiliness to pay for anti-environmental behaviour" is gathered. Our questionnaire will also allow us to compare both tools.

The analysis is performed on data for University of Castilla-La Mancha (UCLM) students and employees. The receptivity to the use of sustainable transport is low. Commuting by car occurs 47%, only slightly below the 53% EU mean considering the Spain favourable weather conditions (Eurobarometer, 2011). In addition, Spain is among the European Union (EU) countries with a lowest rate of bicycle commuting, according to the European Cyclist Federation it relative position in modal share for bicycle commuting has improved five posts between 2013 and 2015, however it is still in the 18th out of 28 countries.

Previous literature has analysed the main factors behind commuting decisions for the population and, specifically, for university students and employees. A very first work by Joshi and Senior (1998) reveals that governmental engagement in bicycle commuting propelling is necessary, since among the main factors to change to bicycle commuting are the existence of improved roads and adequate bike lanes and a reduction in the possibilities of suffering an accident. This conclusion is common to de Duarte, Sancho, y Sarasa (2018), that also include weather conditions as a relevant, and Gilderbloom, Grooms, Mog, and Meares (2016), that also considers the importance of the improvement in facilities, bike parking spaces, bike repairing shops or showers for bikers. Gilderbloom et al include a new parameter in the equation, by acknowledging the importance of the cost of fuel in decisions making, although its impact on bicycle commuting is considered in an indirect way, as a key element to choose the household localization, which changes the options of commuting by bike. Security, facilities and economic factors are then recognized as relevant in the previously mention works and in some others taken form economic and health disciplines (Tin Tin, Woodward, Thornley, Langley, Rodgers and Ameratunga, 2009; Lois, Moriano and Rondinella, 2015).

The present work acknowledges the previously found relevant factors, and also focuses on the importance of psycho-sociological factors to break individuals' habits and attitudes that hinder our ability to meet our environmental goals. Numerous investigations have shown that different dimensions of identity play a role in the prediction of environmental concerns, ecological cooperation for obtaining resources and pro-environmental behaviours (Hoot & Friedman, 2011; Olivos & Aragonés, 2014). Positive correlations have been observed between different measures of environmental identity, such as the Connectedness with Nature scale or the Inclusion of Nature in Self Scale, with the general ecological behaviour (Dutcher et al., 2007; Mayer & Frantz, 2004; Olivos, Aragonés & Amérigo, 2011; Schultz, 2001). The topic has also been studied for bicycle use in Lois, Moriano, y Rondinella (2015), Caballero, Franco, Mustaca, and Jakovcevic (2014), or Noland and Kunreuther (1995).

This paper investigates the link between psycho-sociological factors and objective emissions measures, and proposes measures to encourage pro-environmental commuting patterns by stimulating identity features, and quantifying its expected environmental effects.

The paper focuses on the impact of urban transport, and more specifically, active transport, in a context where cities have been given a relevant role in fulfilling the commitments to greenhouse gas emission reduction, following the explicit EU recognition of the importance of cities as are key players in the reduction of CO2 (EEA, 2011) and transport (EU, 2016) in emissions generation. All of this reflects the major potential of intracity transport in achieving the curbing emissions goals for Spain, 26% in 2030 based in 2005 levels, according to the 2018 binding agreement (EU, 2018).

Leaving aside other spheres of transport means, such as its production phase, transportation from the producer to the consumer, or when it has to be disposed, we would focus on measuring the emissions generated by students and employees when commuting to university. Public and private transport emissions will be measured from the pollution generated to extract, transform, and transport fuel together with the emissions produced by burning fossil fuels while commuting. Considering emissions from bicycle use to be null is a simplifying assumption accepted in this analysis. It is generally accepted that bike commuters have to increase its nutrients intake to be physically capable of driving a bike compared to a car, but the calculation of this energy intake and its associated emissions is imprecise and will not be performed in this paper.

Methods and data

Our empirical application entails a intertwining of two different and complementary methods. As a starting key element, data on transport choices for university students and staff is collected through a survey, performed through a web platform. These data provide information on actual commuting decisions and individual's identity beliefs, which feed the other two methodological tools, a MRIO and an econometric model. Gathered information is rearranged to match the requirements of a MRIO, that allows calculating both the actual carbon footprint and future desirable scenarios, explained below. As a second procedure dovetailed with the previous one, an econometric model will be regressed to identify the links between socioeconomic and psychological factors and environmental attitudes, providing new information to define future desired scenarios. Proposed scenarios are improved by considering information on respondent's opinions on the main factors that benefit or obstruct the use of bicycle for commuting, together with their revealed environmental identity information. This will be reinforced with the information on life satisfaction that would allow to analysed whether it is linked to wiliness to change the usual transport mean. The three methods are now commented.

Survey

This paper is a first approach to a broader project that encompasses a survey to the whole of the UCLM community. At this stage, the study is performed on the Faculty of Economic and Business placed in the Albacete's Campus.

Following Borges del Rosal (2002) the adequate sample size for the survey is 258 surveys for an uncertainty of less than or equal to 2 % at the 95 % confidence level. To achieve this number of students the survey is proposed as a class voluntary task. The survey has been created in the online platform Google-Forms. The survey questions are organized in seven blocks, general features of these are commented below, while the survey is included in Annexe A1.

Block 1: Includes socioeconomic questions such as age, gender, civil status, birthplace, place of residence, distance to the faculty, vehicle availability, usual transport mean, monthly income and transport expenditure.

Block 2: Environmental psychology and bicycle commuting perception questions, based in Passafaro et al. (2014).

Block 3: Questions related to the wiliness to pay to maintain de actual transport mean, and factors that benefit or obstruct the use of bicycle, inspired in relevant literature on the topic (Joshi and Senior (1998), Duarte, Sancho, y Sarasa (2018), Gilderbloom, Grooms, Mog, and Meares (2016), Tin Tin, Woodward, Thornley, Langley, Rodgers and Ameratunga, 2009; Lois, Moriano, and Rondinella, 2015).

Block 4: A unique question on personal satisfaction with life, based on Cantril et al. (1965).

Block 5: Residence GPS coordinates for a better calculation of distance to the faculty.

MRIO

Data expenditure on private and public transport are matched to an environmentally extended multi-regional input-output model (EE-MRIO), according the following matricial expression:

$$F = \hat{e} \cdot (I - A)^{-1} \cdot \hat{y} \quad (1)$$

F states for carbon footprint, that accounts for the emissions generated to satisfy UCLM students and employees transport demand, $\hat{e}$ is the emissions coefficient that premultiplies the Leontief inverse matrix that distinguishes 41 countries or regions and 35 sectors, while $\hat{y}$ stands for final demand. The circumflex signals diagonalized matrices, that allows to distribute emissions either by sector or by country. The calculation will result in emissions measured according to the consumer responsibility, emissions generated everywhere around the world to satisfy a local demand. Calculation of expression (1) only account for indirect emissions, which have to be completed by direct emissions generated when fuels are burnt in the commuting phase, resulting in a quantitative and objective emissions measure.

The methodological MRIO framework can be analysed in deeper detail in (R.E. Miller & P.D. Blair, 2009), and it is been profusely applied by actual literature (R.C. Johnson and Noguera (2011); Trefler and Zhu (2010)) (Kanemoto, Lenzen, Peters, Moran, and Geschke (2012); Murray and Lenzen (2013)); and specifically for environmental impacts: (S. J. Davis et al. (2011); Kanemoto, Moran, Lenzen, and Geschke (2014); A. Skelton, D. Guan, G.P. Peters, and D. Crawford-Brown (2011)).

Econometric model

There is a growing interest in the role of social values, policy inclinations and subjective beliefs in the awareness of climate change and other environmental problems. All of the above determines in a great deal the potential of the range of policies applicable. Previous literature has focused on the relationship between beliefs and subjective norms with pro-environmental behaviour intention. This paper proposes going a step further by linking this variables to the real consumption decision for transport and its quantified CO2 impact. To do so, we propose a logarithm lineal regression model, the analysis of the endogeneity and multicolliniarity relationships that would allow identifying the most adequate regression model. The general model will approximate the following expression:

$$TF_i = \beta_0 + \beta_1 NI_i + \beta_2 NIS_i + \beta_3 RP_i + \beta_4 BI_i + \beta_5 EI_i + SD_i' \beta_6 + \varepsilon_i \quad (2)$$

TF stands for the total carbon footprint, which adds direct emissions to the indirect expression (1) measure. NR accounts for the individuals' net income, and NIS for its square to control for the possibility of the income-elasticity being positive up to a maximum, above which it gets smaller with successive income growth, given the luxury consumption nature of environmental concern. RP is an index developed on the answers on risk perception as an intervallic scale. BI is the behavioural intention index, also as an intervallic scale. It has the same characteristics for environmental identity. Other socio-demographical variables, gathered in the survey block 1, are also included within SD, since previous studies suggest that they can explain a part of the individuals' environmental commitment. However, given the limitations of the sample group for our analysis, results arising from this group will not be revealing. Expression (2) also includes an error term and will be estimated in logs, following the procedure that will be more adequate according to the previous data analysis.

A second estimation will focus on the analysis of the wiliness to pay to keep the same polluting transport mean that has been presented as a question on percentage increase in the price of fuels in the questionnaire. The proposed model is similar to that in expression (2), although considering the wiliness to pay answer, WP, as the dependent variable.

$$WP_i = \beta_0 + \beta_1 NI_i + \beta_2 NIS_i + \beta_3 RP_i + \beta_4 IC_i + \beta_5 ID_i + SD_i' \beta_6 + \varepsilon_i \quad (3)$$

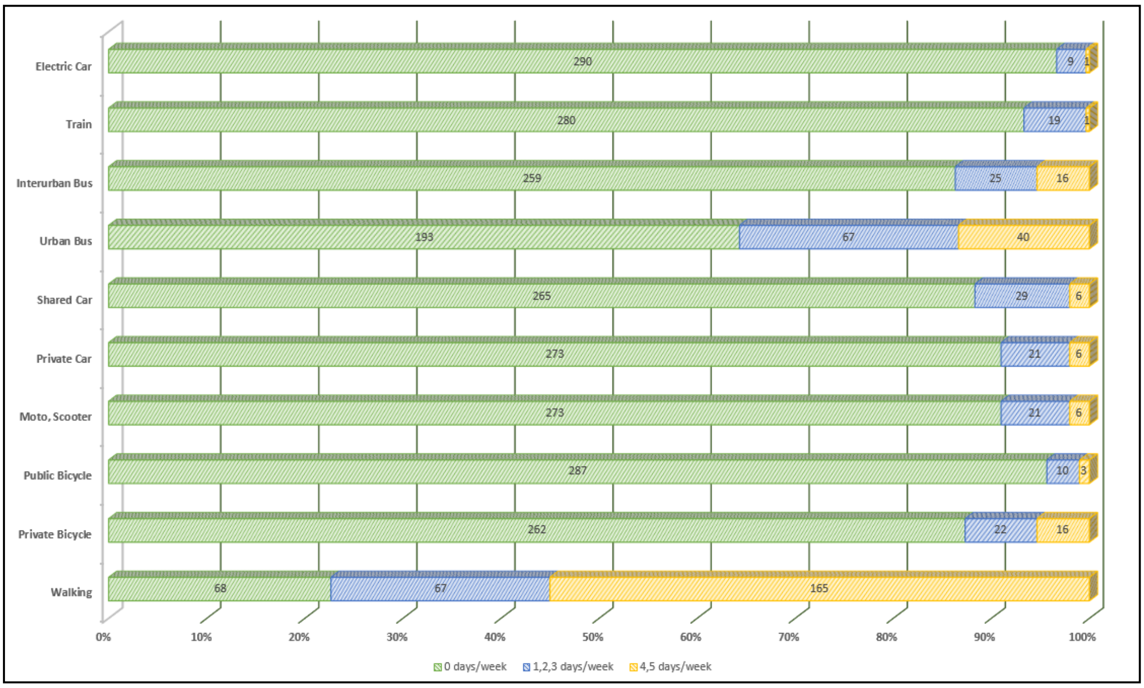
Data and Results

The interview was open for 9 days from the 02/10/2018. It had 308 respondents, and after revision, 300 were considered valid. The interviewees are between 17 and 48 years. In this distribution, 94.5% of the subjects are between 17 and 24 years old, and 6.5% between 25 and 48. The sample is comprised of 49.7% men and 50.3% women. In turn, with regard to the marital status of the whole spectrum, 89.9% of the individuals are single, 8.1% have a common-law partner, 1.6% are married and 0.3% widowed.

As a general overview of the respondents, we comment on some of the socioeconomic questions. In relation to the work condition of the individuals, 96.4% of them are students, 2.9% Teaching staff, 0.3% administrative staff and the remaining 0.3% are workers. Furthermore, 52.6% of the interviewees moved from their homes to be able to come to class. On the other hand, 7.8% of the total had to commute from another locality to the campus daily. Regarding the interviewees' vehicles (and not for this reason these vehicles are used) of a total of 308 surveys, 81 of the subjects own a bicycle, 128 a car, 17 a motorbike/scooter and the remaining 134 do not have any vehicle.

The frequency of use for each mean of transport is shown in graph 1. Walking is the most common way to get to the Faculty, followed by public transport, and very closely for both everyday use and frequent use is private bicycle. On the other end, Electric cars and Public Bicycle is almost non-existent.

Graph 1. Frequency in the use for each mean of transport.

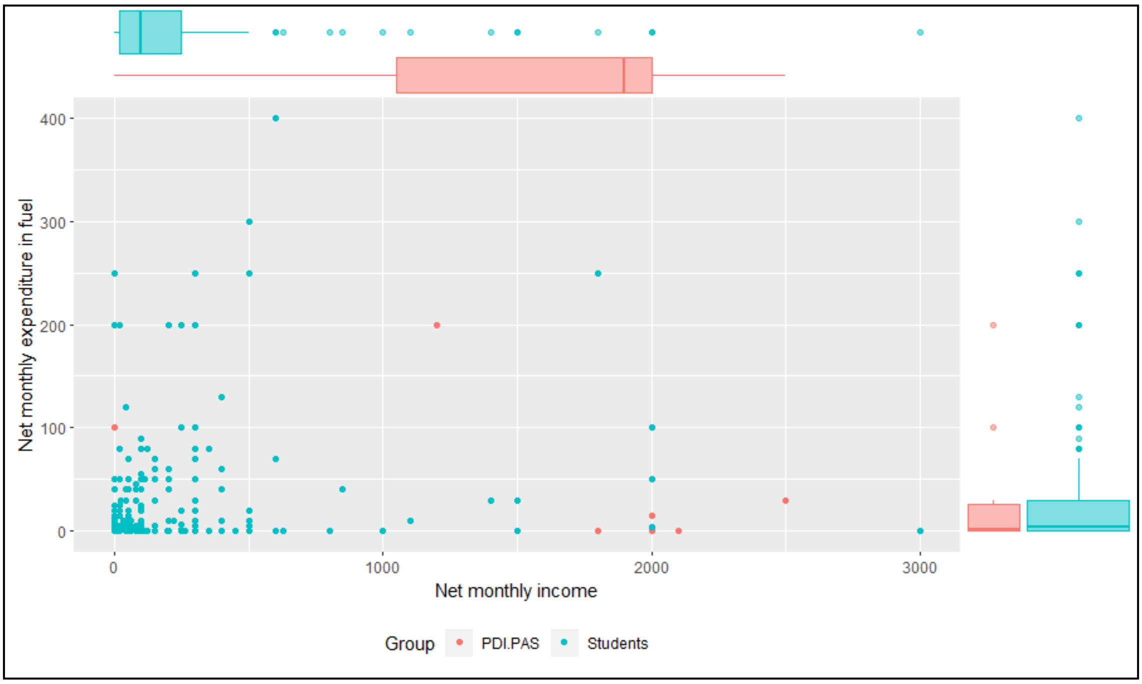


Source: Own calculations.

On individual monthly income, the mean is in 240€, with a minimum of 0 and a maximum of 3000€, in a survey answered by both students and staff. Variability is, as expected, smaller for transport expenditure, with a mean of 26.44€ and a maximum of 400€.

Table 1.Income and expenditure in transport to UCLM, quartile distribution and boxplot.

	Minimum	*1st Q.*	*Median*	*Mean*	*3rd Q.*	*Maximum*
Net income	0	20	100	240.80	250	3000
Net spending	0	0	4	26.44	30	400

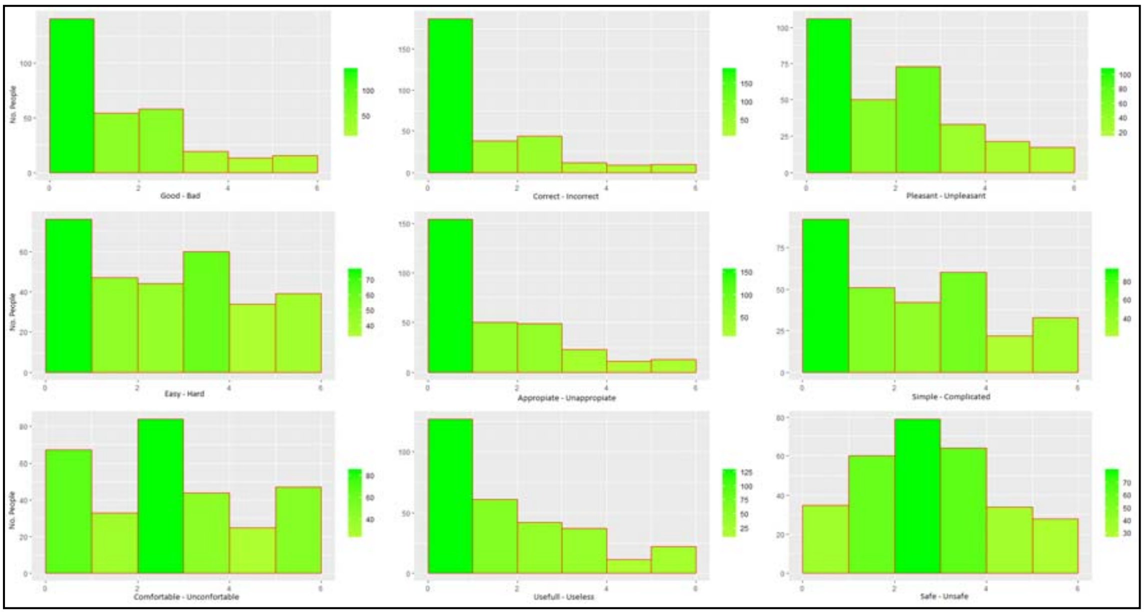


Source: Own calculations.

Survey data points to a positive perception of bicycle in many aspects, however it does not resonate in a disposition to use bicycle, since most of the individuals answered that they “didn’t feel like using the bicycle”.

A few comments on the bicycle perception, there is a positive receptivity towards bicycle commuting for most measured items, as it is shown in Graph 2, that summarizes risk perception items. The risk perception block contained nine items that the respondents had to grade from 1 till 6. Results show that respondents consider massively that commuting by bike is correct and appropriate, and with a lower intensity, it is considered pleasant, simple, useful, good and, only slightly positive, easy. More than half of the sample are neutral in relationship to the safe-unsafe and confortable-unconfortable.

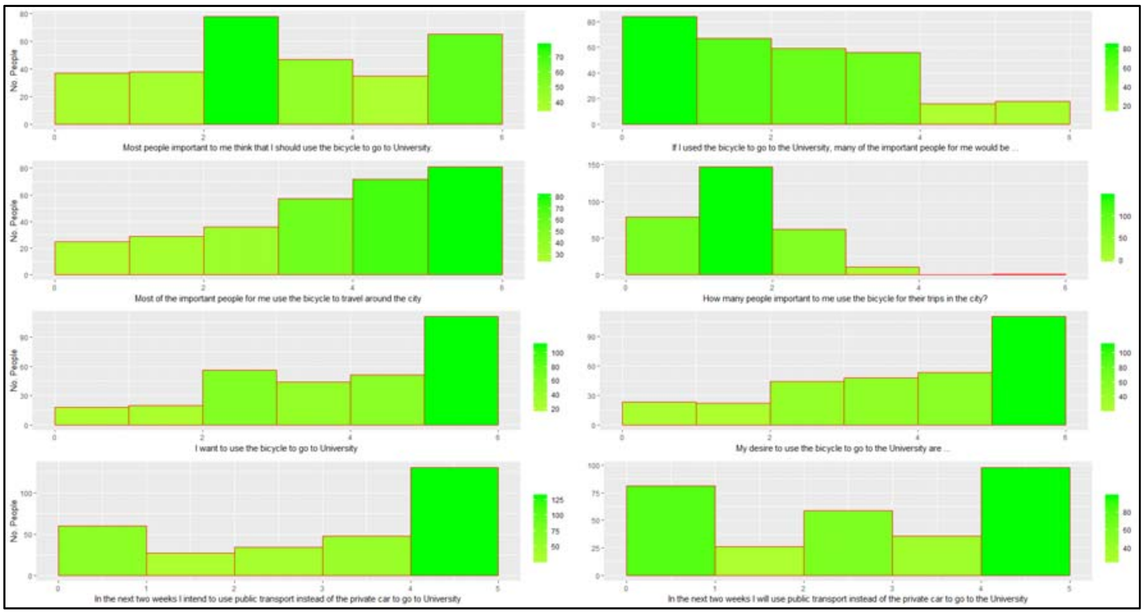
Graph 2. Bicycle commuting perception for respondents, Risk Perception items.



Source: Own calculations.

The behavioural intention block contained eight questions on respondents perception towards their important people’s attitudes concerning bicycle. Graph 3 analysis is less positive that the previous one. With 1 in totally probable and a 6 in totally improbable, respondents consider that most important people for them where in many cases neutral about whether respondents should use the bicycle to go the university, with answers evenly distributed and a slightly higher frequency for scales 3, with 26% of the answers, and 21% for scale 6. There is a positive perception of how important people would consider the respondent decision of using the bicycle, with 70% answers in the agreeable range. When it comes to actual commuting patterns for important people, respondents perceive that bicycle is far of being the first option, with around 70% belonging to a social context where important people around do not use the bicycle. To confirm this perception, only around 4% of the respondents are in a context or a lot of people around them using the bicycle. Own intention questions in this group show that only 12% (14%) of the respondents have high or very high willingness (desire) of using the bicycle, while, when asked about a specific period. When they were asked about the chances to change to public transport, attitudes were not very open, with around 60% considering this change most improbable.

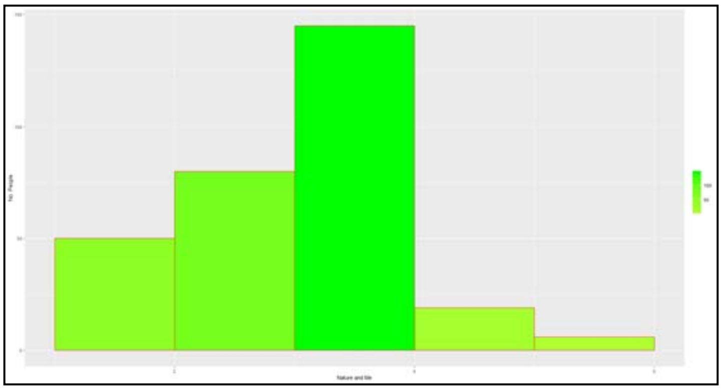
Graph 3. Bicycle commuting perception for respondents, Behavioural intention items.



Source: Own calculations.

We consider connection with nature as a main variable in order to determine and a potential key for changing towards environmental consumption patterns. For our sample, most of the respondents, almost 50% consider themselves in a medium position, and there was a higher percentage of individuals with low links to nature, over 40%, while only around 8% of the sample consider themselves highly linked to nature.

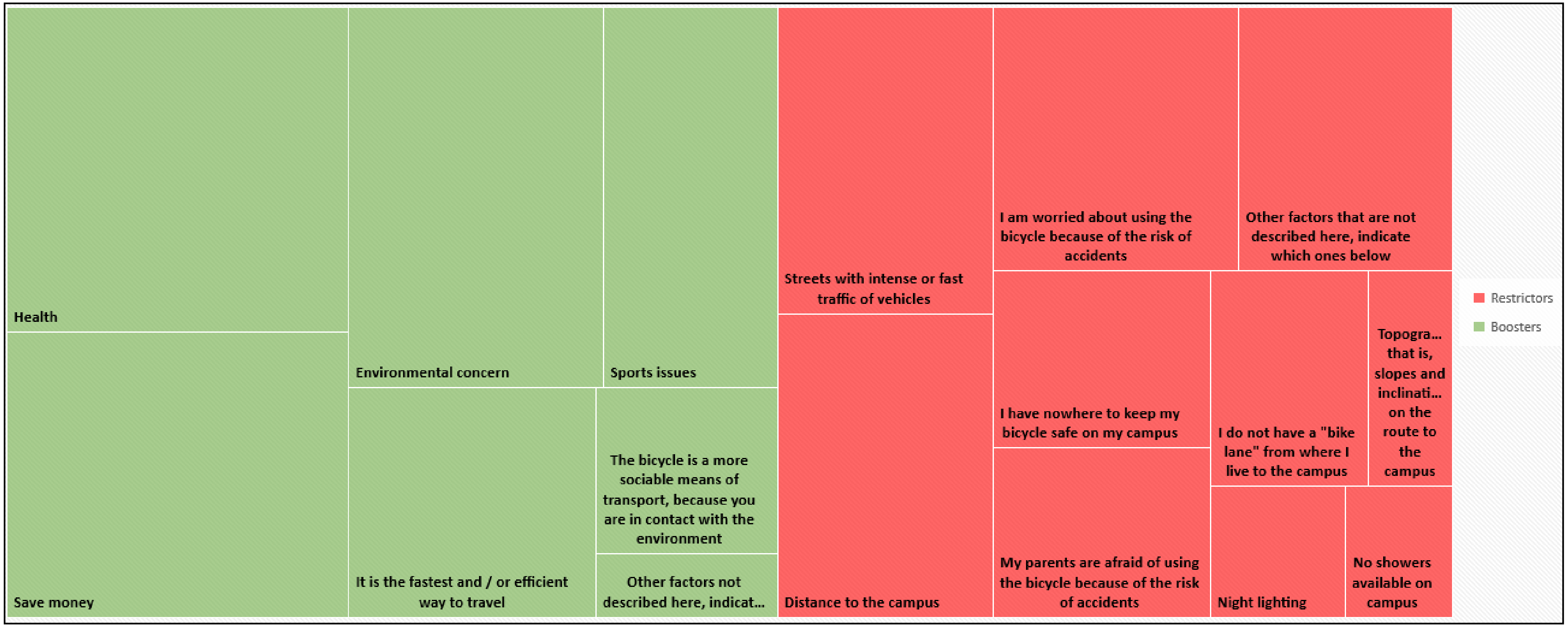
Graph 4. Scope 3 emissions generated by each mean of transport.



Source: Own calculations.

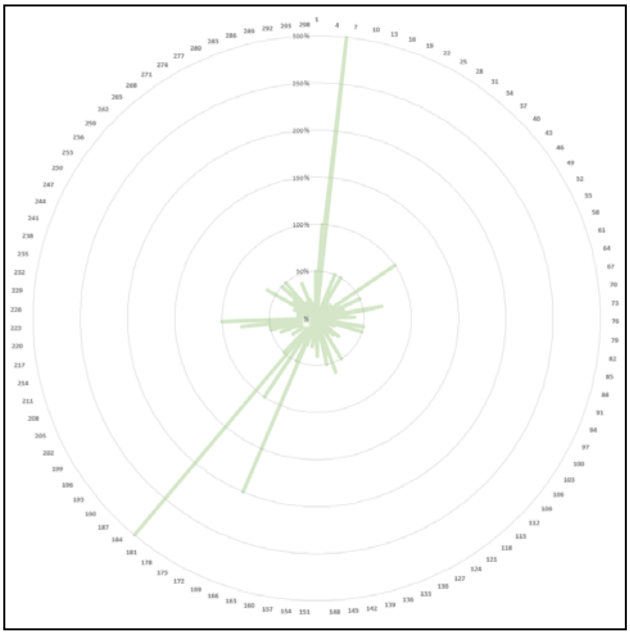
Two more questions where introduced to dive into the restrictors and boosters of the bicycle use according to respondents. From a list of nine plus the option of "other", the respondents choose up to five restrictors for the use of bicycle. Similarly, up to five boosters were chosen from a list of eight plus an open option. The weight of those reasons is shown in graph 5. Among the restrictors, although some of the factors are out of the university or municipality competence, such us distance to the campus, however there are other options that can be improved for academia members. Safer lanes for bike users, affects to 5 out of the 10 resulting restrictors, while security in parking is also a feasible improvement for the University that affects half of the respondents.

Graph 5. Boosters and restrictors of Scope 3 emissions generated by each mean of transport.



Source: Own calculations.

Graph 6. Distribution of wiliness to pay.



Source: Own calculations.

Results of the question of wiliness to pay for a higher fuel (public transport) rather than change the usual transport means show that it was not interpreted the way it was meant, so the main conclusion is that the question has to be improved for future analysis. An overview of the answers is shown in Graph 6, however the amount of respondents that considered that they would change the mean of transport if there where increases of fuel or transport below 10% does not seem realistic. Proposed regressions are therefore postpone to future versions of the paper.

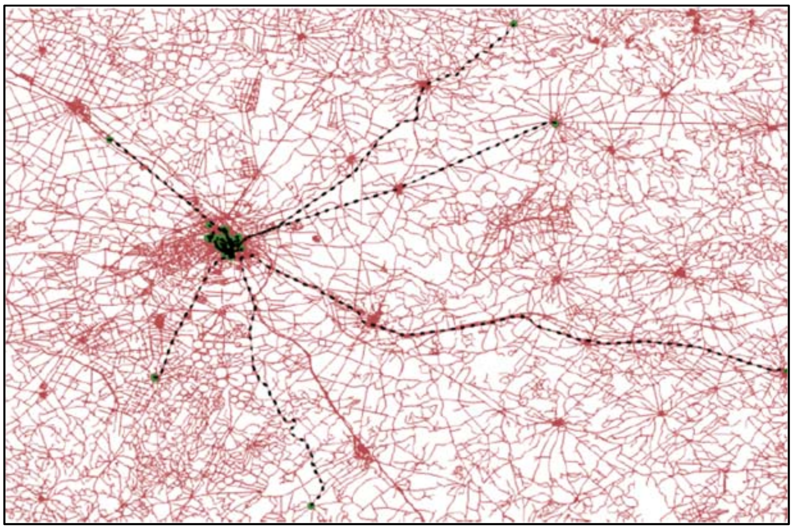
The information on total expenditure in transport to university allowed the calculation of a global carbon footprint, which resulted in a carbon footprint of 0,801493Kts CO_2. This is a simplified figure, only considering one trip of the respondents, without including a normal two-trips commuting, nor applying factors to elevate results to the total of the faculty population, or the whole of academic year. These required improvements are planned to improve the paper for a future version.

Working with the actual results, they show that the distribution by scopes, of the actual carbon footprint shows that 97,43 % of emissions are in scope 1 (60 % coming from private transport and 37,43% form public transport), while the remaining 3,57% goes to scope 3 emissions. Since there are not electric cars in the fleet of university students and staff, there is no % of carbon footprint in scope 2.

A few words on the emissions calculation for both scopes. About scope 1 emissions, GPS coordinates were asked to the respondents, and the most probable route from that point to the faculty was calculated using CuantumGIS software considering the vector layers offered by CartoCIudad[1].

[1] Those cases of respondents living out of the Faculty province were calculated using Google maps distance.

Graph 7. Sorter routes from dwelling to home for survey respondents (in black), from the local vector layer (in red).



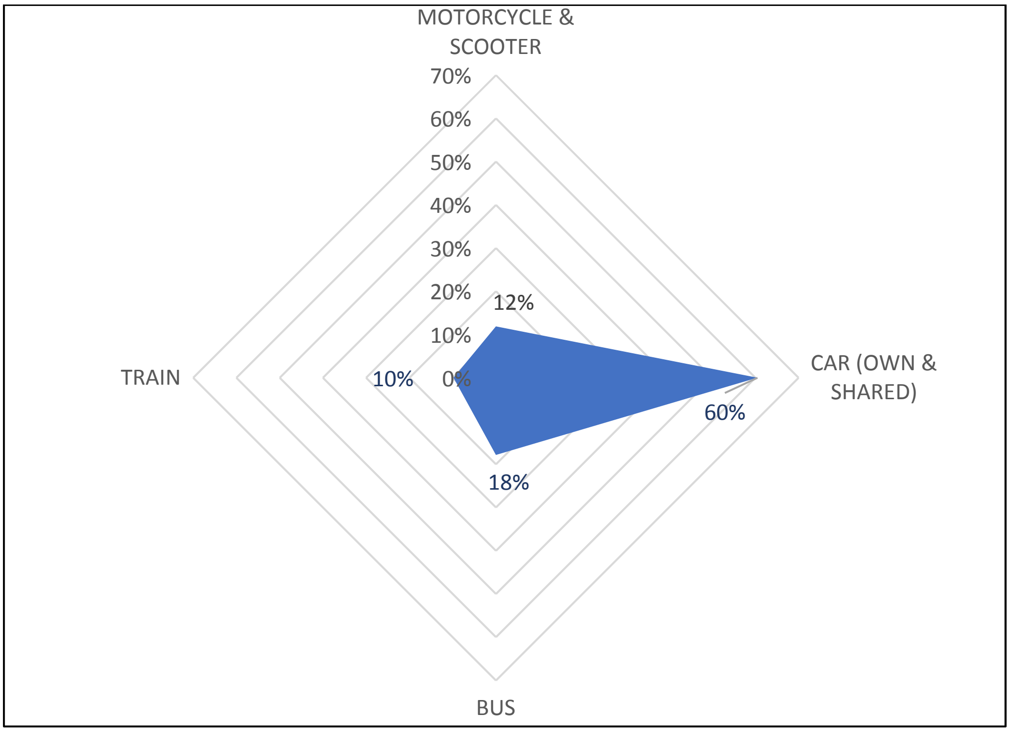
Source: Publi data library, from CartoCiudad (2018).

Considering exclusively indirect emissions, scope 3, it is possible to know the regional distribution of these emissions. Spain is the main producer f the goods and services required to provide the fuel and the public transport demanded by university students and staff.

The emissions generated in the production of the goods and services used to satisfy the transport patterns of the UCLM staff and students are mainly generated in Spain, followed by Other EU countries and Rest of World. Emissions are generated while producing the intermediate services required to transform the imported petroleum (mainly Spanish and EU emissions) or when extracting that petroleum (mostly originated in Rest of World, Nigeria, Saudi Arabia, Libia…).

About the mean of transport originating those scope 3 emissions, Graph 8, car is the main polluter, both by its extensive use and the intensity of its emissions, followed by bus and, with a similar value, motorcycle & scooter and train.

Graph 8. Scope 3 emissions generated by each mean of transport.



Source: Own calculations.

The sectors where these indirect emissions come from are mainly related to energy, minerals, or transport, specifically, those are Electricity, Inland transport, Gas and Water Supply, Other non-metallic minerals, Mining and quarrying, and Coke, refined petroleum and Nuclear fuel. All are very polluting sectors both for resources required and for production procedures.

Graph 9. Emissions by sector for car commuting (up) or bus transport (down).

Source: Own calculations.

The observation of the calculated responsibilities point to a clear conclusion. Emissions are coming from sectors whose production characteristics makes difficult to reduce its responsibility in a short run, and the measures required for that are national or even global, so that no institution has competence to impose them and enforce compliance. In order to ensure emissions reduction, a measure that can improve the likelihood of success must be controlled at local level and introduced with the lower possible cost. On the other hand, measures that imply attitudinal changes are expected to effects for have longer periods without additional effort. For the UCLM commuting decisions, the reduction of the use of car and encouraging active transport means, especially bicycle, are key options to curb emissions. If the UCLM as an institution is capable of transmitting the many positive side effects of active transport, for physical and psychological health, together with economic advantages, the attitudinal change will remain with the students throughout their adult life, since individuals are reluctant to renounce to well-being according to microeconomics theory. In order to decide the more adequate measures, within the considered parameters in terms of university or local competence, easiness and cheapness to introduce and durable benefits, different alternatives where proposed and its reachable emissions reduction effects were calculated.

Regressions expressed in equations (2) and (3) must be taken with caution, however they are showed below in Table 2. Those tentative results support, in general, expected signs for significant variables, with the exception of the Good-bad perception. Future analyses will be performed with indexes summarizing the blocks answers, leading to more revealing results.

Table 2. Regressions results.

VARIABLES	Frecuency of bike use	Williness to pay to keep transpor means
Age	-1.0083	0.2737
	(0.5546)	(0.8803)
Income	0.1161	-0.1378
	(0.6296)	(0.4846)
Fuel Expenditure	0.4751**	0.3315
	(0.0413)	(0.1585)
Good-Bad	-0.5502*	-0.4208**
	(0.0911)	(0.0159)
Correct-Incorrect	0.7961**	0.3501
	(0.0203)	(0.1800)
Pleasant-Unpleasant	-0.0310	0.3299
	(0.8948)	(0.1221)
Hard-Easy	0.0915	-0.0056
	(0.7498)	(0.9774)
Appropriate-Unappropriated	-0.1849	-0.3420*
	(0.4724)	(0.0977)
Complicated-Simple	-0.1290	0.3124
	(0.6608)	(0.1507)
Comfortable-Uncomfortable	-0.0935	0.0195
	(0.6650)	(0.9076)
Useless-Useful	0.1760	-0.1195
	(0.4987)	(0.5632)

Safe-Unsafe	-0.1209	-0.0899
	(0.5476)	(0.6254)
Close People considerations	-0.1186	-0.0151
	(0.4397)	(0.9145)
Close people agree with bike use	0.0546	-0.0603
	(0.7725)	(0.7340)
Number of close people using	-0.5567	0.8647
	(0.4746)	(0.1410)
Feeling like using	-0.4285	0.5958*
	(0.2197)	(0.0531)
Considering using	0.4087	-0.6916**
	(0.2101)	(0.0220)
Propability of using public transport	0.1759	-0.5203**
	(0.4510)	(0.0249)
Probability of moving from car to bus	-0.1577	0.4669*
	(0.5198)	(0.0638)
Conection to Nature	1.0139	-1.5494
	(0.3562)	(0.1460)
Postal code	-0.0011	-0.0000
	(0.7503)	(0.7872)
Own bike	1.1339**	0.0597
	(0.0360)	(0.9069)
Own car	0.8904	0.7322
	(0.1452)	(0.1653)
Own motrobike	1.8301*	
	(0.0564)	
Constant	-0.0468	1.5391
	(0.9950)	(0.7562)
Observations	121	111
pval in parentheses, *** p<0.01, ** p<0.05, * p<0.1	Pseudo R2=0.4402	Pseudo R2=0.3549

Conclusions

Environmental concerns do not always match consumption decisions, as it is the case for transport decisions for UCLM students and staff, where a positive attitude towards bicycle commuting and a positive perception towards social acceptability of bicycle does not lead, in general, to bicycle use. The survey found that around 50% of the respondents use polluting commuting means frequently or always, such as car, on their own or shared, motorbike or public transport. The use of those means lead to a transport carbon footprint, considering both direct and indirect emissions, of 0.801493 CO_2 kt, of which around 60% where due to car transport, so that it only concerned between 15 and 20% of the interest population.

Conclusions on the emissions reduction achievable with different curbing decisions that could be implemented either by the UCLM or by the local government will be ready to discuss in the next version of the paper.

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Annexe A1