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Behavioural changes in transport and future repercussions of the COVID-19 outbreak in Spain

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ABSTRACT

COVID-19 (Coronavirus disease 2019) brought about a huge change in the behaviour and mobility of citizens in all parts of the world. This change was mainly a consequence of the strong measures of isolation and social distancing taken by the different governments in most countries through the world. The specific measures adopted in each country, in combination with the particular characteristics of the spread of the virus, generated differentiated, although similar, behavioural changes. This article presents the analysis of a survey carried out in Spain in March 2020, where citizens were asked about their mobility preferences before, during and after the lockdown due to the virus. In turn, questions were asked about the preferred modes of transport in each of the situations and the perception of safety on public transport in their current conditions. The mobility questions were differentiated between commuting to work or studies, shopping and leisure. The results show that public transport was the most affected transport mode, with a considerable increase in the use of the bicycle and walking trips. At the same time, changes were observed in the behaviour of shopping trips, including a considerable decrease on the use of large supermarkets. Citizens perceived great uncertainty in planning leisure trips, the consequence of which could be that a higher proportion of people not being able to carry out their planned trips.

1. Introduction

The outbreak of the Coronavirus disease 2019 (COVID-19), and the subsequent declaration of a pandemic by the World Health Organization the 11th of March 2020, implied important changes in the mobility sector in many countries. The policies adopted by different governments tried to slow down the rate of infection applying diverse measures such as: cancelling public events, schools' closures, public transport closures, border closures and even complete national lockdowns (Askitas et al., 2020; Goniewicz et al., 2020; Hadjidemetriou et al., 2020; La et al., 2020). Many of these measures have had a direct impact on citizens' daily choices and mobility in a scale do not seen in decades, although the studies indicate that they have been effective in containing the spread of the virus, especially in the early stages of the outbreak (Kraemer et al., 2020). However, many of these measures have been taken with limited evidence on their effects on mobility based on previous experience of past epidemics and pandemics. Studies prior to the COVID-19 pandemic already showed the importance of transport, and especially air transport, in the spread of influenza A (H1N1) and other coronaviruses. Browne et al., (2016) conducted a systematic review presenting evidence for the role of air transport in the spread of influenza A virus in 2009 and 2010 to new areas, both on board aircraft and at airports (see also Ikonen et al. (2018)), while the role of ground transport was more uncertain. This emergency prompted several countries to implement air travel restriction measures to control the pandemic with traffic drops of up to 40% in some countries such as Mexico (Bajardi et al., 2011). However, the measures were ineffective in containing the spread of the virus. This low effectiveness was also noted by Mateus et al., (2014), who quantified that, although the spread of influenza A was slowed down by air traffic restrictions, this slowdown was only for a period ranging from a few days to four months. However, given that the lethality of this pandemic was relatively limited, and was even lower in

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the case of the other immediately preceding pandemics such as SARS (2002–2003), MERS (2012-present) and Ebola (2014–2016), the measures taken in the field of ground mobility restriction were much more limited than in the case of the current COVD-19 pandemic. The mobility effects during the COVID-19 lockdown have been analysed from different points of view, being focused on logistics, tourism impacts and daily mobility pattern and externalities (Aloi et al., 2020; Google, 2020; Ivanov, 2020; Otmani et al., 2020; TomTom Traffic Index, 2020) Orro et al. (2020); Politis et al. (2021); Zannat et al. (2021); Zhang et al. (2021). However, once the lockdown policies relaxed in many countries, the mobility experienced a restarting effect due to changes in tourism and in daily mobility behaviours. Both effects were strongly correlated depending on the region analysed but, in any case, user perspective and choice preferences changed due to the social distance effects, safety perceptions and new border variables appeared during the recovery period (stronger sustainable mobility policies in cities or transport supply variations for instance (Deponte et al. (2020); Shakibaei et al. (2021)).

The touristic side is not a trivial issue due to its importance on the virus propagation and on the economies of the touristic regions. However, the impact of the lockdown could be seen as a new opportunity to implement less intense activities and a sustainable way of tourism (Iaquinto, 2020; Renaud, 2020). This fact is highlighted by many alternative destinations competing to attract the expected reduced tourism demand in this recovery period (Iacus et al., 2020; Wen et al., 2020).

On the contrary, the daily mobility seems grew up in this period but not in the same way that it did it before the lockdown days. Bucsky (2020) detected, using data from Budapest (Hungary), that the decrease in mobility was also followed by a reduction in the modal share of the public transport and an increase in the share of the car and the bicycle, i. e. the private modes were clearly favoured during the lockdown. These results are consistent with those provided by Aloi et al. (2020) for the city of Santander, in the north of Spain. In Asia, India were one of the countries that were forced to carry out a national lockdown in order to avoid a fast extension of the disease among the large population of the country (Saha et al., 2020). Through the analysis of time series data about the mobility in the territories that make up the country, the authors quantified the decline in the mobility for different activities, showing higher drops in leisure purpose trips and in trips with destination to transit stations. In contrast, mobility to residential areas increased by more than 20% (Engle et al., 2020).

All the researchers found that these changes had a negative impact on the public transport systems (MOOVIT, 2020). Most of them were suffering decreasing rates of demand while maintaining or even increasing their supply in order to fulfil the social distancing regulations (Coppola and De Fabiis, 2020; Tirachini and Cats, 2020). However, other means of transport such as bike share systems showed a more resilient behaviour during the virus outbreak, even though they were still suffering a drop in the number of users. Moreover, those alternative public transport modes have taken users from conventional public transport systems (Teixeira and Lopes, 2020). There is evidence that the suffered mobility disruption is changing the mobility trends in the post-COVID era. Thus, some previous research has considered the effects of public health policies on the mobility choices of the citizens. In the Netherlands, de Haas et al. (2020) analysed the effects of the 'intelligent lockdown' carried out by the Dutch government on the mobility behaviour of the citizens. To perform this analysis, the authors conducted a survey to 2500 people, showing how the mobility was reduced by 80% among the people surveyed. Most of the respondents showed a positive view towards the car as mode of transport during the lockdown and a more negative perception about public transport. Furthermore, 27% of the workers had the expectation of working from home more often in the future, and 20% of the people of walking and cycling more when the crisis is over. The authors stated that these results supported the conclusion that the coronavirus crisis could result in long term changes in the mobility patterns of the population. In fact, mobility is changing as the activity system is changing too. Work related activities have strongly been influenced by the COVID-19 pandemic, leading to changes in occupational status. The lockdown has increased the work-from-home activities but has broaden income, gender, racial and ethnic inequality (Kramer and Kramer, 2020).

This negative social impact has was found in Italy, where the consequences of the lockdown measures introduced on the 9th of March were studied by Bonaccorsi et al. (2020) using mobility data collected by Facebook. These authors found that the national lockdown had unequal effects in the Italian municipalities, showing the ones with more fiscal capacity stronger reductions in mobility. In addition, the effects were also more important in those territories with higher inequality and lower income per capita. These results suggest that the lockdown measures were not neutral from a social point of view, affecting more severely vulnerable populations. Similar results were found in USA by Ruiz-Euler et al. (2020). In this country, the New York City residents of richer neighbourhoods were more likely to go out the city during the lockdown while low income neighbourhoods showed more work activity during the day and less time spend in the home during the non-work hours (Coven and Gupta, 2020). Finally, Engle et al. (2020) using data from GPS location showed also that the order to stay at home reduced mobility by 7.8% and that this effect was stronger in counties with older population, with higher population density and with a lower share of citizens that voted to the Republican Party in the last Presidential Election.

All these changes and social inequalities have led some authors to put forward the idea that the COVID-19 crisis may be an opportunity to change the transport choices through new proposals such as promoting responsible transport (Budd and Ison, 2020). This concept of responsible transport is based on the idea that users, when making their transport choices, should be more aware of the consequences of these, both on an environmental level and, crucially in the face of an epidemic, on the possible impacts on the public health of other citizens. However, it is true that while public transport is a preferable mode to the car because of its lower environmental externalities, during an epidemic the risk of contagion and of being infected by others increases in the public transport modes, so the balance between the two effects is far from clear.

Therefore, it is of the utmost interest to examine how the measures applied to contain the pandemic have affected to different aspects of the mobility patterns in order to plan and manage future outbreaks of the COVID-19 or other epidemics. The research developed in this paper has as main objective to examine the behavioural changes seen in the transport sector in the region of Cantabria (Spain) during the lockdown declared by the Spanish Government between the 15th of March and the 21st of June. For doing this, a survey was conducted during April 2020, asking about the changes in the choices made by different individuals before and during the lockdown.

The remaining of the paper is divided in 4 sections. The next one explains how the data was collected, focusing on the survey design and a descriptive analysis of the sample. Next, in section 3, the modelling methods are explained, which are applied in section 4, where all the results are shown. In the final section some conclusions are exposed based on the results obtained throughout the study.

2. Collected data

2.1. Design of the survey

To obtain the necessary data for the analysis, an online survey was conducted and disseminated through social networks and instant messaging services. The survey was released on April 9, 2020 and remained active for 2 weeks. Respondents were not given any incentive to conduct the survey. The survey was divided into 6 parts. The first part focused on obtaining basic socio-demographic information on the respondent, such as, gender, age and city of residence. The second part focused on analysing the work situation of the respondent before and during the lockdown due to the COVID-19. At the same time, it was asked whether they had previously worked from home or not, whether they were working from home during the lockdown and whether or not they performed any work defined as essential (healthcare workers, police officers, supermarket workers, food producers, firefighters, etc.). The next three sections focused on studying three types of mobility affected by the coronavirus, i.e. business trips (daily commuting), shopping trips and leisure trips. For each of these cases, we asked about the impact that the lockdown had generated on trips already planned for this year; additionally, we asked what the preferred mode of transport for each of those trips would be.

In the specific case of business trips, a series of additional stated preference (SP) questions were planned based on Best-Worst (BW) scaling (Case 1) (Marley and Flynn, 2015). In the first one, the respondents had to choose the mode of transport that they would most and least likely choose, if they had to go to work (or to study) during the lockdown period with the virus situation at that time. The second question showed a future situation in which, respondents had to make the same choice, but considering a new situation where government restrictions were relaxed (no effective lockdown) and the virus situation was more or less controlled, yet, there was still a possibility of infection (i.e. the situation called in Spain as new normality). For both cases, the modes of transport were not accompanied by any kind of attributes (BW case 1), so the respondents answered based on their own opinions of the different modes available.

Finally, in the last part of the survey, a series of questions related to public transport were asked: frequency of use, if they used public transport during the lockdown, if they considered important the cleanliness of the vehicles before and after the COVID-19 outbreak, if they considered it safe to travel on public transport once the appropriate preventive measures were taken and if at the end of the situation with the COVID-19 they would continue to use public transport as usual as they did before.

2.2. Description of the sample

The analysed sample consisted of a total of 478 participants, of which 336 were full responses (70%). Table 1 shows the socio-demographic information and the employment situation of the sample. Women are very slightly overrepresented (56%). In terms of age, the bulk of the active age group (25–65 years) is correctly represented while the younger and older people are slightly underrepresented, both being 6% of the sample. As for the city of residence, to simplify the analysis it was decided to make a classification based on population. For this purpose, populated areas with less than 25,000 inhabitants were defined as rural areas. Cities were considered small (<150k inhabitants), medium (<250k inhabitants) and large (<500k inhabitants). Areas with more than 500k inhabitants were considered metropolitan areas. The sample was mainly located in rural areas (30%) and in medium-sized cities (35%).

Regarding their occupation, almost half of the respondents (47%) are private-sector workers, another 18% are public employees and 9% are self-employed. The number of students (6%) is slightly low mainly because of the low participation of young people. The number of retirees is 11%. The above-mentioned data correspond to the situation before the lockdown decreed by the Spanish government. Once the lockdown started, a large number of companies had to stop their economic activity. For that reason, the government gave the opportunity to those companies to temporarily dismiss their workers while the emergency situation due to the COVID-19 lasted. Workers who were unemployed due to this situation would receive an economic compensation from the state. This situation did not apply in the same way to self-employed workers, who continued to be considered self-employed even if they were unable to carry out their economic activity. Therefore, looking at the data on the employment situation during lockdown, it can be seen

Table 1
Characteristics of the collected sample.

Gender	Male	44%	
	Female	56%	
Age	<25	6%	
	25–34	27%	
	35–44	24%	
	45–54	19%	
	54–65	18%	
	>65	6%	
City size	Rural area	30%	
	Small city	14%	
	Medium city	34%	
	Large city	14%	
	Metropolis	8%	
Work status		Before lockdown	After lockdown
	Self-employed	9%	8%
	Unemployed/looking for a job	5%	5%
	Temporarily unemployed	0%	8%
	Public employee	18%	18%
	Company owner	1%	1%
	Student	6%	6%
	Retired	11%	11%
	Housekeeper	2%	2%
	Other	1%	2%
	Employee	47%	40%
Working from home before the lockdown	Never	50%	
	Rarely	19%	
	Sometimes	23%	
	All the time	8%	
Working from home during the lockdown	Yes	48%	
	No	52%	
Essential worker	Yes	28%	
	No	72%	

that 8% of the workers became temporarily unemployed. All public workers continued to carry out their usual activity. As for previous working from home experience, half of the respondents (50%) replied that they had never worked from home before, while the other half had done so at some extent. About 8% of the respondents worked from home on a regular basis. During the quarantine, 52% of the workers did not work from home, however 48% did. It can therefore be concluded that half of the respondents were not able to do their work from home, while those who had ever worked from home started to do so exclusively during the lockdown. Finally, 28% of the sample turned out to be essential workers.

2.2.1. Use of public transport

Public transport (PT) is one of most affected transport modes by the COVID-19 pandemic, mainly due to its consideration as one of the most likely transmission channels (Zheng et al., 2020).

The analysed sample showed great variability in the use of public transport (Fig. 1). Most respondents use public transport between several times a week and several times a year. 5% of the respondents said that they used public transport every day of the week, including weekends, while 12% used it on working days. As for the people who rarely or never use public transport, this segment only represents 11% of the sample.

In the case of the survey carried out, the results analysed are evidently marked by the mobility restrictions imposed by the Spanish government during the period of the pandemic. This decrease affected all modes of transport and especially the PT. The responses showed a clear decrease in the willingness to use the PT by regular users (Fig. 2). Respondents were asked whether they used the PT before, during and if they were willing to use it after the lockdown. The figure shows the evolution in those three stages. A 93% decrease in the use of PT during the lockdown was observed, data that are close to the reality observed by

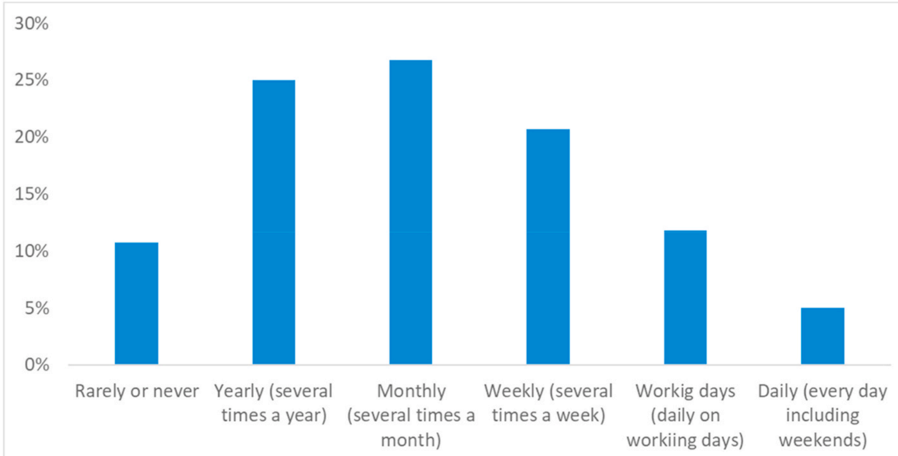

Fig. 1. Public transport usage level.

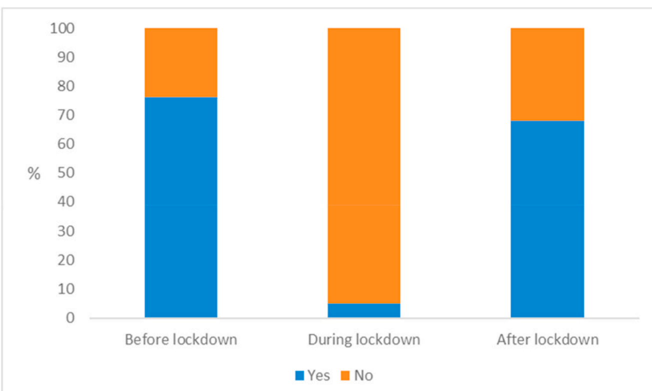

Fig. 2. Evolution of PT us before, during and after the lockdown.

studies such as that carried out by Aloi et al. (2020), where the decrease in the use of PT during the pandemic was 95%. After the lockdown, respondents thought that the negative effects of the pandemic would probably ease, although, a small portion of PT users were reluctant to use public modes as they had used before.

One of the reasons for the decline in PT use was the change in users' perception of the cleanliness of vehicles and infrastructure after the lockdown. Analysing the results of the survey carried out, using a Wilcoxon test with Z = −11,204 (p = 0,000), the null hypothesis of equality between the two distributions can be discarded. We can therefore say that statistically there is a difference between before and after the pandemic on cleanliness importance perception. As Fig. 3 shows, the percentage of users who considered cleanliness to be very important grew from 50% to 90%, with the number of users who did not consider or valued cleanliness of vehicles and infrastructure little having disappeared.

Another factor related to the decrease on the use of public transport was the user perception of security against the virus while using those services. Fig. 4 shows how the respondents perceived health security in PT services. More than 30% of the respondents considered its use to be unsafe or very unsafe. Close to another 30% of the respondents considered that using the PT services was secure. The other third of the respondents were neutral in this regard.

3. Methodology

3.1. Multinomial logit for best-worst scaling

Three type of BW questions are defined in the literature, known as Case 1, Case 2 and Case 3 (Louviere et al., 2015). The questions based on BW used on the survey do not consider any kind of attributes of the available choices, thus, this paper adopts the BW Case 1 method.

There are a total K objects (transport modes) to be chosen on the survey. In each BW task a subset Y of four attributes is shown. In this specific survey, all the alternatives are shown in all the questions, therefore, we can say that$Y = K$. With the answers of the choice task, a vector $\boldsymbol{\delta} = (\delta_1, \ldots, \delta_k)$ is estimated, which is the utility coefficient of each object.

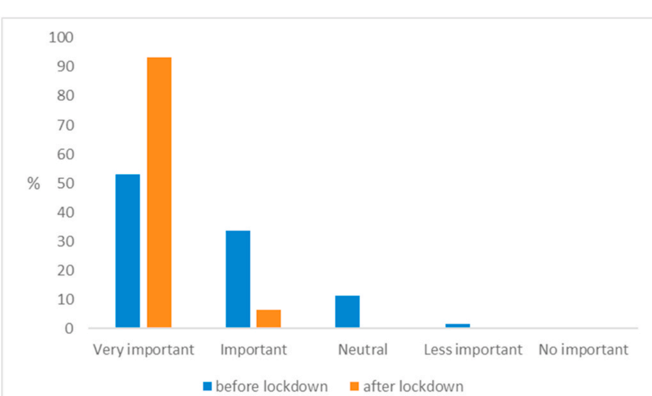

Fig. 3. Importance level of cleanliness of the buses.

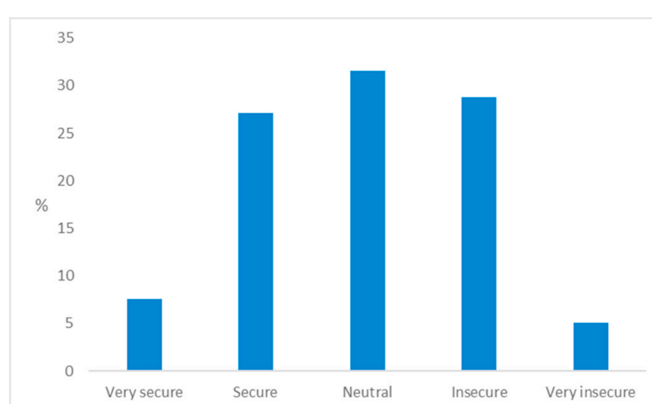

Fig. 4. Safety perception of future PT users regarding to health security.

The probability of choosing an object $b|Y$ as best is denoted as $P_B(b \mid Y)$. In the same way, the probability of choosing an object $w|Y$ as worst is denoted as $P_W(w \mid Y)$. The joint probability of choosing object b as best and object $w \neq b$ as worst is defined as $PBW(bw \mid Y)$. In the experiment, the survey platform was programmed in such a way that the respondent cannot advance if the same choice was selected as both best and worst options. That is, $P_{BW}(xx|Y) = P_B(x|Y)P_W(x|Y) = 0$ since either $P_B(x|Y)$ or $P_W(x|Y)$ or both must be 0.

Adopting a standard logit specification to describe the choice of the best and the worst choices, (i.e. assuming that the unobserved components of the utility follow Type 1 Generalized Extreme Value or Gumbel distribution with random variables independently and identically distributed), the probability $P_{BW}(bw \mid Y)$ for one BW choice task can be defined as the Maxdiff model (Marley and Louviere, 2005). However, the Maxdiff model assumes that the respondent simultaneously chooses the best and the worst options, which is not fulfilled in the survey, as BW tasks were split in 2 consecutive questions. Therefore, it is more correct to assume that the respondent selects the best option first, then eliminate this attribute out of the choice set before selecting the worst option. For that case, the sequential best-worst model specification is more appropriate (Dyachenko et al., 2012), which notation is defined in equation (1).

$$P_{BW}(bw|Y) = P_B(b|Y)P_W(w|Y-\{b\}) = \frac{\exp v(b)}{\sum_{l\in Y}\exp v(l)}\cdot\frac{\exp -v(b)}{\sum_{k\in Y-\{b\}}\exp v(k)} \quad (1)$$

where $v(.)$ is the observable utility components specified as a linear-in-parameter function of alternatives such as $v(k) = \delta_k y_k$ where y_k is an indicator vector of 0 and 1 ($y_k = 1$ when the attribute k is shown to the respondent i and 0 otherwise). The previous notation considers the parameter δ_k to be constant for all respondents i. This is a strong assumption that may not be realistic considering the heterogeneity of the analysed sample. To make this assumption more flexible, a variation of the parameter δ has been included, considering the systematic heterogeneity of the sample. Thus, $\delta_i = \boldsymbol{\delta} + \boldsymbol{\Lambda} z_i$ where $\boldsymbol{\delta}$ remains the vector of constants associated with attributes k, while $\boldsymbol{\Lambda}$ is the vector of parameters associated with the sociodemographic variables z_i of each individual i.

3.2. Sankey diagram

In order to compare the results of the same multiple answer question in two consecutive states, we have chosen to use Sankey diagrams (Sankey, 1896). A series of hypotheses were needed regarding how the property of "having been selected" flows between these situations for each pair of answers, taking into account that both user to user and in aggregate, the number of options selected before and after may be different.

Each survey from the set of surveys carried out is identified as$i$:

$$i \in I; I = \{1 \ldots |I|\} \quad (2)$$

Each answer option is defined as m:

$$m \in M; M = \{1 \ldots |M|\} \quad (3)$$

The answer state or situation is defined by t (0 before lockdown, 1 after lockdown):

$$t \in T;\ T = \{0, 1\} \quad (4)$$

Hence, variable $r_{i,t,m}$ represents, for the analysed question, whether a subject i have chosen option m in a state$t$:

$$r_{i,t,m} = \begin{cases} 1 & \text{if answer } m \text{ is chosen} \\ 0 & \textit{otherwise} \end{cases} \quad (5)$$

In order to create the Sankey diagram, the flows $f_{i,b,a}$ of the number of situations in which a response has been selected are required. In the case of respondent$i$, responses are transferred between answer b in the initial state and answer a in the final state.

$$f_{i,b,a} \in \mathbb{Q}\,;\ 0 \le f_{i,b,a} \le 1 \qquad b \in N \qquad a \in N \qquad N = \{0\} \cup M \quad (6)$$

In addition to referring to one of the possible responses$M$, b and a can take value 0. In those cases, it means that the number of responses selected by the user has increased or decreased in the final situation.

The desired behaviour for $f_{i,b,a}$ is that the subject $f_{i,b,a=}$ marks an alternative both before and after, a transfer of 1 'inclusion in response' (ai) between both states occurs (reflecting that it was considered before, and still is after). In addition, in order for the aggregated values per response to coincide in both situations with the number of respondents who selected it, the total user-generated shift for a response m is sought to be 1 ai if the user intends to use it, and 0 ai otherwise:

$$\begin{array}{lll} r_{i,0,m} = r_{i,1,m} = 1 & \Rightarrow & f_{i,b,a} = \begin{cases} 1 & \text{if } a = m \wedge b = m \\ 0 & \text{if } a = m \wedge b \neq m \vee a \neq m \wedge b = m \end{cases} \\ r_{i,0,m} = 1 & \Rightarrow & \sum_{a\in N} f_{i,m,a} = 1 \\ r_{i,1,m} = 1 & \Rightarrow & \sum_{b\in N} f_{i,b,m} = 1 \\ r_{i,0,m} = 0 & \Rightarrow & \sum_{a\in N} f_{i,m,a} = 0 \\ r_{i,1,m} = 0 & \Rightarrow & \sum_{b\in N} f_{i,b,m} = 0 \end{array} \quad (7)$$

Three sets are defined: C_i, the first set contains those answers selected by the user in both the previous and subsequent situations. The other two sets indicate that answers present in one of the situations are not found in the other, both before but not after (A_i) and vice versa (A_i). Their difference in number of elements (d_i) reveals the reduction (if $|B_i| > |A_i|$) or increase ($|B_i| < |A_i|$) in the number of responses selected by the respondent between the two states:

$$\begin{array}{l} C_i = \{m | r_{i,0,m} = 1 \wedge r_{i,1,m} = 1\} \\ B_i = \{m | r_{i,0,m} = 1 \wedge r_{i,1,m} = 0\} \\ A_i = \{m | r_{i,0,m} = 0 \wedge r_{i,1,m} = 1\} \\ d_i = ||B_i| - |A_i|| \end{array} \quad (8)$$

The in-depth analysis of ($|B_i| > |A_i|$) is:

- For answers selected in both states (C_i), a direct transfer of 1 ai is produced.
- From each of the responses present in the initial situation but not in the final one (B_i), flows are created to each of those that appear in the final situation but not in the initial one (A_i). The magnitude of each one of these will be $\frac{|A_i|}{|B_i|}ai$ so that each mode A_i receives in the later situation 1 *ai.*
- The d_i ai that have been lost materialize in transfers of magnitude $\frac{d_i}{|B_i|}ai$, from each answerB_i to the '*decrease in response*' category (rd), so that their sum is d_i, and the sum of transfers from each modeB_i of the initial situation is also unitary.

The opposite case, in which the number of responses from the respondent increases is treated in an analogous manner, being d_i how many more responses are marked for the subsequent status.$\frac{|B_i|}{|A_i|}ai$ transfers are made fromB_i to A_i, and $\frac{d_i}{|A_i|}ai$ from "*extra answer*"(er) toA_i.

When the number of options used does not change $d_i = 0$, and therefore neither the rd nor the er categories are involved. The treatment can be included indifferently in either of the two previous cases.

Eq. (9) summarizes the calculation process of the ai transfers for each respondent i.

$$f_{i,b,a} = \begin{cases} 1 & \text{if } b = a \wedge b \in C_i \\ \frac{|A_i|}{|B_i|} & \text{if } b \in B_i \wedge a \in A_i \wedge |B|_i \geq |A_i| \\ \frac{d_i}{|B_i|} & \text{if } b \in B_i \wedge a = 0 \wedge |B_i| \geq |A_i| \\ \frac{|B_i|}{|A_i|} & \text{if } b \in B_i \wedge a \in A_i \wedge |B|_i < |A_i| \\ \frac{d_i}{|A_i|} & \text{if } b = 0 \wedge a \in A_i \wedge |B_i| < |A_i| \\ 0 & \text{otherwise} \end{cases} \quad (9)$$

Finally, the aggregated values for each response in both situations (in addition to the categories decrease in responses and extra responses) $V_{j,t}$ provide how many respondents mark each alternative in each situation and also characterize in how many cases the number of options selected has decreased or increased. They are calculated by adding up the relevant volumes:

$$j \in M;\ k \in T$$
$$V_{j,k} = \begin{cases} \sum_{i \in I, a \in M} f_{i,j,a} & \text{if } k = 0 \\ \sum_{i \in I, b \in M} f_{i,b,j} & \textit{otherwise} \end{cases} \quad (10)$$

Each $V_{j,t}$ can take as a maximum value of $|I|$, if the characteristic being represented (a specific answer if $j \neq 0$, a *decrease in answers* if $j = 0$ and $k = 1$; or an extra answer if $j = 0$ and $k = 0$) is present in all responses to the survey in the corresponding situation ($t = 0$ or $t = 1$, before or after, respectively):

$$0 \leq V_{j,t} \leq |I|;$$
$$\sum_{j \in N} V_{j,0} = \sum_{j \in N} V_{j,1} \quad (11)$$

4. Results

4.1. Business trips

Fig. 5 and Fig. 6 show the results of the revealed preference (RP) questions in the survey. Fig. 5 compares the modes of transport used by respondents to access their jobs on a regular basis (Commuter trips). It is worth mentioning that during the lockdown, the number of trips experienced a 62% decline. Therefore, in the data shown in the figure for trips during lockdown, only those trips that were actually made have been considered. The responses collected on the distribution of available transport modes reflect significant changes. The use of public transport decreased by more than 50% due to the fear generated by contagion. The low use shown by shared private vehicles was also reduced to an even more insignificant share. On the other hand, modes of transport considered safe, because they are not shared with any other user, increased their usage level during the lockdown. As Fig. 5 shows, private vehicle (driving) use increased by more than 10 percentage points, as d walking.

Fig. 6 analyses the business trips planned by respondents for the months following the declaration of the state of exception, which led to the entry into force of the lockdown. Respondents were asked about which trips they already have planned and which their intentions were in regard to those trips at the time the survey was being answered. As can be seen graphically, 66% of the trips stopped, this being due to the increase in teleworking and the interruption of the economic activities in some companies. By mode, the car lost half of its share of trips, but instead received small percentages of trips that would have been made in other modes. The airplane was the mode with the most negative impact on user preferences for business trips, with a 50% loss of users. The third most affected mode, and in relative terms the most affected, was the bus, which lost 80% of its expected passengers. Of the users who contemplated its use and intend to continue travelling, half of them moved to means that allow them to travel privately without having contact with other people.

4.1.1. Modelling results

With the stated preference data, based on Best-Worst questions, two models have been estimated for the commuter trips. The first model corresponds to the situation during the lockdown, considering that respondents had to make the trips to work on a regular basis, without having to stay at home. The results of this model are shown in Table 2. The second model correspond to a future scenario, one in which the lockdown restrictions were relaxed and it was possible to attend workplaces. This second model is shown in Table 3.

As for the first model, the following transport alternatives have been considered: walking, bicycle, private car (driving), private car (accompanying), public transport (considering all variants), motorbike and others. In BW case 1 questions, no attribute is considered for the alternatives, so the model to be estimated is the constant-only model. To be able to estimate this model it is necessary to define one of the specific constants as 0, in this case the constant of the alternative "other" has been defined as 0. Although the alternatives do not have specific attributes, it is possible to include the characterisation attributes obtained in

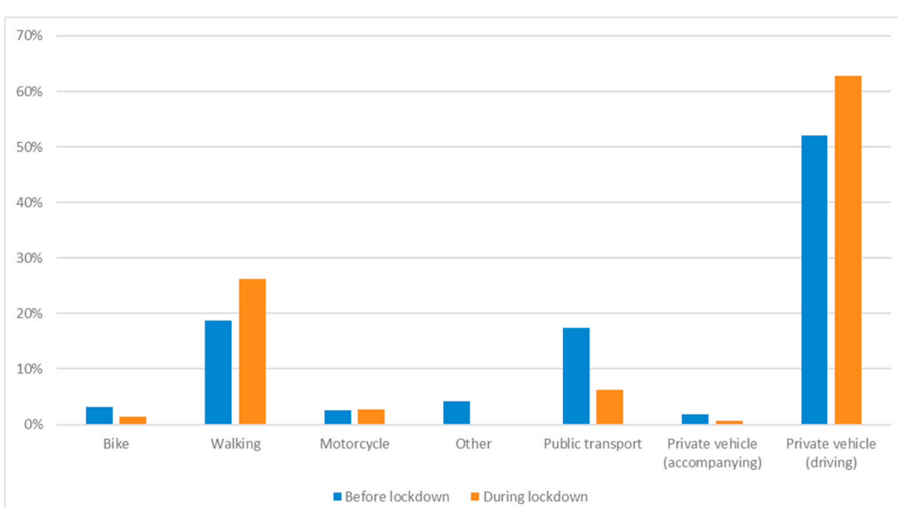

Fig. 5. Modal share before and after the lockdown.

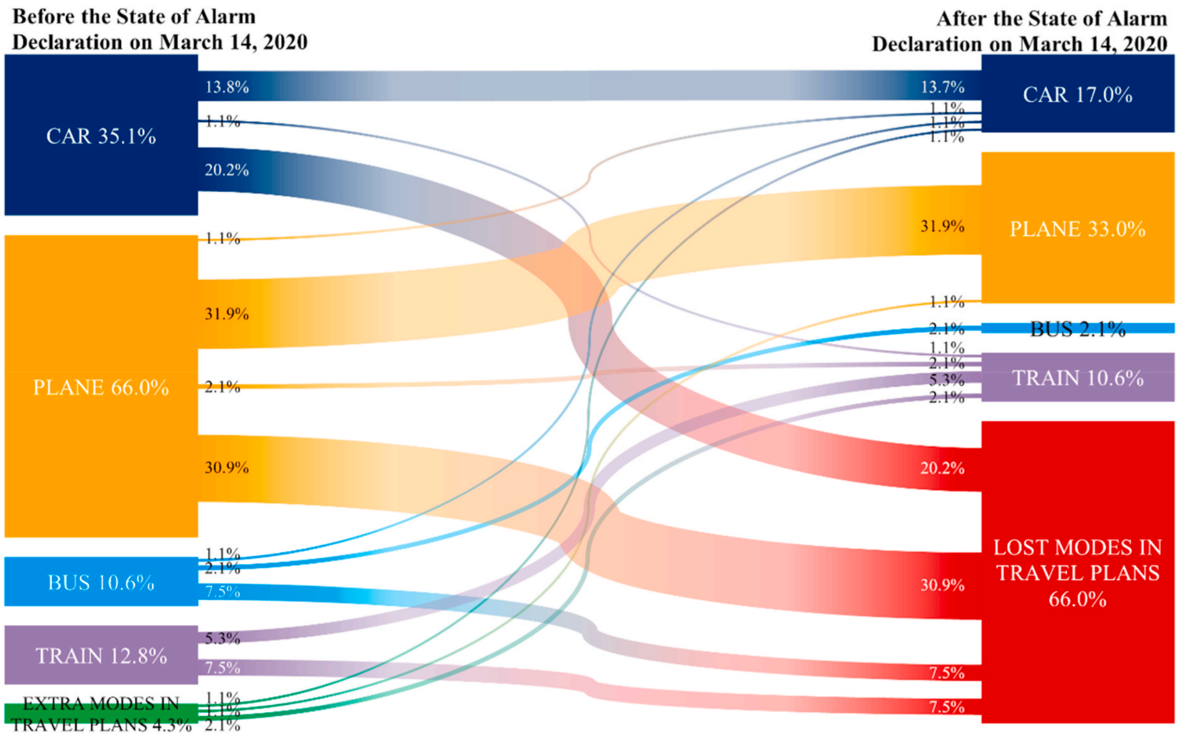

Fig. 6. Sankey diagram of business trips.

Table 2
MNL model during the lockdown.

Variable	Parameter	z-value
Bike (constant)	0.070	0.37
Walk (constant)	−0.016	−0.08
Medium size city (Walk)	0.868	4.23
Car (driving) (constant)	1.550	8.78
Rural areas (Car (driving))	0.613	2.8
Large cities (Car (driving))	−0.816	−3.2
Metropolitan areas (Car (driving))	−0.590	−1.9
TP use - rarely (Car (driving))	0.931	2.44
TP use – yearly (Car (driving))	0.619	2.38
TP use – working days (Car (driving))	−0.844	−2.55
TP use - daily (Car (driving))	−1.485	−3.11
Car (accompanying) (constant)	−0.368	−1.98
Public transport (constant)	−2.062	−10.21
PT safety – Very unsafe (PT)	−0.620	−1.42
PT safety – Unsafe (PT)	−1.048	−4.2
PT safety – Safe (PT)	0.759	3.42
PT safety – Very safe (PT)	1.272	3.71
PT use - rarely (PT)	−1.498	−3.32
PT use – working days (PT)	0.455	1.26
TP use - daily (PT)	1.227	2.57
Moto (constant)	−0.319	−1.71

the survey to study the variations in the choice of the different types of users. In the model shown below, the size of the city, the frequency of use of public transport and the perception of safety in relation to the COVID-19 in public transport have been considered. The sociodemographic information have been included on the model using effects codding (Bech and Gyrd-Hansen, 2005). The socio-demographic attributes have been included in the model through interactions with the different mode parameters, obtaining specific parameters for each mode depending on the defined socio-demographic characteristic. Therefore, if an interaction parameter has a positive sign, that parameter increases the utility of a particular mode, being more likely that mode to be chosen over the others. For example, in the case of the Rural areas (Car (driving)) parameter, the parameter is positive and has a value of 0.613,

Table 3
MNL model after the lockdown.

Variable	Parameter	z value
Bike (constant)	−0.089	−0.49
Walk (constant)	0.066	0.36
Rural area (Walk)	−0.575	−2.37
Medium size city (Walk)	0.644	3.05
Large city (Walk)	0.532	1.93
Car (driving) (constant)	1.108	6.25
Rural areas (Car (driving))	0.361	1.69
Large cities (Car (driving))	−0.493	−1.84
Metropolitan areas (Car (driving))	−0.499	−1.6
TP use - rarely (Car (driving))	1.586	4.1
TP use – yearly (Car (driving))	0.789	3.17
TP use – weekly (Car (driving))	−0.501	−1.78
PT use – working days (Car (driving))	−1.042	−2.98
TP use - daily (Car (driving))	−1.944	−4.02
Car (accompanying) (constant)	−0.281	−1.55
Public transport (constant)	−0.389	−5.77
PT safety – Very unsafe (PT)	−0.805	−1.9
PT safety – Very unsafe (PT)	−0.882	−3.93
PT safety – Safe (PT)	0.522	2.37
PT safety – Very safe (PT)	1.086	3.02
PT use - rarely (PT)	−1.202	−3.33
TP use – yearly (PT)	−0.766	−3.08
TP use – monthly (PT)	−0.502	−2.02
PT use – working days (PT)	1.086	3
TP use - daily (PT)	2.468	5.09
Moto (constant)	−0.569	−3.19
Woking from home (Constant)	−0.138	−0.76

while the Large cities (Car (driving)) parameter has a negative value of −0.816. From these results, it can be concluded that citizens in rural areas will be more likely to use the Car (driving), since its utility increases, while in large cities the tendency is the opposite. Of all the variables included in the model, only those that show a sufficient level of statistical significance have been maintained.

The model constants show that the private vehicle (driving) is the preferred alternative by the respondents, obtaining a constant parameter value much higher than the rest of the alternatives. On the contrary, public transport is the least preferred mode with a clear difference with respect to the rest of the modes. These results are consistent with the empirical data obtained in Aloi et al. (2020), where a greater drop in users was observed in public transport than in the number of private vehicles in circulation. In some cases, the reduction in passengers exceeded 90%. An increase in the preference for the use of bicycle is also observed, as it showed a positive constant value higher than other transport modes.

As for the socio-demographic variables affecting choice, these mainly affect three modes of transport, walking, private vehicle (driving) and public transport. In the case of making the trip on foot, people living in medium-sized cities (<250k inhabitants) show a greater predilection for this mode of transport than the rest of those surveyed. In regard to private vehicles, in smaller urban centres, the predilection for the use of private vehicles is greater, while in larger cities the use is reduced. Moreover, occasional public transport users tend to abandon this mode during lockdown in favour of the private car, while regular users of public transport do not see feasible the alternative of taking the private vehicle. In the case of the public transport alternative, the observed effect is the opposite, users who rarely use public transport show a very negative parameter, so they are very reluctant to use it in a pandemic situation. However, those users are not likely to migrate to their own vehicle, but to another mode. As for frequent travellers, they would continue to use the public transport. Which shows us that this segment of users may be captive of the public transport for their commuter trips. Another important factor in choosing public transport as a mode of transportation is the perception of security regarding the virus. As it was expected, people who consider it unsafe are reluctant to take this mode of transport, while people who perceive it as safe are more likely to choose it.

The second model is shown below based on the questions concerning the choice of mode after lockdown (Table 3). For this case, in addition to considering all the modes of transport used in the previous model, an additional mode has been added. Which consists of not making the trip to work and staying teleworking from home until the situation with the virus improves. As in the previous model, the sociodemographic variables of the respondents have been considered in order to establish variations in the preferences of the travellers.

The results of this second model show similar values to the first model except for a clear decrease in the preference of the private vehicle (driving). Although the private vehicle is still the option with the highest constant parameter, the difference with the other modes is not that great. Public transport also increases the value of its constant, so the probability of choosing the public transport as the preferred mode of travel after lockdown is considerably higher. However, its value is still the lowest of all, so the probability of using public transport is still very low. As regards to the socio-demographic characteristics of the respondents, the effect generated by them is similar to the previous model. In small towns and rural areas, the use of private vehicle increases and people walk less to work, while the use of public transport is more common in large cities. Sporadic users of public transport still prefer private vehicles to public transport, while regular users show positive values for the parameters, which increases the proportion of those who would choose public transport. The perception of security against the virus in public transport remains important, which reinforces the need to establish effective health measures in order to give travellers confidence in using public transport.

By using the models shown above, it is possible to establish the possible trends of the trips made. The following graph (Fig. 7) shows a comparison of the modal split before the pandemic, versus hypothetical cases of travel during the pandemic without lockdown and the possible future scenario once the new normality begins. The clearest effect that can be observed is the drop in public transport users, although after lockdown the number of users increases, it is still far from normal values. The number of people who would choose the bicycle as a means of transport and also the users of motorbikes increase considerably. Bicycle use as seen in Fig. 5 was reduced during the lockdown, however, looking at the survey results, it can be concluded that a large proportion of potential Bicycle users did not make trips during the lockdown. The private vehicle increases to a great extent in the trips that would be made during the lockdown, however, they decrease in the new normality. Some travellers start sharing private vehicles, others start taking public transport systems again and an important part prefers to stay at home until the sanitary situation improves. The results also show a slight trend towards normality prior to the lockdown situation, although this is not achieved immediately after the end of the lockdown.

The last of the estimated models, the one that focuses on analysing the future situation, allows us to observe the effect of different variables on the respondents. On the one hand, in Table 4 we can observe the existing differences in terms of the modal distribution between the different city sizes. The use of private vehicles will be greater in small towns or in rural areas, a logical result considering that this mode of transport is considered the safest in terms of virus transmission and that in these places the restrictions for the use of private vehicles are not very high. The big change starts in the medium sized cities (between 150k and 250k inhabitants), since most of the car trips are transferred to other modes of transport, mainly walking. In larger cities it is possible to expect even fewer car trips, and since the distances to be covered are

Table 4
Modal share simulation for different city sizes.

Transport mode used for commuting	Rural	Small	Medium	Large	Metro
Bike	8%	7%	8%	10%	11%
Walking	5%	4%	18%	19%	12%
Motorcycle	5%	4%	5%	6%	7%
Other (not sure)	9%	8%	9%	11%	12%
Public transport	4%	4%	4%	4%	5%
Private vehicle (accompanying)	7%	6%	7%	8%	9%
Private vehicle (driving)	55%	60%	42%	33%	35%
None	8%	7%	8%	9%	10%

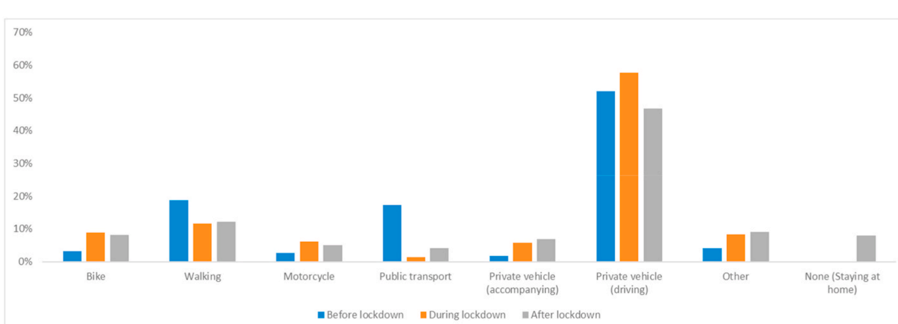

Fig. 7. Modal share simulation - average results.

greater, bicycle use increases. The model shows that the use of public transport will be still very low for commuting after the lockdown. As for the possibility of working from home, this also increases with the size of the city, probably because jobs in big cities are more associated with office jobs that can be done from home, as opposed to more manufacture related jobs in smaller cities.

On the other hand, when considering the perception of safety in the models, it is possible to observe how the safety measures adopted in public transport affect the modal split. Table 5 compares the results of unsafe, neutral and safe public transport. The data shown consider the scenarios with the worst and best modal split for public transport. The difference between one scenario and the other is considerable. In a neutral situation, it is estimated that the modal split will be low, close to a 4%. Compared to the pre-lockdown situation, where the data showed a 17% modal split for public transport, the expected reduction is close to 80%. Considering this situation as a basis, if the necessary hygienic measures are not taken and the citizens consider that public transport is not safe, then, very low levels of use could be reached. Worst case scenario shows half of the neutral situation, in other words, 90% less than in a normal situation without the virus. Similar values to this worst scenario were observed during the lockdown (Aloi et al., 2020). Conversely, if the hygienic measures are adequate and the users perceive the transport as safe, then the use levels of public transport increase considerably. Doubling the modal split of a neutral situation and reaching levels higher than 50% of the pre-lockdown situation.

4.2. Shopping trips

Considering the changes in purchasing behaviour, due to the outbreak of the COVID-19 crisis and the lockdown decreed by the authorities in several countries, these can be examined from different points of view. First, from the perspective of trip generation, or trip frequency for buying purpose, before and during the lockdown, it can be seen how the trip frequency was reduced (Fig. 8), with a significant increase in those households making only one shopping trip for buying and even only one trip every two weeks. This difference was tested using a Wilcoxon signed-rank test in which 33 negative ranges, 209 positive ranges and 130 equal ranges were detected (8 cases corresponding to the category others were excluded). The Z test presented a value of −10.87 (p-value: 0.000) clearly significant and therefore discarding the null hypothesis of equality between the two distributions. In addition, a Chi-Square test comparing both distributions was also performed obtaining the same results. This lower trip frequency for purchase purpose is logical given the health authorities recommendations to reduce contacts with other people because of the risk of contagion, a phenomenon that also influenced the lower mobility during the lockdown.

In relation to these changes in trip generation, the choice of type of establishment in which the households made their purchases also was considered in the survey. The establishment where households most commonly reported making purchases was the local supermarket with 75% positive responses (Fig. 9). Only the differences between the use of Hypermarkets (both inside shopping centres and independently located outside shopping centres) were significant with reductions in their use during the lockdown, according to the Wilcoxon test (p-value: 0.000), in both cases. In contrast, the slightly higher use of grocery stores and E-commerce did not prove to be significant, according to the answers given by households. This reduction in hypermarket users could also be explained by the tendency of people to avoid social contact, especially in situations where many of them may be concentrated. This may also have influenced the reduction in the length of shopping trips, with the nearest local supermarkets being favoured.

Table 5
Modal share simulation according to PT safety against the virus.

Transport mode used for commuting	PT unsafe	Neutral	PT safe
Bike	9%	8%	8%
Walking	13%	12%	11%
Motorcycle	5%	5%	5%
Other (not sure)	9%	9%	8%
Public transport	2%	4%	9%
Private vehicle (accompanying)	7%	7%	6%
Private vehicle (driving)	47%	47%	46%
None	8%	8%	7%

Although the use of E-commerce by households did not appear to increase during the lockdown, it has also been examined whether there has been a change in the type of products purchased online. In general, it can be seen that households reported making fewer online purchases during the lockdown for virtually all products (Fig. 10), with particularly large reductions in services, miscellaneous items and prepared food. Only the perishable products experienced an increase in online shopping, which was also slightly significant at the 95% confidence level, according to the Wilcoxon test (p-value: 0.045). For non-perishable products, although there was a slight decrease in declared online consumption, this difference was not significant. This indicates that certain economic sectors were badly affected by the lockdown, even when online shopping was possible, given the restrictions on mobility that prevent people of moving around to enjoy the services or even because households reduced their demand for non-basic products.

In the first days of the declaration of the lockdown, there were reports, in several countries, of cases of product hoarding and the consequent lack of some of them due to the alarm and social distrust generated (Bravo, 2020; Hansen, 2020) In this regard, some households reported having bought more than the usual amount, especially in products such as milk, canned or non-perishable products and disinfection products (Fig. 11). This problem of a very rapid increase in demand for certain products generated difficulties for purchasing specific goods such as, according to the households, disinfection products (52% of those surveyed stated that they had had problems with their purchase), toilet paper/kitchen paper/tissues and even Flour and Yeast (Fig. 12).

4.3. Leisure trips

One of the main sectors affected by the economic crisis resulting from the pandemic has been tourism, only in Spain the tourism sector stopped earning 10 billion euros during the month of April 2020 (Agencia EFE, 2020). With these data, the expectation for the summer of 2020 was very negative, with a clear decline of more than 10% on planned trips to be made for leisure purposes according to the survey conducted (Fig. 13). In addition, it can be stated that according to the Wilcoxon test ($p = 0.005$), there is no relationship between the distribution of trips before and after so it shows the impact of the pandemic to travel by users.

Sankey's diagram in Fig. 14 captures how the predilections of those respondents who had already planned their leisure trips before the survey was carried out changed between before and after the lockdown started. The analysis enables to study the problem in an aggregate form for each mode, and in terms of user transfers between the different alternatives.

The number of planned trips decreased significantly from before the lockdown started to when the survey was carried out. 52.8% of the planned trips were considered to be lost, as users were not able to make them. However, some respondents still were planning new trips for the following months after the survey, a 10,5% of the total. In absolute terms, airplanes and private vehicles were the most popular modes of transport for leisure trips (16.2% and 14.9% respectively). The bus and the train were the ones that experience a more pronounced relative impact, their demands being reduced to a third and 40% compared to what they had before the pandemic.

It can be observed that there was a clear modal shift between before and after lockdown. For example, by analysing in detail how private vehicle users' preferences changed, even being the mode that manages to retain the largest number of passengers (27.5% of the total, representing more than half of their pre-lockdown demand), there was an

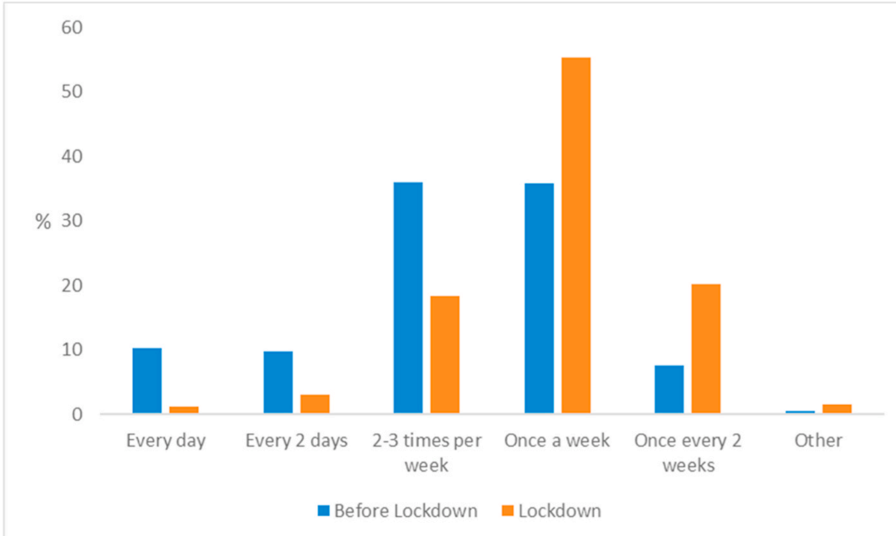

Fig. 8. Percentage of households by frequency of purchases before and after lockdown.

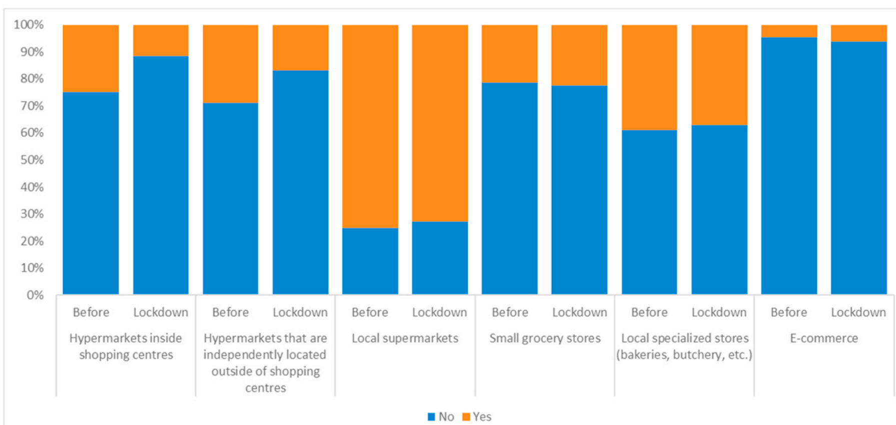

Fig. 9. Type of establishment chosen before and during lockdown by households.

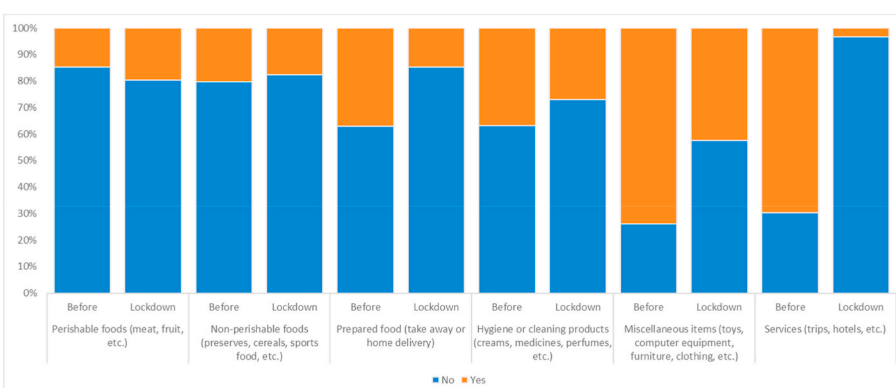

Fig. 10. Online shopping for different types of products before and during lockdown.

important part respondents (15.1% of the total) that were not able (or decided not) to carry out the planned trips. Among those users who decide to replace the private vehicle with another mode, airplanes were the most frequent alternative (7.9% of the total). This result may be due to a desire to travel to places perceived as less risky than national destinations. In absolute numbers, air travellers were the most affected by the global pandemic (25.9% of all users, 58% of those who would have travelled by air before the lockdown). However, it is those who were going to travel by bus that proportionally lost more trips (63% of the bus travellers in the pre-lockdown situation). Bus trips are mainly related to interregional national trips, which were not allowed at the beginning of the lockdown. Also, bus is often chosen because of its price in

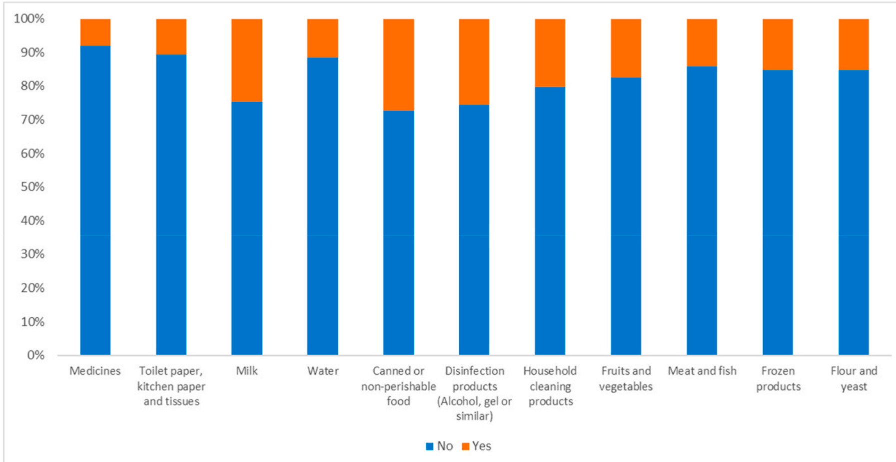

Fig. 11. Purchase of products in larger quantities than usual.

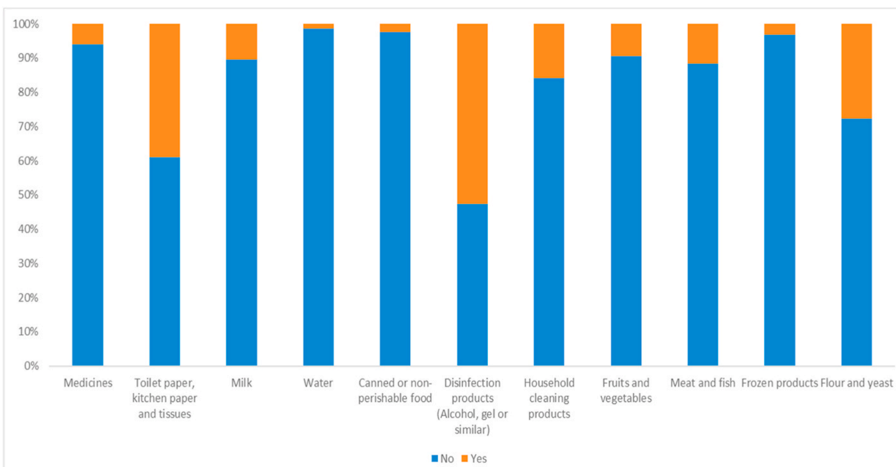

Fig. 12. Products that households have had problems purchasing.

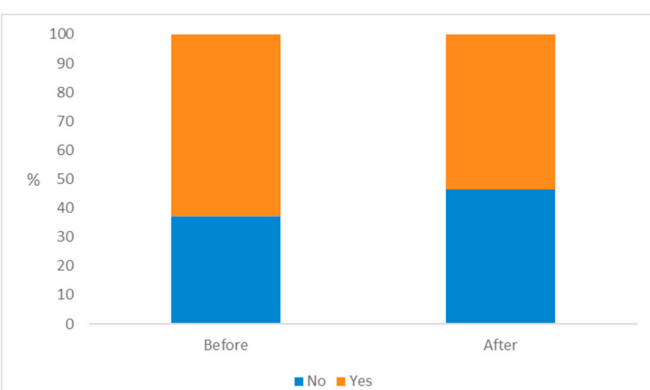

Fig. 13. Planned leisure trips before and after the lockdown.

comparison to faster modes such us the plane, therefore, paying for a much more expensive alternative would not be possible in many cases.

4.4. Trend's analysis based on empirical data

Different data sources have been collected to be compared with the modelling outputs. Several data providers such Google, Apple and some transport planner developers such Moovit and Citymapper are publishing updated statistics of overall mobility, public transport usage and trip purpose variations. Focusing on Spain in 2020 (before vaccine effects), Fig. 15 shows the evolution of trip destinations reported by Google users (Google, 2021). As can be seen, only residential and grocery/pharmacy trips have increased with respect the pre-COVID baseline. It can be seen that retail/recreation and transit stations trips dropped by 40%–50% after the summer. Furthermore, according the data reported by Apple (2021) (Fig. 16), the overall trip requests dropped more than 40% in the same period. These trends are consistent with the results found in this paper.

Specifically, focusing on the data of public transport usage in urban areas provided by Moovit (2021) (Fig. 17), public transport users had dropped between 20% and 60% in 2020 in all the cities. However, this drop is not equally distributed between the analysed cities, being higher in small-mid size cities. It is important to note that Moovit also asked their users about the different attributes for transit usage. According the responses received, the sum of the importance of the COVID safety policies in the vehicles and stops is the most important item, even more than the improving frequencies one (Moovit, 2021). These finding are also consistent with our research. These results have been compared with the data provided by TomTom in the same period. Thus, the congestion level found showed an average drop of 20%, Nevertheless congestion indexes in many spanish mid-size cities increased and they were even higher than in the pre-COVID period (TomTom, 2021).

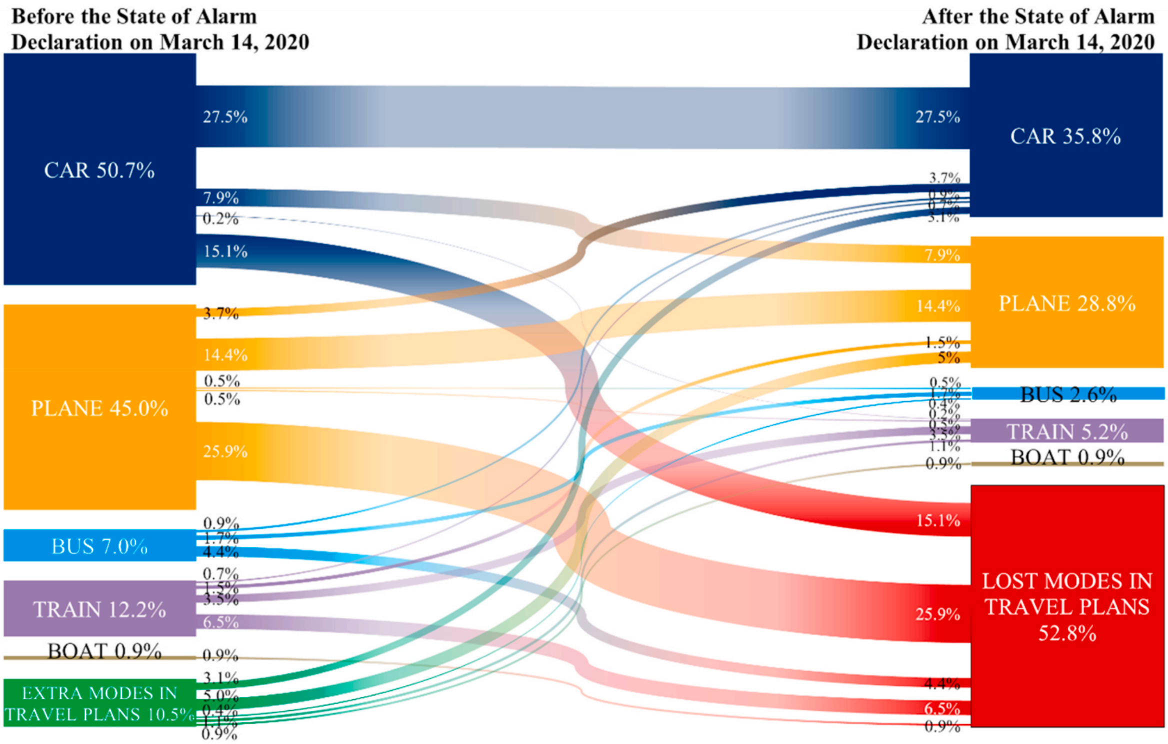

Fig. 14. Sankey diagram of leisure trips.

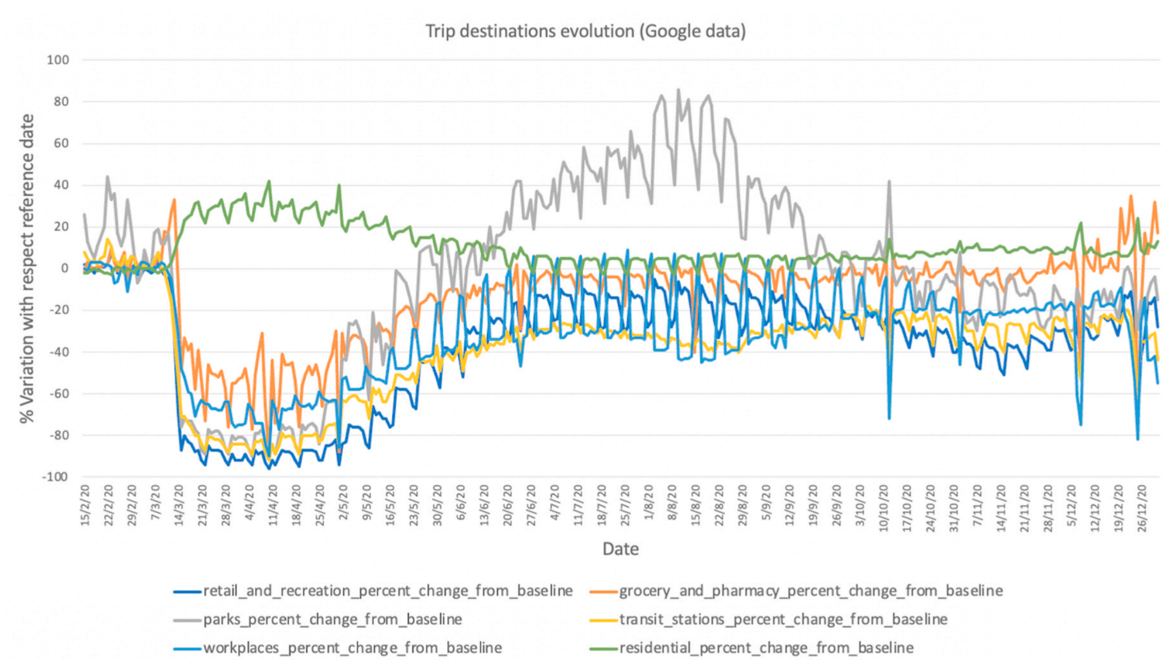

Fig. 15. Evolution of trip destinations based on google data.

Finally we have analysed the mobility data provided by the Spanish Government based on mobile phone data (MITMA, 2021). According to this, the number of people who do not produce any trip in a day increased 20%. This means that more than 2,5 million people have reduced their mobility patterns.

5. Policy recommendations

The pandemic has generated a need to rethink the city's mobility, especially considering collective modes of transport. A decline in public transport ridership is inevitable, but measures can be taken to reduce the decline and recover more quickly.

It is worth mentioning that there are three distinct situations in terms of mobility due to the pandemic. First, there is the moment of general lockdown, where almost all type of mobility is strongly restricted. Secondly, there is the situation after the lockdown but still in a pandemic situation, where mobility is initially restricted and then gradually released. In this second phase, it must be borne in mind that the global

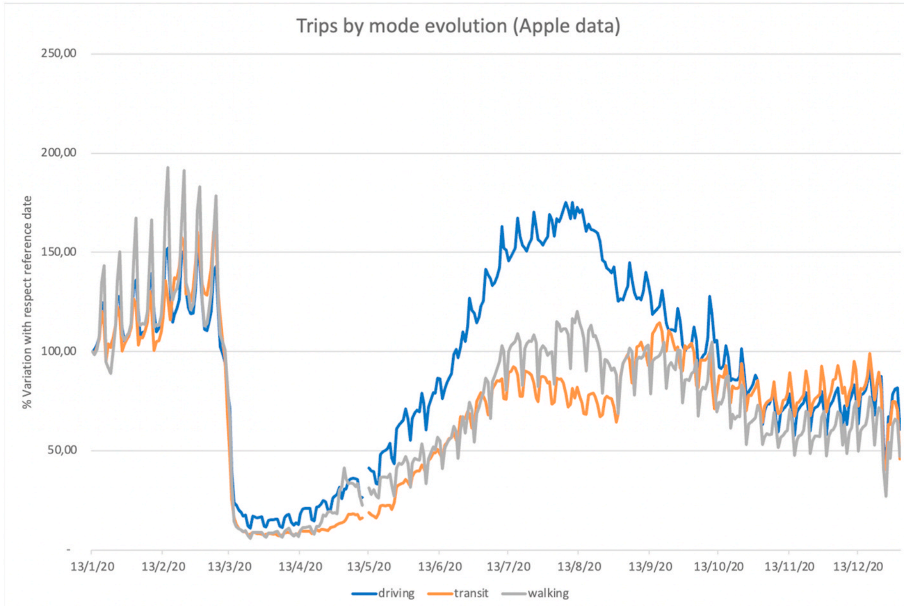

Fig. 16. Evolution of trips by mode based on Apple data (data based on number of trip planner requests).

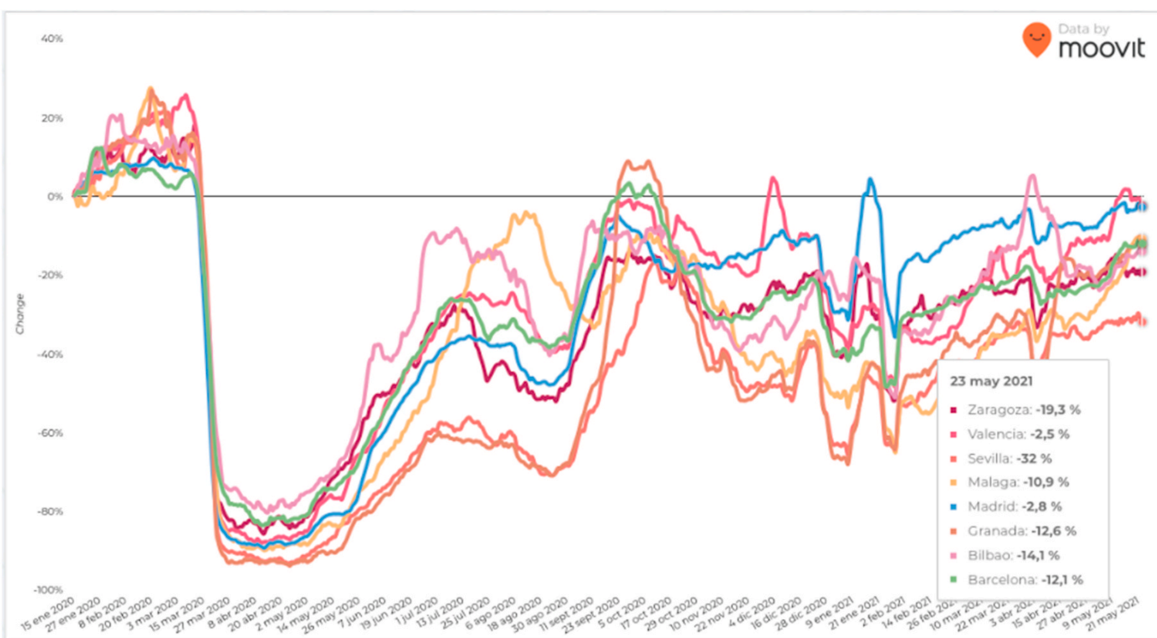

Fig. 17. Evolution of public transport users in Spain (source:www.moovit.com).

pandemic does not subside instantaneously, and that as the situation progress, it is possible that there will be a rebound in contagion. In this second phase, economic activity begins to recover gradually, so that the need for transport increases. Finally, there is an undefined future term situation where the experience of the pandemic will affect people's choice of transport. This future period will have an uncertain duration and will affect each country and each individual differently.

At the time lockdowns in the different countries started, the use of transport in general dropped dramatically in all countries of the world without distinction. Due to the drop in ridership, the economic equilibrium of public transport operators was affected, so the first measures that was applied in many cases consisted of reducing the frequency of services. This measure, while reducing the operators' costs, led to a concentration of passengers in the vehicles, which did not improve the pandemic situation. Another measure adopted in public transport was to reduce the permitted capacity and to protect the driver from possible contact with the users, even allowing free travel in some cases to avoid interaction with the driver. Although additional measures were taken, in the early stages of the pandemic any measures taken on public transport did little to improve the use of public transport.

As the restrictive measures were relaxed, mobility began to grow and the tendency of citizens was to use private modes of transport, avoiding public transport. The choice of the specific mode depended on the location, since in cities where car use is more restricted, the use of bicycles and personal mobility vehicles (i.e. scooters) increased considerably. In those cities where car use was possible, car use also increased considerably. One of the measures adopted worldwide to promote sustainable and active mobility was the conversion of road traffic lanes into bicycle lanes. This measure increased the capacity of the cycling infrastructure in cities and restricted the use of private vehicles. It is important to note that the pandemic brought with it a new working philosophy were working from home was adopted in a large number of companies, a modality that continues to be applied even after the reduction of restrictions. As a result, the need for work related mobility has been greatly reduced. Authorities should incentivise companies to allow their workers to work from home more often as morning peak hour congestion can be reduced.

Finally, as far as the future situation is concerned, the trend will be to return to the normal pre-pandemic situation, however it is not possible to know exactly whether this progression will be fast or slow. One way to achieve the usual level of ridership is to return to the usual level of service as soon as possible. Since passenger revenues are reduced due to low ridership, it is necessary for public authorities to provide the necessary resources for operators to maintain normal service. Another important aspect is the need for an adequate information policy to inform citizens about the real risk of contagion in public transport and the existing measures to minimise those risks. On the other hand, focused on promoting sustainable mobility, it is important to maintain the sustainable measures adopted during the pandemic, especially those measures that were taken in relation to the implementation of pedestrian zones, bicycle lanes and the reduction of the use of private vehicles. Finally, although the pandemic has brought much of the policy and transformation plans aimed at improving sustainable mobility to a halt, it is important that the recovery investments that will be made around the world focus on those aspects that will improve mobility in cities, focusing on active, proximity and sustainable mobility.

6. Conclusions

The results of this article have shown the great effect that COVID-19 had on the mobility of cities and on the behaviour of citizens. This fact has been widely demonstrated in different parts of the world by different authors. Generally speaking, it has been observed that citizens were somewhat wary of using shared modes of transport, especially public transport, mainly due to the risk of contagion that their use entails. Users' perception of the safety of the modes of transport against the virus affects their choice, therefore, in order to achieve a successful recovery of the public transport sector, it is necessary to establish the appropriate hygienic measures to ensure the safety of the users against the virus. Moreover, users' safety perception must be good, so that appropriate communication efforts are needed to inform travellers that appropriate hygienic measures are being applied.

As regards the different types of trips, business and leisure trips showed a similar trend in terms of a reduction of public transport use and an increase in the use of private vehicles. The results show that, although the trend is towards a return to normality, this transition will not be instantaneous once lockdowns are over and pandemic situation improved with vaccines, but will require some time until the situation is normalised. The return to normal may be affected by further outbreaks of the virus, resulting in the need to maintain certain levels of restrictions in some areas.

The alteration of the existing shopping habits of the population was another important effect of the virus, strongly related to the ensuing lockdown imposed in response to it. In the first place, the frequency of purchases by citizens was reduced, giving priority to making a weekly purchase in this specific case study. In addition, the establishments visited also changed, avoiding as far as possible large retail stores where one may encounter big crowds.

To sum up, in a pandemic situation like the one we were experiencing in 2020, it can be seen that the main behaviour of citizens is to avoid areas and transport modes where there may be a large number of people. A large part of the trips made in a normal situation no longer take place, and those that occur are generally made by individual modes of transport. In more rural areas the transfer has been more towards the private motorized vehicle, however, in large cities, the transition has turned out to be to more sustainable modes such as walking or cycling. Public transport was the most affected mode in the pandemic, and a good virus safety policy is needed to return to pre-pandemic levels of users.

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