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The Anticipated Use of Public Transport in the Post-Pandemic Era: Insights from an Academic Community in Thessaloniki, Greece

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Abstract: This paper investigates how the travel behavior relating to Public Transport (PT) changed during the COVID-19 pandemic, and which are the expectations about the extent of PT use post-pandemic. A revealed preferences questionnaire survey was distributed within an academic community in the city of Thessaloniki, Greece. To understand the factors potentially determining the future PT use, hierarchical ordered probit and bivariate ordered probit models were estimated. Results showed that the frequent PT users reduced by almost 75% during the pandemic. More than 29% of the local academic community members are reluctant to resume PT use at pre-pandemic levels. Non-captive users, teleworkers and those being unsatisfied with cleanliness and safety are less willing to travelling by PT post-pandemic. Female and under-stress passengers were found to particularly appreciate the use of facemasks and the increased service frequencies as post-pandemic policy measures. The study findings can inform the recovery strategies of transport authorities in order to retain the PT ridership at levels that will not threat the long-term viability of service provision. Future research may complement these findings by examining other population segments, such as the commuters and the elderly, under more advanced modelling techniques to account for additional unobserved behavioral patterns.

Keywords: public transport demand; policy measures; post-pandemic mobility; COVID-19; ordered probit; bivariate probit; public perceptions

1. Introduction

The COVID-19 pandemic has had an immense impact on travel behavior worldwide. The imposed mobility restrictions, and the fear of contagion have led to a reduction of trips and a significant change in travel mode preferences. Worldwide, public transport systems lost a very important share of passengers because they were considered as confined environments which, due to congestion and close contact with other people, favor the transmission of the disease (Basbas et al. 2021b; Bhaduri et al. 2020; Bucsky 2020; Campisi et al. 2021a; Gutiérrez et al. 2020; Kłos-Adamkiewicz and Gutowski 2022; Lucchesi et al. 2022; Przybylowski et al. 2021; Torbacki 2021; Zunjic et al. 2020). In some cases, the public transport demand dropped more than 90%, especially during the lockdown periods (Aloi et al. 2020; Echaniz et al. 2021; Orro et al. 2020; Pozo et al. 2022). Correspondingly, the use of private cars, which was considered as more comfortable and safer, increased during the pandemic (Abdullah et al. 2020; Labonté-LeMoyne et al. 2020; Munawar et al. 2021). Even after the onset of the vaccination campaigns and the lift of COVID-19 related restrictions, there are strong indications that a significant part of passengers will not return to public transport post-pandemic (Christidis et al. 2021; Downey et al. 2022; Medlock et al. 2021; Monterde-i-Bort et al. 2022; Orro et al. 2020; Przybylowski et al. 2021; Semple et al. 2022; Ton et al. 2022; Torbacki 2021; Vickerman 2021). The reduction of public transport use will inevitably lead to an increase in traffic congestion, a deterioration of environmental

conditions and further challenges in achieving the goals of sustainable transformation of transport, which is of key importance for tackling climate change.

In Greece, the first nationwide lockdown in March–May 2020 brought about important changes of travel behavior. Survey findings from the research work of Politis et al. (2021a) highlighted that commuting trips decreased by 62%, an important share of public transport commuters shifted to walking and private car modes, but cycling did not earn great attention. Similarly, for Thessaloniki, the second largest city in Greece, comparisons of mobility data before and after the start of the pandemic revealed that only a tiny percentage of trips (less than 1%) continued to be performed by public transport during the first lockdown, while walking had become the main travel mode (65% of reported trips) (Politis et al. 2021b). Furthermore, low-income population groups and male individuals tended to take comparatively more and longer (in duration) trips (Politis et al. 2021b).

In this paper we examine the observed and expected changes in public transport use in Thessaloniki, Greece under the modified circumstances induced by COVID-19 pandemic. Specifically, we strive to identify the characteristics of the users that are reluctant to use public transport post-pandemic at the same level as pre-pandemic, as well as the characteristics of those being likely to use public transport the same or even more post-pandemic. To also understand the potential of some policy measures to shape expectations towards future public transport use, we also examined public attitudes towards policy measures, which were introduced during the pandemic, and could potentially remain in place even post-pandemic. We focus on a specific segment of population that is potentially captive to public transport use, i.e., an academic community consisting of university students and staff. From a sample of the latter group, data was collected through an online survey, which, in turn, were statistically modeled through discrete outcome approaches that can account for some aspects of unobserved heterogeneity (Washington et al. 2020).

The paper is organized as follows. In the next section, the short- and long-term effects of COVID-19 restriction measures on public transport systems are reviewed. Section 3 describes the questionnaire we utilized for data collection as well as the public transport system of the area we studied. The methodology for analyzing our data is explained in Section 4. Results are provided and discussed in Section 5, while Section 6 is devoted to the policy implications and conclusions that derived from our research.

2. Literature Review

Globally, the public transport modal shares have dramatically decreased during the various COVID-19 pandemic waves and they have not so far reached or surpassed the pre-pandemic levels, despite the relaxation or abolition of the relevant anti-COVID-19 measures (Monterde-i-Bort et al. 2022). These trip frequency reduction rates have been particularly high in the bus public transport systems of Europe, North America, and Oceania. In London, UK, the bus public transport ridership figures were reduced by 86% in April 2020 and remained 40% below the pre-pandemic levels, even after the relaxation of the COVID-19 restriction measures in the summer of the same year (Vickerman 2021). In Spain, Orro et al. (2020) explained that the bus public transport demand was reduced approximately 84–92% during the first COVID-19 lockdown in A Coruna, and when restrictions were lifted, the relative passenger numbers reached 60% of the typical ridership figures of the year 2019. Public transport demand reduction rates of over 90% were also found in other cities of Spain during the first lockdown (Aloi et al. 2020; Echaniz et al. 2021; Pozo et al. 2022), and demand did not fully restore after its ending (Pozo et al. 2022). Aparicio et al. (2021) compared demand data for bus, tram and metro services in Lisbon between 2019 and 2020 and discovered important decreases of up to 80% in certain public transport stations. In Italy, Basbas et al. (2021a) and Campisi et al. (2022b) analyzed responses from a sample of frequent bus public transport users in Sicily and discovered that almost 40% of them totally abandoned public transport for commuting purposes by the end of 2020. Analogous findings were also obtained from a questionnaire survey in Gdansk, Poland, where 47% of frequent public transport travelers discontinued the use of this transport mode after the

pandemic outbreak (Przybylowski et al. 2021). Results from a large-scale online survey, during the spring lockdown of 2020 in Germany, revealed that the bus and tram public transport modal shares decreased from 18% to 4%, while walking modal shares increased from 26% to 40% (Anke et al. 2021). During the same period, unfavorable modal shifts for public transport were also reported in Germany by Eisenmann et al. (2021). Though that in Sweden the public transport supply remained relatively unchanged in the first wave of COVID-19, Jenelius and Cebecauer (2020) examined ticket sales data from the three largest regions of the country and observed a severe decrease of 40–60% in public transport ridership figures, especially in the capital of the country, Stockholm. In Australia, Munawar et al. (2021) assessed the impact of COVID-19 containment policies on public transport sector and they highlighted a reduction of 80% in ridership figures compared to the pre-pandemic period. Even after the easing of restrictions, the increase of passengers was weak (Munawar et al. 2021). Hu and Chen (2021) reported an average demand decline of 75% at public transport stations in Chicago, USA, due to the outbreak of the pandemic, and they emphasized demand variations over sociodemographic and land use characteristics of the examined areas. Liu et al. (2020) examined mobile app data during the spring of 2020 and discovered an average decline of almost 73% in public transport ridership across 113 systems in USA. This decline was comparatively higher in university and high-tech cities. During the first wave of the pandemic in 2020, Labonté-LeMoyne et al. (2020) studied survey data from residents of all major cities in Canada and found that public transport use generally declined, while private car and cycling trip frequencies increased.

The main reason behind this modal shift away from public transport is that people perceive their use as a facilitator for virus transmission, especially during the outbreaks of the pandemic (Bucsky 2020; Zunjic et al. 2020; Bhaduri et al. 2020; Torbacki 2021). Gutiérrez et al. (2020) emphasized the fear of being infected with COVID-19 and the associated stress while travelling by public transport modes. According to Tirachini and Cats (2020), and Kłos-Adamkiewicz and Gutowski (2022), the relatively small areas of passenger cabins, the limited ventilation of vehicles, the inability to identify people who can spread the virus, and the interior surfaces (i.e., seats, doors, ticket issue machines and handrails), which are touched by multiple individuals, are factors that may contribute to COVID-19 infections. In fact, the close proximity with other passengers and the crowded vehicles and stations were the main explanatory factors for demand reduction in public transport services in Brazil (Lucchesi et al. 2022). In Warsaw, Poland, people reported that they felt less secure when travelling by public transport because of the crowding conditions and the fact that fellow passengers did not always follow the rule of wearing a face mask (Kłos-Adamkiewicz and Gutowski 2022). Additionally, the fear of infection and the possibility of working and fulfilling commitments remotely (on-line) were the most common reasons for abandoning or reducing the use of public transport (Przybylowski et al. 2021). The fear of crowding vehicles during lockdown and the possibility of teleworking in the post-lockdown phase were among the key factors that explained the reduced demand for bus public transport services in Sicily, Italy (Basbas et al. 2021b).

In response to these concerns, public transport authorities have developed and implemented tailored policies and measures to safeguard passengers and sustain public transport use during and after the pandemic period. These strategies include, inter alia, the reduced passenger capacity of vehicles, the use of dedicated vehicle doors for boarding/alighting, the respect of on-board spacing, and the purchase of tickets online or via apps (Basbas et al. 2021b; Munawar et al. 2021). In this context, Labonté-LeMoyne et al. (2020) highlighted the meticulous cleaning of vehicles and the compulsory hand sanitation as useful mitigation strategies that can help tackle the passengers' concerns of using public transport. In fact, the level of cleanliness at vehicles' interiors and stop/station facilities has emerged as a critical factor for using public transport during the COVID-19 pandemic (Basnak et al. 2022; Beck and Hensher 2020; Echaniz et al. 2021; Naveen and Gurtoo 2022) and many public transport agencies came up with advanced programs for securing a high-level of hygiene in their fleet and facilities.

An interesting discussion is currently underway about the future of public transport in the aftermath of COVID-19. Christidis et al. (2021) support that due to the new employment regimes and the health risks, which have been associated with public transport, travelers will gradually prefer private car over public transport modes, and public transport systems will eventually lose important revenues due to lower ridership figures. Vickerman (2021) does not foresee a return to pre-pandemic passenger volumes for public transport due to the teleworking patterns that emerged during the pandemic. Munawar et al. (2021) state that even in the post-pandemic period, Australians have adopted the teleworking routine. The impact of teleworking on the future public transport use has been also demonstrated in other regions, such as in Scotland (Semple et al. 2022), in the Netherlands (Ton et al. 2022), and in the USA metropoles (Medlock et al. 2021).

This set of habits and behavioral changes that emerged during the COVID-19 pandemic are already reflected on the intentions regarding the future use of public transport. Evidence from the research work of Torbacki (2021) showed that 61% of the public transport commuters intend to buy a car within the next 12 months and that it would be quite difficult to dissuade current private car users from using them in the future. In their mobility preferences survey, Przybylowski et al. (2021) proved that one out of four pre-pandemic public transport passengers will continue avoiding the use of this mode, because they are not convinced anymore of its safety. In Scotland, UK, Downey et al. (2022) found that more than 30% of residents are going to make fewer public transport trips in the post-COVID-19 period, and that key factors for this decision were the frequent use of private cars before pandemic as well as the lack of cleanliness and hygiene in public transport modes. On the other hand, frequent or captive users have been associated with greater willingness to continue or resume travelling by public transport means during or after the pandemic (Campisi et al. 2021b; Downey et al. 2022; Echaniz et al. 2021; Kopsidas et al. 2021). In this context, previous research works have proposed the modified circumstances under which public transport systems should operate in the post-COVID-19 period. These include, inter alia, mechanisms and strategies able to screen and inform on potential infections, while ensuring a high level of cleanliness and monitoring passengers' perceptions and preferences (Budd and Ison 2020; Echaniz et al. 2021; Subbarao and Kadali 2021).

3. Case Study and Data Collection

3.1. Overview

To understand the factors that may determine public expectations and attitudes towards the use of public transport in the city of Thessaloniki, Greece, an online survey was carried out. The latter took place in May 2021, with the questionnaire being disseminated only to residents of the metropolitan area of Thessaloniki. May 2021 was a milestone month for the country's public response towards the COVID-19 pandemic, as major mobility restrictions eased, being in place since the onset of the second national COVID-19 lockdown (in November 2021). These restrictions were related to the required pre-approval of out-of-home movements, the operation of the retail sector only upon appointment, and the travel ban for all trips out of the region of residence. However, significant restrictions and movements remained in place, such as work-from-home mandates, physical distancing of two meters in all indoor spaces, the mandatory use of facemasks in outdoor and indoor spaces (and, of course, in public transport), and many others.

The survey was restricted only to the academic community of the Aristotle University of Thessaloniki. The Aristotle University of Thessaloniki includes ten (10) faculties, with a campus of about 33.4 hectares. It is the largest university in Greece with a total of 88,283 enrolled students and 1682 faculty members (AUTh 2022). The survey was distributed through the official email list of the University to the members of its community, i.e., staff, and students. Therefore, simple random sampling was implemented for data collection through the use of a list-based sampling frame (Fricker 2008). The validity of the questionnaire design was assessed through cross-comparisons with other published surveys (e.g., National Travel Attitudes Study (DfT 2020), Public Attitudes Survey (Transport Scotland

2022)) and studies on travel behavior changes due to COVID-19 (to name a few, Abdullah et al. 2020; Basbas et al. 2021a; Downey et al. 2022), in an effort to ensure that the main behavioral components underpinning travel choices before and during the pandemic as well as future intentions were indeed reflected in the questionnaire.

The questionnaire was approved, upon a rigorous review of its content, by the Institutional Ethics Committee of the Aristotle University of Thessaloniki.

3.2. The Public Transport System of Thessaloniki

The metropolitan area of Thessaloniki is heavily urbanized and hosts a population of approximately one million inhabitants, which is equivalent to the 10% of total population of Greece (Politis et al. 2021b; Tsioulianos et al. 2020). Before the pandemic, most of the daily trips were made by private car (41.3%) and public transport (33.7%), whereas much lower modal shares applied for walking (9.2%), taxi (3.0%) and cycling (1.7%) (MoT 2019). Among university students, the public transport bus (65.3%), and walking (26.7%) were indicated as the main travel modes for commuting to the campus of the Aristotle University of Thessaloniki (Tsioulianos et al. 2020), which is located in the center of the city.

Public transport services in Thessaloniki are provided only by buses. The local public transport operator provides high and medium frequency services over a dense network of routes and terminals, which enable intermodal connections with other bus lines and suburban rail. There are more than 70 fixed bus lines that cover both the city center and the surrounding urban districts and suburbs of Thessaloniki. The fleet consists of approximately 600 mini, standard, and articulated diesel buses. A considerable number of bus stops is equipped with screens that display real-time info on the arrival of buses thanks to the AVL system that is installed in the entire fleet. However, no recent investments on ITS technologies have been made and therefore e-ticketing, multimodal travel planners and monitoring of bus lanes have not been adequately introduced so far. In fact, during the first half of the previous decade, though that the economic crisis led to an increase of public transport ridership, the satisfaction from the delivered quality of services was relatively low (Papagiannakis et al. 2018). An underground metro line is under construction, and it is expected to be fully operational in 2023. The line will be in the city center and provide high frequency connections across 13 stations.

3.3. Survey Questionnaire

The Revealed Preference (RP) questionnaire consisted of four separate sections. The first section included questions about the socio-demographic profile of the respondents, and particularly about gender, age, employment status, educational attainment, annual household income, residence location, and ownership/access to a car. The socio-demographic characteristics have been long established as major influential factors of travel behavior (Lu and Pas 1999) and constitute an indispensable part in most travel surveys. The second section was devoted to the travel behavior of the respondents before the pandemic. The goal of that section was to establish the travel choices and habits of the respondents under normal circumstances, which may also determine, to some extent, post-COVID intentions and behaviors (Zhao and Gao 2022), and especially those relating to the public transport use (Downey et al. 2022). Specifically, the questions surrounded issues such as the main mode of travel, frequency of public transport use, main trip purpose, and perceived level of satisfaction with various aspects of public transport operations and services (such as, seat availability while on-board, level of cleanliness, waiting conditions at the bus stop, boarding/alighting conditions, frequency of arrivals/departures, and so on). The respondents were also asked to self-report their frequency of experiencing various emotions while using public transport. The emotional items in the relevant question were specified in light of previous evidence on travel satisfaction, with a particular emphasis on the elements determining the affective dimension of travel (De Vos et al. 2015). The third section contained similar conceptual elements with the previous one, but now focusing on travel behavior and working patterns of the respondents during the pandemic. This

section aimed at capturing changes in travel and activity behavior that were prompted by the COVID-19 measures, which are also likely to affect future travel patterns (van Wee and Witlox 2021; Ton et al. 2022).

The fourth section included questions eliciting respondents' expectations about the level of public transport use in the future (when the COVID-19 will no longer pose a public health emergency), their perceptions about the importance of various measures to remain on public transport post-pandemic, and finally, their expectations about their future working patterns (e.g., working from home, working from office, no work at all). The final section of the survey focused not only on future travel intentions with public transport but also on the potential factors that may affect these intentions, such as the expected level of telecommuting (Zhao and Gao 2022) as well as the attitudes towards the "modus operandi" of public transport in the post-pandemic era (Downey et al. 2022). It should be noted that attitudes constitute a well-established determinant of travel choices in the context of the Theory of Planned Behavior—TPB (Ajzen 1991), which has been extensively adopted in transport research to understand travel behavior. Given that attitudes towards public transport operation may be heavily affected by risk perception at different stages of the COVID-19 pandemic (van Wee and Witlox 2021), the questions about satisfaction with public transport were repeated in both second and third sections, whereas the questions about importance of measures were repeated in both third and fourth sections, so as to factor in any potential attitudinal shifts over time.

All the questions eliciting respondents' perceived level of satisfaction, perceived importance of measures, and frequency of emotional states were structured on a 5-point Likert scale. The remaining questions were formulated as closed-ended items.

To assess the reliability of the survey-collected data, we calculated the Cronbach's alpha values for all the Likert-scale questions of the survey. The Cronbach alpha constitutes one of the most widely used measures of internal consistency for a set of questionnaire items (Brown 2002), and it was calculated for various dimensions of the questionnaire, such as satisfaction with public transport operations before and during the pandemic, emotional state while using public transport before and during the pandemic, perceived importance of measures during and after the pandemic. All the calculated Cronbach's alpha values were far greater than 0.7, thus implying an acceptable internal consistency of the survey items (Tavakol and Dennick 2011).

4. Methodology

To identify the factors that shape expectations about the use of public transport post-pandemic compared to pre-pandemic, we estimated a discrete choice model with the relevant survey question acting as the dependent variable of the model. The question was formed on a 5-point Likert scale, with the possible answers being: much less, slightly less, about the same, slightly more, and much more. As such, the outcomes of the dependent variable were recorded on a discrete, ordinal scale, hence, the ordered probit framework was employed for the statistical modeling, given its capability to inherently accommodate the ordered nature of the dependent variable (Washington et al. 2020). The ordered probit model is defined on the basis of a latent variable, ω^*, as follows:

$$\omega_i^* = \beta \mathbf{X}_i + \varepsilon \tag{1}$$

where, $\mathbf{X}$ is a vector of variables affecting the expectations of each respondent i, β denotes a vector of estimable parameters that determine the impact of $\mathbf{X}$ on respondents' expectations, and ε indicates an error term tailored to follow the standard normal distribution (i.e., the mean of the distribution is equal to zero and the variance is equal to one). Even though the latent variable is unobservable, we specify its counterpart ω as an integer, which indicates the observed outcome for each respondent i, and can take the following values:

$$\omega_i = \begin{cases} 0 \text{ if } \omega_i^* \leq \mu_0 = 0 \\ j \text{ if } \mu_{j-1} < \omega_i^* \leq \mu_j \text{ , for } 1 \leq j < J \\ J \text{ if } \omega_i^* > \mu_{J-1} \end{cases} \quad (2)$$

where, j is the observed outcome of the dependent variable, J denotes the outcome at the highest order, μ is a vector of estimable parameters defining the thresholds between adjacent, ordered outcomes. Without loss of generality, we assume that μ_0 is equal to zero, as such $n - 2$ thresholds are estimated, with n being the number of outcomes of the dependent variable (Washington et al. 2020). Given that the dependent variable comprises five outcomes, three threshold parameters are estimated in this case. Previous research in statistical and econometric modeling has shown that the presence of heterogeneity in the data can adversely affect the thresholds of the ordered outcomes, potentially leading to biased parameters (Eluru et al. 2008; Fountas and Anastasopoulos 2018). That is particularly important for survey-based perceptual and attitudinal data, where the extent of observed and unobserved heterogeneity is quite pronounced (Eker et al. 2020). Hence, to control for the impact of potential heterogeneity, the threshold parameters are not kept fixed, as in the traditional ordered probit models, but they are allowed to vary across the survey responses as a function of exogenous variables. Hence, the thresholds are formulated as:

$$\mu_{i,j} = \exp\left(a_j + \mathbf{k}\mathbf{Z}_i\right) \quad (3)$$

where, $\mathbf{Z}$ is a vector of exogenous variables that determine the thresholds between the ordered outcomes, $\mathbf{k}$ is a vector of coefficients associated to $\mathbf{Z}$, and α is a threshold-specific intercept. Given the specific modeling treatment we introduced to account for threshold heterogeneity, this variant of the ordered probit model is known as Hierarchical Ordered Probit (HOPIT) or generalized ordered probit model (Greene 2016). For brevity, this model will be referred to as HOPIT hereafter. For the estimation of the HOPIT model, a maximum likelihood estimation approach was used (Greene 2016).

To investigate attitudes towards the importance of measures to remain in place on public transport, even after the end of the public health emergency, an ordered response modeling framework was employed in this case too. This is because the relevant question was structured on a 5-point Likert scale consisting of the following outcomes: not at all important, slightly important, moderately important, important and very important. Public perceptions towards these measures may share some unobserved, yet systematic patterns, as all the measures are tailored to achieve the same goal: to provide a safer environment in public transport by minimizing the COVID-19 infection risk, and at the same time, to address the risk perception of a considerable portion of users. Regardless of whether the same or different factors influence perceptions, such systematic patterns potentially affect the error terms (which, in principle, capture unobserved preferences, taste or characteristics—see also Washington et al. 2020) associated with each dependent variable, thus leading to their correlation. If conventional, univariate models are to be estimated for analyzing such perceptual data, the potential correlation of the error terms is not taken into account, thus inducing a major caveat on the unbiasedness and accuracy of the model parameters. To explicitly account for the correlation of the error terms (which is also referred to as cross-equation error term correlation), a bivariate ordered modeling framework was used (Eker et al. 2020). The latter enables the joint estimation of two dependent variables with ordinal outcomes in a single computational framework, acknowledging also the impact of the cross-equation error term correlation. The bivariate ordered probit model is defined as follows:

$$\begin{aligned} \omega_{i,1}^* &= \beta_{i,1}\mathbf{X}_{i,1} + \varepsilon_{i,1} \\ \omega_{i,2}^* &= \beta_{i,2}\mathbf{X}_{i,2} + \varepsilon_{i,2} \end{aligned} \quad (4)$$

where, $\omega_{i,1}^*$ and $\omega_{i,2}^*$ are the latent variables defining the ordered probit components for the jointly modeled dependent variables, and all other terms are as previously defined. The error terms corresponding to the two dependent variables are estimated by a priori

considering a bivariate standard normal distribution, with the cross-equation correlation being expressed as (Anastasopoulos et al. 2012):

$$\begin{pmatrix} \varepsilon_{i,1} \\ \varepsilon_{i,2} \end{pmatrix} \sim N \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right] \tag{5}$$

where, ρ denotes the coefficient of the cross-equation error term correlation, which is also estimated along with the other parameters of the model. For the estimation of the Bivariate Ordered Probit model (it will be called as BOP hereafter), the full information maximum likelihood estimation approach was used (Greene 2016).

To better understand the relative importance of the impact of explanatory variables on the dependent variables, marginal effects were also estimated. The marginal effects provide the change in the predicted probability for each outcome of the dependent variable, due to a one-unit change in the value of each independent variable (Washington et al. 2020).

5. Results and Discussion

5.1. Overview

A number of 787 respondents filled out the online survey. With regard to the socio-demographic profile of the sample, 77.5% of the respondents belong in the age group of 18–27 years; the observed skewness towards younger participants is an expected outcome, as the questionnaire was distributed only within a university community. Regarding the gender distribution, approximately 63% of the respondents were females, whereas the rest were male respondents. The median annual household income of the respondents falls in the range of 12,000 to 24,000 euros, which is in line with recent statistics on the national net adjusted disposable income of Greece (OECD 2020). With regard to the educational attainment of the sample, more than 60% of the respondents had a Higher Education degree (either a Bachelor's or Master's/doctorate degree). As expected, the vast majority of the respondents were students (76%), with one out of five participants being either an employee (in a public or private sector organization) or self-employed. Approximately 54% of the respondents either owned a vehicle or had access to a private vehicle they can use for their everyday needs, whereas the rest of respondents did not have access to a private vehicle.

Focusing on the travel behavior characteristics of the respondents, Table 1 shows a cross-tabulation of shares of the main travel mode of the respondents (i.e., the mode that was mainly used for their most common trip regardless of the purpose) before and during the pandemic. While before the pandemic, almost 64% of the respondents used the bus as their main mode to accommodate their usual travel needs, this proportion is found to dramatically decrease during the pandemic, as only 15.5% of the respondents continued to use the bus as their main travel mode. That immense reduction in the bus share led subsequently to a surge increase of the share of walking (from 18.42% pre-pandemic to 47.90% during the pandemic), and, to a notable rise in the car share (from 14.87% pre-pandemic to 27.57% during the pandemic). Minor increases were also observed in the shares of bicycle and taxi during the pandemic, but despite these, the overall shares of these modes remain remarkably low (less than 4%). Overall, the cross-tabulation results highlight the tendency of people to abstain from mass transport during the pandemic, where the perceived risk of COVID-19 infection is higher, and switch to private modes, either motorized (car) or non-motorized (walking). The latter modes are typically perceived as safer due to the lack of interaction with non-household members (Downey et al. 2021).

Table 1. Cross-tabulation of mode shares among the survey respondents before and during the pandemic.

		Mode Share during the Pandemic							
		Bus	Taxi	Car	Motorcycle	Bicycle	E-scooter	Walking	Sum
	Bus	14.87%	3.43%	14.49%	0.38%	1.91%	0.13%	28.72%	63.91%
	Taxi	0.00%	0.25%	0.13%	0.00%	0.00%	0.00%	0.00%	0.38%
Mode share	Car	0.25%	0.00%	12.07%	0.13%	0.38%	0.00%	2.03%	14.87%
before the	Motorcycle	0.00%	0.00%	0.00%	0.76%	0.00%	0.00%	0.13%	0.89%
pandemic	Bicycle	0.00%	0.00%	0.00%	0.00%	1.14%	0.00%	0.25%	1.40%
	E-scooter	0.00%	0.00%	0.00%	0.00%	0.00%	0.13%	0.00%	0.13%
	Walking	0.38%	0.25%	0.89%	0.00%	0.13%	0.00%	16.77%	18.42%
	Sum	15.50%	3.94%	27.57%	1.27%	3.56%	0.25%	47.90%	100.00%

Figure 1 shows the frequency of public transport use[1] for the survey respondents before and during the pandemic. The observed shift in the frequency of public transport use during the pandemic further corroborates the findings of the cross-tabulation. A significant decline of frequent public transport users is evident; whereas more than three out of four respondents used public transport at least once a week pre-pandemic, less than one out of three respondents continued to use them at a similar rate during the pandemic. On the opposite end, the proportion of respondents who did not use at all public transport surged from only 4% pre-pandemic to 27% during the pandemic. This trend, in combination with the shift towards private modes for most public transport users (as shown in Table 1) is quite alarming for Public Authorities and service providers, as the viability of public transport services remains at stake should this decline of frequency would not fully and promptly recover in the post-pandemic era. The responses of the survey question about future expectations to use public transport provide some preliminary evidence about the extent to which previous users are likely to abandon public transport in the aftermath of COVID-19.
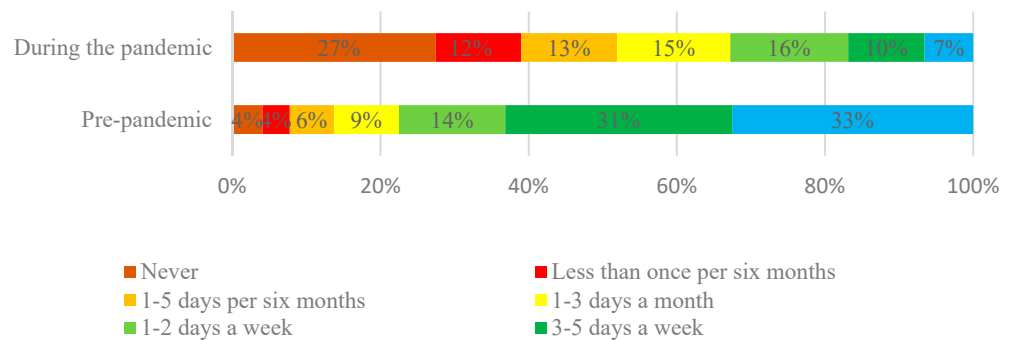

Figure 1. Trip frequency with public transport bus before and during the pandemic.

Figure 2 shows that more than 29% of respondents expect to use public transport much or slightly less in the future (compared to their pre-pandemic use), whereas the rest 71% of respondents expect to use public transport about the same or more in the future. These results are comparable to similar evidence from several countries across the globe, as, for example, in Scotland (Downey et al. 2021) and the Netherlands (Ton et al. 2022).
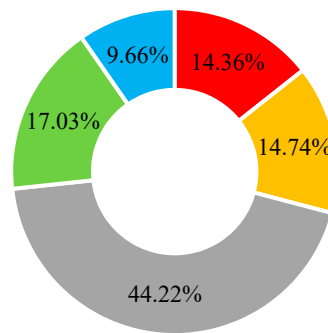
■ Much less ■ Slightly less ■ About the same ■ Slightly more ■ Much more

Figure 2. Expectations towards the use of public transport post-pandemic.

Over the last couple of years, Public Authorities and public transport providers have considered various policy actions to retain the users whose risk perception in combination with their access to transport alternatives make them more likely to become permanent "public transport leavers". These actions consist of measures aimed at mitigating the risk of infection while using public transport (Tirachini and Cats 2020). Perceptions of respondents about the importance of keeping some of these measures after the end of the COVID-19 emergency are presented in Figure 3, which includes only measures identified as statistically significant factors in the subsequent statistical analysis. It is evident that an overwhelming majority (almost 94%) of respondents perceive the increased frequency of services as an important or very important measure to be retained post-pandemic. In contrast, the mandatory use of facemasks and continued observance of physical distancing, even upon the end of the public health emergency, are considered as important or very important by significantly lower proportions of the sample, and specifically, by 29.35% and 36.85% of the respondents, respectively. It can be inferred that the increased frequency of public transport services gained more popularity, not only because of its potential to curb the perceived risk associated with on-board crowdedness, but also due to the long-standing issues with the operation and level of service of the bus network in Thessaloniki.
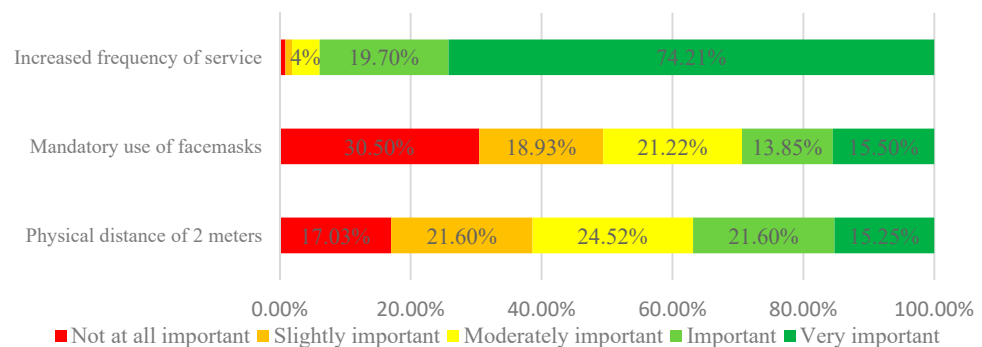

■ Not at all important ■ Slightly important ■ Moderately important ■ Important ■ Very important

Figure 3. Perceptions toward the importance of various measures to remain on public transport post-pandemic.

5.2. Expectations towards the Use of Public Transport Post-Pandemic

Table 2 provides the results of the HOPIT model, which was estimated to understand the factors that shape expectations towards the use of public transport in the future, when the COVID-19 pandemic will no longer constitute a public health emergency. Table 3 presents the detailed marginal effects of the variables that were identified as influential factors in the model. A positive parameter sign indicates that the specific variable increases the probability of the highest outcome (i.e., much more), and concurrently, it decreases the probability of the lowest outcome (i.e., much less). Marginal effects can show what is

the exact impact of each variable on the intermediate outcomes (i.e., slightly less, about the same, and slightly more). For model estimation, all possible variables available in the dataset as well as several interactive variables were trialed, but only those with statistically significant effects were kept in the model.

Table 2. Estimation results of the HOPIT model for expectations towards the public transport use post-pandemic.

Variable Description	Percentage	Parameter	t-Stat	*p*-Value
Constant	-	1.090	7.16	0.000
Employment status (1 if student, 0 otherwise)	75.98%	0.275	2.77	0.006
Main mode of travel (1 if bus before and during the pandemic, 0 otherwise)	14.87%	0.344	2.83	0.005
Shift of main travel mode (1 if bus before the pandemic but car during the pandemic, 0 otherwise)	14.49%	−0.442	−4.19	0.000
Frequency of public transport use (1 if once every six months or never, before and during the pandemic, 0 otherwise)	3.81%	−0.546	−2.78	0.005
Satisfaction with cleanliness on public transport during the pandemic (1 if not at all or slightly satisfied, 0 otherwise)	60.48%	−0.208	−2.18	0.029
Satisfaction with safety and security on public transport during the pandemic (0: not at all satisfied; 1: slightly satisfied; 2: moderately satisfied; 3: satisfied; 4: very satisfied)	[0]: 29.22%; [1]: 26.68%; [2]: 32.02%; [3]: 10.29%; [4]: 1.78%	0.129	2.98	0.003
Expectations about work-from-home post-pandemic (1 if partially or fully working from home, 0 otherwise)	25.29%	−0.176	−2.00	0.045
Mandatory use of facemasks on public transport post-pandemic (1 if perceived as moderately important, important, or very important, 0 otherwise)	53.49%	−0.206	−2.54	0.011
Thresholds				
μ_1		−0.515	−3.68	0.000
μ_2		0.644	5.52	0.000
μ_3		0.970	8.52	0.000
Threshold heterogeneity				
Age (1 if younger than 37 years old, 0 otherwise)	88.06%	0.173	2.03	0.042
Physical distancing on public transport post-pandemic (1 if perceived as important or very important, 0 otherwise)	61.37%	−0.093	−2.02	0.044
Increased frequency of public transport (1 if perceived as important or very important, 0 otherwise)	93.90%	−0.150	−1.82	0.069
Number of observations		787		
Restricted log-likelihood [LL(0)]		−1140.27		
Log-likelihood at convergence [LL(β)]		−1089.97		

Table 3. Marginal effects of the variables included in the model for expectations about the use of public transport in the future.

Variable Description	Marginal Effects				
	Much Less	**Slightly Less**	**About the Same**	**Slightly More**	**Much More**
Employment status (1 if student, 0 otherwise)	−0.061	−0.035	0.013	0.044	0.039
Main mode of travel (1 if bus before and during the pandemic, 0 otherwise)	−0.061	−0.046	−0.011	0.055	0.063
Shift of main travel mode (1 if bus before the pandemic but car during the pandemic, 0 otherwise)	0.108	0.053	−0.035	−0.070	−0.056
Frequency of public transport use (1 if once every six months or never before and during the pandemic, 0 otherwise)	0.145	0.059	−0.062	−0.083	−0.060
Satisfaction with cleanliness on public transport during the pandemic (1 if not at all or slightly satisfied, 0 otherwise)	0.042	0.027	−0.002	−0.034	−0.034
Satisfaction with safety and security on public transport during the pandemic (0: not at all satisfied; 1: slightly satisfied; 2: moderately satisfied; 3; satisfied; 4: very satisfied)	−0.027	−0.017	0.002	0.021	0.020
Expectations about work-from-home post-pandemic (1 if partially or fully working from home, 0 otherwise)	0.038	0.023	−0.006	−0.029	−0.026
Mandatory use of facemasks on public transport post-pandemic (1 if perceived as moderately important, important or very important, 0 otherwise)	0.042	0.027	−0.003	−0.034	−0.033

　　　　Starting with the factor with the strongest (in magnitude) impact (i.e., the largest marginal effect), Table 3 shows that infrequent users of public transport before the pandemic are among those who will drastically reduce their (already low) use of public transport in the future. In fact, these users are associated with the most pronounced increases in the probabilities of lower outcomes (i.e., much less and slightly less use in the future), and with the largest reductions in the probabilities of using public transport about the same or slightly more than before. Infrequent users were not appealed by public transport services even before the pandemic, while the emergence of the pandemic and the associated health risks that it bears may have exacerbated their negative perceptions or attitudes. In fact, previous evidence from Spain showed that occasional users of public transport were among the first to give up public transport during the pandemic (Echaniz et al. 2021), and this trend seems to stabilize in the future. Similar unfavorable intentions towards future bus use were also identified in Scotland, where occasional bus users (less than one day per week) before the pandemic were less likely to use public transport more post-pandemic (Downey et al. 2022). On the other hand, individuals having bus as their main mode of travel before and during the pandemic are more likely to use them slightly or much more post-pandemic. As shown in Table 3, the variable representing these users yields the strongest marginal effect on the highest ordered outcome, as it increases the probability of using public transport much more post-pandemic by 0.063. This group may pick up captive to the public transport users who also had to continue traveling by public transport during

the COVID-induced lockdowns, because either they were key workers or carers, or they did not have any other mobility alternative for their essential travel. Given that they continued to use public transport, even during the most critical phase of the pandemic where the infection and transmission risk was high, it is likely that these users have adjusted their level of risk perception while traveling, hence, they may perceive that the post-pandemic conditions will be risk-free rendering public transport more attractive to them. Another group of captive users encompasses the University students, who are likely to use public transport the same or more post-pandemic, as shown in Table 3. Students constitute the majority of individuals in the sample (approximately 76%, as demonstrated in Table 2), with bus being the main travel model pre-pandemic for more than 2 out of 3 students in the sample. Students expect to continue using public transport post-pandemic; this behavioral tendency could be attributed not only to their potential lack of transport alternatives, but also to their relatively lower risk perceptions compared to other groups of the traveling population (Shelat et al. 2022).

In stark contrast, users that are non-captive to public transport have a greater propensity to abandon them post-pandemic. Specifically, those who mainly traveled by bus pre-pandemic, but they switched to car during the pandemic are less likely to travel by bus the same or more than before. This group of users represents approximately 15% of the sample, as can be seen in Table 2. This shift from public transport to private modes has been continuously observed during the various outbreak stages of the pandemic in most urban contexts worldwide (Das et al. 2021; Schaefer et al. 2021). Such a behavioral adaptation may stem from the fear of bus users to contract COVID-19, which could be even more pronounced in Thessaloniki, where a considerable majority of users typically perceive the bus services as crowded (Malandrakis et al. 2019). Given the access of these individuals to private transport means, their expectations to revert to their pre-pandemic travel mode patterns remain low.

Focusing on the impact of users' satisfaction on future intentions, those who were unsatisfied or slightly satisfied with the in-vehicle cleanliness of buses during the pandemic were found to be likely to use them less in the future. The level of cleanliness indeed serves as a factor of perceived service quality for public transport, especially during the COVID-19 pandemic (Basnak et al. 2022). Many public authorities and service providers established intensive programs of enhanced cleaning and frequent sanitization on vehicles, stations and stops to mitigate the risk of infection (Tirachini and Cats 2020). These measures also aimed at curbing the users' concerns about the in-vehicle sanitary conditions, the perceived importance of which flourished during the pandemic (Beck and Hensher 2020; Naveen and Gurtoo 2022). As such, travelers with low levels of satisfaction towards the cleanliness of public transport during the pandemic may be discouraged from their future use. This finding is in line with previous evidence from Scotland, where the lack of cleanliness and hygiene was cited as the second most important reason for not using public transport in the future (Downey et al. 2022). Satisfaction with safety in public transport during the pandemic was also found to determine expectations for future use. Specifically, Table 2 suggests that the higher is the level of satisfaction, the more likely for users to travel the same amount or more by bus in the future. The role of personal safety, which is an influential factor of public transport ridership (Delbosc and Currie 2012), is gaining even more importance during a public health crisis, where the generalized anxiety in the society about COVID-19 and the potential to contract it in confined spaces serves as a barrier towards the perceived safety of public transport (Dong et al. 2021).

Another factor that may determine the post-pandemic use of public transport is related to the anticipated working patterns of the users. According to the results of the HOPIT model, individuals that expect to work from home, either partially or fully post-pandemic, are more likely to use public transport less. Considering that the latter accommodates a significant number of daily commuters, especially in the city of Thessaloniki (Politis et al. 2021b), this result suggests that the reduction of commuting trips, due to the stabilization of teleworking patterns that emerged during the pandemic, may reduce the patronage of

public transport. This trend is also in line with recent evidence from Scotland, where the possibility for high work-from-home patterns in the aftermath of COVID-19 is associated with an expected decrease in the use of public transport for commuting trips (Semple et al. 2022). The negative association between telecommuting and public transport ridership has been also confirmed in urban areas of the US, where transit systems were extensively used by commuters pre-pandemic (Medlock et al. 2021).

Attitudes towards retaining preventative measures, even when COVID-19 will no longer be a public health emergency, were also found to shape expectations towards the future use of public transport. In particular, people that perceive as important—to a small or large extent—the mandatory use of facemask while traveling by public transport post-pandemic, are more likely to reduce the amount of their public transport use. Such favorable attitudes towards the continued use of face coverings in conjunction with the reluctance to use public transport, may imply the high level of risk perception of these individuals. They may expect that, even when the virus will be contained at the community level, the crowding conditions on public transport, especially if these return to the pre-pandemic levels, will still bear a relatively higher risk of COVID-19 infection. In fact, several segments of the population, especially those at a higher risk, continue to wear a mask after the end of mask-wearing mandates, as they view it as a straightforward and seamless way to protect themselves and others from COVID-19 and other airborne diseases as well (MacIntyre 2022).

Attitudes towards other policy measures were found to affect the thresholds of the HOPIT model. Specifically, the variables capturing favorable attitudes towards the maintenance of measures related to physical distancing and increased frequency of bus services were identified to reduce the thresholds of the model. Given that the thresholds define the probability ranges between two adjacent outcomes in the ordered probit setting, reductions in the threshold values overall imply wider probability ranges for the higher outcomes (Fountas and Anastasopoulos 2018). That could suggest that users that value the importance of these measures to remain in place have more favourable expectations towards the future use of public transport compared to those who are less appealed by the provision of these measures post-pandemic.

5.3. Attitudes towards Policy Measures on Public Transport Post-Pandemic

As shown by the results of the HOPIT model, policy measures that may remain in place after the end of the COVID-19 emergency have an observable potential to determine intentions towards the future use of buses. To better understand the factors that may shape the varying attitude levels towards these measures across the sample, a Bivariate Ordered Probit (BOP) model was estimated, where the attitudes towards the mandatory use of face masks and the increased frequency of bus services post-pandemic were jointly modeled. It should be noted that attitudes towards these measures were selected for simultaneous statistical modeling, as: (i) they were detected to directly or indirectly influence expectations about future use of public transport post-pandemic in the HOPIT model and; (ii) these measures have long been under scrutiny and continuous monitoring by Public Authorities across the globe since the point where COVID-19 restriction began to ease, whereas the prospect of their continued implementation has sparked mixed reactions in the public sphere. The other measure that was found to affect expectations in the HOPIT model, i.e., the physical distancing, was not further considered, as it has been deemed impractical to remain on public transport in the long term (Kamga and Eickemeyer 2021). The results of the BOP model are presented in Table 4, whereas the marginal effects of the explanatory variables of the model are shown in Table 5.

Table 4. Estimation results of the BOP model for attitudes towards policy measures on public transport post-pandemic.

Variable Description	Percentage (%) of Distribution	*Mandatory Use of Facemasks*		*Increased Frequency of Services*	
		Parameter	**t-Stat**	**Parameter**	**t-Stat**
Constant		0.168	1.91	1.768	9.60
Gender (1 if female, 0 otherwise)	63.28%	0.414	4.83	0.291	2.85
Age (0: 18–27; 1: 28–36; 2: 37–45; 3: 46–54; 4: 55–64; 5: ≥65 years)	[0]: 77.51%; [1]: 10.55%; [2]: 5.21%; [3]: 4.07%; [4]: 2.67%	0.094	2.25	-	-
Frequency of bus use pre-pandemic (1 if at least 3 days per week or more, 0 otherwise)	63.15%	-	-	0.344	3.46
Main travel purpose pre-pandemic (1 if leisure, 0 otherwise)	19.44%	−0.263	−2.70	-	-
Satisfaction with boarding/alighting (1 if not at all or slightly satisfied before the pandemic but moderately satisfied/satisfied/very satisfied during the pandemic, 0 otherwise)	18.93%	−0.229	−2.27	-	-
Satisfaction with cleanliness on public transport (1 if not at all or slightly satisfied before and during the pandemic, 0 otherwise)	55.91%	-	-	0.339	3.50
Stress while using public transport (1 if often or very often stressed before and during the pandemic, 0 otherwise)	41.93%	0.187	2.31	0.313	3.10
Fear while using public transport (1 if fear has increased during the pandemic compared to before, 0 otherwise)	42.57%	0.186	2.33	-	-
Thresholds					
μ_1		0.520	13.18	0.302	2.88
μ_2		1.103	20.71	0.849	6.17
μ_3		1.599	24.48	1.795	12.22
Cross equation error correlation (ρ)				0.135	2.47
Number of observations		787			
Restricted log-likelihood [LL(0)]		−1770.83			
Log-likelihood at convergence [LL(β)]		−1835.30			

Table 5. Marginal effects of the variables included in the BOP model for attitudes towards policy measures on public transport post-pandemic.

Variable Description	Mandatory Use of Facemasks					Increased Frequency of Services				
	[Ω = 0]	[Ω = 1]	[Ω = 2]	[Ω = 3]	[Ω = 4]	[Ω = 0]	[Ω = 1]	[Ω = 2]	[Ω = 3]	[Ω = 4]
Gender (1 if female, 0 otherwise)	−0.147	−0.017	0.029	0.047	0.089	−0.006	−0.006	−0.020	−0.061	0.093
Age	−0.033	−0.005	0.006	0.011	0.021	-	-	-	-	-
Frequency of bus use (1 if at least 3 days per week, 0 otherwise)	-	-	-	-	-	−0.007	−0.007	−0.024	−0.072	0.110
Main travel purpose (1 if leisure, 0 otherwise)	0.095	0.010	−0.020	−0.030	−0.055	-	-	-	-	-
Satisfaction with boarding/alighting (1 if not at all or slightly satisfied before the pandemic but moderately satisfied or more during the pandemic, 0 otherwise)	0.076	0.009	−0.015	−0.025	−0.045	-	-	-	-	-
Satisfaction with cleanliness on public transport (1 if not at all or slightly satisfied before and during the pandemic, 0 otherwise)	-	-	-	-	-	−0.007	−0.006	−0.023	−0.070	0.107
Stress while using public transport (1 if often or very often stressed before and during the pandemic, 0 otherwise)	−0.065	−0.011	0.011	0.021	0.044	−0.006	−0.006	−0.020	−0.065	0.097
Fear while using public transport (1 if fear has increased during the pandemic compared to before, 0 otherwise)	−0.067	−0.011	0.011	0.022	0.045	-	-	-	-	-

The gender was found to exert similar impacts on attitudes towards both the mandatory use of facemasks and increased frequency of services. Specifically, Table 5 shows that females are more likely to perceive as moderately important, important or very important the use of facemasks post-pandemic, and as very important the increased frequency of services. Notably, the gender variable has the strongest, yet negative impact on the lowest outcome (i.e., not at all important) of attitudes towards masks. During the pandemic, females were more supportive towards preventative measures that were in place on public transport compared to males (Aydin et al. 2022), whereas their compliance rates with such measures were also higher (Machida et al. 2020). Female travelers have been identified to be more risk averse when using public transport, not only during the pandemic (Shelat et al. 2022), but also under normal circumstances (Gnerre et al. 2022), which may explain their propensity to continue observing measures in public transport in the post-pandemic era. Another socio-demographic characteristic that was found to affect attitudes towards the post-pandemic use of face masks is the age. As Table 4 suggests, older participants are more likely to view the mandatory use of face masks as an important measure to be retained, whereas younger participants are less supportive toward wearing face coverings in the long term. That is another intuitive finding, which could be attributed to the higher

risk perception of older individuals, who are more conscious about COVID-19, given their susceptibility to severe disease in case of infection (Shelat et al. 2022). However, this result should be interpreted with caution, due to the skewness of the sample towards younger respondents—only 12% of the sample consists of participants older than 37 years.

Focusing on the travel behavior characteristics pre-pandemic, Table 4 shows that frequent bus users (who use them at least 3 days per week or more) are more likely to have positive attitudes towards the continuation of bus services with higher frequencies after the end of the pandemic. A significant proportion of these users may be captive to public transport; hence, they may feel that the extension of increased frequencies can ameliorate the in-vehicle crowding conditions, and in turn, further contain the risk of infection on-board. This attitudinal trend of keen bus users could be also attributed to issues related to the pre-pandemic service provision. Interestingly, in the city of Thessaloniki, the level of satisfaction with bus frequencies a few years before the pandemic was quite low, thus contributing to a decline in the perceived quality of service (Papagiannakis et al. 2018). In this context, higher bus frequencies in the aftermath of the pandemic could be perceived from the users not only as a means of suppressing the infection risk, but also as a pathway to improving the quality of services. Furthermore, participants who mainly carried out leisure trips pre-pandemic are less favorable towards the continued use of facemasks in public transport. In fact, the relevant variable was found to have the largest, positive impact on the lowest outcome of the Likert scale (i.e., not at all important), as shown in Table 5. Recent evidence from Japan shows that there is a relationship between perceived fear of COVID-19 and frequency of leisure trips during the pandemic (Parady et al. 2020), whereas in Australia, engagement in leisure trips was associated with higher levels of self-reported non-compliance with the lockdown restrictions (Murphy et al. 2020). Hence, this finding of the BOP model re-affirms the prevalence of low-risk perception and perceived importance of preventive measures for individuals who are habitually involved in leisure trips.

The results of the BPOP model also show that the level of satisfaction with public transport operations before and during the pandemic also shapes the attitudes towards keeping in place preventative measures on public transport. Specifically, participants who were unsatisfied or slightly satisfied with the cleanliness in buses, both before and during the pandemic, are highly favorable for increased frequency of services to remain in place. This group of users probably anticipates less crowdedness and more comfortable, in-vehicle conditions with more frequent bus services. In fact, on-board cleanliness and available space in the vehicle constitute separate, yet interrelated elements of travel comfort (Le-Klähn et al. 2014), which serves as a major dimension of satisfaction and loyalty to public transport (van Lierop et al. 2018). The perceived value of these elements becomes even more pronounced under the circumstances of a pandemic, as they can also mitigate the risk of COVID-19 infection or transmission during travel. Another angle of satisfaction with an observed impact on attitudes towards facemasks stems from the boarding and alighting conditions. Specifically, users who were unsatisfied or slightly satisfied with boarding and alighting before the pandemic, but their level of satisfaction increased during the pandemic, do not seem appealed by the possibility of using face masks on public transport in the future. The relevant variable represents approximately 19% of the sample and may capture the attitudes of users who may have seen improvement in the boarding and alighting conditions during the pandemic. Such improvements may originate not only from the measures been in place, but also from the potential behavioral adaptations of other passengers (e.g., avoidance of crowdedness; practice of physical distancing; following personal hygiene etiquette). These users may expect that such improved conditions may last post-pandemic, hence, the stabilization of more restrictive measures, such as the use of a face mask, may not be needed.

The emotional status of users while using public transport was also found to affect attitudes towards public transport measures. Users who often or very often experienced stress while using public transport before and during the pandemic are more likely to have a more favorable stance towards both measures, i.e., use of facemasks and increased

frequency of services. Apart from the female indicator, the stress indicator was the only additional variable with statistically significant effects on both attitudes. The emotion of fear was also found to influence attitudes towards the future use of facemasks. Intuitively, users whose level of fear increased during the pandemic are also highly favorable towards the maintenance of this measure post-pandemic. The frequency of encountering fearful and stressful situations determines—to a significant extent—the level of subjective well-being of people, which has been long linked with the decision mechanism underpinning travel choices (De Vos et al. 2013). The emergence of COVID-19 brought forth additional pressures on subjective well-being, with fear and stress being reported by a significantly greater proportion of bus users compared to before (Campisi et al. 2021b, 2022a). As Gutiérrez et al. (2020) pointed out, the fear of getting a COVID-19 infection and the associated stress can serve as disincentives to use crowded transport means, such as buses, and can encourage people to opt for more private and perceived as less risky transports options. As such, the strong propensity of users, whose subjective well-being has been negatively impacted by the public transport use before and during pandemic, is an anticipated outcome, which needs to be set under scrutiny by Public Authorities and service providers.

6. Policy Implications and Conclusions

The COVID-19 has had unprecedented effects on several aspects of urban mobility, triggering shifts not only to the way we travel, but also to the circumstances that generate the need for travel. Although some of the COVID-induced changes in mobility and lifestyle are hoped to remain in the longer term and become permanent, such as the uptake of active mobility, the growing rate of telecommuting, and the urban infrastructure interventions in favor of non-motorized mobility, there are some changing patterns that need to be urgently addressed, as they serve as caveats in the pathway towards sustainable and inclusive mobility. The decline of public transport use, due to the turn of commuters towards private and perceived as less risky modes constitutes a major caveat, which needs to alert all the key stakeholders. Through survey-collected data from an academic community, this study showed that in a city where the commuting trends are largely dependent on the provision of bus services, as in Thessaloniki, Greece, the bus use reduced fourfold during the pandemic, with more than 29% of the users being reluctant to reinstate their public transport use at pre-pandemic levels. If this group of users permanently moves away from public transport, the patronage of the latter will considerably decrease, thus putting at risk their financial viability, and in turn, their capacity to provide ubiquitous, and reliable service. Such a consequence will not only induce additional inequalities on the degree of accessibility for several population groups, especially for captive to public transport users, but it will also impede the decarbonization of the transport sector, as more people will turn back to private, motorised modes, thus increasing the carbon footprint of urban travel in total.

The findings of this study shed light on particular areas where policy actions need to be taken by stakeholders to restore trust and faith to public transport. Overall, these actions should aim at addressing risk perception arising from various dimensions of public transport operation (Tirachini and Cats 2020). The HOPIT model suggested that low satisfaction with the cleanliness of public transport vehicles acts as a disincentive to using them in the future. Service providers should continue implementing enhanced cleaning and disinfection of the interior of vehicles and bus stations/stops on a regular basis, not only during the pandemic outbreaks, but also in the longer term. This will effectively reduce the viral load of airborne diseases (including COVID-19), and it will also make passengers feeling safer and more comfortable while traveling with public transport. Public transport authorities should also target at bringing back passengers who were found to alter their travel behavior characteristics during the pandemic, but they are keen to maintain such behavioral shifts post-pandemic. These include those who left public transport in favor of car, the occasional users, and those who will continue to work from home to some extent, post-pandemic. The installation of additional bus lanes, and the prioritization of buses in traffic signals (through urban traffic management systems, such as SCOOT) in

combination with the increased frequency of services, could improve the performance of buses, in terms of travel time. At the same time, a considerable portion of road space will be taken from cars in order to be reallocated to more sustainable modes—that could potentially serve as a comparative advantage for public and active transport over cars (Semple et al. 2021). In addition, employers could encourage their employees through incentives (e.g., replacement of parking subsidies with monthly passes for public transport) or flexible work arrangements (commute during off-peak hours and spread of working hours throughout the day) to use public transport in their trips to workplace, including those who partially work from home.

The continued use of facemasks and the increased frequency of services constitute policy measures, which have been actively involved in the public debate about the post-pandemic recovery of transport, and hence, these were separately investigated in this study. Both measures seem to have appeal on users who felt stress by using public transport before or during the pandemic, while the extension of the face covering use is considered as important by users whose public transport-induced fear increased during the pandemic. Evidence from across the globe has shown the extension of the mask mandate boosted the ridership of public transport when most of the other measures had been already lifted (Hsieh and Hsia 2022). In cases where the mask-related restrictions fully eased, concerns about increased health risks from the public transport use emerged again (Washington Post 2022), acting as an additional caveat to the recovery of the sector. In this context, the extension of the mask-wearing mandate in public transport has a great potential in retaining users with high-risk perception, and, at the same time, it constitutes a low-hassle measure, which does not cause great discomfort to the vast majority of users (Bearth and Siegrist 2022). The increased frequency of service was identified as the most attractive measure among the respondents, with 94% of the respondents considering it as important or very important to remain in place. Despite the capacity of increased frequencies to improve on-board crowdedness and boarding/alighting conditions, such a perceptual consensus toward this measure may reveal the low satisfaction of users with the level of service from even before the pandemic; interestingly, more than 76% of the respondents in the survey stated that were not at all satisfied or slightly satisfied with the frequency of bus arrivals and departures. The increased public transport frequency, especially during peak periods, has been globally seen as a potentially effective measure that can facilitate the post-pandemic recovery (C40 Knowledge Hub 2020). However, it requires significant public investment and a cautious design and implementation by transport Agencies and service providers, in order to keep the increase of operational costs at acceptable levels.

Even though the insights of this study could be useful in the process of preparing and monitoring the post-pandemic recovery of public transport, these should be interpreted in light of the limitations of our experimental design and analysis. Given that the data are derived from an academic community, the study inferences are predicated on a young and highly active sample, which is largely dependent on the provision of public transport services. Future research should also focus on the behavioral shift of segments of population, which were under-represented in this sample, such as daily work commuters and elderly people. A possible reduction in the public transport supply post-pandemic may pose irrevocable impediments in the level accessibility for these users. In terms of the statistical analysis, the estimation of the HOPIT and BOP models partially accounted for the impact of unobserved heterogeneity, which may be present in the survey data. Future studies could apply even more advanced modeling techniques (e.g., random parameters), which can control for multiple layers of users' unobserved preferences, taste, or behavioral patterns. Lastly, apart from the public transport-induced emotions, which were examined in this study, future endeavors could take into account the influence of other socio-psychological factors on expectations about public transport, such as personality traits and behavioral norms, which were also found to affect risk perceptions during the COVID-19 pandemic (Tagini et al. 2021).

Note

[1] The only available public transport mode in Thessaloniki is the bus, whereas a subway network (metro) is currently under construction, and it is expected to be partially launched by 2023.

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