Factors Influencing Public Transport Demand in Sicily During COVID-19 Era: A Study of Commuters' Travel and Mode Choice Behaviors

Socrates Basbas[1], Georgios Georgiadis[2(✉)], Tiziana Campisi[3], and Giovanni Tesoriere[3]

[1] School of Rural and Surveying Engineering, Faculty of Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece

[2] School of Civil Engineering, Faculty of Engineering, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
ggeorgiadis@civil.auth.gr

[3] Faculty of Engineering and Architecture, University of Enna Kore, Cittadella Universitaria, 94100 Enna, Italy

Abstract. Since the spread of the COVID-19 pandemic in March 2020, the transport system has suffered a profound reduction in demand worldwide. In order to understand which factors played a crucial role in reducing transport demand, an online questionnaire survey was conducted exploring one of the regions of Italy, i.e. Sicily, which was severely affected by the pandemic and was characterized by the greatest transport disruption among the other Italian regions. The survey was answered by 700 respondents who were frequent PT commuters before the outbreak of the pandemic. It collected sociodemographic information, highlighted the public transport demand figures before and after the lockdown period in Sicily and assessed the acceptance rates of the national recommendations which aimed to prevent contagion and encourage the use of PT. The survey data were analyzed using descriptive and cluster analysis techniques. During the examined periods, the results demonstrated three (3) clusters of PT commuters in Sicily and associated them with certain sociodemographic characteristics and acceptance rates of the national PT recommendations. Our findings lay the basis for public transport service improvements which could help local authorities to cope with such extreme conditions and perform a successful restart of operations.

Keywords: Public transport · COVID-19 · Italy · Transport demand · Travel behavior · Transport policy · Cluster analysis

1 Introduction

European cities are increasingly confronted with transport problems. Migration from cities to the suburbs is leading to settlement structures with long distances to travel. This urban sprawl goes hand in hand with an increase of car ownership rates and commuter

© Springer Nature Switzerland AG 2021
O. Gervasi et al. (Eds.): ICCSA 2021, LNCS 12954, pp. 339–353, 2021.
https://doi.org/10.1007/978-3-030-86979-3_25

traffic. Boosting mobility is one of the main objectives of governments while reducing traffic, accidents and pollution is a common challenge for all major cities. According to the European Commission, transport congestion in and around urban areas represents a cost of around EUR 100 billion a year, or 1% of EU GDP, due to delays and pollution [1]. In addition, one in three fatal accidents occurs in urban areas. Urban mobility accounts for 40% of CO_2 emissions from road transport and up to 70% of other pollutants [1]. Another serious problem in urban areas, which unfortunately continues to worsen, is noise pollution, mainly from road traffic.

In this context, the relationship between Public Transport (PT) and the environment is a topic which is constantly under investigation worldwide towards achieving sustainable urban mobility objectives [2–5]. The EU has earmarked funds to co-finance projects to help cities implement or/and upgrade urban PT systems by means such as metro, trams and buses. In addition, PT priority measures [6, 7] have been implemented in urban areas in order to increase the attractiveness of the systems and subsequently increase the demand.

There are many factors which affect the demand for PT and quality plays an important role among them. PT agencies need to receive a feedback from passengers in order to improve the quality of delivered services [8]. This task becomes more essential in the COVID-19 era due to the restrictions imposed in the operation of the various PT systems. Intelligent Transportation Systems (ITS) can offer a lot in the bidirectional communication between PT operators and passengers that can yield significant benefits towards the fulfilment of sustainable urban mobility goals and the promoting of PT systems by increasing their attractiveness and their adaptability to continuously changing environments [9, 10]. For instance, the traditional information provided through Variable-Message Sign (VMS) screens at bus stops [11] can be complemented with the new regulations due to the COVID-19 pandemic. The use of questionnaire-based surveys also proved to be a very effective tool to investigate the impact of COVID-19 to transport systems and particularly to the perceived quality of transport services [12–15]. The impact of the COVID-19 pandemic to PT is an issue of major concern worldwide and it has been investigated in countries such as the UK, Germany, China, the Netherlands etc. [16–19].

This paper focuses on Sicily, which is one of the most affected regions in Italy from the COVID-19 pandemic. Since March 2020, there has been a collapse in the use of PT in Italy due to the COVID-19 related restrictions and measures [20, 21]. In fact, people preferred to walk or cycle for short journeys or use private transport for medium and long distances [22]. Italy, along with other European countries, has issued a series of national recommendations which aimed at reducing infection while travelling by PT and respecting social distancing. In order to adapt and sustain PT services, both during and after the pandemic, it is essential to understand the PT demand trends and classify the PT users in order to identify the criticalities related to the implementation of national recommendations. This process will enable authorities to develop short- and long-term plans of PT service improvement measures. This paper analyses sociodemographic, PT demand and perception data from a questionnaire survey that was implemented in Sicily and targeted PT commuters. The objective of this research is to shed light on the PT demand variations during the COVID-19 pandemic in Sicily and to investigate,

by means of cluster analysis, whether the travel behaviour of PT commuters was influenced by their sociodemographic profiles and their opinion on the nationwide PT related recommendations.

The rest of the paper is as follows. The next section describes the COVID-19 timeline, PT characteristics and related recommendations in Sicily and Italy. Section 3 explains the questionnaire survey and the methodology we applied to analyse the collected data. Section 4 presents and discuss the results of our analysis while Sect. 5 summarizes the conclusions.

2 Background

2.1 PT Characteristics in Sicily Prior to the COVID-19 Outbreak

Before the COVID-19 pandemic, the Italian National Institute of Statistics (ISTAT) recorded that in 2019 PT buses, trolleybuses and trams were used at least once by around 13 million people, i.e. a quarter of the population aged 14 and over (24.6%). This was mainly habitual use: around 3 million people in Italy used PT every day and the same number of people used it at least a few times during the week. PT services were used mainly in metropolitan areas, in the central regions and in the North-West of Italy.

In the region of Sicily, until 2019, there were approximately 0.4 buses in circulation per 1,000 inhabitants (for a total of 2,490 buses), which is a figure that is slightly below the national average (0.7). Of these, 936 buses provide urban Local PT (LPT) services, and the rest of them are devoted to the Regional PT services (RPT). According to ISTAT and ACI data (2017), in Sicily, 12.4% of the population uses PT for commuting (i.e. work and study purposes). The number of cars and motorbikes to the total population, which is considered as an indicator of private transport that could substitute PT, is rather high, i.e. 779 per 1,000 inhabitants. The data show that LPT plays a subordinate role with respect to personal mobility, even when compared to the already low average use in southern Italy. Sicily is the Italian region with the lowest frequent use of rail transport. According to recent data provided by the ISTAT (2018), only 1.2% of workers, schoolchildren and students aged three years and over use the train on a frequent basis to travel to work, kindergartens, or schools (against a national average of 6%). Particularly low PT shares are also found in other southern Italian regions, such as Sardinia. Opposite figures are recorded in Northern Italy and in Campania (8.9%).

Overall, there is a very high level of user dissatisfaction with the PT services in Sicily. The greatest criticism pertains to the frequency of PT services, their punctuality, the availability of seats on-board, the cleanliness of the vehicles, the cost of tickets, and the availability of PT information. In the pre-pandemic phase, Sicily already showed a reduction in the use of PT, even though this negative figure is more limited for bus transport than that observed for the use of rail transport. Before the pandemic, PT was used to a greater extent by female users, both in Sicily (21.5%) and in Italy (25.5%). The spread of teleworking and the closure of schools at various COVID-19 periods from March 2020 until March 2021 have reduced the number of PT users while the fear of potential contagion has often prompted travellers to use their private cars.

2.2 The COVID-19 Pandemic Timeline in Italy

The timeline of the COVID-19 pandemic in Italy can be defined by three (3) periods:

1. The first period, which is characterised by social distancing rules and finally by the lockdown (started on 11 March and ended on 16 May 2020), aimed at reducing the possibility of encountering the new Coronavirus, which was freely circulating in the environment. The adopted measures made it possible to reduce new infections as much as possible and to relieve the pressure on the intensive care units of hospitals.
2. The second period covers the summer and autumn period of 2020 and ends in December 2020 with the discovery of the COVID-19 vaccine. The second period can be divided in two (2) phases:

    a. Phase I, during May–September 2020, in which certain mobility and other restrictions were relaxed and
    b. Phase II, during October–December 2020, in which COVID-19 infections began rising and restrictions started gradually to apply again.

3. The third period from January 2021, which is still ongoing, is associated with new waves of infection and modified forms of the new Coronavirus.

2.3 The PT Recommendations Issued by the Italian Government

In order to travel safely during the second period of the COVID-19 pandemic in Italy, a set of eight (8) recommendations for bus PT systems has been issued taking into account the "Guidelines" contained in the Annex 9 of the Prime Ministerial Decree of 26 April 2020, which pertained to personal mobility matters. The objective of these recommendations was to safeguard the health protection of PT personnel (i.e. drivers, customer care staff etc.) and PT passengers at stops/stations and on-board, in order to support the resumption of operations and therefore the mobility of people through the efficient management of critical issues related to the risks of crowding and exposure to possible sources of contagion. Table 1 lists these eight (8) recommendations.

In light of these eight (8) recommendations, local governments and transport operators in Italy have realised that planning new sustainable and resilient strategies is necessary to restore the balance between transport supply and demand [23, 24]. Specifically, the PT operators have drawn up operational plans to differentiate the flows of passengers boarding and alighting PT vehicles and to limit movements within transport hubs as well as at passenger waiting areas. They have also periodically arranged for the systematic sanitation of premises, vehicles and equipment used by travellers and/or personnel in accordance with the methods defined by the Ministry of Health and related Institutes. Disinfectant solution dispensers have been installed in PT stations and inside vehicles' cabins. Waiting areas have been equipped with staff to check body temperature or with automatic systems for this purpose. In PT buses, limitations in the maximum number of people on board have been applied, while PT agencies have also set up ad hoc signs and markers on seats to indicate those of them that cannot be used in line with the social distancing requirements. In the case of non-scheduled transport services, passengers

Table 1. National recommendations in Italy for PT systems after the COVID-19 lockdown

#	Recommendation	Location
1	Do not use PT if you have suspected symptoms of COVID-19 disease	General
2	Purchase tickets electronically, online or via app, whenever possible	PT stops and stations
3	Follow the signs and routes indicated inside stations or at stops, always keeping a distance of at least one (1) meter from other people	
4	Use the indicated vehicle access doors for boarding and alighting, always keeping a safe distance of one (1) meter from other people	On-board
5	Sit only in the permitted seats, keeping a distance from other occupants where required	
6	Avoid approaching or asking the driver for information	
7	During trip, frequently sanitize your hands and avoid touching your face	
8	Use the IMMUNI app to control the spread of the virus	General

were forbidden to occupy the seat next to the driver and no more than two passengers were allowed on the rear seats provided they were equipped with safety devices. In the absence of such devices, only one passenger was allowed. On vehicles approved for the carriage of six or more persons, not more than two passengers were permitted per row of seats, provided that they were wearing facemasks. If possible, bulkheads could be fitted. In addition, the use of a Bluetooth-based application, called IMMUNI [25] for smartphones and tablets was disseminated for the general control of the presence of "COVID-19 positive" people in the vicinity of the user.

3 Methodology

3.1 Study Area and Sample

The region of Sicily was among those most affected by the number of COVID-19 infections and deaths during the first and second period of the pandemic. It is also characterised by a medium-low infrastructure and is an island that is easily reached by plane or ferry. Sicily has been the subject of studies in the PT sector for a number of years [26, 27], and in the pandemic phase some researchers have attempted to analyse the trends between transport supply and demand in advance [28, 29]. The sample investigated, was randomly selected from the lists of frequent passengers of LPT and RPT services. All these passengers reside in the main cities of Sicily and frequently use PT to travel from/to home to/from work, i.e. they are defined as PT commuters. The survey sample consists of 700 PT commuters.

3.2 Questionnaire Survey

The implementation of an online questionnaire survey made it possible to easily acquire data from these 700 PT commuters and in particular data relating to three (3) different aspects:

1. Sociodemographic characteristics, such as gender, age, residential area, and income.
2. Trip frequency for commuting by LPT and RPT services in Sicily during three (3) distinct time periods of the COVID-19 pandemic: (a) before the COVID-19 pandemic, (b) Phase I (May–September 2020) and (c) Phase II (October–December 2020).
3. The level of PT commuters' acceptance against the national recommendations for PT systems (Table 1). The survey participants were asked to indicate their agreement or disagreement with each one of the recommendations, by answering to the following question: "*Do you agree, remain neutral or disagree with the following eight (8) national recommendations for PT systems?*".

The questionnaire survey was carried out from October to December 2020. It was designed and uploaded on the Google platform and disseminated via Facebook and WhatsApp websites.

3.3 Data Analysis

In this study, descriptive statistics were used to estimate and compare: (a) the PT demand trends in Sicily, during the three (3) examined periods of the COVID-19 pandemic and (b) the acceptance rates of survey participants against the national PT recommendations.

In order to investigate whether the PT demand is associated with certain personal characteristics and opinions, we employed a two-step cluster analysis approach to identify homogenous groups of PT commuters. Therefore, we selected the PT trip frequency and sociodemographic variables as input variables for the clustering and we ran two (2) separate analyses to reflect Phase I and Phase II conditions respectively. Then, the acceptance rates on national PT recommendations were compared between cluster members so as to highlight any important differentiations among their opinions.

Two-step cluster analysis has been extensively used in a variety of research fields and disciplines, and allows for the simultaneous analysis of diverse data, such as demographic, psychographic, and behavioral [30]. For this study, we utilized the SPSS software [31] to perform this analysis using the log-likelihood measure. In the two-step cluster analysis, the original cases are first grouped into pre-clusters and then the standard hierarchical clustering algorithm is used to define a range of possible clustering solutions. To define the best number of clusters, the Schwarz's Bayesian information criterion is considered [32]. To validate the cluster analysis results we took into account the *silhouette measure of cohesion and separation*, which is required to be over 0.0, as well as the *importance* of each input variable in the clusters, which are determined by the respective χ^2 -tests' results that are automatically performed by the SPSS routines for all categorical variables.

4 Results and Discussion

4.1 PT Commuters' Profile and Demand Trends

The sociodemographic information, which was collected by the questionnaire survey, demonstrates the basic profile attributes of the 700 PT commuters in our sample. Female (56.3%) and male (43.7%) PT commuters are almost equally represented within our sample. The majority of the PT commuters belongs to the young age groups of 22–25 (33.57%) and 26–30 years old (39.43%). The age groups of above 36 years old have much lower representation (4.7%). The PT commuters are categorized against freelancers (14.7%), employees (59.7%) and other type of occupation (25.57%). Regarding their household monthly income, 25.1% of the respondents earns an income which is below 1,000 euros, while 31.6% of them earns between 1,001–1,500 euros. Incomes of 1,501–2,000 euros and of more than 2,000 euros are also satisfactorily represented in the sample (26.1% and 17.1% respectively). The 33.4% of the survey participants live in Cities (Ragusa, Siracusa, Caltanissetta, and Trapani), the 28.3% in towns (Enna and Agrigento), and the 19.9% of them in Metropolises (Palermo, Messina, and Catania) of Sicily. The rest of them (18.43%) resides in small towns.

Figure 1 shows the trip frequency rates, which were reported by the 700 PT commuters for the LPT services they used in Sicily, during the three (3) examined COVID-19 periods. Before the COVID-19 outbreak, almost all of the survey participants (92%) used LPT services for one or more times per day for commuting. After the end of the lockdown, in Phase I, only a small percentage of them (9.9%) continued to use LPT in the same frequency rates, while almost half of them (46.9%) abandoned LPT. In Phase II, though we observe a slight increase of the PT commuters who returned to the frequent use of LPT (14%), the percentage of those who stopped using LPT still remains high (41.6%), indicating that the return to typical PT ridership and operational conditions was not achieved. Figure 2 presents a similar trend for RPT services as well.

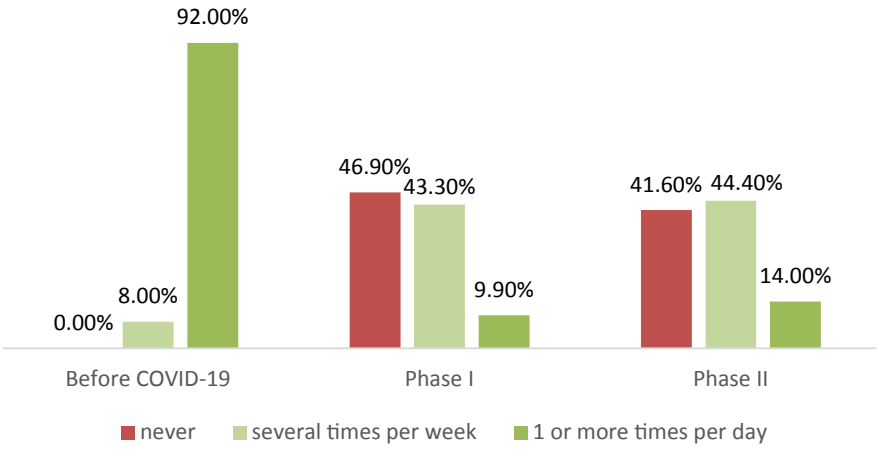

Fig. 1. LPT trip frequency for commuting purposes during COVID-19 periods in Sicily.

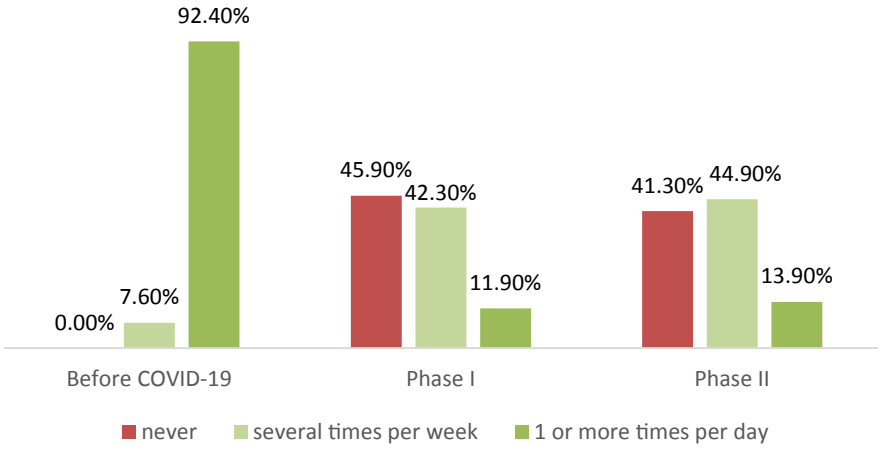

Fig. 2. RPT trip frequency for commuting purposes during COVID-19 periods in Sicily.

4.2 Acceptance Rates of National PT Recommendations

Figure 3 presents the agreement levels on the eight (8) national PT recommendations, which were expressed by the 700 PT commuters in the questionnaire survey.

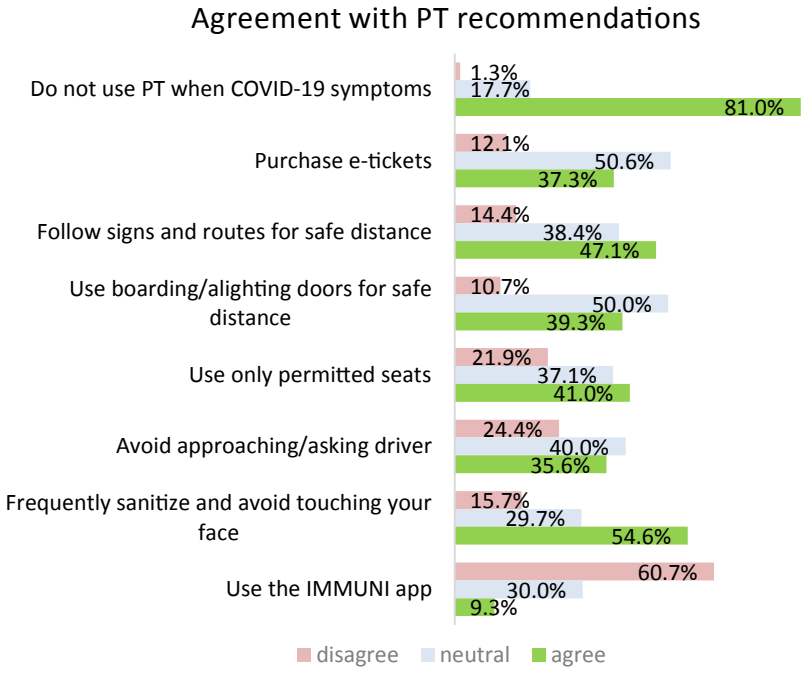

Fig. 3. Acceptance rates of recommendations when using PT among survey participants.

Among the eight (8) recommendations, the one which asks travelers to avoid using PT when they have suspected COVID-19 symptoms concentrates a very high level of agreement among participants (81%). Almost no one was found to disagree with this recommendation (1.3%). This finding demonstrates the relative importance that the PT commuters show on the personal responsibility they carry in terms of spreading the COVID-19 disease. In the same manner, high acceptance rates are also observed for the recommendations: "*During trip, frequently sanitize your hands and avoid touching your face*" (54.6%), and "*Follow the signs and routes indicated inside stations or at stops, always keeping a distance of at least one meter from other people*" (47.1%). Contrary to them, the use of IMMUNI app seems that has not attracted the attention of PT commuters, since 60.7% of them disagrees with the effectiveness of the respective advice. The rest of the recommendations gather similar acceptance levels, ranging between 35% and 41%. Interestingly, the purchasing of e-tickets and the use of the designated boarding/alighting doors are indifferent to the majority of the respondents (neutral opinions of 50.6% and 50% respectively). This probably indicates the relative difficulty to follow these two advices in practice within the PT network of Sicily.

4.3 Clustering of PT Commuters

The results of the two-step cluster analysis indicated two (2) clusters of PT commuters for Phase I. Table 2 shows their basic features. We obtained a silhouette measure of cohesion and separation which is over 0.5 and denotes a good fit of this clustering model. As explained in the Methodology Section, we tested all trip frequency and sociodemographic variables as inputs to the clustering procedure. However, only three (3) of them were found to be important and able to define homogenous groups of PT commuters. Specifically, the frequency of LPT and RPT use were the most important variables (input importance > 0.8) and thus determined the labels of the two clusters, namely Regular &

Table 2. Composition of PT commuters' clusters in Phase I.

Cluster features		1	2
Label		Regular & Frequent PT commuters	Non-PT commuters
Size		386 (55.1%)	314 (44.9%)
Ratio of largest to smallest cluster sizes		1.23	
Silhouette measure of cohesion and separation		>0.5	
Input variables	Trip frequency LPT	Several times per week (100%) & 1 or more times per day (100%)	Never (95.7%)
	Trip frequency RPT	Several times per week & 1 or more times per day (100%)	Never (97.8%)
	Age	26–30 (64.5%)	22–25 (54.0%)

Frequent PT commuters and Non-PT commuters. This fact also reconfirms the descriptive statistics results which showed that the LPT and RPT demand figures follow similar trends after the lockdown period in Sicily.

Age was a less important variable (input importance < 0.2), and highlights that the first cluster concentrated the majority (64.5%) of the 26–30 age group, while the second cluster gathered the most respondents (54%) which belonged to the 22–25 age group. No other sociodemographic variable was found to be an important factor for clustering. This is an indication that the PT mode choice for commuting in Phase I is not significantly associated or explained by the sociodemographic attributes of the travelers.

Similar findings were also obtained from the Phase II clusters and presented in Table 3. The frequency of LPT and RPT use appear again as the dominant input variables (input importance > 0.8) which characterize three (3) clusters of PT commuters, namely Frequent, Regular and Non-PT commuters. Regarding the residential area, the 49% of the town residents belong to the cluster of the Non-PT commuters and the 47.9% of the city residents to the cluster of the Regular PT commuters. However, the importance of this variable is comparatively lower (input importance < 0.2). As in Phase I, no other sociodemographic variable was found to be a critical factor for determining clusters of PT commuters.

Table 3. Composition of PT commuters' clusters in Phase II

Cluster features		1	2	3
Label		Frequent PT commuters	Regular PT commuters	Non-PT commuters
Size		101 (14.4%)	314 (44.9%)	285 (40.7%)
Ratio of largest to smallest cluster sizes		3.11		
Silhouette measure of cohesion and separation		>0.5		
Input variables	Trip frequency LPT	1 or more times per day (100%)	Several times per week (99%)	Never (97.6%)
	Trip frequency RPT	1 or more times per day (100%)	Several times per week (100%)	Never (98.6%)
	Residential area	City (15.8%)	City (47.9%)	Town (49.0%)

Table 4 shows the four (4), out of the total eight (8), national PT recommendations that had differentiated acceptance rates within the cluster members in Phase I and Phase II.

For Phase I clusters, Table 4 shows that the majority (57.5%) of the Frequent and Regular PT commuters are neutral towards the "Purchase of e-tickets" while most of the Non-PT commuters (45.2%) agree with this advice. Additionally, the "Use of permitted seats on-board" concentrates the agreement of the 45.1% of Cluster 1 members, while

38.9% of Cluster 2 members are indifferent to this advice. The same pattern also applies for the "Avoiding approaching/asking drivers" recommendation, which draws comparatively more attention within Frequent and Regular PT commuters (38.1%) compared to the Non-PT commuters (32.5%). These findings indicate the relative importance that was given to the two recommendations, i.e. "Use of permitted seats on-board" and "Avoiding approaching/asking drivers", from the commuters who resumed PT use after the end of the lockdown period in Sicily, and demonstrate two important fields where PT agencies should pay attention for successfully adapting their services in the COVID-19 era. The relatively lower agreement for the "Purchase of e-tickets" within Cluster 1 members probably highlights practical difficulties to follow this recommendation in the PT system of Sicily.

In the same manner, for Phase II clusters, Table 4 figures also show that there are differentiations among the opinions of the three (3) cluster members, regarding the recommendations on permitted seats, approaching driver, and use of boarding/alighting doors. However, these differentiations are much lower compared to the Phase I case and cannot easily demonstrate a certain opinion pattern.

Table 4. Acceptance rates of recommendations within the clusters of PT commuters

Recommendations		Phase I clusters		Phase II clusters		
		1	2	1	2	3
Purchase e-tickets	Disagree	11.7%	12.7%	10.8%	8.9%	14.7%
	Neutral	57.5%	42.0%	51.0%	50.5%	50.2%
	Agree	30.8%	45.2%	38.2%	40.6%	35.1%
Use only permitted seats	Disagree	19.2%	25.2%	19.4%	21.8%	24.6%
	Neutral	35.8%	38.9%	40.8%	37.6%	33.0%
	Agree	45.1%	36.0%	39.8%	40.6%	42.5%
Avoid approaching/asking driver	Disagree	24.6%	24.2%	26.1%	24.8%	22.5%
	Neutral	37.3%	43.3%	41.7%	38.6%	38.6%
	Agree	38.1%	32.5%	32.2%	36.6%	38.9%
Use boarding/alighting doors properly for safe distancing	Disagree	9.6%	12.1%	8.6%	9.9%	13.3%
	Neutral	53.9%	45.2%	51.9%	44.6%	49.8%
	Agree	36.5%	42.7%	39.5%	45.5%	36.8%

5 Conclusion

In this study we used questionnaire survey data to investigate the PT demand characteristics and their explanatory factors in Sicily, Italy after the end of the COVID-19 lockdown period. Our sample consisted of 700 PT users who were frequent PT commuters before

the COVID-19 pandemic. Their answers were analyzed by employing descriptive statistics and cluster analysis. Empirical findings showed that the PT demand for commuting trips was reduced by half in the LPT and RPT services of Sicily during the second period of the pandemic (approximately May–December 2020). This reduction of demand was horizontal among the different groups of commuters, since the cluster analysis results showed that their sociodemographic attributes play no or little importance for explaining the frequency of LPT and RPT commuting trips. Commuters in Sicily were found to be great supporters of the national recommendations that pertained to their personal responsibilities against COVID-19 spread when using PT. The recommendations regarding the "Use of permitted seats on-board" and the "Avoiding approaching/asking bus drivers on-board" were highlighted as the most critical ones among the commuters that returned to LPT and RPT services after the end of lockdown. On the other hand, the national PT recommendations that were based on online applications, such as IMMUNI and e-ticketing, did not gather high acceptance due to (potential) practical difficulties.

Our findings highlighted the most important national PT recommendations and thus highlighted the fields where local authorities and PT agencies should focus in order to adjust the PT operations in the post lockdown phase and create attractive PT services during any pandemic or relatively extreme situation that may appear again in the future. In fact, when the restrictions will be reduced, national and local authorities will have to understand whether the mobility changes triggered by COVID-19 are positive or negative, in terms of their impact on energy use, safety and long-term health and environmental outcomes. Certainly, governments that have already designed sustainable transport policies for the post-COVID-19 period can draw on previous crisis experiences to predict likely behaviour and design policies that are fit for purpose.

Therefore, in view of the inconveniences caused by the pandemic, this study indicated that it is necessary to analyse PT using a bottom-up approach that rewards participatory planning [8, 11, 28, 33]; it is also necessary to analyse not only the characteristics of the service provided but also the psycho-social aspect of users [34] and possible mobility alternatives that allow social distancing to be respected and the service to be complementary, such as DRT and minibus services [35, 36], and shared mobility services [37, 38]. In this respect, considering the low acceptance rates of online apps in Sicily, PT agencies should continue developing attractive customer service platforms and investing in their social media strategies to promote such apps to their customers [36, 39].

The most important limitation of this study was that the sample of PT commuters did not adequately represent all demographic groups, especially the age-related ones. This is due to the inherited weaknesses of online surveys, which do not attract the attention of older people, but they are the only feasible survey tool under COVID-19 restriction measures. Further research should also explore the role of additional PT qualitative attributes in PT demand and should also cover the third period of the pandemic (i.e. from January 2021 and onwards) so as to determine a more comprehensive understanding of the PT demand under these extreme conditions.

Acknowledgments. The authors acknowledge financial support from the MIUR (Ministry of Education, Universities and Research [Italy]) through a project entitled WEAKI TRANSIT: WEAK-demand areas Innovative TRANsport Shared services for Italian Towns (Project code: 20174ARRHT/CUP Code: J74I19000320008), financed with the PRIN 2017 (Research Projects

of National Relevance) program. We authorize the MIUR to reproduce and distribute reprints for Governmental purposes, notwithstanding any copyright notations thereon. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the MIUR.

Author Contributions. This paper is the result of the joint work of the authors. 'Abstract', 'Introduction', 'Methodology', and 'Results' were written jointly by the authors. T.C. and G.T. discussed on the state of the art. S.B. and G.G. designed the methodological approach and discussion. Supervision and research funding; T.C., S.B., and G.T.

Funding. This research work was partially funded by the MIUR (Ministry of Education, Universities and Research [Italy]) through a project entitled WEAKI TRANSIT.

Conflicts of Interest. The authors declare no conflict of interest.

References

1. European Commission: Green Paper - Towards a new culture for urban mobility {SEC(2007) 1209} COM/2007/0551 final
2. Basbas, S., Nikolaou, K., Toskas, G.: Environmental impacts of bus traffic in the Thessaloniki Metropolitan Area. J. Environ. Prot. Ecol. **2**(3), 567–574 (2001)
3. Mahmood, M.N., Avishai (Avi), C., Farzan, G., Scott, T.: Environmental impacts of public transport systems using real-time control method. Transp. Res. Part D: Transp. Environ. **51**, 216–226 (2017)
4. Vicente, P., Sampaio, A., Reis, E.: Factors influencing passenger loyalty towards public transport services: does public transport providers' commitment to environmental sustainability matter? Case Stud. Transp. Policy **8**(2), 627–638 (2020)
5. Ma, L., Graham, D., Stettler, M.: Air quality impacts of new public transport provision: a causal analysis of the Jubilee Line Extension in London. Atmos. Environ. **245**, 118025 (2021)
6. Pettersson, F., Sørensen, C.H.: Why do cities invest in bus priority measures? Policy, polity, and politics in Stockholm and Copenhagen. Transp. Policy **98**, 178–185 (2020)
7. Goryaev, N., Myachkov, K., Larin, O.: Optimization of "green wave" mode to ensure priority of fixed-route public transport. Transp. Res. Proc. **36**, 231–236 (2018)
8. Stelzer, A., Englert, F., Hörold, S., Mayas, C.: Improving service quality in public transportation systems using automated customer feedback. Transp. Res. Part E: Logist. Transp. Rev. **89**, 259–271 (2016)
9. Torrisi, V., Garau, C., Inturri, G., Ignaccolo, M.: Strategies and actions towards sustainability: encouraging good ITS practices in the SUMP vision. In: AIP Conference Proceedings, vol. 2343, no. 1, p. 090008. AIP Publishing LLC (2021). https://doi.org/10.1063/5.0047897
10. Coni, M., Garau, C., Pinna, F.: How has Cagliari changed its citizens in smart citizens? Exploring the influence of ITS technology on urban social interactions. In: Gervasi, O., et al. (eds.) ICCSA 2018. LNCS, vol. 10962, pp. 573–588. Springer, Cham (2018). https://doi.org/10.1007/978-3-319-95168-3_39
11. Politis, I., Papaioannou, P., Basbas, S., Dimitriadis, N.: Evaluation of a bus passenger information system from the users' point of view in the city of Thessaloniki. Greece. Res. Transp. Econ. **29**(1), 249–255 (2010)

12. Campisi, T., Basbas, S., Skoufas, A., Akgün, N., Ticali, D., Tesoriere, G.: The impact of COVID-19 pandemic on the resilience of sustainable mobility in Sicily. Sustainability **12**, 8829 (2020)
13. Przybylowski, A., Stelmak, S., Suchanek, M.: Mobility behaviour in view of the impact of the COVID-19 pandemic—Public transport users in Gdansk case study. Sustainability **13**, 364 (2021)
14. Politis, I., et al.: Mapping travel behavior changes during the COVID-19 lock-down: a socioeconomic analysis in Greece. Eur. Transp. Res. Rev. **13**(1), 1–19 (2021). https://doi.org/10.1186/s12544-021-00481-7
15. Nikiforiadis, A., Ayfantopoulou, G., Stamelou, A.: Assessing the impact of COVID-19 on bike-sharing usage: the case of Thessaloniki, Greece. Sustainability **12**, 8215 (2020)
16. Eisenmann, C., Nobis, C., Kolarova, V., Lenz, B., Winkler, C.: Transport mode use during the COVID-19 lockdown period in Germany: the car became more important, public transport lost ground. Transp. Policy **103**, 60–67 (2021)
17. Dong, H., Ma, S., Jia, N., Tian, J.: Understanding public transport satisfaction in post COVID-19 pandemic. Transp. Policy **101**, 81–88 (2021)
18. Gkiotsalitis, K.: A model for modifying the public transport service patterns to account for the imposed COVID-19 capacity. Transp. Res. Interdisc. Perspect. **9**, 100336 (2021)
19. Vickerman, R.: Will COVID-19 put the public back in public transport? A UK perspective. Transp. Policy **103**, 95–102 (2021)
20. Murgante, B., Borruso, G., Balletto, G., Castiglia, P., Dettori, M.: Why Italy first? Health, geographical and planning aspects of the COVID-19 outbreak. Sustainability **12**(12), 5064 (2020)
21. Gutiérrez, A., Miravet, D., Domènech, A.: COVID-19 and urban public transport services: emerging challenges and research agenda. Cities Health 1–4 (2020). https://doi.org/10.1080/23748834.2020.1804291
22. Moslem, S., Campisi, T., Szmelter-Jarosz, A., Duleba, S., Nahiduzzaman, K.M., Tesoriere, G.: Best–worst method for modelling mobility choice after COVID-19: evidence from Italy. Sustainability **12**(17), 6824 (2020)
23. Cartenì, A., Di Francesco, L., Martino, M.: The role of transport accessibility within the spread of the Coronavirus pandemic in Italy. Saf. Sci. **133**, 104999 (2021)
24. Tuite, A.R., Ng, V., Rees, E., Fisman, D.: Estimation of COVID-19 outbreak size in Italy. The Lancet. Infect. Dis. **20**(5), 537 (2020)
25. IMMUNI Homepage. http://www.immuni.italia.it/. Accessed 21 Mar 2021
26. Franzitta, V., Curto, D., Rao, D., Viola, A.: Hydrogen production from sea wave for alternative energy vehicles for public transport in Trapani (Italy). Energies **9**(10), 850 (2016)
27. Genna, G.: The transportation system in the Sicilian touristic development. In: ERSA Conference Papers, number ersa06p652 (2006)
28. Campisi, T., Akgün, N., Ticali, D., Tesoriere, G.: Exploring public opinion on personal mobility vehicle use: a case study in Palermo, Italy. Sustainability **12**(13), 5460 (2020)
29. Campisi, T., Basbas, S., Skoufas, A., Akgün, N., Ticali, D., Tesoriere, G.: The impact of COVID-19 pandemic on the resilience of sustainable mobility in Sicily. Sustainability **12**(21), 8829 (2020)
30. Rundle-Thiele, S., Kubacki, K., Tkaczynski, A., Parkinson, J.: Using two-step cluster analysis to identify homogeneous physical activity groups. Mark. Intell. Plann. **33**(4), 522–537 (2015)
31. IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. IBM Corp., Armonk, NY
32. Norusis, M.J.: IBM SPSS Statistics 19 Procedures Companion. Addison Wesley, TX, Boston (2011)

33. Tesoriere, G., Campisi, T.: The benefit of engage the "crowd" encouraging a bottom-up approach for shared mobility rating. In: Gervasi, O., et al. (eds.) ICCSA 2020. LNCS, vol. 12250, pp. 836–850. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-58802-1_60
34. Al-Rashid, M.A., Goh, H.C., Harumain, Y.A.S., Ali, Z., Campisi, T., Mahmood, T.: Psychosocial barriers of public transport use and social exclusion among older adults: empirical evidence from Lahore, Pakistan. Int. J. Environ. Res. Public Health **18**(1), 185 (2021)
35. Akrioti, M., Basbas, S., Georgiadis, G., Nathanail, E.: Investigation of minibus public transport service characteristics in an urban area through the use of a stated and revealed preference survey. In: Nathanail, E.G., Adamos, G., Karakikes, I. (eds.) CSUM 2020. AISC, vol. 1278, pp. 11–20. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-61075-3_2
36. Abdullah, M., Ali, N., Shah, S.A.H., Javid, M.A., Campisi, T.: Service quality assessment of app-based demand-responsive public transit services in Lahore, Pakistan. Appl. Sc. **11**, 1911 (2021)
37. Campisi, T., Torrisi, V., Ignaccolo, M., Inturri, G., Tesoriere, G.: University propensity assessment to car sharing services using mixed survey data: the Italian case study of Enna city. Transp. Res. Proc. **47**, 433–440 (2020)
38. Campisi, T., Ignaccolo, M., Inturri, G., Tesoriere, G., Torrisi, V.: The growing urban accessibility: a model to measure the car sharing effectiveness based on parking distances. In: Gervasi, O., et al. (eds.) ICCSA 2020. LNCS, vol. 12255, pp. 629–644. Springer, Cham (2020). https://doi.org/10.1007/978-3-030-58820-5_46
39. Georgiadis, G., Nikolaidou, A., Politis, I., Papaioannou, P.: How public transport could benefit from social media? Evidence from European agencies. In: Nathanail, E.G., Adamos, G., Karakikes, I. (eds.) CSUM 2020. AISC, vol. 1278, pp. 645–653. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-61075-3_63