

How the COVID-19 changed the urban mobility ecosystem: A perspective for new hybrid services

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Abstract

The unfettered expansion of cities is pushing our environment to the brink, as it faces a slew of unprecedented challenges that are intensifying the already critical issue of climate change. Part of the responsibility is due to the high carbon emissions generated by transport, rising demand for transportation, and an increased digitalized world where e-commerce grows. Mobility patterns changed during the last two and a half years due to the pandemic restrictions and consequent lifestyle changes.

This paper focuses on a study in the city of Porto, Portugal. It contributes to an understanding of the main changes in frequency and mobility choices and urban mobility trends for this sector, focusing on sustainable urban mobility. In addition, it seeks to bring the service design lens to the analysis and visualization of the interactions of mobility services before and during the pandemic and propose solutions for a hybrid context characterized by cycles of restrictions and flexibilization of sanitary measures. The findings are a launching pad to implement new business models focused on sustainable new hybrid services.

Keywords: Service Design, Sustainability, Urban Mobility Services, COVID-19.

Introduction

The COVID-19 pandemic forced people to spend most of their time at home in an effort to avoid viral spread (Dietz et al., 2020). As a result, the world quickly adapted to new lifestyle changes and strict security measures (Tokazhanov et al., 2020). Several studies have reported a significant reduction in human mobility during the pandemic, as well as substantial changes in travel patterns, including an increased

adoption of active and soft modes of transportation and a decrease in the use of public transportation ((Monterde-I-Bort et al., 2022; Glavan et al., 2022). Despite the relaxation of COVID-19 restrictions, the world still faces the need to become more resilient to potential disease outbreaks or lockdowns, presenting challenges for adaptation to a new reality (Tokazhanov et al., 2020). Thus, there is an urgent need for urban mobility services to be more adaptable and responsive to pandemic and climate issues.

In light of these challenges, this study aims to adopt a service design approach to analyze existing mobility services and their adaptation to Sustainable Development Goals (United Nations, 2016) and new measures that have emerged due to the pandemic. This approach was chosen due to the growing presence of the service sector in addressing transformative changes influenced by technological innovations, global pandemics, social upheavals, and climate crises (Ostrom et al., 2021). Additionally, service design is recognized for its ability to improve existing services and create new ones (Polaine et al., 2013) by providing an interdisciplinary, holistic approach to solving complex problems (Ostrom et al., 2010).

Mobility patterns during COVID-19 in Portugal

Portuguese quickly adopted social distancing and changed their mobility patterns in response to the COVID-19 pandemic (Tamagusko & Ferreira, 2020). This resulted in negative variations in the number of passengers transported in Portugal, with Metro do Porto and trains showing decreases of 44.7% and 41.7%, respectively. The lower circulation of vehicles on Portuguese roads also led to a 25.6% reduction in accidents (INE, I. P., 2021).

Bicycles and scooters saw increased use for short trips at the local level, along with government incentives such as bike lane construction and subsidies for purchases (de Haas et al., 2020). However, unfulfilled needs remain, especially for bike sharing systems, where shortages of bikes, lack of stations, and poor bike conditions were the main reasons for quitting (Costa et al., 2022; Teixeira et al., 2021). Protected infrastructure and parking facilities are also important for increasing adoption and satisfaction rates of this transport mode (Handy et al., 2014).

Urban mobility trends

Newman (2015) argues that car-dependent urban planning exacerbates social and economic inequalities and is unsustainable. To address this, the European Commission has proposed a long-term strategy vision that advocates for spatial planning reform and the promotion of clean, safe, and connected mobility (European Commission, 2018).



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Paiva et al. (2021) discuss the future of mobility, highlighting the concept of smart mobility, which involves the integration of technological advancements such as the Internet of Things (IoT), Big Data, and Artificial Intelligence (AI) into the transportation system. The authors suggest that smart mobility will revolutionize goods transport through the robotization of delivery operations and will transform people transport through mobility as a Service (MaaS). MaaS aims to reduce private vehicle ownership and replace them with electric, shared, lighter, and smaller vehicles that incorporate autonomous driving technology.

The implementation of interoperable systems is crucial for the development of efficient MaaS, personalized user experiences, and emission reduction using shared vehicles and micro-mobility. However, there are significant policy barriers and bureaucratic challenges that must be overcome for interoperable systems to become a reality in urban mobility (Paiva et al., 2021). To achieve a fully integrated transport system, governments need to actively participate in the development, operation, and regulation of MaaS (Vij & Dühr, 2022). They should also require transport operators to provide integration APIs and open data to ensure interoperability, which will allow access to existing and new partners (Yang & Kankanhalli, 2013).

Methodology

To better understand what the impacts of the pandemic on the mobility sector were and what are the opportunities in technological and sustainable terms, 25 semi-structured interviews were conducted focused on three elements:

1. The changes observed in mobility patterns and behaviors during the pandemic.
2. The understanding of the main barriers and opportunities in applying technologies in the mobility sector.
3. The understanding of barriers and opportunities in implementing more sustainable mobility.

Semi-structured interviews tend to produce limited data per question, which requires a larger sample size to generate richer data and achieve saturation (Morse, 2000). Our study further underscores the importance of a larger sample size as our participants had diverse backgrounds and perspectives. Therefore, purposeful sampling (Creswell & Poth, 2017) was adopted, resulting in the selection of 25 Portuguese participants with theoretical and practical relevance in the technology, mobility, and urban planning sectors, and who also possessed a deep understanding



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and experience within the context of Portugal. The sample included 12 mobility and technology specialists, 1 behavioural scientist, 2 councillors, 5 employees of public transport companies, and 5 professors and researchers in the transport and urban planning field.

All interviews, lasting between 30 to 60 minutes, were conducted remotely and in person. Participants were invited to share their impressions on a range of topics related to the pandemic's impact on urban mobility, future perspectives, technology, public transport, micromobility modes, and carbon neutrality. The interviews were then literally transcribed and analyzed using NVivo 12 software.

Data Analysis

Qualitative research categorizes and selects topics until a comprehensive set of themes is established (Creswell & Poth, 2017). This study employed Thematic Analysis to identify patterns in COVID-19's impact on sustainability and mobility services. According to Braun and Clarke's (2006) this method included six stages: familiarization with data, initial codes and theme searching, review and new code creation, theme definition and naming, and report production, which included a second round of literature review (Nowell et al., 2017).

It generated a pool of 261 primary codes that were grouped into 11 sub-themes and then aggregated into three global themes: Mobility and Urban Planning, Experience requirements for public and alternative transport modes, and Carbon Neutrality.



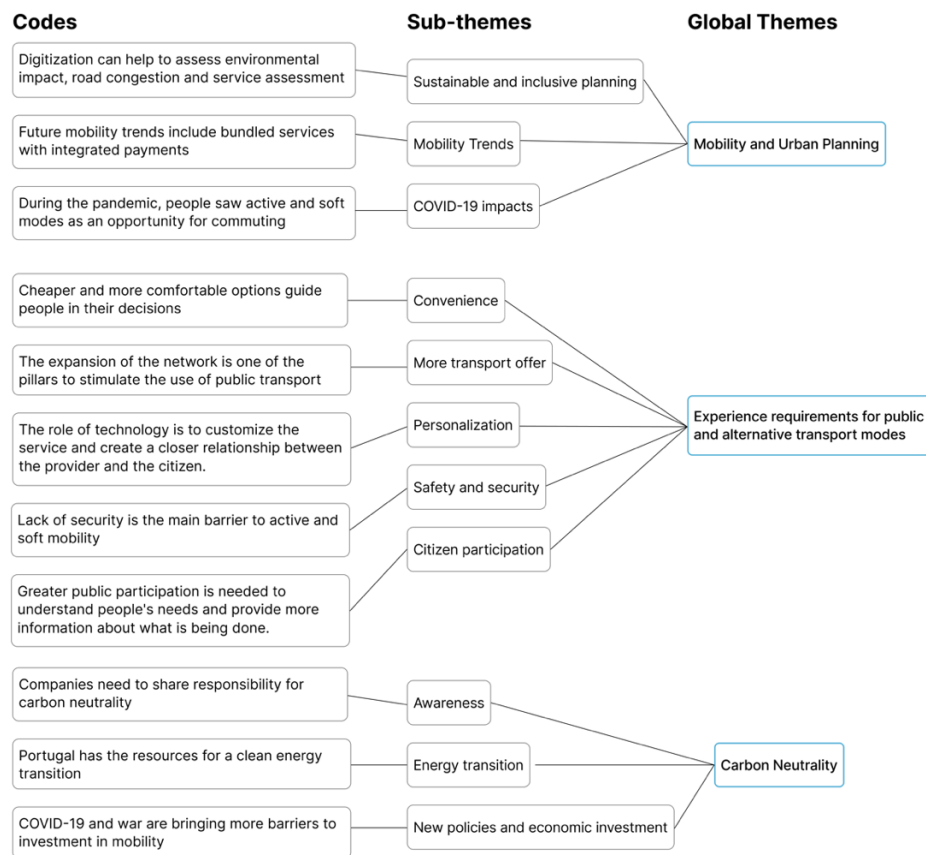


Figure 1. Global themes, sub-themes, and codes

The research utilized qualitative data and literature to inform the application of a set of service design tools. The first step involved mapping potential stakeholders, followed by building customer journeys, as it leverages a mode of temporal reflexivity, which allows an awareness of social structures through the experience of duration between events Vink et al. (2021). Customer journeys compared different transport services in both pre-pandemic and pandemic periods. The ECO-SD method presented by Sierra-Pérez et al. (2021) was used to identify diverse barriers from environmental impacts to user experience issues during service provision.

After mapping the main steps and actions for each type of transport, service barriers were added based on input from the interview results. These barriers were categorized to consider sanitary safety during the pandemic and environmental impacts that go against carbon neutrality goals. Other barriers were also reported as indicated by the following examples:

- Physical
 Due the lack of appropriated infrastructure



“The main barrier is still that people do not feel safe. There are many, but security is perhaps number 1”. (Specialist in mobility and technology)

- Technological

Due the lack of data exchanging among different systems.

“...Combine the various pricing systems, and information, making it the only one. Technologically, I think we already have some maturity to move forward. The difficulty is bringing together several service providers.” (Employee of a public transport company)

- Behavioral

Due the lack of alignment between individuals using different modes of transportation and not adhering to traffic rules.

“...I think that's the first barrier, which is behavioral, and must be changing the behavior of car drivers and all people who want to use alternative transport.” (Behavioural Scientist)

Figure 2 provides an example of a citizen's journey when using bike and scooter sharing services. The service barriers that stand out involve the experience of using the application to rent a bike, the lack of availability of this transport in non-central areas. Physical and behavioural barriers also play a role.

“...if I have to go by bike from Lisbon to the Cascais area, I have to install at least 3 applications, put credit in 3 applications...” (Specialist in mobility and technology)

“...there has been a lot of conversation about integrating bicycle and scooter modes connecting residential areas to large stations... having a way to get people to public transport through t on-demand transportation...” (Mobility researcher)



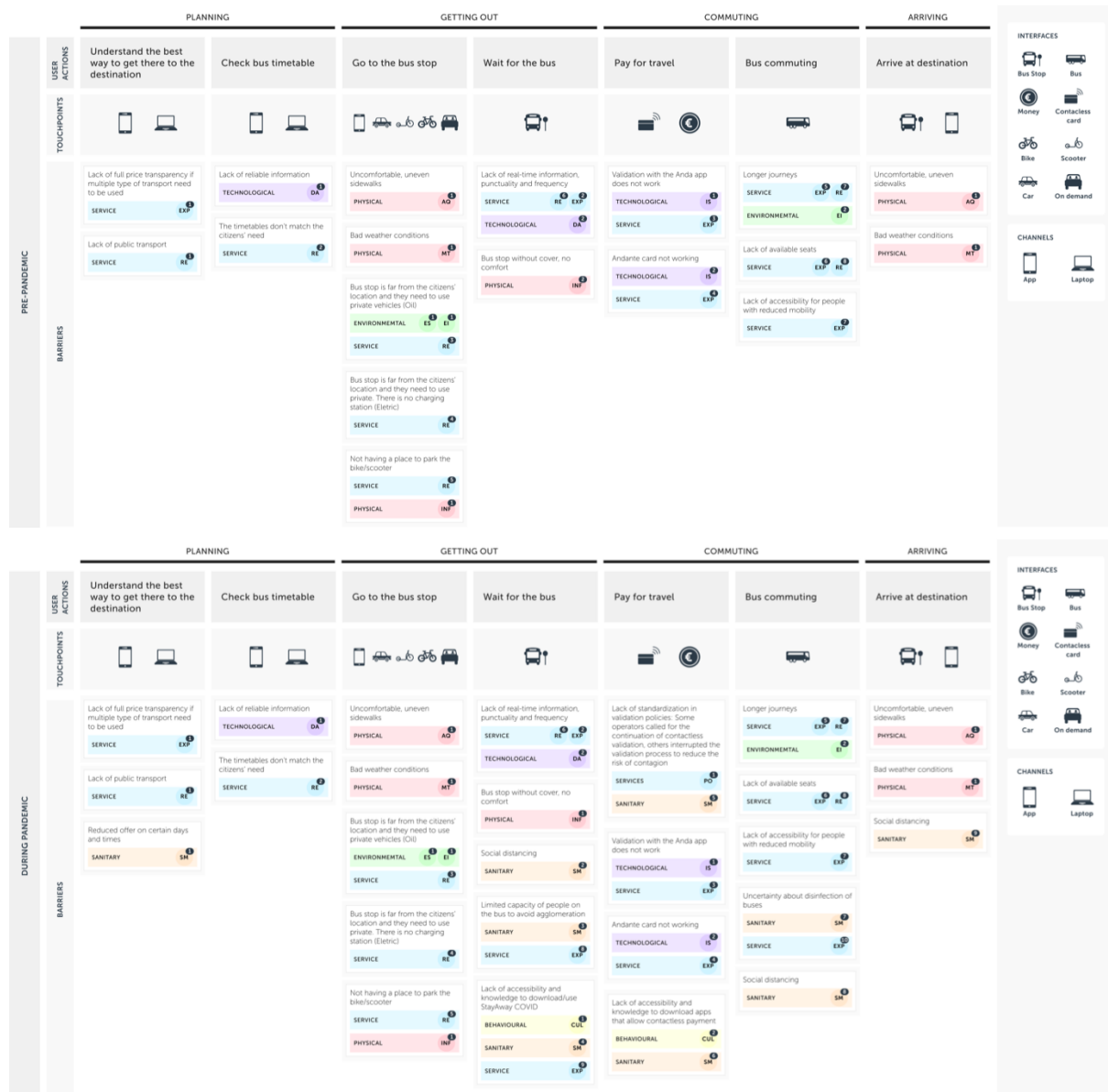


Figure 2. Example of the customer journey's structure pre and during pandemic, respectively

To overcome physical barriers, recommendations such as offering helmets and protective materials, along with transport rental, and providing route options based on architectural barriers were suggested. This suggestion arose from a conversation with a mobility expert interviewee, where it was presented that material technologies such as inflatable helmets¹ and other physical protection elements could encourage the use of active and smooth mobility. To improve the mobility experience and

¹ Hövding Sverige AB, see <https://hovding.com/>, accessed 06 June 2022.



promote cultural affirmation, it is recommended to create partnerships between public transport and micro mobility companies to offer discount coupons on bicycle and scooter rentals. Additionally, it is recommended to enable integrated mobility marketplaces, allowing users to access a variety of mobility options in a single environment, based on their convenience and, essentially, on the cost, time, and carbon footprint. The Porto City Council has been planning initiatives to integrate intermunicipal routes with public transport, to calm traffic and promote a reduction in carbon footprint as well as better use of public spaces (Baganha, 2021).

Discussion

The results of the qualitative research, combined with the literature review, have synthesized four dimensions. These dimensions represent opportunities for new business models to consider when creating sustainable mobility services in a context of fluctuating sanitary measures and restrictions.

The following Table 1 provides a detailed overview of each dimension along with supporting evidence.

Dimensions	Evidence	Opportunities
Reaping the benefits of new technologies	Interoperability is critical for data exchange among systems (Giesecke et al., 2016), but data collection remains a challenge in Portugal. Interviewees from technology companies and mobility researchers state that they have technological capability to create interoperable mobility services but face difficulties when negotiating with public entities due to public tender requirements. Transport systems in Portugal and even more in Porto have failure to collect and use data. When asked about this, employees of public transport companies and city councillor stated that one of the	<ul style="list-style-type: none"> • To implement new data exchange systems with business partners using defined interoperability and exchange standards for urban intelligence platforms. • To combine blockchain, big data, AI, and IoT to provide transparent information about urban spaces and occupancy levels, in order to prevent overcrowding. • To offer self-services with predictive scenarios for commuting, such as door-to-door travel, considering external and internal factors of the user's life. • To enhance intramodality by strengthening the availability of



priorities of the municipal plan² to overcome data collection barriers is to monitor the city and establish partnerships with GPS companies to share real-time information.

alternative transportation modes to private cars.

- To invest in physical infrastructure and sensors to increase safety and security for pedestrians and bicycle users.
- To ensure that regulations adapt to the security of users on different transportation modes, data management, privacy, and connectivity.

Addressing mobility and urban planning challenges

Car-dependent urban planning is a challenge we face today (Newman, 2015). To address this, interviewees from research, public transport, and behavioural science groups recommend investing in express bike lanes to promote alternative modes of transportation, connecting suburbs to major stations and city centers, and implementing initiatives to change driving behaviours for cars, bicycles, and scooters.

“I think public policy is to change some infrastructure but change people’s mentality. I don’t see it being done. I think it’s a behavioural issue.” (Behavioural Scientist)

- To enhance intramodality by strengthening the availability of alternative transportation modes to private cars.
- Data-driven decision-making can be used to optimize bus route lines and demand-responsive transportation.
- To invest in infrastructure and sensors for safer pedestrian and bicycle use.
- Regulations must adapt to ensure user security across transport modes, data management, privacy, and connectivity

Increasing awareness for carbon neutrality

The Portuguese government is prioritizing investment in the decarbonization of public transport and developing a national strategy for active mobility, including subsidies for electric bicycles and plans to expand bike lanes to 10,000 km by 2030 (IEA, 2021). These efforts, combined with tools that

- To create awareness, companies should share the responsibility for reducing emissions with their employees and offer benefits for the use of more sustainable transportation.

² Municipal Master Plan (PDM), see <https://portoinnovationhub.pt/wp-content/uploads/2021/04/SbO22-PDM-1.pdf> (in Portuguese), accessed 05 June 2022.



incentivize sustainable behaviors like the AYR platform³ by CEiiA, can enable citizens to track and reduce their emissions. Through gamification and rewards programs, such tools might motivate customers to become more involved in sustainable behaviors (Ostrom et al., 2021).

- Providing people with information about their emissions footprint and provide some rewards.
- To collaborate with renewable energy providers to create an energy storage system for vehicles.

Analysing the service ecosystem

(Cambra-Fierro et al., 2022) emphasize the importance of business managers planning and developing new business models based on the entire network, rather than solely on the customer-centric approach. This idea is reinforced by (Koskela-Huotari et al., 2021) that state that service design methods and techniques combined with of ecosystem analysis provide a deeper understanding of the complex context in which business interacts.

- Micro-level - Define which ecosystem will be analysed (mobility industry or specific transport service), considering its norms, rules, beliefs, actors involved, and emerging intentions in the feedback loop.
Methods/techniques: interviews, observations, system mapping.
- Meso-level - Identify alignment/conflicts in service processes and consider the influence of pandemic, new technologies, and climate crisis on service reproduction.
Methods/techniques: Benchmarking, replicating, and creating scenarios.
- Macro-level- Identify external emerging trends in health, technology, mobility sectors/services and understand their impacts on the broader system as well as actor-actor and company-customer relationships.
Methods/techniques: Actors map, benchmarking, replicating, and creating scenarios.

Table 1. Managerial implications

³ AYR Platform, <https://weayr.com/#/home>. Accessed July 4, 2022.



Conclusions and future research

Adopting service design in this project involves understanding the mobility service ecosystem in Porto before and during the pandemic and envisioning new opportunities for the future. The study also investigates potential stakeholders for new business models based on insights from interviews and literature review. The importance of considering the entire service network and ecosystem when designing new business models and services is reinforced, as well as the need to understand the complexity of social practices, cultural context, and transformative changes (Vink et al., 2021). The combination of ecosystem analysis and service design approaches provided broader insights into the service delivery context, representing an example of how to develop tangible guidelines for adaptable services to the context in which they are inserted.

By using ethnographic research and interviews, behaviour patterns and reproduction of services can be better understood across different types of urban mobility. While this project captured expert perspectives and those directly involved in the mobility field, the qualitative research should be extended to include citizens who utilize mobility services. Future studies should incorporate interaction with potential stakeholders to validate involvement strategies and recommendations. Additionally, it is important to consider value co-creation at all levels of the ecosystem and apply service design approaches to visualize and analyze multiple levels of new services to be developed.



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