Digital Shared Mobility Services: Operationalizing the Capabilities Approach to Appraise Inclusivity

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Abstract. Digitalization has fostered the emergence and transformation of transport services, such as shared transport. Digital literacy and having access to digital platforms are increasingly necessary prerequisites to be mobile and benefit from these services. Consequently, new forms of transport disadvantages have emerged, which might result in the exclusion of vulnerable populations.

This paper reviews the literature about transport disadvantages, digital exclusion and shared transport to identify a comprehensive approach to the study of digital shared mobility services (DSMS). By incorporating the digital divide into the Capabilities Approach, a theoretical framework to study DSMS is proposed.

The findings of this paper are relevant to decision-makers, practitioners and researchers working within the field of urban mobility and shared transport services. The theoretical framework proposed is useful to understand the unequal use of DSMS and appraise their inclusivity. This framework is also useful for transport operators and policy-makers interested in adopting a user-centred perspective.

1 Introduction

Digitalization is defined by Gray and Rumpe (2015) as the process in which a wide range of information and communication technologies (ICTs), also referred to as digital technologies, are integrated into all aspects of daily life. During the past decade, digitalisation has accelerated, having a transformative impact on mobility and transport systems (Macharis and Geurs 2019). Citizens increasingly need digital technologies for conducting tasks related to their mobility (Snellen and de Hollander 2017) such as checking schedules, acknowledging incidents, purchasing tickets or booking transport services (Durand et al. 2021). Transport operators have adopted digital technologies as a means to increase cost-efficiency and improve user experience (Davidsson et al. 2016). Moreover, such technologies are the main drivers behind the emergence and development of new transport solutions such as autonomous vehicles, Mobility-as-a-Service (MaaS) and shared transport (Macharis and Geurs 2019; Pangbourne et al. 2020; Shibayama and Emberger 2020).

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Shared transport is defined as the services that allow users to have short-term access to a transportation mode, such as a vehicle or a bicycle, which is shared with other users (Shaheen and Cohen 2018). Shared transport has become increasingly relevant in urban policy agendas, as a means to potentially reduce congestion levels and greenhouse gas emissions in cities (Cohen and Kietzmann 2014; Machado et al. 2018; Santos 2018). Some scholars even argue that we are currently in an era of shared transport services due to the fast development of solutions and tools that enable the rapid adoption of such services (Shaheen et al. 2016).

Shared transport is highly dependent on digital technologies, with most providers relying on digital platforms to operate their services (Jittrapirom et al. 2017). This requires travellers to have access to a reliable internet connection and a digital device (Groth 2019; Pangbourne et al. 2020). Consequently, not being able or willing to adopt digital technologies may result in a form of transport disadvantage (Schwanen et al. 2015).

Although transport services based on digital technologies, such as digital shared transport, might be especially useful for groups facing transport disadvantages, some of these groups are also at higher risk of digital exclusion (Goodman-Deane et al. 2021). When faced by vulnerable populations, transport disadvantage might result in transport-related social exclusion (TRSE) (Yigitcanlar et al. 2018). In this regard, vulnerable populations are defined as those social groups that suffer from transport disadvantages as a result of their personal characteristics (Maffii and Bosetti 2020). Lucas (2019) refers to TRSE as the form of social exclusion resulting from scarce access to transport services and limited mobility, preventing individuals from reaching necessary destinations and participating in the social life of their community. In this paper, shared transport is not considered a goal in itself, but a means to enable individuals to fulfil their needs more sustainably while reducing transport disadvantages and TRSE. Thus, the study of digital shared transport from a user-centric perspective is considered relevant to enable a transition towards more sustainable and inclusive transport systems.

In current literature, a well-defined framework for the study of DSMS that considers related transport disadvantages and potential forms of exclusion is missing. This results in the lack of a comprehensive understanding of the inclusivity of DSMS. Therefore, this paper aims to fulfil this knowledge gap by proposing a new framework to apprise such services. The following section reviews the literature on transport disadvantages and identifies what population groups are more vulnerable to facing disadvantages when using DSMS. The second section identifies an approach that incorporates the factors that produce such disadvantages and considers the needs of vulnerable groups. Consequently, the Capabilities Approach (Nussbaum and Sen 1993; Sen 1979, 2005, 2009) is adapted to the study of DSMS resulting in a specific framework. To conclude, the last section summarizes the different arguments contained in this paper, proposing further and future advancements.

2 Existing Perspectives on Transport Disadvantages

This paper aims at developing a theoretical framework to allow a comprehensive understanding of the barriers and difficulties that citizens may encounter when using DSMS.

This inquiry starts with a review of existing perspectives on transport disadvantages to compare existing approaches and inform the development of the theoretical framework.

In recent years, transport disadvantages have increasingly been studied from different perspectives, (Jeekel 2018; Pereira et al. 2017). Currie et al. (2010), for instance, define transport disadvantages as the difficulty to reach necessary destinations. Vecchio and Martens (2021), on the other hand, focus on the difficulties to gain accessibility, which they understand as the potential mobility to reach spatially distributed opportunities. Other authors have broadened the understanding of this concept by including the lack of influence on transport-related policies (Hodgson and Turner 2003), or the exposure to negative external impacts, such as pollution or accidents (Feitelson 2002; Schwanen et al. 2015).

Transport disadvantages are a multidimensional construct, as they are the result of the complex interactions between transport systems, land use patterns and individual circumstances (Delbosc and Currie 2011; Jeekel 2018; Páez et al. 2012). This research field can therefore be considered inherently interdisciplinary, resulting in diverging definitions depending on the set of contributing factors considered by the authors. The terminology used in the literature on transport disadvantages includes concepts such as transport poverty, transport justice and transport equity. Thus, the terms transport and mobility services are used in this paper to refer to those services that allow citizens to be mobile, being transported by someone else, as in the case of public transport, or by themselves, as in the case of shared bicycles.

Although such broad terminology might cause conceptual inconsistency (Dodson et al. 2004), in all cases it refers to the distribution of benefits and burdens derived from transportation systems, incorporating central concepts in the transport disadvantages debate, such as equity and justice. The idea of equity is especially relevant for scholars studying the distribution of transport services and related resources (Benenson et al. 2011; Meijers et al. 2012). Likewise, authors that use the term transport justice, also consider equity as the most important criterion. In this case, the concept is used to refer to equal accessibility levels (Martens et al. 2014). Martens et al. (2019, p. 13) define equity as 'the morally proper distribution of benefits and burdens over members of society', while Anderson et al. (2017, p. 65) suggest the following definition: 'ensuring that residents can reach destinations across the city in a time and cost-effective manner, irrespective of their geographic location or socioeconomic status.

The distribution of benefits and burdens derived from transport systems is studied in existing literature from several perspectives. Martens et al. (2014) differentiate three normative approaches which can be found in other scholarly work (Lewis et al. 2021; Pereira and Karner 2021): the egalitarian, sufficientarian and prioritarian approaches. Egalitarianism focuses on the distribution among geographical areas or social groups (Benenson et al. 2011; te Boveldt et al. 2020; Meijers et al. 2012). This approach advocates that everyone should benefit from the same level of services and accessibility and investigates why certain groups or regions have a higher level of accessibility or enjoy better services (Pereira et al. 2017). Sufficientarianism focuses on basic needs, referring to a minimum level of transport services, goods and accessibility that should be available to everybody (Delbosc and Currie 2011). Herein, absolute levels are more important than relative inequalities, all the while highlighting the need for a minimum

level of accessibility (Pereira and Karner 2021). It also introduces the idea of transport poverty, referring to the situation of individuals and groups who do not benefit from the minimum acceptable level of transport services (Martens et al. 2014; Pereira et al. 2017). Finally, prioritarianism focuses on the benefits concerning accessibility, advocating increasing benefits for those who suffer more from transport disadvantages (Casal 2007). This perspective combines elements from the two previous approaches, aiming to overcome transport poverty by reducing inequality without necessarily targeting equality (Martens et al. 2014).

3 Factors that Prevent Vulnerable Groups from Using DSMS

Transport disadvantages are experienced unevenly by individuals depending on their characteristics. Populations that encounter a greater number of disadvantages to using a transport service, and as a consequence suffer from low levels of accessibility, are more vulnerable to social exclusion (Jeekel 2018; Lucas 2012; Lucas et al. 2016). Considering how transport disadvantages are experienced depending on the characteristics of an individual is a central step to improving the level of transport services and accessibility of these groups. To allow individuals to better reach necessary destinations and gain mobility, the disadvantages encountered by each individual when using DSMS must be thoroughly considered. In this section, previous research about forms of disadvantages and factors that lead to exclusion are reviewed as a means to identify the vulnerable groups that encounter difficulties to use DSMS.

Although it is widely accepted that improving accessibility is needed to enhance the freedom of choice and equality of opportunities, new perspectives imply that focusing solely on accessibility may lead to overlooking the needs of vulnerable populations (Kuttler and Moraglio 2020). Scholars such as Sheller (2018), argue that increasing accessibility will not improve the mobility of vulnerable groups if the social processes that produce transport disadvantages are ignored. Furthermore, focusing on resources can be misleading, as the needs and abilities of people are heterogeneous, and resources will not be used equally. The provision of resources and accessibility alone cannot ensure improved mobility of vulnerable individuals (Martens et al. 2019; Pereira et al. 2017). In this respect, the transport disadvantages debate should explicitly consider any form of discrimination and marginalisation while acknowledging the needs and abilities of citizens who are vulnerable to exclusion (Kuttler and Moraglio 2020).

The transport disadvantages debate is increasingly interested in the process of digitalisation (Durand et al. 2021) because it is transforming current systems and enabling the emergence of new services (Macharis and Geurs 2019). Cities have been addressing the challenges and opportunities associated with digital transport services, such as shared transport. As Anderson et al. (2017) argue, shared mobility offers the opportunity to improve the mobility of vulnerable populations. However, to ensure that vulnerable populations benefit and use such solutions, their requirements, abilities, and motivations to travel must be thoroughly understood (Kuttler and Moraglio 2020). Moreover, new transport solutions should be tailored to the needs of users (Bierau-Delpont et al. 2019). Therefore, it is necessary to assess to what extent different social groups benefit from such services and if they are protected from the burdens that services may cause

(Martens et al. 2019). This assessment requires the identification of the groups that are more vulnerable to transport disadvantages and potential forms of exclusion.

Although it should be kept in mind that individuals may belong to several groups that are vulnerable to exclusion and therefore suffer from several forms of disadvantages (Jeekel 2018), the existing literature offers useful approaches to systematically distinguish such groups. Aspects such as age, gender, ethnicity, income, education levels and residential location have an impact on the disadvantages experienced by citizens when using digital transport services (Durand et al. 2021; Venkatesh et al 2012). Church et al. (2000) denoted seven elements of the transport system that contribute to the exclusion of certain populations: physical exclusion, which refers to physical barriers; geographical exclusion, concerning the residential location of users and the availability of services in that area; exclusion from facilities, highlighting the distance to key facilities; economic exclusion, concerning monetary cost; time-based exclusion, which refers to constraints related to working hours and schedules; fear-based exclusion, concerning fears for personal safety; and space exclusion, highlighting security or management of the space, which prevents access of certain groups. Currie and Delbosc (2016) listed six main forms of deprivation that might result in forms of disadvantages concerning shared transportation. These include the lack of information, money, support, security, adapted design, appropriate operating practices and self-confidence. Furthermore, Goodman-Deane et al. (2022) identified seven groups that are defined by some of the characteristics previously mentioned. However, they do not refer to ethnicity and highlight two additional characteristics that define vulnerable groups: having a migration background and a disability.

Age-related disadvantages are identified as being especially problematic for DSMS. This is because older citizens face several barriers when using digital solutions (Harvey et al. 2019; Pangbourne et al. 2020). Firstly, they are often more reluctant to try and adopt new technologies that they are less familiar with. Secondly, a relevant portion of this group cannot drive a car or no longer benefits from the same level of physical ableness as younger adults. This hampers the use of certain services or requires the adaptation of DSMS.

The aspect of gender proves to be relevant when identifying vulnerable groups. Several studies show how women benefit less from shared transport services and face more disadvantages than men, especially in developing countries (Durand et al. 2021; Zhang et al. 2020; Wiegmann et al., 2020). Similarly, ethnicity correlates with greater deprivation of transport services (Golub et al. 2019) which as van Egmond et al. (2020) argue is mostly related to income, discrimination and cultural preferences. Moreover, women, sexual minorities and certain ethnic minorities are, for instance, more likely to face additional forms of disadvantages as they might potentially suffer from harassment while travelling (Martens et al. 2019).

Income plays another important role because material deprivation is generally associated with low levels of engagement with digital technologies (Longley and Singleton 2009). Moreover, it has been identified that people with lower incomes, who often do not have a bank account and do not own a credit card, are less likely to own digital devices, have access to a reliable internet connection or be able to do online payments (Sherriff et al 2020). Likewise, the level of education is related to income, producing

similar disadvantages in addition to the potential difficulties related to understanding information necessary to the use of DSMS. For instance, Wiegmann et al., 2020 found that the average car-sharing user in Brussels is highly educated.

The residential location might play a crucial role in the use of DSMS and the related benefits for citizens. The type of region and built environment will considerably limit the offer of such services. For instance, peri-urban or rural regions tend to host fewer transport options and, similarly, ICT infrastructure is less reliable and present in rural regions (Malik and Wahaj 2019). Moreover, residential location correlates with some burdens citizens face, such as air and noise pollution, or accidents (Martens et al. 2019).

As highlighted by Goodman-Deane et al. (2022), having a migration background might result in barriers related to language and cultural differences, and the transportation needs of people with a migrant background may also vary. The last characteristic that may result in a form of disadvantage and vulnerability is related to disabilities. Di Ciommo and Shiftan (2017) state that people with disabilities frequently experience difficulties and require assistance and additional information. Moreover, depending on the disability, physical access to the service and digital interfaces can be highly problematic (Reis and Freitas 2020).

4 A Framework to Thoroughly Understand Transport Disadvantages in DSMS

As explained in the previous section, increasing accessibility is not enough to overcome transport disadvantages, regardless of whether these efforts are aimed at obtaining equity or a minimum level for everyone. This is because transport disadvantages are related to complex social processes depending on factors not considered by egalitarian, sufficientarian or prioritarian approaches. Moreover, all three approaches might be oversimplifying, since the abilities and needs of people are heterogeneous and not everyone uses available resources in the same manner (Martens et al. 2019; Pereira et al. 2017). These approaches tend to be problematic in that they require assumptions about an acceptable level of inequality or a minimum level of accessibility (Kuttler and Moraglio 2020). Therefore, the study of shared transport from the perspective of transport disadvantages and social exclusion requires the use of a more comprehensive approach. A fourth normative approach, the Capabilities Approach (CA) (Nussbaum and Sen 1993; Sen 1979, 2005, 2009) could help to overcome the blind spots of the egalitarian, sufficientarian or prioritarian approaches.

The CA shifts the focus from ‘resources’ to ‘capabilities’, arguing that all individuals should enjoy a level of ‘capabilities’ which allow them to fulfil their needs and develop their lives (Luz and Portugal 2021; Pereira et al. 2017). For Nussbaum and Sen (1993), the focus on the distribution of resources overlooks the diversity of preferences and needs of individuals. Resources are not ends in themselves, but rather means to achieve aims. Therefore, the CA builds on the assumption that the most important dimension of life is the freedom of individuals to choose how to lead their life (Ryan et al. 2015).

The freedom of choice and agency considered by the CA are understood through five main concepts: resources, conversion factors, capabilities, choices and functionings

(Vechio and Martens 2021). Sen (1992, 2009) defines 'resources' as tangible and intangible goods and commodities available to a person, while 'conversion factors' are the social, cultural, environmental and personal context that frame and limit the possibilities of an individual. 'Capabilities' are sets of opportunities and freedoms available for people to choose and act, which are related to their resources and conversion factors. Sen (1992) defines 'choice' as the decision of a person in favour of a particular thing over another, and 'functionings' are what an individual actually achieves when putting their choices into practice and exercising their capabilities (Vechio and Martens 2021).

The concepts of 'conversion factor' and 'choice' help to understand that the capacity of each individual to use a resource for a specific objective will highly vary. The CA investigates the process of converting a 'resource' into a 'functioning'. It considers 'capabilities' a prerequisite to reaching opportunities and enjoying freedoms, which enable individuals to achieve their aims (Sen 2009). Furthermore, the CA assumes an adequate or minimum level of 'capabilities' exists that all individuals must enjoy. However, this assumption is challenged by the difficulty to establish such a minimum level and the fact that 'capabilities' are related to personal attributes such as gender, ethnicity, level of income, age and education (Kuttler and Moraglio 2020).

In the main theorisations of the CA, mobility is simply described as the ability to move from one place to another (Nussbaum 2000), without any explicit mention of transportation. The approach does not incorporate a thorough understanding of mobility, such as the one found in mobility studies (Urry 2007). However, the CA has been increasingly used in transport studies in recent years, having been incorporated by several researchers from different perspectives (Beyazit 2011; Flamm and Kaufmann 2006; Martens 2016; Pereira et al. 2017; Ryan et al. 2019). For instance, Banister (2018) argues that the CA is a relevant approach to studying transport inequality as it does not focus on maximising the potential mobility of people but rather on satisfying the choices and objectives of individuals. Likewise, many scholars state that the CA is the most adequate fairness approach to understanding the complexity of transport networks (Martens 2016; Pereira et al. 2017; Vecchio and Martens 2021). It takes into account various important elements: the diverse needs and motivations of individuals, how people interact with the transport system, and the resources at their disposal to reach opportunities depending on their characteristics and choices (Luz and Portugal 2021; Vecchio and Martens 2021). Furthermore, the adoption of the CA in transport studies offers the opportunity to move beyond traditional socio-technical perspectives and bring into the debate the cultural dimension of transportation.

An example of how the CA has been applied in transport studies is the work of Smith et al. (2012), who studied the transport disadvantages encountered by rural households compared to urban inhabitants. Likewise, Cao and Hickman (2019) used the CA to study the different uses that Beijing inhabitants make of metro line 1 depending on their socioeconomic characteristics and geographical location. Concerning shared transport, Sherriff et al. (2020) applied the CA to study the use of dockless shared bikes in Manchester and identified how personal and social conversion factors play a role in the use of such services. Hence, a range of diverging perspectives has emerged on how to apply the approach in practice, with two main strands of literature that diverge in what the concept of capability refers to.

The first strand of literature conceptualises the 'capabilities' as the ability of individuals to be mobile (Beyazit 2011; Flamm and Kaufmann 2006). From this perspective, a 'functioning' is the exercise of mobility, which is influenced by the context of individuals and limited by the skills and knowledge they possess. Kaufmann (2002) incorporates this perspective through the concept of 'motility', defined as the way in which individuals appropriate the range of possible actions concerning their mobility. The second strand focuses on the study of accessibility as a capability, envisioning capabilities as the possibility of an individual to engage in a variety of activities outside their home (Martens 2016). This conceptualisation comprises the idea of mobility as the ability to move through space. Herein, mobility is considered as a means to achieve an objective and not as an end in itself. From this perspective, a functioning is the exercised participation of a person in such activities, focusing on the person's ability to convert resources into participation in activities (Ryan et al. 2015; Vecchio and Martens 2021).

This second approach seems more adequate to convey the main theorisations of the CA, which revolves around the freedom of each person to develop their life. Moreover, since the concern of research on transport disadvantages and related social exclusion is not only to ensure people's mobility but rather that they participate in society and reach opportunities, this second perspective lends itself better to transport research from the point of view of social inclusion (Luz and Portugal 2021; Pereira et al. 2017).

If the aim is to enhance accessibility as a means to guarantee individual freedom, the focus should be to guarantee each individual an adequate level of access to essential activities that are necessary to meet basic needs and enjoy opportunities. Nevertheless, this does not entail that everybody benefits exactly from the same level of transport resources. Hence, traditional approaches that only focus on providing more resources to increase overall levels of accessibility might overlook the ability of individuals to convert resources into capabilities (Ryan et al. 2015). In this regard, the definition of accessibility, which in transport research is generally labelled as the physical access to goods, services and destinations, is repurposed by the CA. For instance, Pereira et al. (2017) consider accessibility as an individual attribute resulting from the interaction of personal characteristics, such as age, gender, socioeconomic conditions and ableness, with the person's environment, and sociocultural context. The literature that adopts this perspective is interested in how different social groups can participate in activities, studying the levels of accessibility of vulnerable groups, such as the elderly (Ryan et al. 2019), children (Borgato et al. 2020), ethnic minorities (van Egmond et al. 2020), low-income groups (Borgato et al. 2020; Cao and Hickman 2019), and people with impairments (Reis and Freitas 2020).

5 Adapting the Capabilities Approach to Appraise DSMS

As a result of the advent of digital transport services, studies on accessibility have increasingly incorporated the digital divide. Digital exclusion occurs when a person cannot appropriately use app-based transport solutions due to the lack of digital connection, the availability of a necessary device or the lack of digital skills (Groth 2019). Digital exclusion has become central to understanding the unequal use of digital transport services, such as DSMS, raising the concern about how digitally illiterate individuals

could benefit from these solutions. As previously explained, vulnerable populations which already suffered transport disadvantages, often also face digital-divide exclusion, resulting in additional difficulties for vulnerable users and creating new forms of deprivation (Durand et al. 2021). Thus, Luz and Portugal (2021) incorporate the digital-divide exclusion into their definition of the CA.

As a continuation of the research mentioned in previous paragraphs, such as the work of Kaufmann (2002) and Luz and Portugal (2021), this paper proposes a framework to appraise DSMS through the lens of the CA. With this contribution, we aim at enabling a comprehensive understanding of the inclusivity of DSMS, a knowledge gap identified in the literature. The novelty of this framework is that it operationalizes the theoretical grounds of the CA to better understand the inclusivity of DSMS, and the use that vulnerable groups can make of such services. This framework implies that a person's use of DSMS relies on three main factors (see figure): 'material access', 'skills' and 'cognitive appropriation'. As shown in the figure, DSMS can be conveniently used when the three factors are met. Thus, when only two factors are met, the use of the services might be difficult or impossible. For instance, when an individual is lacking the necessary skills to use a service, the service cannot be instrumentalised, and when someone cannot cognitively appropriate the service, it will be unattractive to this person. Likewise, when there is no material access to a service, the service remains unavailable for users. Moreover, DSMS should consider these three factors to the extent to which such services will be useful for a person to freely fulfil an aim and reach a necessary destination (Fig. 1).

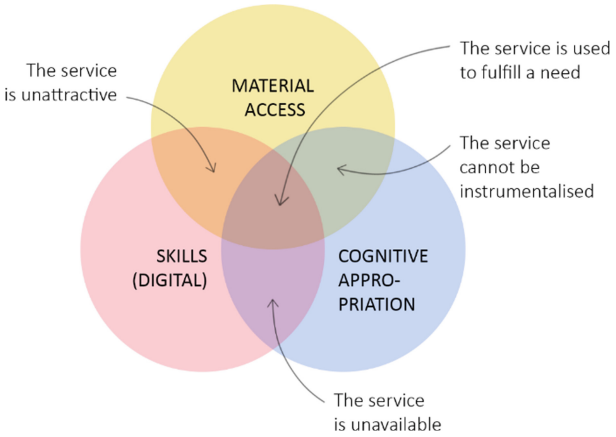

Fig. 1. Applying the CA to the study of DSMS.

The first factor, 'material access', refers to the 'resources' necessary to use DSMS, such as an available vehicle nearby, and the cost of use. Material access also refers to having a reliable internet connection and an adequate digital device, such as a smartphone or a tablet. In recent years, the smartphone has taken an increasingly central role in transport services (Gebresselassie and Sanchez 2018) with transport operators using a wide variety of applications that are often free. However, devices are not free of charge, and although there is available free wifi in some urban locations, having a reliable

and permanent internet connection comes at a cost (Golub et al. 2019). Moreover, it is necessary to have an up-to-date operating system installed in the device, and enough battery or access to a charging point (Groth 2019).

The second factor, 'skills', refers to the 'conversion factors' that enable the instrumentalisation of a resource to fulfil an objective. This is because material access to technology does not ensure that someone benefits from a DSMS. Thus, 'skills', refer to the knowledge and the abilities necessary to use a DSMS, including the use of devices and applications. Vecchio and Tricarico (2018), argue that the skills necessary to use digital transport services are permanently evolving, and they can be differentiated into two types of skills: medium-related skills, which are related to operating a digital device, and content-related skills, which refer to information and strategic skills. The latter allows an individual to make strategic choices and select the most convenient information, route, services and use of their personal data (Durand et al. 2021).

The third factor, 'cognitive appropriation', refers to 'choices', which are informed by opinions, values, attitudes and motivations. Groth (2019) states that this factor is a crucial 'mental precondition' for individuals to engage with DSMS and identifies five dimensions that enable it: the autonomy experienced by users; the flexibility of the service; the excitement that the use of such service produces; the impact on social status perception; and privacy-related concerns. In this regard, Durand et al. (2021) define two main reasons that hamper the cognitive appropriation of an individual. The first one is related to a lack of trust in the technology, and a fear of security, reliability, and privacy, also highlighted by Harvey et al. (2019) and Groth (2019). The second one is due to the lack of desire or interest in the technology, either because the person does not know it or because the person does not want to use it, as stated by Zhang et al. (2020).

6 Discussion and Conclusions

Shared transport services are increasingly popular in cities around the world, allowing citizens to have short-term access to a vehicle, such as a shared car, bicycle or scooter, and potentially improving the mobility of vulnerable populations. Shared mobility providers mostly rely on digital technologies to operate their services, expecting users to learn and use their proposed app-based solutions. Thus, the lack of digital skills or internet connection and not having an adequate digital device, together with other factors related to digitalisation, may hamper the adoption of DSMS by a broader segment of the population. Not considering the needs and requirements of all social groups, may lead to transport disadvantages and deprivation, especially in the case of vulnerable populations. Nonetheless, the broader adoption of DSMS is not considered an objective per se, but a means to enable individuals to fulfil their needs more sustainably.

This work has identified existing approaches to the study of transport disadvantages to select an approach that can foster a better understanding of the needs and requirements of vulnerable populations concerning DSMS. Transport disadvantages are a complex social construct, and their study must consider the diverse characteristics of individuals. Therefore, aspects like gender, age, ethnicity, income, physical or cognitive impairments, education level and residential location must be taken into account by practitioners and researchers.

We consider the Capabilities Approach adequate because it goes beyond other approaches, not only looking at the availability of resources but also the capabilities of individuals. The CA argues that all individuals should benefit from a level of capabilities that allow them to freely fulfil their needs and develop their life, considering the needs of different social groups while acknowledging individual characteristics. This approach also diverges from the traditional perspective adopted to appraise transport services by going beyond socio-technical considerations and acknowledging cultural factors. Moreover, since the experience of individuals concerning DSMS is dependent on digital literacy, it is relevant that the CA incorporates the process of digitalisation.

Among other uses, this framework may be relevant to appraise the inclusivity of DSMS and facilities, evaluate uses among social groups, improve existing services, and orient policy-making. Likewise, this framework could also be used to appraise other transport services that comprise a digital dimension. By using predefined indicators, the three factors previously explained could be analysed. In order to facilitate the adoption of the framework by practitioners and policy-makers, a set of more concrete indicators related to study cases should be developed. Moreover, the framework needs to be integrated into existing working processes and should not require significant additional resources. From a research perspective, it is recommended to adopt qualitative methods, such as interviewing and focus groups, because the framework entails elements that concern complex socio-cultural phenomena.

Future studies could aim at identifying a standard set of indicators to operationalize this framework. For instance, analysing material access will require different data than studying skills or cognitive appropriation. The latter might be more difficult to grasp due to its intangibility and the fact that it is culturally embedded. Likewise, the lack of available data can be an obstacle to fully deploying the framework which considers personal characteristics and circumstances. Moreover, future research could seek to overcome the two main challenges of this framework. Firstly, the difficulty to fully incorporate the needs of vulnerable populations because such needs are the result of complex and multidimensional social processes. And secondly, to identify a possible minimum level of capabilities that should be facilitated to all individuals, by reducing the obstacles that impede their acquisition, and propose an adequate form of measurement.

References

Anderson, K., Blanchard, S.D., Cheah, D., Levitt, D.: Incorporating equity and resiliency in municipal transportation planning: case study of mobility hubs in Oakland, California. Transp. Res. Rec. **2653**(1), 65–74 (2017). https://doi.org/10.3141/2653-08

Banister, D.: Inequality in Transport. Alexandrine Press, Abingdon (2018)

Benenson, I., Martens, K., Rofé, Y., Kwartler, A.: Public transport versus private car GIS-based estimation of accessibility applied to the Tel Aviv metropolitan area. Ann. Reg. Sci. **47**(3), 499–515 (2011). https://doi.org/10.1007/s00168-010-0392-6

Beyazit, E.: Evaluating social justice in transport: Lessons to be learned from the capability approach. Transp. Rev. **31**(1), 117–134 (2011). https://doi.org/10.1080/01441647.2010.504900

Borgato, S., Maffii, S., Bosetti, S.: People on low income and unemployed persons. In: Re-thinking Mobility Poverty, pp. 124–134. Routledge (2020)

te Boveldt, G., Keseru, I., Macharis, C.: Between fairness, welfare and feasibility: an approach for applying different distributive principles in transport evaluation. Eur. Transp. Res. Rev. **12**(1), 1–13 (2020). https://doi.org/10.1186/s12544-020-00428-4

Bierau-Delpont, F., Müller, B., Napoletano, L., Chalkia, E., Meyer, G.: Building an action plan for the holistic transformation of the European transport system. In: Müller, B., Meyer, G. (eds.) Towards User-Centric Transport in Europe. LNM, pp. 3–14. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-99756-8_1

Cao, M., Hickman, R.: Understanding travel and differential capabilities and functionings in Beijing. Transp. Policy **83**, 46–56 (2019)

Casal, P.: Why sufficiency is not enough. Ethics **117**(2), 296–326 (2007). https://doi.org/10.1086/510692

Church, A., Frost, M., Sullivan, K.: Transport and social exclusion in London. Transp. Policy **7**(3), 195–205 (2000)

Cohen, B., Kietzmann, J.: Ride on! Mobility business models for the sharing economy. Organ. Environ. **27**(3), 279–296 (2014)

Currie, G., et al.: Investigating links between transport disadvantage, social exclusion and well-being in Melbourne – updated results. Res. Transp. Econ. **29**(1), 287–295 (2010). https://doi.org/10.1016/j.retrec.2010.07.036

Currie, G., Delbosc, A.: Transport disadvantage: a review. In: New Perspectives and Methods in Transport and Social Exclusion Research. Emerald insight (2016)

Davidsson, P., Hajinasab, B., Holmgren, J., Jevinger, A., Persson, J.A.: The fourth wave of digitalization and public transport: opportunities and challenges. Sustainability **8**, 1248 (2016). https://doi.org/10.3390/su8121248

Delbosc, A., Currie, G.: The spatial context of transport disadvantage, social exclusion and well-being. J. Transp. Geogr. **19**(6), 1130–1137 (2011)

Di Ciommo, F., Shiftan, Y.: Transport equity analysis. Transp. Rev. **37**(2), 139–151 (2017)

Dodson, J., Gleeson, B., Sipe, N.: Transport Disadvantage and Social Status: A Review of Literature and Methods. Griffith University, Australia, Urban Policy Program (2004)

Durand, A., Zijlstra, T., van Oort, N., Hoogendoorn-Lanser, S., Hoogendoorn, S.: Access denied? digital inequality in transport services. Transp. Rev. **42**(1), 32–57 (2021)

Feitelson, E.: Introducing environmental equity dimensions into the sustainable transport discourse: issues and pitfalls. Transp. Res. Part D: Transp. Environ. **7**(2), 99–118 (2002). https://doi.org/10.1016/S1361-9209(01)00013-X

Flamm, M., Kaufmann, V.: Operationalising the concept of motility: a qualitative study. Mobilities **1**(2), 167–189 (2006). https://doi.org/10.1080/17450100600726563

Gebresselassie, M., Sanchez, T.W.: "Smart" tools for socially sustainable transport: a review of mobility apps. Urban Sci. **2**(2), 45 (2018)

Gray, J., Rumpe, B.: Models for digitalization. Softw. Syst. Model. **14**(4), 1319–1320 (2015). https://doi.org/10.1007/s10270-015-0494-9

Golub, A., Satterfield, V., Serritella, M., Singh, J., Phillips, S.: Assessing the barriers to equity in smart mobility systems: a case study of Portland. Or. Case Stud. Transp. Policy **7**(4), 689–697 (2019). https://doi.org/10.1016/j.cstp.2019.10.002

Goodman-Deane, J., et al.: Toward inclusive digital mobility services: a population perspective. Interact. Comput. **33**(4), 426–441 (2021)

Groth, S.: Multimodal divide: reproduction of transport poverty in smart mobility trends. Transp. Res. Part A: Policy Pract. **125**, 56–71 (2019)

Harvey, J., Guo, W., Edwards, S.: Increasing mobility for older travellers through engagement with technology. Transp. Res. F: Traffic Psychol. Behav. **60**, 172–184 (2019)

Hodgson, F.C., Turner, J.: Participation not consumption: the need for new participatory practices to address transport and social exclusion. Transp. Policy **10**(4), 265–272 (2003). https://doi.org/10.1016/j.tranpol.2003.08.001

Jeekel, H.: Inclusive Transport: Fighting Involuntary Transport Disadvantages. Elsevier, Amsterdam (2018)
Jittrapirom, P., Caiati, V., Feneri, A.M., Ebrahimigharehbaghi, S., Alonso González, M.J., Narayan, J.: Mobility as a service: a critical review of definitions, assessments of schemes, and key challenges (2017)
Kaufmann, V.: Re-thinking Mobility: Contemporary Sociology, 1st edn. Ashgate, Aldershot (2002)
Kuttler, T., Moraglio, M.: Unequal mobilities, network capital and mobility justice. In: Re-thinking Mobility Poverty, pp. 39–48. Routledge (2020)
Lewis, E.O.C., MacKenzie, D., Kaminsky, J.: Exploring equity: How equity norms have been applied implicitly and explicitly in transportation research and practice. Transp. Res. Interdisc. Perspect. **9**, 100332 (2021)
Longley, P.A., Singleton, A.D.: Linking social deprivation and digital exclusion in England. Urban Stud. **46**(7), 1275–1298 (2009)
Lucas, K.: Transport and social exclusion: where are we now? Transp. Policy **20**, 105–113 (2012). https://doi.org/10.1016/j.tranpol.2012.01.013
Lucas, K.: A new evolution for transport-related social exclusion research? J. Transp. Geogr. **81**, 102529 (2019)
Lucas, K., Mattioli, G., Verlinghieri, E., Guzman, A.: Transport poverty and its adverse social consequences. In: Proceedings of the Institution of Civil Engineers-Transport, vol. 169, no. 6, pp. 353–365. Thomas Telford Ltd (2016).
Luz, G., Portugal, L.: Understanding transport-related social exclusion through the lens of capabilities approach. Transp. Rev. 1–23 (2021)
Machado, C.A.S., de Salles Hue, N.P.M., Berssaneti, F.T., Quintanilha, J.A.: An overview of shared mobility. Sustainability **10**(12), 4342 (2018)
Macharis, C., Geurs, K.: The future of European communication and transportation research: a research agenda. Region **6**(3), D1–D21 (2019)
Maffii, S., Bosetti, S.: Preface. Re-thinking Mobility Poverty: Understanding Users' Geographies, Backgrounds and Aptitudes (2020)
Malik, F., Wahaj, Z.: Sharing economy digital platforms and social inclusion/exclusion: a research study of uber and careem in Pakistan. In: Information and Communication Technologies for Development 2019: Strengthening Southern-Driven Cooperation as a Catalyst for ICT4D, pp. 248- 259 (2019). https://doi.org/10.1007/978-3-030-18400-1_20
Martens, K.: Transport justice. In: Transport Justice: Designing Fair Transportation Systems. Routledge (2016). https://doi.org/10.4324/9781315746852
Martens, K., Di Ciommo, F., Papanikolaou, A.: Incorporating equity into transport planning: Utility, priority and sufficiency approaches (2014)
Martens, K., Bastiaanssen, J., Lucas, K.: Measuring transport equity: key components, framings and metrics. In: Measuring Transport Equity, pp. 13–36. Elsevier (2019)
Meijers, E., Hoekstra, J., Leijten, M., Louw, E., Spaans, M.: Connecting the periphery: distributive effects of new infrastructure. J. Transp. Geogr. **22**, 187–198 (2012). https://doi.org/10.1016/j.jtrangeo.2012.01.005
Nussbaum, M.C., Sen, A.K.: The Quality of Life. Clarendon, Oxford (1993)
Nussbaum, M.C.: Women and Human Development: The Capabilities Approach. Cambridge University Press, Cambridge (2000)
Páez, A., Scott, D.M., Morency, C.: Measuring accessibility: positive and normative implementations of various accessibility indicators. J. Transp. Geogr. **25**, 141–153 (2012). https://doi.org/10.1016/j.jtrangeo.2012.03.016
Pangbourne, K., Mladenović, M.N., Stead, D., Milakis, D.: Questioning mobility as a service: Unanticipated implications for society and governance. Transp. Res. Part A: Policy Pract. (2020). https://doi.org/10.1016/j.tra.2019.09.033

Pereira, R.H., Schwanen, T., Banister, D.: Distributive justice and equity in transportation. Transp. Rev. **37**(2), 170–191 (2017)
Pereira, R.H., Karner, A.: Transportation equity. Int. Encycl. Transp. **1**, 271–277 (2021)
Reis, V., Freitas, A.: The predicaments of European disabled people. In: Re-thinking Mobility Poverty, pp. 147–161. Routledge (2020)
Ryan, J., Wretstrand, A., Schmidt, S.M.: Exploring public transport as an element of older persons' mobility: a capability approach perspective. J. Transp. Geogr. **48**, 105–114 (2015). https://doi.org/10.1016/j.jtrangeo.2015.08.016
Ryan, J., Wretstrand, A., Schmidt, S.M.: Disparities in mobility among older people: findings from a capability-based travel survey. Transp. Policy **79**, 177–192 (2019)
Santos, G.: Sustainability and shared mobility models. Sustainability **10**(9), 3194 (2018)
Sen, A.: Equality of what? Tanner Lect. Hum. Values **1**, 353–369 (1979)
Sen, A.K.: Inequality Reexamined. Clarendon, Oxford (1992)
Sen, A.: Human rights and capabilities. J. Hum. Dev. **6**(2), 151–166 (2005). https://doi.org/10.1080/14649880500120491
Sen, A.: The Idea of Justice. Belknap Press of Harvard Univ. Press, Cambridge, MA (2009)
Smith, N., Hirsch, D., Davis, A.: Accessibility and capability: the minimum transport needs and costs of rural households. J. Transp. Geogr. **21**, 93–101 (2012). https://doi.org/10.1016/j.jtrangeo.2012.01.004
Shaheen, S., Cohen, A., Zohdy, I.: Shared mobility: current practices and guiding principles (No. FHWA-HOP-16–022). United States. Federal Highway Administration (2016)
Shaheen, S., Cohen, A.: Overview of shared mobility. ITS Berkeley Policy Briefs, **2018**(01) (2018)
Sheller, M.: Theorising mobility justice. Tempo Soc. **30**, 17–34 (2018)
Schwanen, T., Lucas, K., Akyelken, N., Cisternas Solsona, D., Carrasco, J.-A., Neutens, T.: Rethinking the links between social exclusion and transport disadvantage through the lens of social capital. Transp. Res. Part A: Policy Pract. **74**, 123–135 (2015). https://doi.org/10.1016/j.tra.2015.02.012
Sherriff, G., Adams, M., Blazejewski, L., Davies, N., Kamerāde, D.: From mobike to no bike in greater manchester: using the capabilities approach to explore Europe's first wave of dockless bike share. J. Transp. Geogr. **86**, 102744 (2020)
Shibayama, T., Emberger, G.: New mobility services: Taxonomy, innovation and the role of ICTs. Transp. Policy (2020). https://doi.org/10.1016/j.tranpol.2020.05.024
Snellen, D., de Hollander, G.: ICT's change transport and mobility: Mind the policy gap! Transp. Res. Procedia **26**, 3–12 (2017). https://doi.org/10.1016/j.trpro.2017.07.003
Urry, J.: Mobilities. Polity Press, Cambridge (2007)
van Egmond, P., Wirtz, J.: Mobility poverty in Luxembourg. In: Kuttler, T., Moraglio, M. (eds.) Rethinking Mobility Poverty: Understanding Users' Geographies, Backgrounds and Aptitudes, pp. 251–259. Routledge, London (2020). https://doi.org/10.4324/9780367333317-23
Vecchio, G., Martens, K.: Accessibility and the capabilities approach: a review of the literature and proposal for conceptual advancements. Transp. Rev. **41**, 833–854 (2021) https://doi.org/10.1080/01441647.2021.1931551
Vecchio, G., Tricarico, L.: "May the force move you": roles and actors of information sharing devices in urban mobility. Cities **88**, 261–268 (2018). https://doi.org/10.1016/j.cities.2018.11.007
Venkatesh, V., Thong, J., Xu, X.: Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. MIS Q. **36**(1), 157–178 (2012). https://doi.org/10.2307/41410412
Yigitcanlar, T., Mohamed, A., Kamruzzaman, M., Piracha, A.: Understanding transport-related social exclusion: a multidimensional approach. Urban Policy Res. **37**(1), 97–110 (2019)

Zhang, M., Zhao, P., Qiao, S.: Smartness-induced transport inequality: Privacy concern, lacking knowledge of smartphone use and unequal access to transport information. Transp. Policy **99**, 175–185 (2020)

Wiegmann, M., Keserü, I., Macharis, C.: Carsharing in the Brussels region. Brussels Studies. La revue scientifique pour les recherches sur Bruxelles/Het wetenschappelijk tijdschrift voor onderzoek over Brussel/The Journal of Research on Brussels **146** (2020)