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Public transport as travel alternative for users of Special Transport Services in the Netherlands

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ABSTRACT

Introduction: Special Transport Services (STS), a.k.a. paratransit, help keep people with an impairment mobile. Yet these services face financial and organisational challenges. Public transport (PT) is usually seen as a way to alleviate some of these burdens. In fact, the discussion around the potential for PT to substitute STS has been on the agenda of policymakers in the Netherlands for years.
Methods: In this paper, we relied on survey data and STS trip registrations to analyse the extent to which STS can be substituted with regular PT in the Netherlands. Using the Capability Approach as a conceptual framework, we link conversion factors to individuals' opportunity to use PT. We then provide a range of the substitution potential of STS with public transport.
Results: Virtually all STS users have difficulties that make travelling independently challenging. The first and last mile and getting in and out of vehicles are main obstacles for PT use. Many passengers rely on STS because of a lack of support from their network. Besides, long walking distances and travel times for PT trips compared with door-to-door STS trips can deter people from switching mode. Lastly, STS seem to be particularly important during bad weather conditions, emphasizing their role as safety nets rather than go-to options. In the current state of affairs, 0%–16% of STS trips in the Netherlands could be done by public transport instead. The upper limit of 16% is likely an overestimation as it does not account for many factors like health and weather.
Conclusions: Our results show that STS play an important role in people's mobility, especially at times when and for destinations where no other option exists. This study confirms that, despite efforts to make public transport more accessible, it is not a panacea for people with an impairment.

1. Introduction: The balancing act of Special Transport Services

Travelling independently can be challenging for people with impairments. Since age is a key predictor in the development of functional impairments (Hajek and König, 2016), older adults form a large share of people with impairments. In Europe, the population of older adults is growing: the share of those aged 80 years or above is projected to increase from 5.8% to 14.6% between 2019

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and 2100 (Eurostat, 2020). Furthermore, people are increasingly expected to be self-reliant (Keizer et al., 2019; Schwanen et al., 2012) and therefore to travel independently. Yet people with impairments drive and cycle much less than people without impairments, and they are more likely to have trouble using public transport (PT) (Bakker and van Hal, 2007; Bigby et al., 2019; Low et al., 2020; Luiu et al., 2017, 2018).

A strategy to facilitate independent travel among people with an impairment is the regulated provision by authorities of Special Transport Services (STS), also known as Dial-a-Ride or paratransit. STS are demand-responsive and eligibility-restricted services that provide door-to-door or first/last-mile solutions for people with impairments, and for whom driving, cycling and using public transport is either limited or impossible. In Europe, countries such as Sweden, Finland, Switzerland and the Netherlands have experience with STS; see respectively Wretstrand et al. (2009), Luoma-Halkola and Häikiö (2020), Marita et al. (2022) and Zijlstra and Bakker (2016).

Nevertheless, the economic sustainability of STS is being questioned. Demand-responsive transport schemes prove difficult to keep financially viable (Brake et al., 2007; Davison et al., 2014; Jokinen et al., 2017; Ryley et al., 2014). An ageing population raises concerns about the increasing number of people who will get access to STS, as more passengers means more subsidies (Jittrapirom et al., 2019). Hansson and Holmgren (2018) reported that the yearly costs per STS trip increased by 66% between 1999 and 2015 in Sweden. Much of the associated costs pertain to the drivers' salaries (Jokinen et al., 2017), but opportunities to achieve substantial productivity gains are limited. Therefore a shift from STS to other modes and the integration of STS to other modes have become policy goals, with cost reduction as a central motive (Hansson and Holmgren, 2017).

The Netherlands is no exception to such debates. In fact, much of the available literature about STS in the Netherlands was commissioned for policy purposes and eagerly anticipates public transport serving as an alternative to STS (Dijkstra, 2017; Forseti, 2015; Kwakernaak and van Os, 2016; MuConsult, 2007, 2013, 2016; Transumo, 2006). According to MuConsult (2016), 30–50% of STS users in the Netherlands would be able to switch from STS to PT. However, this range is based on a 2007 study using results from small-scale pilots from 2002. Besides, it assumes that all barriers that STS users experience to use public transport have been addressed (physical accessibility, feelings of safety, having access to travel assistance, etc.) (MuConsult, 2007). Dijkstra (2017) suggested another range; based on his review of 17 studies, 5%–60% of the trips made with STS could be substituted for PT. This large range is based on many customer surveys from municipalities or regions working with various assumptions.

In all of these ranges, the perspective of STS users only plays a limited role. Besides, these substitution ranges are fragmented and mostly outdated. Therefore, there is a need for a more up-to-date, nation-wide and user-centred research on the substitution of STS for public transport. This need is even more salient in the context of an ageing population. Furthermore, there is a need for a transparent method to come to such an estimate, so that other countries or regions might learn from this user-centred approach.

The goals of this study are twofold. First, we aim at shedding light on Special Transport Services' users by exploring who they are, how they move and the context in which they operate. Second, we aim at estimating the substitution potential of STS for public transport, that is to say, the share of current STS trips in the Netherlands that could potentially be made with public transport.

There are numerous, partly complimentary STS operating in the Netherlands (Zijlstra and Bakker, 2016). In this study, we focus on the most extensive form of STS in the Netherlands, namely Wmo collective transport. It was established under the Social Support Act 2015 (*Wet Maatschappelijke Ondersteuning* in Dutch), which provides a legislative framework entrusting municipalities to assist people who are not self-reliant. People with a so-called Wmo status are entitled to use public social assistance. Note that there is no national eligibility criterion for this status. Municipalities may decide how they attribute it. In some municipalities, all people above 75 are entitled to a Wmo status. In others, civil servants may individually assess who is eligible, based on people's ability to be self-reliant or not. Wmo collective transport is meant for local and regional socio-recreational trips. In the rest of this paper we refer to Wmo collective transport as STS.

This paper is organised as follows. In the next section we present our conceptual framework. Section 3 details our method, section 4 presents the results and we discuss these results in section 5. We finish with conclusions in section 6.

2. Conceptual framework

Our theoretical framework draws from the Capability Approach as developed by Sen (1992). In this approach, an individual's command over their resources is said to produce their capability set. The capabilities that they choose to achieve from this set are then referred to as functionings. In transport terms, functionings can be seen as the realised travel behaviour while capabilities can be seen as the opportunities to realise a certain travel behaviour (Ryan, 2019). By focusing on capabilities, attention is drawn to what enables or suppresses an individual's ability to perform an activity or action, instead of focusing solely on proxies such as resources and realised travel behaviour (Ryan et al., 2019).

Table 1
Categories of conversion factors, from Robeyns (2017).

Category of conversion factors	Description of category
Personal conversion factors	Physical, mental and cognitive conditions, gender, specific skills (e.g. ability to cycle, to read), intelligence.
Social conversion factors	Public policies, social norms (e.g. access to a car, a bike, to social support), practices that unfairly discriminate, societal hierarchies, or power relations related to class, gender, race or other.
Environmental conversion factors	Climate, pollution, geography, built environment, infrastructure, means of transportation and communication.

A useful notion and core idea of the Capability Approach is that of conversion factors. These factors determine the extent to which a person can transform a resource into a functioning (Robeyns, 2017; Vecchio and Martens, 2021). Operationalising the Capability Approach in research has been traditionally seen as challenging because of a lack of measurement and definition of capabilities (Comim, 2008). This is why the categorisation of conversion factors into three groups done by Robeyns (2005) and Crocker and Robeyns (2009), deemed an "influential codification" in the Capability Approach field (Hvinden and Halvorsen, 2018, p. 6), provides a useful departure point for researchers. These groups are (1) personal conversion factors, (2) social conversion factors, and (3) environmental conversion factors (Table 1).

Therefore, individuals' possibilities to convert resources into realised travel behaviour do not solely depend on individual characteristics (such as having a cognitive or a physical impairment). They also depend on the realities and structures they face, such as social norms, public policies and infrastructure. Note that our conceptual framework aligns well with the person-environment fit concept (Lawton and Nahemow, 1973). This ecological approach to the aging process also recognises the need for a balance between (changing) personal competences and resources on the one hand, and the environment in which the person lives on the other hand (Nordbakke and Schwanen, 2014).

Describing conversion factors is more useful than describing resources a person has access to. Conversion factors enable a deeper exploration of both the person *and* the circumstances in which he or she is living, *while* allowing for a greater diversity among people (Robeyns, 2017). Conversely, resources are not necessarily enabling every person in every circumstances (Verlinghieri and Schwanen, 2020, pp. 2–3). This is why conversion factors make sense when considering equity topics. In transport research, Sherriff et al. (2020) have recently used the notion of conversion factors to describe what enables or hinders people to use dockless bike-sharing in Manchester. With the lens of the Capability Approach, and more specifically conversion factors, we aim at getting a better understanding of what enables or hinders the use of public transport among STS users.

3. Method and data

We relied on two main types of data sources, which we analysed through descriptive analysis and two models as explained below.

3.1. Main data sources

The first type of data we used was a survey conducted in 2018. The questions focused on individuals' most recent trip with Wmo collective transport, their general travel behaviour and personal characteristics. The survey was completed online or via telephone. Our sample is drawn from participants from the research panel of the public opinion consultancy agency Kantar. The composition of their panel aligns with socio-demographic standards set by Statistics Netherlands. We screened potential respondents by asking a large pool from this panel whether they had used Wmo collective transport and Valys[1] at least once in the past three months. We also used snowballing: people were asked whether they knew someone in their inner circle of family and friends using Wmo transport or Valys. This resulted in inviting 2343 potential respondents to fill in the full survey. 900 people started the survey, but only 560 made it through the re-iterated control questions on the use of Wmo collective transport and Valys in the past three months. This difference could be due to a misunderstanding of the screening question, poor snowballing or to the elapsed time between the screening question and the actual invitation to fill in the full survey. We then deleted 36 cases due to inconsistent answers and non-differentiation in matrix questions. In the end, our net sample contains 524 respondents.

One fifth of the net sample had completed the interview by phone. The rest had done so online. Weights were calculated and applied, based on known gender and age distributions of the population using Wmo collective transport (Statistics Netherlands, 2017). This extra step allowed us to improve the representativeness of the sample.

The second type of data were trip registration datasets from transport companies providing Wmo collective transport from 2016 to 2018. These datasets included all the reservations made for Wmo collective transport in a given region. The origin, destination, desired departure time and required transport mode (passenger car, taxi van, wheelchair van, etc.) were known for each trip. We obtained data covering a few months or an entire year for various regions across the Netherlands (see Zijlstra et al. (2019) for an overview).

3.2. Method

Thanks to our diverse data sources, we were able to include a diversity of aspects to describe each conversion factor, as shown in Table 2. We used descriptive statistics for survey items and models for aspects relying on trip registration datasets. One caveat is that our data limit the range of aspects we can investigate for each factor. Note that the survey contained more information than the items reported in Table 2; we limit ourselves to reporting the most relevant ones with regards to a potential substitution of STS for PT in this paper. The models are shortly described below.

Alternative travel options model: We determined alternative travel options via public transport by coupling 5000 STS trip registrations from 5 different regions with Directions API from Google Maps. Postal codes for origin and destination, plus day of travel and departure time were derived from the trip registration data. The API can save up to four alternative travel options via public transport, from which we used three different choice criteria to come to a pertinent selection: (1) fastest option, (2) shortest walking distance

[1] Valys is the supra-regional counterpart of Wmo collective transport. A Wmo status is required to use Valys. All Valys users are usually users of Wmo collective transport. Valys, and its users, are not considered separately in this paper.

Table 2
Data sources that inform our discussion on each conversion factor.

Aspect covered and type of data source used	Type of conversion factor		
	Personal	Social	Environmental
Age, ability to travel independently outside of home, impairments (survey)	X		
Reasons for not using PT/barriers encountered in PT (survey)	X	X	X
Influence of weather on trips with Wmo collective transport (trip registrations and weather data)			X
Alternative travel options (trip registrations and Google Maps data)			X

option (to/from the transport stops/stations and between vehicles), and (3) minimum number of transfers option. Because the option of travelling via public transport must be compared with travelling with STS, we requested the trip time (with and without delays) and trip distance by car. We subsequently call this trip distance by car *taxi* trip time. The use of *taxi* is meant to differentiate these trip times, computed via the Google API, from the STS trip registrations times. Therefore, in this paper, taxi stands for a proxy of STS. Getting taxi trip times allowed us to calculate a trip time ratio between a proxy for STS and PT.

Two caveats need to be mentioned here. First, postal codes do not give the exact departure and arrival locations. Second, Google API can only plan in the present and future. Therefore, the public transport timetable and available road infrastructure may have changed between the data and the moment we estimated the model (in 2018). We planned two weeks in advance to avoid any complications arising from current roadworks. Consequently, road or rail works and diversions were excluded from our analysis. Expected (regular) delays on the road network are included.

Weather model: Customer satisfaction surveys of Dutch STS and fluctuations in trip registrations hinted at the fact that weather conditions play a role in the way STS is used. According to previous research on the relationship between weather and transport, the daily weather forecast guides people's travel behaviour (Faber et al., 2022). This is why we built a weather model. The aim was to uncover how weather conditions impact the number of trips taken via STS. The variable to be explained in the model was the total number of STS trips per day. We used the dataset of trip registrations in Northeast-Brabant[2] from 2017 because it was one of the few available datasets covering an entire year, amounting to 233,460 registered trips. Weather data are the model's independent variables, obtained from the open source weather data from the Royal Netherlands Meteorological Institute's Volkel measuring station in the Northeast-Brabant region. The weather data included temperature, precipitation, humidity, visibility and wind speeds, to which we added code orange and code red weather alerts. Additionally, we controlled for day of the week, holidays and public holidays.

A caveat here is that we have not been able to correct for the moment trips were booked or cancelled. Many trips are routine trips and planned well in advance. Conversely, weather conditions are only known shortly prior to the planned trip. Unfortunately, it proved impossible to make such corrections to our dataset.

To get an accurate estimate of the share of current STS trips that could potentially be done with PT, we would need a thorough understanding of each STS user's conversion factors coupled with data on their use of STS – for a representative share of STS users. However, such a detailed approach is difficult with the available data. As previously explained, STS users are a particularly hard-to-reach group and the survey needed to stay concise and simple in order to reach enough respondents. Instead, we determine a range for the substitution potential. This range is primarily based on the alternative travel options model and informed by our results on conversion factors.

4. Results

In this section we successively describe the personal, social and environmental conversion factors for Special Transport Services' users and explicitly link these conversion factors to the opportunity to use public transport.

4.1. Personal conversion factors

Special Transport Services' users are relatively old and almost all of them have difficulties travelling independently outside of home. The average age is 71, although the presence of a few young adults lowers this average. More than half of the STS users in our sample are aged 75 or older. According to the GALI (Global Activity Limitation Indicator), 58.3% of the people aged 75 or older have an impairment in the Netherlands (Statistics Netherlands, 2019). In our survey, 90% report having an impairment impacting their ability to travel independently outside of home. A majority of them report making fewer trips because of their impairment. 19% of the STS users reporting an impairment state having mental or cognitive health issues. Such issues translate into difficulties understanding travel information or in anxiety disorders such as agoraphobia. Nearly all (96%) of those reporting an impairment have a physical impairment. Walking, sitting and maintaining balance are the most commonly cited physical issues.

Among the remaining 10% who report having no impairment, half answered positively to the statement "Public transport is not suitable for me given my impairment or handicap". This means that virtually all STS users have difficulties travelling independently. This fact is hardly surprising since it is often a condition to get access to the Wmo status. In total, 70% of our sample state that they have (great) difficulty walking 300 m. Nevertheless, with the right mobility aids such as walking aids, wheelchairs and canes, people may be

[2] Northeast-Brabant counts 663,000 inhabitants, approximately 4% of the Netherlands' population (Provincie Noord-Brabant, 2020).

able to partially mitigate the impact of their impairment. 70% of STS users always or frequently require their mobility aid to travel.

Despite STS users' health conditions and advanced ages, their public transport use is not insignificant, yet still constrained. 39% say they occasionally use the bus, the tram or the metro, while 37% state that they occasionally travel by train. Still, this does not necessarily mean that they do so independently. This PT use is not exceptionally low compared with the Dutch population in general, where 55% and 56% occasionally use the bus/tram/metro or the train, respectively. 11% of our respondents use public transport at least once a month. We explicitly asked the rest of the sample their reasons for not using public transport more often. 88% of them do not use public transport more because of accessibility issues. Only 8% mentioned that they do not feel the need to use PT more. For almost two thirds of these low- or non-PT users, the main barrier is the first and last mile (to/from stop or station) (64%), followed by stepping in and out of the train, bus, tram or metro (61%).

Finding travel information, orienting oneself in the transport system and buying the right ticket was mentioned by a third as a barrier. In the Netherlands, digitalisation in public transport is increasingly pervasive (Snellen and de Hollander, 2017). This notably translates into cuts in service desks. It also means that digital skills are becoming increasingly important to navigate public transport services, such as buying a ticket (Durand et al., 2022). We did not ask STS users more about such skills. However, only 20% of STS users usually rely on the internet to book a trip with STS, while almost all STS providers have and encourage online booking. During phone interviews, some respondents have also voiced their concerns about not having the digital skills to understand the public transport system.

4.2. Social conversion factors

Special Transport Services' users often need to be accompanied when travelling out-of-home, but do not necessarily have the possibility to get the help they need. This can hinder their public transport use. Around half of our respondents (47%) state that they need someone to accompany them when travelling out-of-home. We do not know how many STS users would need someone to accompany them if they were to use public transport. Still, based on this statistic and the previous section on personal conversion factors, we can assume that at least half of the STS users would need support when using public transport. Yet a significant number of STS users do not want to or cannot rely on their social network. When asked why they would not ask for a lift instead of using STS, 86% mentioned one of the following three reasons: there was no one available with a suitable car for them, they did not want to burden anyone, or there was no one they could ask. Respondents used a lot the open answer field for this question, stating for instance: "I can't ask people around me every week/every time" or "There is no one around me I can ask". Furthermore, a majority of STS users live alone (51%) and can therefore not rely on a partner for help. This is explained by the older demographic of this group.

There are reasons to believe that people actually rely on STS *because* of a lack of social support. We observed that STS users are more likely to live in (highly) urbanised areas than the general Dutch population. This could be explained by differences in municipalities' policies in terms of access to STS or by the way the interview was distributed (mostly online). But another explanation could be that people living in more rural areas usually have stronger bonds with their neighbours, surrounding friends and family (Hortulanus et al., 2003; Scharf and de Jong Gierveld, 2008). As a result, they would not need to rely on STS much. Both the observation of STS users as more likely to live in urbanised areas and the explanation of a lesser social cohesion in cities have been supported by recent Dutch research (Das and de Jonge, 2020). In fact, 46% of STS users value the social aspects of STS above aspects such as reliability and travel time. These social aspects include the contact with and the friendliness of the driver, the extent to which people feel safe in company of other passengers and the driver as well as the ease of booking.

Facilities exist for people with a mobility impairment to be able to request assistance to use public transport. However, these are not known by all and also come with barriers. The phone interviews, which have left respondents more space to reflect than online interviews, revealed that many low- and non-PT users are unaware of the possibilities to get help at stations. In the Netherlands, people with an impairment who wish to take the train can get free assistance. The assistance mostly consists of help to step in and out of the train. Passengers are required to make an appointment online at least 1 h before the assistance is needed. They meet with a trained assistance provider at a station meeting point. However, such assistance requires creating an online account and is not available for buses or for the local train companies operating in the Netherlands.

Table 3
Results of the alternative travel options model: substitution of 5000 STS trips for public transport.

	Units	Options		
		Fastest	Shortest walking distance	Minimum number of transfers
No PT available	%	1.20%	1.20%	1.20%
Average total waiting and trip time	min	138	139	117
Average trip time	min	36	40	38
Average waiting time prior to departure	min	100	96	74
Waiting time longer than 1 h	%	7.9%	6.3%	4.2%
Average trip distance	km	10.5	11.7	10.7
Average walking distance	m	1120	985	1377
Walking distance less than 500 m	%	9.9%	15.1%	7.3%
Only walking	%	9.7%	8.1%	16.6%
Average number of transfers	n	0.47	0.64	0.33
Three of more transfers	%	0.4%	0.8%	0.1%

4.3. Environmental conversion factors

Special Transport Services' users may rely on these services rather than public transport because there is no suitable public transport option available for them at the desired time and location. This was cited by 19% of the low-to non-PT users in our survey as a main reason for not using public transport more. Our alternative travel options model is particularly useful to explore in more details the extent to which STS trips have realistic public transport alternatives. According to the results of our model (Table 3), there are only a few STS trips (1.2%) that PT cannot substitute, either because no public transport service is available or because Google Maps deems the total walking distance unrealistic. The average trip time via PT is approximately 38 min, with the fastest option only slightly lowering this estimated trip time. The waiting times until departure are considerable, because PT travel options are not always available every 15 or 30 min. In fact, some trips (4%–8%) have extremely long waiting times of more than 1 h prior to departure. The average walking distance in the total trip easily exceeds 1 km. Even if the walking distance is minimised – the 'shortest walking distance' option – the average walking distance is still 985 m. In 8% of the cases with a minimum walking distance, Google Maps advised to walk the entire distance, thereby avoiding the public transport option altogether. When travelling via public transport, the average walking distance for access and egress transport is 1.6 km. In the best case scenario here ('shortest walking distance' option), 15% of public transport trips have walking distances of less than 500 m. In terms of number of transfers, the findings were relatively positive: many trips require no transfers, and only 0.1–0.8% of trips require three transfers or more.

To complete our analysis, we also provided trip times via taxi, and trip time ratios for the same origin-destination pairs at the same trip times (Table 4). The average trip time by taxi is 12.5 min, excluding waiting times, road congestion, detours, and entering/exiting the vehicle. However, when road congestion, detours, and entering/exiting the vehicle are taken into account, we arrived at a more realistic average trip time of 24 min via taxi. Congestion is provided by Google Maps, detours are based on the average detour as reported in confidential reports from regional studies (travel time $^{1.145}$) and we added a 5-min penalty for waiting/entering/exiting. Note that although STS can be a shared ride in the Netherlands, most journeys are with a single rider. The average occupancy is below 2 in most regions (driver excluded). Therefore, STS is usually faster than PT, despite detours, entering/exiting vehicles, and en-route delays. This holds for 84% of trips. In other words: public transport is only faster than STS for 16% of trips.

The weather model shows another aspect of why STS is being used. Findings of the regression model are depicted in Table 5. The model's explanatory power is considerable (adj. $R2 = 0.71$). The reference scenario consists of 527 trips made over the course of one day in the Northeast-Brabant region. The reference day is a Friday, excluding vacations and public holidays, with a maximum temperature of 0 °C and no snow or weather alerts.

The findings confirm the relationship between weather and the number of trips made via STS. STS is more used on colder, wetter days. There are 2.7 fewer trips for each additional degree Celsius. The number of trips increases during rainy weather. According to the model, 465 trips are expected on a good weather day (max. temp. 32 °C; relative humidity 30%), while an estimated 614 trips are expected on a very cold, damp day (−5 °C; relative humidity 85%). This is a 32% increase compared to the "good weather" day. These effects are significant but not extreme.

We do not know for sure whether people who use STS more on colder and wetter weather use public transport in good weather. Still, unfavourable weather conditions most probably makes public transport less attractive for STS users. Those who can walk or bike may also switch to STS in colder weather. STS would then become their safety net. The model results also show that in case of relatively extreme weather conditions, such as with code orange and code red, STS are less used. This is probably because people stay home; everyone is advised to stay home when these codes apply.

5. Discussion

5.1. Substitution potential

Before providing a range for the substitution of STS with PT, we note that STS use is particularly skewed. 20% of the people with the right to use STS account for 80% of the trips made with STS. It is estimated that 1 in 3 Wmo status holders do not use STS at all over a one-year period (Zijlstra and Bakker, 2016). Hence, we likely have two different user groups: one that is highly dependent on STS, and the other that primarily uses the service as a second best option when other travel options are momentarily unavailable or too unattractive.

This skewed distribution of STS users has implications in terms of substitution potential. Often, STS will already be substituting a transport mode, and for others public transport will simply never be an option. Nevertheless, we determine a substitution potential for STS users in general, not for both groups separately. This heterogeneity among STS users also explains why we do not determine a substitution potential at the level of users, but rather at the level of trips. Data on trips is more easily available. The data we have on

Table 4
Comparison of taxi (proxy for STS) and PT.

Performance	Unit	Result
Trip time via taxi (direct)	minutes	12.5
Trip time via taxi (with congestion, detours, enter/exit vehicle)	minutes	24
Trip time ratio PT/taxi (direct)	ratio	3.0
Trip time ratio PT/taxi (with congestion, detours, enter/exit vehicle)	ratio	1.5

Table 5
Regression model estimates.

Coefficient	Estimate (std. error)
Constant	527.01 (30.34)***
Maximum temperature (ref. 0 °C)	−2.74 (0.44)***
Snow	−23.79 (15.43)
Relative humidity (ref. 0%)	0.86 (0.31)**
Code orange	−36.85 (20.19)
Code red	−248.91 (50.21)***
Monday	−33.16 (9.83)***
Tuesday	6.16 (9.79)
Wednesday	30.45 (9.84)**
Thursday	56.97 (9.87)***
Saturday	−120.64 (9.99)***
Sunday	−104.39 (9.85)***
Public holiday	62.6 (21.92)**
Holiday period	−108.45 (7.14)***

NB. Stars indicate the significance levels: *** <0.001, ** <0.01, * <0.05.

users, through the survey, focuses on people who have used STS at least once over a the past three months, and is therefore already biased towards more frequent users.

Lower limit: In theory, the right to use STS is granted by the local municipality, mostly on the basis of people's ability to travel independently. Therefore, it would be odd if one could manage without STS. However, local municipalities are not always consistent in granting this right, as explained in the introduction. Still, we argue that the lower limit in terms of substitution potential is equal or close to zero. This means that at worst, none of the trips currently made by STS users could be made with public transport. This lower limit is mainly explained by the existence of STS captives. These people have few to no options outside of STS. Impairments and the (perceived) mismatch between abilities and the PT system can severely limit one's ability to use public transport (low personal conversion factor). Asking for lifts is not always an option (low social conversion factor). In some cases, there is simply no suitable public transport option (low environmental conversion factor). 70% of the surveyed STS users explained having difficulties walking more than 300 m. Mobility aids can help, but only 15% of PT trips with the "shortest walking distance" option are under 500 m. Besides, 77% of STS users in our survey already report making fewer trips in general because of their impairment. This points towards the fact that they only use STS when really needed.

Upper limit: Yet there are people for whom STS are not the only transport options, meaning that the upper limit in terms of substitution potential is not equal to zero. The results of our survey also show this. 11% of (more frequent) STS users said that they would have used public transport for their latest STS trip, had STS been unavailable. This gives a first estimate of 11% of trips that could be substituted. Coincidentally, 11% of our respondents report using public transport at least once a month. To gain a better understanding of the upper limit, we conducted a sensitivity analysis of public transport alternatives to STS trips, using our alternative travel options model. For this, we had to define a set of (partly arbitrary) reference points constituting what might be an acceptable public transport trip.

- Max. 800 m walking, considering that passengers can get some support from a person, that they use mobility aids like a rollator walker, and that they likely would not have to walk 800 m in one stretch (e.g. 400 m access and 400 m egress walks),
- Max. 30 min waiting time between desired departure time and actual departure time,
- Max. 1 transfer,
- The trip time via PT (excluding waiting time) is at most 1.5 times longer the average adjusted trip time via taxi for the equivalent trip.

If we apply these criteria to the sample of 5000 STS trip registrations, 794 trips meet such criteria. This results in an initial upper limit of 16% of STS trips that could be covered by public transport, and therefore a provisional range of 0–16%.

In practice, this upper limit is likely an overestimation. First, our survey gives an estimate of 11% of trips that could be substituted. Second, trips are not randomly divided between the group with a high probability for substitution and the group with a low probability for substitution in our randomly selected sample of trip registrations. Third, this analysis does not account for aspects that contribute to personal, social and environmental conversion factors. Fourth, a total of 800 m is still a long walking distance for many STS users. We briefly explain our last three arguments.

In our random sample of 5000 STS trips, we distinguished between trips that comply and do not comply to our criteria. The group of trips complying to our criteria contains nearly twice as many trips involving people using walking aids (10.1% vs. 5.7%) and significantly more people requiring a mobility scooter. People seemingly have practical reasons for using STS. This is why 16% may be an overestimation.

The analysis of trip registrations does not include aspects that contribute to personal, social and environmental conversion factors and their day-to-day fluctuations. To begin with, we cannot observe fluctuations in the users' health conditions (punctually lower personal conversion factor). Our survey reveals that 27% of STS trips are to/from medical appointments. After certain medical procedures like surgeries, people are probably not in a good enough condition to travel via public transport. Besides, they may not have someone to accompany them on the specific day they need to go out (low social conversion factor). Next, a static PT trip planner does not account for roadworks, delays and disruptions. Weather conditions, and how they impact travellers and public transport services, are also unknown. Such circumstances could negatively affect one's environmental conversion factor.

Walking 800 m is likely to be a lot for STS users, especially if they cannot get support. If we change our criteria to 300 m, the upper limit plummets to 1.1%. The sensitivity analyses we conducted on our four parameters (see Appendix A) reveal that the walking distance is a decisive factor for the upper limit of the substitution range. It does not matter whether one can walk 100 or 200 m, as in both cases the upper range would be equal to zero. It is only when walking more than 500 m that the share of trips via public transport increases.

As explained at the beginning of this section, the population of STS user is heterogenous. There is arguably a group of passengers for whom such an upper limit is irrelevant, namely STS captives. Conversely, some passengers have more choice because they are more mobile. This is why the possibility for Dutch STS users to ride public transport is not insignificant. However, such people are also less frequent STS passengers. Consequently, a voluntary or involuntary substitution of STS with public transport by the 10% most mobile STS users would not have a one-to-one effect. It would not result in a 10% reduction in number of trips: the reduction would be much smaller.

5.2. *Policy implications*

In an inclusive society, people with impairments would ideally be able to take part in the same activities and use the same facilities as everyone else. The objective of the Social Support Act is to assist people so that they may continue to participate in society and live independently at home for as long as possible. Based on this study, we conclude that the current Wmo collective transport policy instrument does contribute to achieving such an objective. As such, this study confirms the importance of STS in keeping vulnerable people mobile, like multiple other studies also do (Marita et al., 2022; Stjernborg et al., 2014). Special Transport Services offer a transport option to people who would otherwise have limited or no alternative available to them. 52% of the STS users we reached indicated that they would have stayed home, had STS not been available for their most recent trip.

Even with the public transport accessibility improvements of the past decades (ProRail, 2021), we find that only 11% of STS users would have used public transport, had STS not been available. Besides, it is unlikely that more of 16% of all STS trips can be substituted for public transport. Our results show that public transport is not a panacea for people with an impairment, as other studies have stressed in the past (Bakker and van Hal, 2007; Hansson and Holmgren, 2017; Neven et al., 2015). In particular, we observed that the first and last miles in public transport are major limiting factors for STS users. This raises the question of whether simply making public transport accessible is enough to allow everyone to be self-reliant and to participate in society.

When public transport in its traditional form is not accessible at certain origins and destinations, more flexible transport options might be considered, such as open-for-all demand-responsive buses (see e.g. De Jong et al. (2011) and Cottrill et al. (2020)). These options are sometimes put forward together with technological solutions like autonomous vehicles and apps. Although autonomous vehicles may be a solution to get from A to B without an "expensive" driver, our results show that STS users value a lot the social aspect of the service. The driver helps them get in and out of vehicles, gives information while driving, etc. Assistance to use (demand-responsive) public transport in the form of a smartphone app may help to overcome some barriers, but most STS users have difficulties with digital developments. Besides, cognitive issues would likely make the use of an app while on-the-go difficult (Van Holstein et al., 2021). This is not to say that technological solutions have no role to play in alleviating financial and organisational challenges faced by STS, but they are no cure-all.

Many STS users already seem to choose to use other mobility solutions wherever possible, and use STS mainly in situations where they have no other option. For instance, bad weather or unavailability of a family member might prompt them to book a STS ride. Promoting independent mobility with public transport through free day passes, public transport ambassadors and campaigns could prove beneficial to foster the travelling flexibility that some STS users have. However, it should not be expected that the use of STS will drastically reduce as a result of such measures. As long as accessible public transport *with sufficient coverage* is not available, dedicated transport services fulfil an important function for people with mobility impairments to be self-reliant and participate in social activities.

6. Conclusion

Special transport services (STS) in the Netherlands help keep people with an impairment mobile, yet these services face financial and organisational challenges. In this paper we took a multi-faceted approach to analysing the substitution potential of STS with regular public transport services.

Our analysis of STS users and their opportunities to use public transport shows that such services are important in people's mobility, especially at times when and for destinations where no other option exists. On the one hand, our survey clearly demonstrates that public transport is challenging for many STS users. Virtually all STS users have difficulties to travel independently. STS users mostly report physical difficulties. The first and last mile and getting in and out of vehicles are main obstacles in public transport use. Many passengers seem to rely on STS because of a lack of support from their social network, or because they do not dare to (repeatedly) ask for help. Their family and friends may be busy, or STS passengers may have no one to turn to. As such, being accompanied for their public transport trips is probably not an option.

On the other hand, our analysis of STS trip registrations shows that STS users value these services – whether they be highly dependent on STS or using them when all else fails. We see that high walking distances and travel times for public transport trips compared with STS trips can deter people from making the switch. Lastly, STS seem to be particularly important during bad weather conditions, emphasizing the role of these services as safety nets rather than go-to options for a majority of users. Nevertheless, a minority of people with access to STS remain highly dependent on these services.

In the current state of affairs, 0% to a maximum of 16% of STS trips (specifically trips falling under the 2015 Social Support Act, Wmo) could be done by public transport instead. The upper limit of 16% is likely an overestimation as it does not account for one's health, weather conditions, roadworks, whether they have the possibility to be accompanied, etc.

All in all, this research confirms that STS fulfil an important function for people with mobility impairment to be self-reliant and to participate in society; public transport is hardly an alternative.

CRediT author statement

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Data availability

The data that has been used is confidential.

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Appendix A. Sensitivity analyses

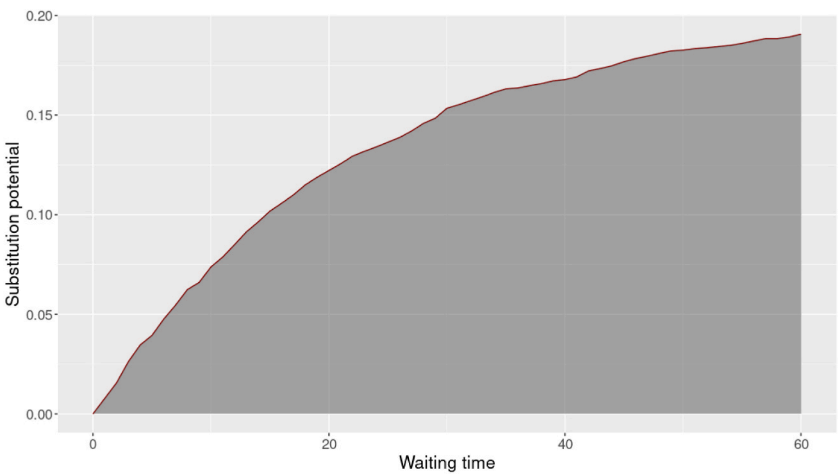

Fig. A1. Effect of the waiting time on the upper limit of the substitution potential

Fig. A.2. Effect of the total walking distance on the upper limit of the substitution potential

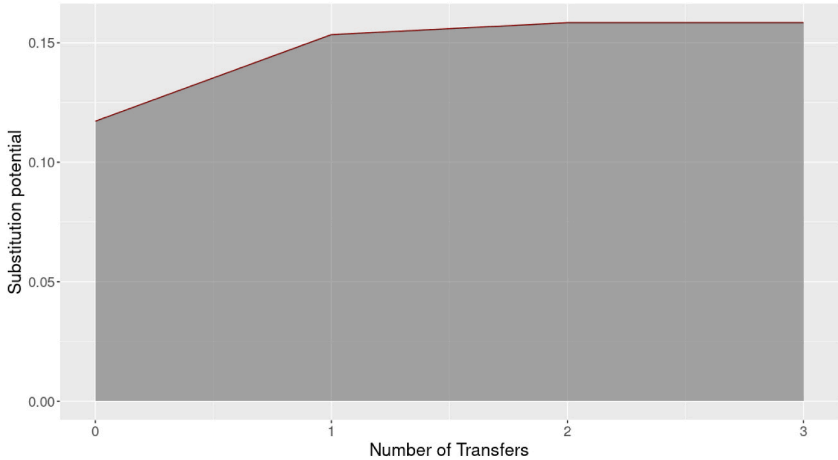

Fig. A.3. Effect of the number of public transport transfers on the upper limit of the substitution potential

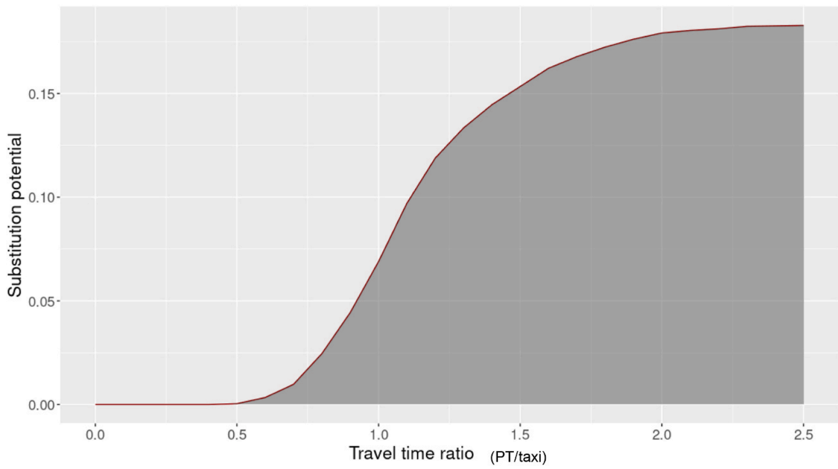

Fig. A.4. Effect of the ratio public transport trip time versus taxi trip time on the upper limit of the substitution potential. Taxi refers to STS with trip times computed via Google API, not the STS trip registrations. Here, taxi trip times account for congestion, detours and entering/exiting the vehicle.

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