Transportation Research Interdisciplinary Perspectives 10 (2021) 100340

Contents lists available at ScienceDirect

Transportation Research Interdisciplinary Perspectives

journal homepage: www.elsevier.com/locate/trip

Integration of ridesharing with public transport in rural Switzerland: Practice and outcomes

Vu Thi Thao [a,*], Sebastian Imhof [a,b], Widar von Arx [a]

[a] Lucerne University of Applied Sciences and Arts, Competence Center for Mobility, Rösslimatte 48, P.O. Box 2960, CH-6002 Lucerne, Switzerland
[b] Institute of Geography, Center for Regional Economic Development, University of Bern, Hallerstrasse 12, 3012 Bern, Switzerland

ARTICLE INFO

Keywords:
Ridesharing
Public transport
Integration
Cooperation
Rural
Acceptance

ABSTRACT

Using advanced technologies, ridesharing has transformed transportation in many cities. The effective integration of ridesharing into public transport systems can provide an opportunity for public transport authorities to solve the common problem of rural transport, namely poor accessibility due to the dispersal of the population. However, literature on the integration of ridesharing with public transport is rather scant. At the same time, while ridesharing has been extended to rural communities, so far this has attracted little research. To fill in these gaps, this paper seeks to explore the practice and outcomes of integrating ridesharing with public transport. The analysis is based on a case study of a community-based ridesharing scheme in four rural municipalities in central Switzerland. Using a mixed methods approach, the key findings show the public transport authority designing the integration with a goal to complementing public transport with ridesharing. To achieve this goal, three crucial approaches were adopted: the provision of information on the ridesharing scheme, the integration of ridesharing notice boards into the local bus stop and regional railway station networks; and the price strategies as a means to signify a contractual relationship between rider and driver and to reduce a potential competition. Even though ridesharing use is still only moderate, the authorities are satisfied with the outcome and do not consider cost-effectiveness to be important.

Introduction

Although ridesharing is far from being a new mode of transport, with the appeara + nce of mobile technology and real-time information (Chan and Shaheen, 2012; Henao and Marshall, 2018) it has changed the transportation market in many cities, especially in providing a reliable and affordable service in neglected city areas (Hall et al., 2018). Along with this significant gain, ridesharing also creates challenges for the transport authorities in terms of demand management. On the one hand, we have witnessed strong protests by traditional taxi-drivers against ridesharing companies like Uber on the basis that 'uberization' threatens their livelihoods (Malalgoda and Lim, 2019; Srinivasan, 2019). Alongside these protests there are also disputes over authorization to operate (Contreras and Paz, 2018). On the other hand, empirical studies of the impacts of ridesharing provide contradictory findings. Some studies report that ridesharing attracts riders away from public transport (Franco et al., 2019) and increases vehicle miles travelled (Henao and Marshall, 2018) and traffic congestion (Hall et al., 2018), while others claim the opposite (e.g. Hall et al., 2018; Feigon and Murphy, 2016; Chan and Shaheen, 2012).

However, these studies have primarily focused on cities and major ridesharing companies. To date, little research has been conducted in a rural context, even though ridesharing has been extended to rural communities (Hofmann and Daskalakis, 2019; Joseph, 2018). It is therefore of great interest to explore alternative ridesharing models in rural areas.

Public transport in rural areas worldwide faces a common problem of poor accessibility due to the dispersal of populations (Nutley, 2003; Petersen, 2016). Although Switzerland, like other countries in western Europe, has higher rural densities (FSO, 2014), its public transport services in rural areas are still characterized by low frequencies, limited operating hours and indirect routes (Petersen, 2012). Public transport users face the first/last mile problem (Reck and Axhausen, 2019). Poor public transport services also cause a high dependence on private cars. Nevertheless, around 22% of the Swiss rural population do not own a car (FSO, 2017), leaving the travel needs of the non-car population, as

* Corresponding author.
E-mail address: thaothi.vu@hslu.ch (V.T. Thao).

https://doi.org/10.1016/j.trip.2021.100340
Received 5 December 2020; Revised 5 March 2021; Accepted 7 March 2021

well as the elderly and young people,[1] unmet. Meanwhile public transport authorities are increasingly being pushed to improve the efficiency and effectiveness of how public transport is organized. They are already required to ensure the provision of public transport to meet a range of social policy goals, such as social equality and sustainable mobility (Chen et al., 2017; Docherty et al., 2018). The effective integration of ridesharing into the public transport system can provide an opportunity for the public transport authorities to improve accessibility and to increase public transport usage in rural areas by addressing the first/last mile problem (Stiglic et al., 2018), and managing ridesharing as a complement to public transport as seen later in the empirical part of this current paper. Yet the literature on the integration of ridesharing and public transport is rather scant. Moreover, to persuade the authorities to pursue this solution, future research should document successful practices through case studies (Murray et al., 2012).

Against this backdrop, the present paper seeks to explore the practice and outcomes of integrating ridesharing with public transport in a rural context. We first pay special attention to the ways in which key stakeholders cooperate with each other in designing and implementing the integration process. We then look at the outcome of the integration by means of a descriptive analysis. Because identifying suitable geographical areas plays a crucial role in designing the integration of ridesharing with public transport, we also examine the impact of factors in the built environment on ridesharing use. To do so, we adopt a mixed methods approach by combining qualitative interviews with data on level of demand and geographical information. The analysis is based on a case study of a community-based ridesharing scheme, Taxito, in four rural municipalities of central Switzerland. Our findings highlight that filling a gap in public transport and mitigating outmigration to cities are the most important reasons for integrating ridesharing with public transport. Even though ridesharing use is at present modest in amount, the authorities are satisfied with the outcome of this scheme and do not consider cost-effectiveness to be important. Instead they are concerned much more with how to design the integration such that ridesharing should complement and enhance the use of public transport. Our paper also enriches knowledge of the associations between ridesharing and the built environment, another underexplored research area (Yu and Peng, 2019).

The remainder of the paper is organized as follows. Section 2 briefly introduces the ridesharing terminology, the classification of ridesharing models, the impacts of the built environment on ridesharing, and the integration of ridesharing with public transport. Section 3 describes the context for the study, followed by a presentation of the data and methods used in Section 4. Section 5 discusses findings about the actual integration process and its outcomes. Section 6 assesses the implications for policy-makers in integrating ridesharing with public transport in a way that increases use of the latter.

Literature review

As mentioned previously, the integration of ridesharing with public transport is still under-researched. This literature review therefore adopted an integrative review method to provide a knowledge base and to present insights from different integration models. We begin with the terminological distinction between ridesharing and ridehailing. Both ridesharing and ridehailing refer to carpools (or vanpools) in which two or more individual travelers share a journey in a private automobile. However, ridesharing differs from ridehailing in its financial goals and types of travel route. Ridesharing is non-profit because the payment only covers part of the driver's costs. Conversely, ridehailing by, for instance, Uber, Lyft or Grab is a variation on the for-profit taxi. In a ridesharing system, the driver and the passengers share a common route (origin and/or destination); conversely ridehailing drivers typically do not have the same destination as their passengers (Chan and Shaheen, 2012; Clewlow and Mishra, 2017).

Based on modes of operation and participants' relations, Chan and Shaheen (2012) classify a ridesharing scheme into three subgroups. The 'acquaintance-based' carpool is formed by families, friends and coworkers. The 'organization-based' carpool is arranged around a formal institution: to use this service, formal membership or a visiting organization's website is required. The 'ad-hoc' form of ridesharing involves casual carpooling in which the driver and the passengers do not know each other. Membership is not required. The shared rides are organized by various mechanisms such as self-organization, notice boards/meeting points and computerized ride-matching systems. Because of the characteristics of the case study, this current paper only focuses on the integration of ridesharing with public transport.

Rural areas lag behind urban areas on digitalization due to their physical remoteness and low population densities (Salemink et al., 2017). The available ITC infrastructure in rural regions influences the technologies adopted by ridesharing schemes. In addition, unlike urban areas, where ridesharing services are more individual-oriented and profit-oriented, ridesharing models in rural areas are often characterized by 'community participation, individual altruism and collaborative initiatives' (Joseph, 2018, p. 3). A study conducted in rural Scotland also reports that strong local social networks have positive impacts on the feasibility of ridesharing (Gray et al., 2001).

Previous research has shown that the built environment has certain impacts on travel behavior (Thao and Ohnmacht, 2019). However, the relationship between the built environment and ridesharing remains under-researched (Yu and Peng, 2019). While empirical evidence from a few existing studies confirms the impacts of the built environment on ridesharing behavior, findings on the magnitude of the impact proved contradictory. Conducting a study of ridesharing in Texas, Pu and Peng (2019) claim that there are strong associations between the built environment (density, land use, infrastructure and transit accessibility) and the demand for ridesharing. However, a study of ridesharing in Los Angeles conducted by Brown (2020) indicates relatively weak impacts of built environment factors on ridesharing, in comparison to neighborhood socioeconomic characteristics. These two studies were conducted in a city context. In rural settings, there have been no studies of this issue to date. In the empirical section of the paper, we will provide initial findings from our case study of four rural municipalities in central Switzerland.

In practice, several ridesharing models have been developed as complementary to public transport services in rural areas. For example, Carlos was the first ridesharing service to be implemented in a non-urban context in Switzerland. It was simply incorporated into local and regional public transport services by installing call boxes around bus stops and railway stations. The project was ended after the pilot phase (2002–2005) due to the long waiting times, weak communication and low demand (Hofmann and Daskalakis, 2019). The Mobilfalt ridesharing scheme, implemented in 2013 in north Hesse, Germany, has achieved stronger integration because it is combined with the routes and timetables of local and regional public transport services. It bundles not only private cars but also taxis with public transport modes (Benz and Kepper, 2019). The Garantiert Mobil ridesharing scheme implemented in the south of Hesse goes a step further in being fully integrated into local and regional public transport services (routes, timetables and tariffs). Besides private cars and taxi, it bundles rental cars with modes of public transport (Krämer and Weiss, 2019). Other common characteristic between Mobilfalt and Garantiert is the active involvement of local transport agencies and the municipal authorities, which finance a large share of the operating costs, thus reducing fares for riders (Benz and Kepper, 2019; Krämer and Weiss, 2019).

[1] The number of Swiss people applying for driving licenses has declined in recent years. In 2017, this figure fell by 2% for the whole population. The strongest reduction (3%) was in the young population group (ages 18–24) (ASTRA, 2018).

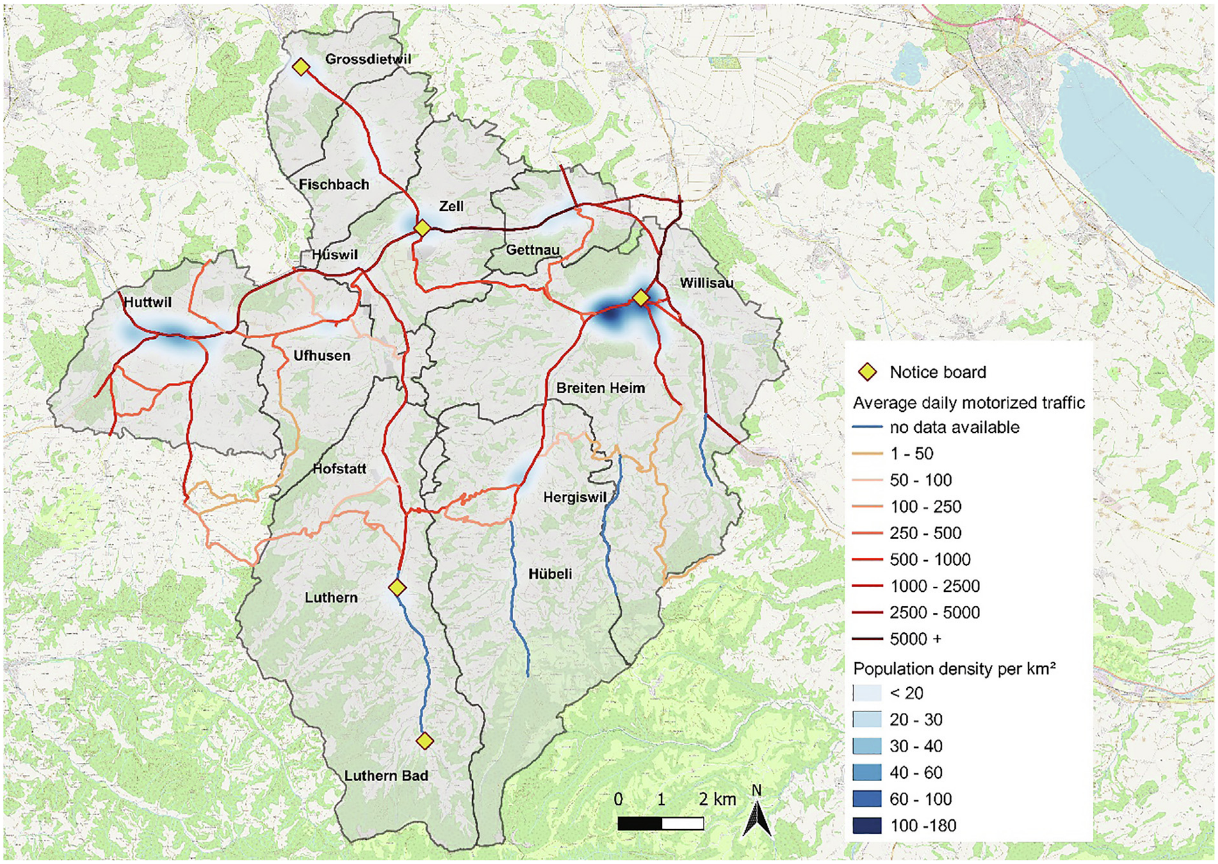

Fig. 1. The area of study.

A survey of public transport agencies and ridesharing operators in the United States conducted by Murray et al. (2012) is one of a few studies devoted to the integration of ridesharing with public transport. According to these authors, bridging the gap in transit services in areas with sparse populations and addressing customer demand are the most important reasons for ridesharing operators and public transport agencies to cooperate. To evaluate the outcome of the integration, ridesharing services are commonly used by both ridesharing and public transport agencies. For the latter, cost-effectiveness is reported as being less important. This suggests a reason why few public transport agencies have considered substituting ridesharing for a fixed route as a cost-saving measure.

The study context

In the past few years, several pilot projects (e.g. Taxito, Ebuxi/mybuxi, Kollibri, sowiduu) promoting the integration of on-demand mobility with public transport have emerged in Switzerland. These projects have been implemented in urban, peri-urban and rural areas and are varied in their technological characteristics and product design, but all seek to achieve synergies between on-demand mobility and public transport. On-demand bus and ridesharing are designed to combine with local bus routes and/or to connect with regional railway stations. It is therefore not surprising to see the strong involvement of public transport operators like the Swiss Federal Railways (SBB), PostAuto,[2] and cantonal and regional public transport associations. Besides their duty to meet customer demand, by becoming involved in these projects, public transport operators can increase their customer base and protect their market positions. Project stakeholders have formed a working group to share practical experiences and to stress the potential of this mobility solution to the Federal Office of Transport.

The case study for this paper is Taxito, the successor to the Carlos ridesharing scheme mentioned earlier. A key feature of Taxito ridesharing is that it aims to complement public transport and operates in areas with no or limited public transport services. Taxito has the characteristics of a community-based, organization-based and ad-hoc ridesharing scheme. It requires no membership registration for either riders or drivers. However, if the driver wants to receive a free highway charge sticker (worth CHF 40) and payments (CHF 1 per ride), he or she can register at the operator's website. To use Taxito ridesharing, a rider walks to the nearest Taxito notice board and sends the Taxito platform a destination code via mobile phone. The destination name will be lit up on the notice board. A driver sees the destination and can spontaneously decide whether or not to take the rider. To ensure security, the rider must send the vehicle's registration number to the Taxito platform. The rider must pay CHF 2 per ride, which is directly charged by a mobile network operator. The price can cover only a small proportion of the operating costs.

We chose Taxito for our investigation because it is the most widespread ridesharing scheme to operate in low population density areas of Switzerland. This suggests that Taxito has certain advantages that other ridesharing schemes do not. In Switzerland, Taxito is currently operating in Luthern, Willisau, Zell and Grossdietwil (Canton Lucerne), Maladers (Chur), Hé Léman (Geneva) and Emmental-Entlebuch (Bern and Lucerne). We selected Taxito's activities in the four rural municipalities of Luthern, Willisau, Zell and Grossdietwil for investigation here. The first three municipalities were the first where Taxito began operating in June 2015. This timeframe can be considered long enough to be able to evaluate the outcome of the integration of Taxito ridesharing with local public transport. Furthermore, other operational areas cover either part of some agglomeration or are

[2] PostAuto provides rural and regional bus services throughout Switzerland.

still in the pilot phase. However, we included Grossdietwil in our study, even though Taxito ridesharing only started in this municipality on 30 December 2019. This is because we are interested in knowing why Grossdietwil decided to participate in the Taxito ridesharing project at a much later date, even though it is located in the same neighborhood and faces similar problems with public transport.

As can be seen in Fig. 1, the municipalities all have low population densities, ranging from 20 person/km^2 in Luthern (and Luthern Bad) to 180 person/km^2 in Willisau. Due to low demand, the quality of public transport services is rather poor. There is a regional train connection serving the traffic corridor Willisau – Gettnau – Zell – Huttwil, but it only runs once an hour and every half hour at rush hours. A bus line serves the traffic corridor Zell – Hüswil – Luthern – Luthern Bad, but it runs much less frequently, only five times on weekdays and four times at weekends. Another bus line serves the traffic corridor Hüswil – Zell – Grossdietwil with a direct connection seven times on weekdays and twice at weekends.

Like other rural areas, the share of individual motorized traffic in total traffic volumes is high in these communities. At the same time, the average vehicle occupancy rate is rather low, at 1.37 person/car. These factors provide favorable conditions for the implementation of a ridesharing service.

With its very sparse population density and therefore very poor public transport services, Luthern was the municipality where the integration of Taxito ridesharing with public transport was initiated. Luthern has two notice boards, instead of one notice board as in the other three municipalities. From each notice board, riders can request a trip to different destinations in the neighborhood.

Data and methods

In this study, we have used a mixed methods approach. To explore the ways in which the public transport authorities cooperates with the Taxito company in implementing the integration of ridesharing with public transport, three in-depth interviews with the founder and CEO of Taxito company, the Lucerne Transport Association[3] and a member of the municipal council of Luthern were conducted. The interviews were tape-recorded and lasted between one and two hours. These interviewees were selected because they were responsible for the design and implementation of the ridesharing service in the study area. The interviews covered the following topics: cooperation goals and activities, stakeholder involvement in the implementation process, cost-effectiveness and challenges. In addition, secondary data like technical and evaluation reports on the pilot project were also collected.

To assess the outcome of the integration of Taxito's ridesharing scheme with public transport, we used an anonymized dataset of 3562 trips recorded from 1 June 2015 to 16 March 2020.[4] For each trip, Taxito and the Lucerne Transport Association provided eight variables, as listed in Table 1 below.

The accessibility of the notice boards and destinations was analyzed in order to investigate the impact of population and employment densities on the use of Taxito ridesharing. We plotted the catchment areas for each of the five notice boards and the eight destinations by using the Open Routes Service 'ORS Tools' plug-in in QGIS. Catchment areas were defined as polygonal areas with their centroid placed on Taxito's notice boards and at the destinations on the center-most point of a transport axis within a municipality or settlement, with all their vertices placed on connected transport axes (roads, streets, paths). The catchment area is determined by fixed geographical distances (500 or 1000 m) along all transport axes from their centroid to their vertices. The shape of the catchment areas depends on the structure of the road network and therefore does not form circular isochrones. For all thirteen catchment areas, isochrones of 500 and 1000 m were calculated. The geographical distances used were chosen because they are equivalent to the accessibility of the public transport connections in rural areas. The accessibility is defined by a distance to the transport stop from the household location (FOSD, 2020). In order to investigate the proportion of the population with access to the notice boards within a walking distance of 500 and 1000 m, the population living within the areas defined by each isochrones was determined by clipping the isochrones with the dataset of Swiss statistics for the Swiss population (Statpop) (FSO, 2018a). This provides the population number on a hectare grid. This step was repeated for employees working

Table 1
Taxito trip data Taxito data, n = 3562 trips.

Variable	Description
Date	
Time of day	
Place of departure	Taxito's notice boards
Destination	Destination of the trip. No information on the actual place of arrival
Waiting time	The time from the rider requesting the service to the time confirming the successful match. The real waiting time could be shorter because the rider might not send a message immediately after being picked up
Registered rider	Yes/No. This information was included in the dataset recorded
Registered driver	from 1 June 2015 to 9 January 2019
Confirmation message	A short message sent by the rider to confirm the successful match. It might also contain the number plate of the vehicle picking up the rider. The authors of this paper received only the first two letters of the number plates indicating the cantons in which the vehicles are registered. This information was included in the dataset recorded from 10 January 2019 to 13 June 2019

To investigate the impact of aspects of the built environment on ridesharing use, we combined the demand dataset in Table 1 with a dataset for the built environment. Built environment data and sources are summarized in Table 2.

Table 2
Data on the built environment.

Variable	Description	Source
Population	Number of people living in catchment areas of 500 m and 1000 m around municipality/settlement center	(FSO, 2018a)
Employees	Number of employees working in catchment areas of 500 m and 1000 m around municipality/settlement center	(FSO, 2018b)
Point of interest (POI)	Classification of amenities in the neighborhood that can influence the use of ridesharing services, including - Company and small businesses (e.g. retail, supermarket, health service) - Restaurants and entertainment - Residential areas (e.g. camping site, hotel, retirement home) - Public organizations (e.g. school, church, police station) - Tourist attractions (e.g. pilgrimage destination, tourist information, animal zoo) - Infrastructure and other (e.g. parking, gas station, fireplace)	(Openrouteservice, 2020)
Regional railway network	Location of regional railway stations	(SBB, 2020)
Daily motorized traffic volume	Individual traffic model with average daily traffic	(FOSD, 2017)

[3] The interviewee's identity was concealed at the interviewee's request.

[4] From 17 March 2020 to 24 September 2020, the Taxito ridesharing scheme had to suspend its services due to prevention measures connected with Covid-19 pandemic. This was because the local authorities considered Taxito to be a public transport service.

within the catchment area defined by the isochrones in order to determine the number of employees with access within a walking distance of 500 or 1000 m by using the dataset of Swiss statistics for the structure of enterprises (Statent) (FSO, 2018b). This provides the number of employees on a hectare grid. The same analytical procedure was carried out for the destinations.

To explore the impact of land-use diversity on ridesharing, we first counted the points of interest (POIs) in the immediate vicinity of each notice board and destination by using the POI application programming interface (API) Openrouteservice (2020). Adapting the categories of POIs by Kong, Zhang and Zhao (2020) for rural areas, we assigned each POI to one of the six categories shown in Table 2. We used the POI categories to calculate land-use diversity, represented by the Shannon entropy (Shannon, 1948):

$$H = -\sum_{j}^{n} p_j log_n p_j$$

where H represents the entropy with a range from 0 to 1; *pj* is the proportion of each category of POI (j); and *n* is the number of categories, here eight categories. The higher the entropy, the higher the land-use diversity.

In Taxito's ridesharing concept, notice boards can be considered to be the places where trips originate. We plotted the number of trips recorded between a notice board and its possible destinations. In this step, we added the regional railway locations (SBB, 2020) in the municipal neighborhood in order to explore the possible impact of regional railway locations on ridesharing use. In addition, daily motorized traffic volumes and the directions of traffic were taken into consideration (FOSD, 2017) to determine the relationship, if any, between the number of trips departing from each notice board and daily motorized traffic volumes and directions.

Results

The practice of the integration process

Goals of the integration

The actors involved in the design, implementation and operation of the Taxito ridesharing scheme are the Lucerne Transport Association (VVL), the Taxito company and the local municipalities. VVL's roles in general include planning and financing public transport in the canton of Lucerne. In this particular ridesharing project, VVL is a contracting authority that sets goals and provides funds. VVL's goal is to improve public transport services in local municipalities. The agency requires a design for the integration in which ridesharing is treated as an integral part of public transport. The ridesharing service should complement public transport in terms of both frequency and routes. There is no clearly defined goal for how many trips should be undertaken by ridesharing per year. It is important to stress that the public transport authority is not attempting to reduce the ownership of private cars by introducing the ridesharing service. In fact, it relies on private cars to achieve its goals.

In addition, the main reason for improving public transport in local municipalities is that the latter expect Taxito ridesharing to reduce outmigration to cities by making village life more attractive to the local population, especially young people. They also hope that the ridesharing service can promote local tourism. Day tourists are therefore considered to be another beneficiary group, apart from local people.

Selection of a suitable on-demand mobility service

As mentioned earlier, there are several ridesharing models in Switzerland currently. VVL has also evaluated other transport service models like regular buses, on-demand buses, collective taxis (*Anrufsammeltaxi*), etc. VVL chose Taxito ridesharing because it offers a low threshold for both riders and drivers using the service. Any rider who has access to a cell phone can use Taxito ridesharing, and it can be accessed by low-income population groups such as students. It costs just 75 pennies more than a single journey on a bus ride, so that Taxito ridesharing does not compete with public transport providers in terms of price. However, the price of a journey by ridesharing must be much cheaper than a taxi ride, which is CHF 3 per kilometer. Moreover, Taxito destination display boards by means of lights increases the ride's appeal to private car drivers, thus helping to reduce waiting times. Another added value of Taxito ridesharing is that can be available 24/7 by exploiting the spare capacities of individual motorized traffic.

Identification of a suitable neighborhood

To identify a suitable neighborhood in rural areas, VVL adopted a phased adoption approach. The agency considered the Taxito ridesharing scheme to be a new mobility solution, a kind of innovation. Using the phased adoption approach, the public transport authority expects decisions to be made in a transparent manner, the experience gained then being taken into account in taking further decisions. It first conducted an analysis to evaluate the suitability of the Taxito scheme by taking into consideration the quality of its transit accessibility, population densities and daily individual motorized traffic volumes (VVL, 2014). Based on the results of this analysis, Luthern, Willisau and Zell were selected for the pilot phase. The goal of the pilot phase was to test the system and probe acceptance among the local population, the local municipalities and the regional development agency, rather than gaining large numbers of riders. After receiving positive feedback from the municipal councils and the regional development agency, VVL decided to start the pilot phase.

Location of notice boards and destinations

The most important task in the pilot phase was to decide the location of the notice boards. There is general agreement among VVL, the municipalities and Taxito that the notice boards should be integrated into the local public transport network. The location must be identified on the basis of the quality of transit accessibility, that is, a poor public transport connection or none at all. A high daily individual motorized traffic frequency is another important criterion for location choice. The location must allow private car drivers to follow the road transport regulations, for instance, no prohibition on stopping and the necessary distance to crossroads. Ideally, individual motorized traffic should be sorted by direction of travel and connected to destinations requested by Taxito riders, thus contributing to more successful 'matching'.

At the same time, the location should not disturb the public transport service. The location should also have pedestrian crossings, so that riders have easy access to the notice boards. Furthermore, the location must guarantee certain security for riders (see Picture 1). During the pilot phase, the location of the notice boards must be adjusted to end-user demand. In principle, there should be one notice board for every municipality. However, if demand increases, additional notice boards can be installed. As a result, except in Willisau, where the notice board is located around 200 m from the railway station, in all other municipalities, they are located at the bus stop. Thanks to the rigorous criteria for the choice of notice board locations, until now no damage, accidents or assaults have been reported.

To install the notice boards, budget applications and an approval request had to be submitted to the municipalities to reconstruct the road space. Approval for the installation of the illuminated signboard had to be obtained from the cantonal road traffic authorities. At this stage, the municipalities were closely involved in the decision-making process because they had good knowledge of local conditions and understood the needs of their communities. They also provided infrastructure and budgets for the installation of the notice boards. The Taxito company supported the municipalities in determining the location of the notice boards and destinations. The company is in charge of maintenance and the provision of a replacement in the event of a defect.

Picture 1. Taxito board (Source: Keystone/Urs Flueeler).

Each Taxito point can connect to several destinations (see Fig. 7 below). Locations of destination are decided based on the following principles: using Taxito ridesharing as a means to overcome the first/last mile problem by transporting villagers in the municipalities to/from regional public transport hubs and as a means of direct connections with other villages in valleys to avoid indirect connections associated with local bus services (for instance Luthern Taxito point – Hergiswil). Destinations are therefore located near regional railway stations and/or in villages in the valleys.

Acceptance of local people

The success of the Taxito ridesharing scheme depends also strongly on the goodwill of individual car-drivers and the local people's willingness to use the service. The stakeholders therefore see local people as an important factor in the success of the integration of ridesharing with public transport. They decided that the municipalities should take responsibility for promoting public acceptance of the scheme. As 'insiders', they have direct access to the local population. However, as the municipalities had little experience in staging communication and awareness campaigns, Taxito worked closely with the municipalities in this activity. It provided the municipalities with communication equipment, for example, and supported them in organizing and holding marketing and communication events for the launch of the pilot phase.

A series of intensive communication and marketing activities were carried out to raise awareness and increase acceptance of Taxito ridesharing. Two weeks before launching the pilot phase, a flyer introduced the goal of Taxito's scheme and explaining how it works was sent to each household in the municipalities. Awareness events to introduce the concept and functions of ridesharing were held at local schools. Meanwhile, several media press events were organized at the invitation of representatives of local media agencies, like newspapers and television and radio programs before and at the launch of the pilot phase, at the opening of the first notice board and before the ending of the pilot phase. The launch of the pilot phase even received attention from national media agents. Meanwhile, the testimonies of local people as both drivers and riders were collected and used in communications and advertising concerning the ridesharing.

Participation in costs

As the contracting authority, VVL bore the costs of the initial analysis, the pilot phase, and the marketing and communication activities. It also pays for renting four Taxito notice boards (VVL, 2014). The municipality of Grossdietwil pays for the notice board itself. The municipality decided to join the Taxito ridesharing network having observed the good experience with it in the neighborhood.

The municipalities finance the installation of notice boards and provide solar panels for them. The Taxito company makes its revenue by renting out the notice boards and by charging 0.1 CHF per ride. The remainder of a charge per ride goes to a telecom company and the registered driver or, if the charge is waived, to VVL. This suggests that the Taxito company makes a very low profit, but it still provides the ridesharing service because it sees itself as a social entrepreneur promoting an environmentally friendly mobility solution that contributes to the attractiveness of village life.

To find out whether the Taxito ridesharing solution is a cost-effective solution or not, we calculated the total costs of the entire ridesharing scheme and the cost per ride, based on the costs provided by the interviewees. The rent for one notice board is 5988 CHF in the first year and 3950 CHF for each of the following two years. The installation of one notice board costs 4450 CHF. In total, in the first three years and for all five notice boards, the entire Taxito ridesharing service will cost 91,690 CHF. The costs of planning and obtaining approval of the locations is not included because it is too complicated to estimate the human resource costs of local authorities.

Fig. 2 shows the development of the costs per ride and the total costs of the service. In the first three years, the ridesharing service is

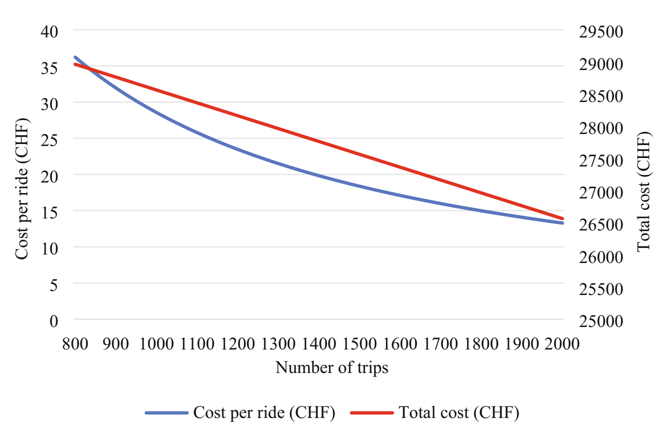

Fig. 2. Cost of Taxito ridesharing service.

shown as being used by an average of 708 passengers a year, without the Grossdietwill notice board. By adding 180 passengers who would use the Grossdietwill notice board, we arrive at a total of 888 passengers using the ridesharing service per year. The total cost (fixed costs minus fare) per ride is around 32 CHF. That is a high amount. However, the total cost would be reduced over time if the number of passengers remained stable or increased. Nevertheless, the total cost of the Taxito ridesharing service is still much lower than a single regular bus line that runs five times a day and would cost 1 million CHF per year to run in rural areas, with just 30% of the cost being covered by the fare.

Collecting the fare of 2 CHF per ride is actually expensive due to the high roaming cost charged by telecom providers. However, VVL does not want to provide a free-of-charge ridesharing service. Beside competition avoidance, appreciation is another reason to charge a fare: the fact that the ride costs the rider something establishes a contractual relationship between the driver and the rider. Ridesharing trips should not be perceived as 'charity' work, according to the contracting authority.

Challenges and weaknesses

Optimization of the ridesharing service in regular operation has proved to be a big challenge. For example, the location of the notice board in Willisau is not considered suitable because potential riders have to walk some distance away from the center of the municipality to get to the notice board. However, it has not been moved somewhere better, mainly because no clear responsibly for doing so was established after the pilot phase. Furthermore, the number of notice boards are viewed by the Taxito company as requiring expansion. The introduction of more notice boards would increase ridesharing use. The authorities agree on this point, but they have other priorities than pursuing this goal. One reason for the reluctance to expand is that ridesharing could become a competitor to local public transport operators.

The Taxito company itself speaks of a relative high level of acceptance and sensitization of the local population to the relevance of ridesharing. However, it is difficult to maintain the acceptance and willingness of drivers to take part. The basic belief that 'Taxito brings something to our region – we participate' (Taxito founder) must be regularly communicated to the public. While Taxito is relatively well known in very remote areas in those municipalities without public transport services, drivers in regional centers (where regional railway stations are located) hardly know anything about Taxito's ridesharing scheme. Since the completion of the pilot phase, no institution has been made responsible for marketing the scheme. There is no service mandate for this, and accordingly no responsibility and budget. Nonetheless, except in the Luthern municipality, which is affected by outmigration, awareness activity is still somehow carried out at a certain level.

Since Taxito is not integrated into public transport's central communication channels (timetable and ticketing channels), there is an acute danger of the service being neglected. During the Covid19 lockdown, Taxito was banned from operating. However, this information was not shown on the notice boards. Riders did not receive any information via mobile phones. Only by visiting the website of the Taxito company could they access to this information. Therefore, the interviewees agree that communication and marketing activities should be implemented after the pilot phase in order to maintain local people's participation in Taxito's ridesharing scheme, especially in the regional centers.

While Taxito sees simplicity of use as a central and unique selling point, the municipality finds it rather complicated. Because the rider has to enter a message code to activate the notice board and send the vehicle's number plate.

Satisfaction with ridesharing

Despite the above challenges and weaknesses, VVL is satisfied with the outcome. The contracting authority views a low but constant number of trips, given the sparsely populated area and low level of marketing effort, as positive. Even though the municipalities agree on this, there is nonetheless some skepticism. One municipal councilor reported that he has never seen anyone at a bus stop and accordingly has never taken anyone with him. There is even a certain distrust of the statistics because, 'if it were needed, you would have seen people?' As our descriptive results below show, local people do use the ridesharing service, but only at a modest level. Tourists seem to use the service more often. Taxito ridesharing can probably be seen as an enhancement of tourist provision in the municipalities.

VVL is also satisfied that the Taxito ridesharing service does not compete with local public transport once it has been in operation for longer. Instead, it increases the modal split in local bus services in the third year of the ridesharing operation, though at a very modest rate (VVL, 2017). As the notice boards are at bus stops, it sometimes happens that riders take the bus while waiting to be picked up by the ridesharing service if a bus arrives beforehand.

The use of Taxito ridesharing

During the period from June 2015 to March 2020, 3562 trips were made using Taxito ridesharing. Of 2215 trips travelled from 2015 to 2018, only 99 were made by registered riders and only 36 by registered drivers. Of 302 recorded trips containing confirmation messages, 85 trips only had information using the words 'OK', 'good', 'go' or 'car'. The remaining 217 trips were undertaken by local drivers (61%), drivers from neighboring cantons (17%), drivers from foreign countries (15%) and buses (7%).

As can be seen in Fig. 3, the number of trips fluctuates overtime, reaching a peak in the second year. This could be due to the effects of the marketing campaign at the end of the pilot phase in which awareness of Taxito ridesharing was widespread in the local municipalities and nearby neighborhoods. For the last ten months of operations (June 2019–March 2020), seven hundred trips were made, roughly as many trips as in each of the two previous years. This increase in demand may suggest that Taxito ridesharing has become an established name and aspect of local public transport services.

On average, riders have to wait less than four minutes to be transported. This is a very short waiting time when compared to the low frequency of public transport services. The waiting time is expected to decline still further in the first four years but to increase again in year five. There are some trips for which riders had to wait more than hour, usually late at night or early in the morning.

Fig. 4 shows that most trips are made between 15:00 and 19:00 and between 21:00 and 23:00. There is no great demand for ridesharing during the morning rush hour. This is because local buses have more

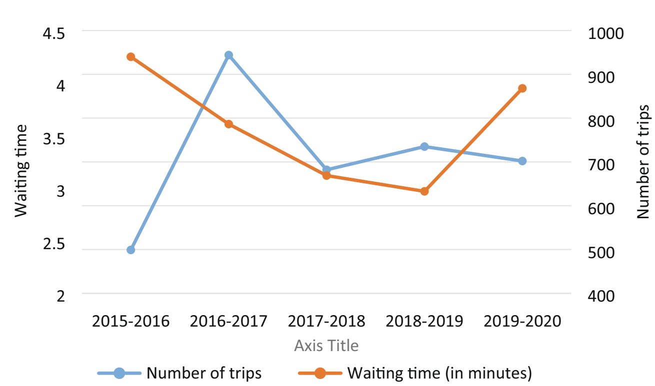

Fig. 3. Number of trips and waiting time.

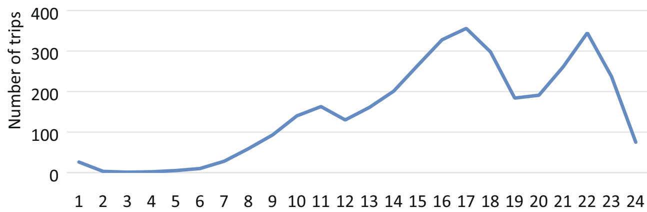

Fig. 4. Daily time travel.

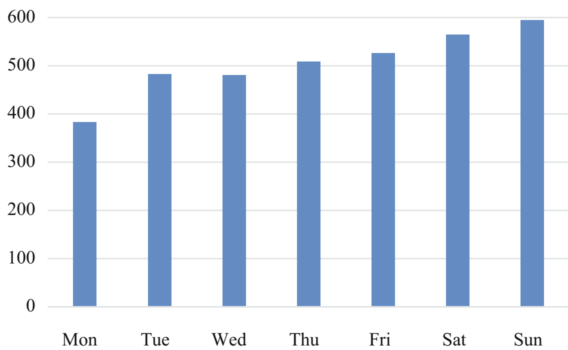

Fig. 5. Distribution of trips throughout the week.

frequent services at rush hours. It seems that riders use Taxito ridesharing at night hours mainly for non-work-related trips.

As shown in Fig. 5, the demand for Taxito's ridesharing scheme gradually increases throughout the week. The high demand at weekends may be because of the even lower frequencies of public transport services on Saturdays and Sundays.

Impact of the built environment on Taxito ridesharing use

Accessibility of notice boards and destinations

The notice board in Willisau is accessible to more than 2000 people living and over 1000 people working at a walking distance of 500 m (see Figs. 6a and 6b). Doubling the walking distance also doubled the population and number of employees with access to the notice board. Similar results were found in Zell. In both cases, notice board use is high, with 962 trips starting in Willisau and 1166 in Zell (see Table 3). However, a low level of population and employee accessibility to a notice board does not necessarily correlate with a low usage for that notice board. Of the five notice boards, that in Luthern Bad had the lowest population and number of employees in both of its catchment areas, but it had the second highest usage, with 1006 trips. The notice board in Luthern recorded 408 rides, less than Luthern Bad, despite its larger population and number of employees with access to it.

Regarding user demand for travel to different destinations, despite having both a high population and a high number of employees, Huttwil shows only a very low number of trips. A similar relationship can be found in Gettnau (see Table 3 below). This suggests that there is no direct correlation between the size of the population or the number of employees and the number of trips to a destination. The potential demand for travel to Luthern Bad, Hübeli and Hüswil can be considered low, taking into account the number of possible users reached. However, the actual level demand suggests the opposite: the numbers of recorded trips to these destinations are among the top five. This

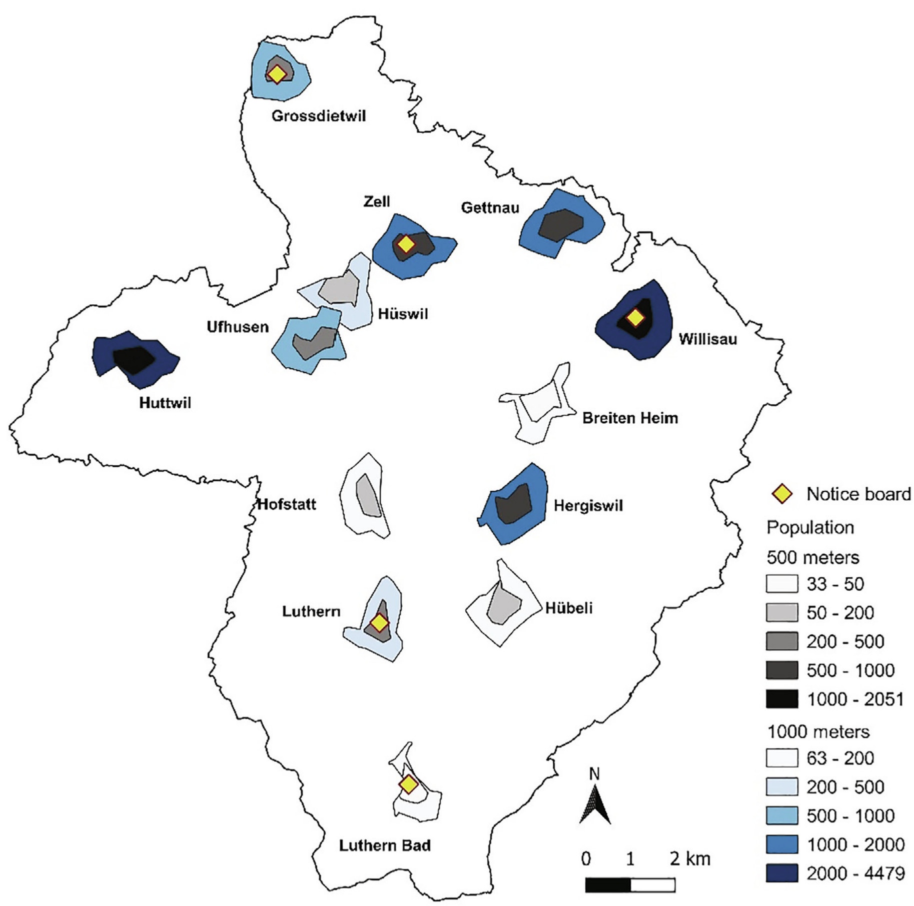

Fig. 6a. Population in catchment areas of 500 and 1000 m of notice board locations and of destination locations.

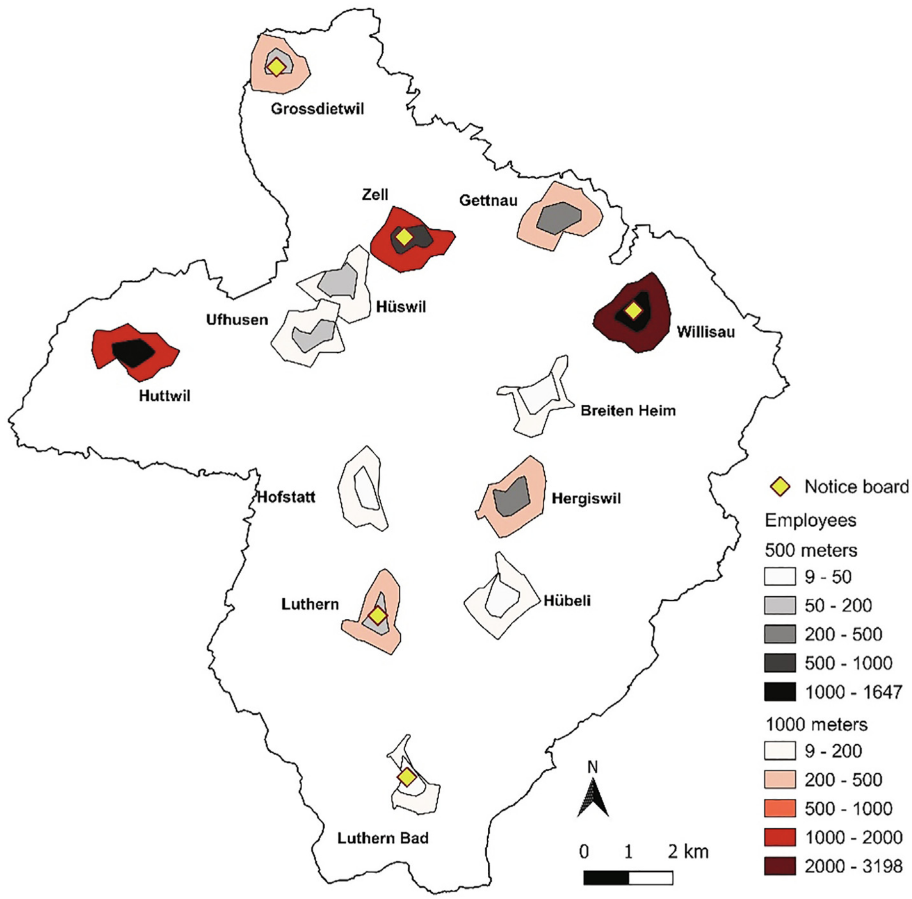

Fig. 6b. Employees in catchment areas of 500 and 1000 m of notice board locations and of destination locations.

Table 3
Land-use diversity at notice boards and destinations.

Destinations	Total trips from notice board	Total trips to destination	Shannon entropy H
Grossdietwil	20	857	0.90
Luthern	408	29	0.81
Willisau	962	42	0.90
Luthern Bad	1006	691	0.62
Zell	1166	334	0.90
Gettnau	–	5	0.70
Ufhusen	–	9	0.72
Hofstatt	–	26	0.36
Huttwil	–	76	0.84
Breiten, Heim	–	80	0.58
Hergiswil	–	134	0.88
Hübeli	–	309	0.39
Hüswil	–	970	0.64

comparison between population and number of employees within 500 and 1000 m and trips ending at destinations show no clear patterns.

Land-use diversity

As shown in Table 3, the notice board locations have a high diversity of land uses, except in Luthern Bad (Shannon entropy H = 0.62). Comparing the total trips departing from each notice board, no association between the land-use diversity index and the demand for Taxito ridesharing was found. A low level of land-use diversity does not imply low use of the notice board.

For the destinations, a similar unclear relationship between the number of trips and the land-use diversity index was observed. A higher land-use diversity index does not lead to a higher number of trips to a destination. For example, Willisau (Shannon entropy of H = 0.90) was found to be the final destination of only 42 trips, whereas Hüswil, with a relatively lower Shannon entropy (H = 0.64), is the most frequent destination in the entire Taxito network.

Daily individual motorized traffic and regional railway stations

Fig. 7 shows two highly used traffic flows in the ridesharing network in the neighborhood. The highest number of trips was observed between Zell and Grossdietwil (852 trips), followed by trips between Luthern Bad and Hüswil (770 trips).

Of the total of 27 possible connections between notice boards and destinations, seventeen connections recorded fewer than fifty trips. They are therefore considered connections of low demand. Of these seventeen low demand connections, six are between two railway stations. However, the presence of a regional railway station at either of the two ends of a connection (either near the notice board or at the destination) appears to be correlated with a higher number of trips in some cases. The destination of Hüswil, which has a railway station, was the most frequent destination (see Table 3). The number of trips from Luthern Bad to Hüswil and from Zell to Grossdietwil are the two most frequent connections in the ridesharing network. In both cases, the regional railway station is situated at the end of a traffic axis going out of the local valley.

As can also be seen in Fig. 7, the existence of a well-frequented route has a positive impact on the success of ride 'matching'. If a route

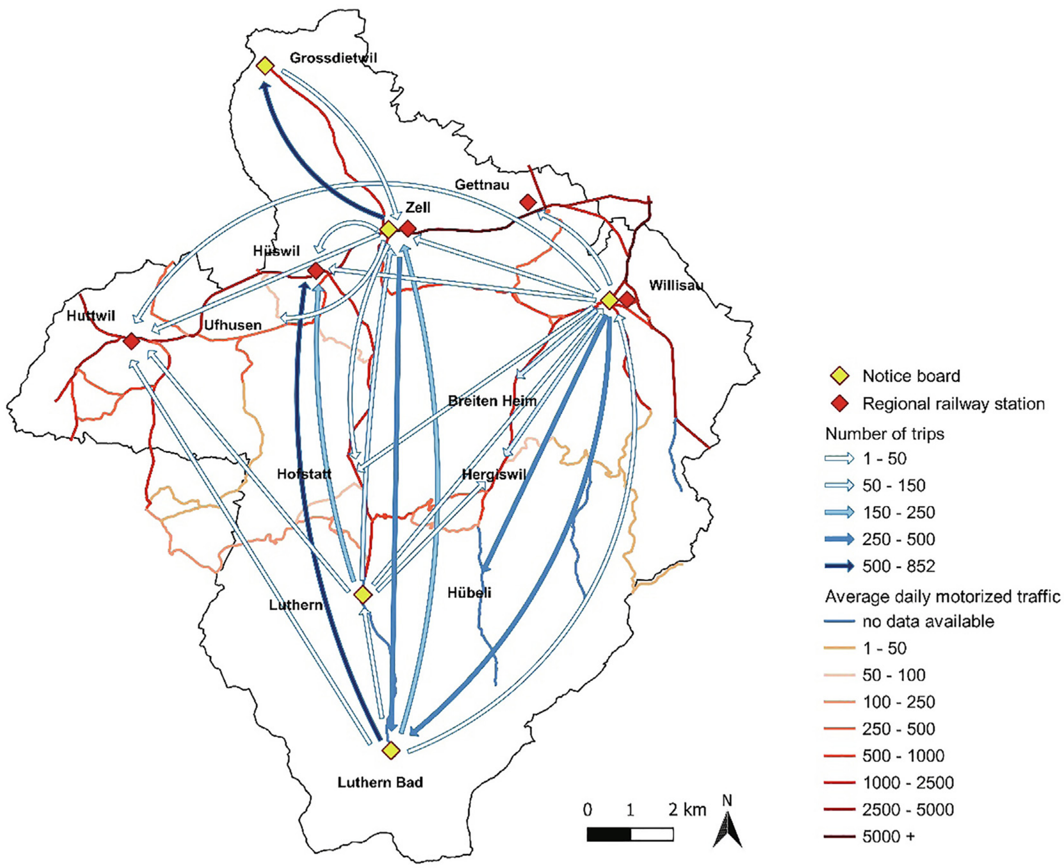

Fig. 7. User demand of traffic connections between notice boards and destinations in relation to locations of regional railway stations and average daily motorized traffic volume.

has a higher daily volume of motorized traffic, it has a tendency to have a higher number of ridesharing trips. For example, the routes from Luthern Bad to Hüswil and from Zell and Grossdietwil have average daily traffic volumes of between 2500 and 5000 cars and the highest number of ridesharing trips, from 500 to more than 850. Likewise, a low daily average traffic volume (below 500 cars/day) on the routes used by ridesharing, e.g. between Luthern and Huttwil, appears to have a low number of recorded ridesharing trips.

Discussion and conclusion

This paper has attempted to explore the practice and outcome of the integration of ridesharing with public transport in a rural context. The findings show the public transport authority carefully designing the integration with a view to complementing public transport with ridesharing. Three crucial approaches were adopted to achieve this goal. First, Taxito's ridesharing scheme was developed and implemented in a participatory way, with strong engagement by the municipalities and local populations concerned. The provision of information on the scheme before and during the pilot phase was carried out in a series of intensive communication and marketing activities to raise awareness of local people and to encourage their participation in Taxito's ridesharing.

Second, ridesharing notice boards are integrated into the local bus stop and railway station networks. This way of integrating ridesharing services with public transport systems can promote the usage of public transport services. Instead of continuing waiting for being transported by the ridesharing service, riders can take a bus trip if the bus arrives beforehand. Indeed, a slight increase in the ridership of local bus services has been observed. Further, the connection from ridesharing notice boards with regional railway stations can bring customers to railway operators, thus promoting rail use.

The third approach is the pricing strategies. The ridesharing ticket is slightly more expensive than the bus fare but much cheaper than taking a taxi. This pricing strategy can ensure that ridesharing does not replace public transport. Empirical evidence from the demand dataset shows that the public transport agency has achieved this goal. This explains why the authority is satisfied with a relatively low but stable use of ridesharing over time. Our findings support Murray et al.'s claim (2012) that for the public transport authorities, cost-effectiveness is less important in seeking integration with ridesharing. In the context of rural Switzerland, the goal of reducing outmigration to urban areas appears to have a higher priority. Furthermore, the low fare is used as a means to signify a contractual relationship between the rider and driver, thus contributing to the appreciation of a ridesharing ride as a service rather than as a kind of charity work.

Our findings suggest that public transport operators, particularly the railway operator, can expand their customer base thanks to the integration of their services with ridesharing. Therefore, local bus and railway operators should actively work with the ridesharing operator in extending a network of ridesharing notice boards and incorporating ridesharing into their central communication channels, for instance provide information on ridesharing services on display boards at regional stations. The public transport authority (VVL) could consider to include these operators in the ridesharing scheme. For the ridesharing operator, it should propose a budget plan for communication activities beyond the pilot phase so that it can communicate with its customers when major disturbances occur such as sending text messages to its customers or regularly hold awareness campaigns.

Two aspects arose on the basis of the findings of this study that should deserve further investigation. One is why the use of Taxito ridesharing rather low despite its advantages. Does this problem lie in the acceptance of local people? We therefore propose a hypothesis that implementing regular communication and marketing efforts in rural municipalities as well as in regional centers during the service life of a ridesharing scheme is likely to increase the participation of local people and potential drivers in ridesharing. Another interesting subject for future research is the impact of built environment on ridesharing demand. We hypothesize that in a rural context, traditional built environment factors such as population and employment densities and land-use diversity have no impacts on the demand of ridesharing whereas the location of regional public transport hubs do have an impact.

The main purpose of the mixed methods approach was used as complementarity to increase the scope of the inquiry, i.e., practice and outcomes of the integration of ridesharing with public transport systems, however, quantitative findings on the use of Taxito's ridesharing support results from qualitative interviews that Taxito's ridesharing scheme is a complement to public transport. This can be seen in a moderate number of ridesharing trips and more demand for ridesharing at weekends and late evenings when local bus operators reduce their services.

Studies on transportation policies are often in favor of quantitative methods such as modelling and macro-trends (Marsden and Reardon, 2017). However, new mobility solutions can involve a complexity of policy making in realities as shown in this present case of the integration of ridesharing services with public transport systems. A mixed methods approach therefore can grasp the complexity of how transportation policies get made and implemented at the local level.

The findings of this paper are based on an exploratory study. The impact between factors of the built environment and ridesharing use has been investigated purely by means of a spatial analysis. Regression models to confirm this impact could not be carried out due to the low level of observation of notice boards and their corresponding destinations. In addition, only three qualitative interviews were conducted with the involved stakeholders. Hence, any generalizations from our findings should take these data limitations into consideration. Nevertheless, the case-study approach described here can provide insightful findings into the integration of ridesharing with public transport in rural contexts, a still rather neglected area of research.

CRediT authorship contribution statement

Vu Thi Thao: Conceptualization, Formal analysis, Writing - original draft, Writing - review & editing. **Sebastian Imhof:** Methodology, Investigation, Visualization, Formal analysis, Writing - original draft. **Widar von Arx:** Methodology, Investigation, Formal analysis, Writing - original draft.

References

PostAuto provides rural and regional bus services throughout Switzerland.

The interviewee's identity was concealed at the interviewee's request.

From 17 March 2020 to 24 September 2020, the Taxito ridesharing scheme had to suspend its services due to prevention measures connected with Covid-19 pandemic. This was because the local authorities considered Taxito to be a public transport service.

ASTRA, 2018. Medienmitteilungen: 5,8 Millionen Menschen in der Schweiz haben das Auto-Permis (Press Release, 5.8 Millions people in Switzerland's own driving licence).

Benz, H., Kepper, J., 2019. Das Untersuchungsbeispiel Mobilfalt [The Investigation Example Mobilfalt]. In: Daskalakis, M., Sommer, C., Rossnagel, A., Kepper, J. (Eds.), Ländliche Mobiliät Vernetzen: Ridesharing Im Ländlichen Raum Und Dessen Integration in Den Öffentlichen Nahverkehr [Connecting Rural Mobility: Ridesharing in Rural Areas and Its Integration in Regional Public Transportation]. OEKOM, Munich, pp. 66–85.

Brown, A.E., 2020. Who and where rideshares? Rideshare travel and use in Los Angeles. Transp. Res. Part A Policy Pract. 136, 120–134. https://doi.org/10.1016/j.tra.2020.04.001.

Chan, N.D., Shaheen, S.A., 2012. Ridesharing in North America: past, present, and future. Transp. Rev. 32, 93–112. https://doi.org/10.1080/01441647.2011.621557.

Chen, C., Achtari, G., Majkut, K., Sheu, J.B., 2017. Balancing equity and cost in rural transportation management with multi-objective utility analysis and data envelopment analysis: A case of Quinte West. Transp. Res. Part A Policy Pract. 95, 148–165. https://doi.org/10.1016/j.tra.2016.10.015.

Clewlow, R.R., Mishra, G.S., 2017. Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States. Institute of Transportation Studies. Universitiy of California.

Contreras, S.D., Paz, A., 2018. The effects of ride-hailing companies on the taxicab industry in Las Vegas, Nevada. Transp. Res. Part A Policy Pract. 115, 63–70. https://doi.org/10.1016/j.tra.2017.11.008.

Docherty, I., Marsden, G., Anable, J., 2018. The governance of smart mobility. Transp. Res. Part A Policy Pract. 115, 114–125. https://doi.org/10.1016/j.tra.2017.09.012.

FOSD (Federal Office for Spatial Development), 2020. Web-GIS ARE. https://map.geo.admin.ch/?lang = de&topic = are&catalogNodes = 954,959,965&bgLayer = ch.swisstopo.pixelkarte-grau.

FOSD (Federal Office for Spatial Development), 2017. Verkehrsmodellierung im UVEK (Traffic modulation in the DETEC - own translation). https://doi.org/10.5281/zenodo.3251588.

Franco, P., Johnston, R., McCormick, E., 2019. Demand responsive transport: Generation of activity patterns from mobile phone network data to support the operation of new mobility services. Transp. Res. Part A Policy Pract. 131, 244–266. https://doi.org/10.1016/j.tra.2019.09.038.

FSO (Federal Statistic Office), 2017. Mikrozensus Mobilität und Verkehr 2015 (Microcensus Mobility and Transport 2015 - Own translation).

FSO (Federal Statistic Office), 2014. Areas with urban character 2012: Explanatory report.

FSO (Federal Statistical Office), 2018a. Statpop (Version 1.10) [Dataset]. https://www.bfs.admin.ch/bfs/en/home/services/geostat/swiss-federal-statistics-geodata.html.

FSO (Federal Statistical Office), 2018b. Statent (Version 1.4) [Dataset]. https://www.bfs.admin.ch/bfs/en/home/services/geostat/swiss-federal-statistics-geodata.html.

Gray, D., Farrington, J., Shaw, J., Martin, S., Roberts, D., 2001. Car dependence in rural Scotland: Transport policy, devolution and the impact of the fuel duty escalator. J. Rural Stud. 17, 113–125. https://doi.org/10.1016/S0743-0167(00)00035-8.

Hall, J.D., Palsson, C., Price, J., 2018. Is Uber a substitute or complement for public transit? J. Urban Econ. 108, 36–50. https://doi.org/10.1016/j.jue.2018.09.003.

Henao, A., Marshall, W.E., 2018. The impact of ride-hailing on vehicle miles traveled. Transportation (Amst). 1–22. https://doi.org/10.1007/s11116-018-9923-2.

Hofmann, D., Daskalakis, M., 2019. Ridesharing im ländlichen Raum [Ridesharing in rural areas]. In: Daskalakis, M., Sommer, C., Rossnagel, A., Kepper, J. (Eds.), Ländliche Mobiliät Vernetzen: Ridesharing Im Ländlichen Raum Und Dessen Integration in Den Öffentlichen Nahverkehr [Connecting Rural Mobility: Ridesharing in Rural Areas and Its Integration in Regional Public Transportation]. OEKOM, Munich, pp. 40–50.

Joseph, R., 2018. Ride-Sharing Services: The Tumultuous Tale of the Rural Urban Divide, in: Twenty-Fourth Americas Conference on Information Systems. New Orleans.

Kong, H., Zhang, X., Zhao, J., 2020. How does ridesourcing substitute for public transit? A geospatial perspective in Chengdu. China. J. Transp. Geogr. 86,. https://doi.org/10.1016/j.jtrangeo.2020.102769 102769.

Krämer, P., Weiss, A., 2019. Vernetzung aller Mobilitätsangebote: der Odenwald in der digitalen Welt der "On-Demand-Mobilität" [Connections of all mobility services: Odenwald in the digital world of "on-demand mobility"]. Der Nahverkehr 1 + 2, 52–57.

Marsden, G., Reardon, L., 2017. Questions of governance: Rethinking the study of transportation policy. Transp. Res. Part A Policy Pract. 101, 238–251. https://doi.org/10.1016/j.tra.2017.05.008.

Malalgoda, N., Lim, S.H., 2019. Do transportation network companies reduce public transit use in the U.S.?. Transp. Res. Part A Policy Pract. 130, 351–372. https://doi.org/10.1016/j.tra.2019.09.051.

Feigon, S., Murphy, C., 2016. Shared mobility and the transformation of public transit. Transit Cooperative Research Program, research report 188. Chicago.

Murray, G., Chase, M., Kim, E., McBrayer, M., 2012. Ridesharing as a Complement to Transit: A Synthesis of Transit Practice. Washington DC.

Nutley, S., 2003. Indicators of transport and accessibility problems in rural Australia. J. Transp. Geogr. 11, 55–71. https://doi.org/10.1016/S0966-6923(02)00052-2.

Openrouteservice, 2020. API interactive examples: Pois service. https://openrouteservice.org/dev/#/api-docs/pois/post.

Petersen, T., 2016. Watching the Swiss: A network approach to rural and exurban public transport. Transp. Policy 52, 175–185. https://doi.org/10.1016/j.tranpol.2016.07.012.

Petersen, T., 2012. Public Transport for Exurban Settlements. The University of Melbourne.

Reck, D.J., Axhausen, K.W., 2019. Ridesourcing for the first/last mile: How do transfer penalties impact travel time savings? International Scientific Conference on Mobility and Transport (mobil.TUM 2019) Conference Proceedings. https://doi.org/10.3929/ethz-b-000342106.

Salemink, K., Strijker, D., Bosworth, G., 2017. Rural development in the digital age: A systematic literature review on unequal ICT availability, adoption, and use in rural areas. J. Rural Stud. 54, 360–371. https://doi.org/10.1016/j.jrurstud.2015.09.001.

SBB (Swiss Federal Railways), 2020. DiDok. https://opendata.swiss/de/dataset/didok

Shannon, C.E., 1948. A mathematical theory of communication. Bell Syst. Tech. J. 27, 379–423. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x.

Srinivasan, R., 2019. Disrupting jobs and lives, in: Beyond the Valley: How Innovators around the World Are Overcoming Inequality. MIT Press, Cambridge, MA, pp. 113–124.

Stiglic, M., Agatz, N., Savelsbergh, M., Gradisar, M., 2018. Enhancing urban mobility: Integrating ride-sharing and public transit. Comput. Oper. Res. 90, 12–21. https://doi.org/10.1016/j.cor.2017.08.016.

Thao, V.T., Ohnmacht, T., 2019. The impact of the built environment on travel behavior: The Swiss experience based on two National Travel Surveys. Res. Transp. Bus. Manag. 100386. https://doi.org/10.1016/j.rtbm.2019.100386.

VVL, 2014. Taxito: Öffentlicher Individualverkehr. Technischer Bericht Phase 1. (Taxito - Public individual traffic. Technical report phase 1- Own translation).

VVL, 2017. Schlussbericht Pilotphase 2015-2017 Taxito: öffentlicher Individualverkehr (Final Report of pilot phase 2015-2017: Taxito as public individual transport - Own translation).

Yu, H., Peng, Z.R., 2019. Exploring the spatial variation of ridesourcing demand and its relationship to built environment and socioeconomic factors with the geographically weighted Poisson regression. J. Transp. Geogr. 75, 147–163. https://doi.org/10.1016/j.jtrangeo.2019.01.004.