Computer Supported Cooperative Work (CSCW) (2021) 30:539–587
https://doi.org/10.1007/s10606-021-09408-1

RESEARCH ARTICLE

The Automation of the Taxi Industry – Taxi Drivers' Expectations and Attitudes Towards the Future of their Work

Christina Pakusch[1,2]*, Alexander Boden[2], Martin Stein[3] & Gunnar Stevens[1]
*[1]*University of Siegen, Siegen , Germany (E-mail: christina.pakusch@uni-siegen.de; E-mail: gunnar.stevens@uni-siegen.de);* [2]*Bonn-Rhein-Sieg University of Applied Sciences, Sankt Augustin , Germany (E-mail: christina.pakusch@uni-siegen.de; E-mail: alexander.boden@h-brs.de);* [3]*Fraunhofer-Institute for Applied Information Technology FIT, Sankt Augustin , Germany (E-mail: Martin.stein@fit.fraunhofer.de)*

Accepted: 5 July 2021

Abstract. Advocates of autonomous driving predict that the occupation of taxi driver could be made obsolete by shared autonomous vehicles (SAV) in the long term. Conducting interviews with German taxi drivers, we investigate how they perceive the changes caused by advancing automation for the future of their business. Our study contributes insights into how the work of taxi drivers could change given the advent of autonomous driving: While the task of driving could be taken over by SAVs for standard trips, taxi drivers are certain that other areas of their work such as providing supplementary services and assistance to passengers would constitute a limit to such forms of automation, but probably involving a shifting role for the taxi drivers, one which focuses on the sociality of the work. Our findings illustrate how taxi drivers see the future of their work, suggesting design implications for tools that take various forms of assistance into account, and demonstrating how important it is to consider taxi drivers in the co-design of future taxis and SAV services.

Key Words: Autonomous vehicles, E-hailing, Shared autonomous vehicles, Taxi app, Taxi driver, TNC

1. Introduction

Digitization and automation have caused radical and disruptive change for many industries, some products to become extinct, and thousands of jobs to disappear (Arntz et al., 2016; Ford 2015; Frey and Osborne 2017). If workplaces are digitized and tasks are increasingly automated, occupations can change dramatically or become obsolete (Autor 2015). Emerging trends in the transportation sector, such as advances in autonomous driving expose professional drivers such as taxi drivers, train and bus drivers, truckers, parcel deliverymen, and many more to this risk

(Pakusch et al., 2016). In a worst case scenario, taxi drivers' jobs could disappear completely. Experts see shared autonomous vehicles (SAV) as having the potential to replace traditional taxis (Davidson and Spinoulas 2015; Litman 2017) as these are expected to provide the same service at reasonable cost (Burns 2013; Fagnant and Kockelman 2015; Fagnant et al., 2015). While members of the taxi industry are certain that 'the profession of taxi driver will not disappear, but will redefine itself' (Mönch 2018), many researchers believe that 'there will be no more employment for taxi drivers'(Alessandrini et al., 2015; Chou 2017; Madrigal 2018; Walker and Marchau 2017). There is a significant strand of European CSCW research which aims to promote democracy at the workplace (Harmon and Silberman 2019), and aims for close cooperation with workers and trade unionists in pursuit of design objectives which support it. This study positions itself in that tradition, by addressing and including taxi drivers as those potentially affected by the radical transformation of the taxi industry.

The taxi business has already been put under pressure by gig economy models such as the spread of transportation services such as Uber or Lyft that are facilitated by mobile technologies (Barro 2014; Taschler 2015). The emergence of these new transportation network companies (TNC) highlights how working conditions might be subject to substantial change, forcing the drivers to adapt their working practices accordingly (Chen 2018a; Zade and O'Neill 2016). SAVs would have an even greater impact on the need for human drivers, potentially rendering their work obsolete and changing transportation services to an even larger extent. Looking at the uptake of these disruptive services allows us to better understand the potential of new ICT-based services, as well as their impact on existing practices and traditional organizational structures. By understanding how the profession of taxi drivers adapted to recent innovations, such as Uber, we can better anticipate how they will adapt to emerging innovations such as SAVs.

In this study, therefore, we want to analyze how technology has recently changed existing work practices in the taxi business in order to draw conclusions for the future impact of SAVs on the industry. We do so, by looking at the case of Germany, where Uber struggles to succeed in the market on a sustainable basis. By comparing our case to studies carried out in other countries such as the US (Lutz et al., 2018; Ma, Yuan, Ghafurian, and Hanrahan 2018; Raval and Dourish 2016), UK/US (Glöss et al., 2016), China (Chen 2018b) or India (Zade and O'Neill 2016), we can better understand how contextual factors influence the uptake of innovations, the acceptance of new technologies and how they influence the profession of taxi drivers.

Our approach is in line with the turn to practice within Human Computer Interaction (HCI), recently reinvigorated by Kuutti and Bannon (2014), and which reminds us that successful system design may need to take into account various contextual factors instead of merely focusing on the interaction between individual user and system. These contextual factors depend on, and are constructed in, practices which are routinely carried out in situ. Here, 'interaction is no longer at the center, but is one aspect among many, serving its specific part in the performance'

(Kuutti and Bannon 2014 p. 3549). Following this approach, we consider it necessary to involve affected stakeholders in the research to find out how roles might change, in this case those of taxi drivers. A number of studies have investigated TNC drivers (see 2.3), we focus on traditional taxi drivers whose clientele substantially differs from Uber drivers, for instance, and thus serving slightly different needs.

Thus, we contribute to the existing literature in three ways: First, by analyzing why otherwise successful disruptions failed in Germany, we provide a complementary study to those investigating the impact of these disruptions in other countries. Second, by analyzing the specific practices of traditional taxi drivers and their situated practices, we highlight current changes that illustrate the possible effect of further automation on their work, allowing us to derive design implications for HCI researchers and third, we build on prior work by reflecting on the potential of SAVs given the backdrop of the existing practices of taxi drivers. The study also shows that a human centric computing perspective can be a resource for practitioners' activities and for current policy debates on 'the future of work'and can act as an impulse for policy, practice and public discourse (Harmon and Silberman 2019).

Our study is based on 19 semi-structured interviews with German taxi drivers. The interviews centered on their work practices, experiences with current technologies such as e-hailing and ridesharing apps, as well as their attitudes towards possible future developments such as SAVs. Our analysis provided a rich picture of how emerging technologies affect their work, and how they adapt to changes in their infrastructure, as well as how they take advantage of new technologies and adapt to potential threats.

2. Background and related work

2.1. The German taxi industry

By addressing opportunity-based mobility, taxis are still an important part of modern public transportation (Gwilliam 2005). In Germany, most taxi customers use cabs for getting from and to parties or events (59%), for getting from or to airports and train stations (11%), for medical reasons (10%), when other private or public transportation is not available (7%), or for journeys with a transport of goods or objects (2%) (IFAK 2014). Taxis thus provide mobility especially in situations where customers cannot or do not want to drive themselves, or where no alternative modes of transportation are available for a one-way journey (Davidson and Spinoulas 2016). A study among taxi customers showed that 77% of taxi trips happen in situations where no other adequate means of transportation are available (IFAK 2014).

To understand the attitudes and perspectives of taxi drivers, it is important to consider the context of the German taxi industry, which is quite distinct from the situation in the USA, for example (EU Commission 2016). In 2018, there were around 21,700 German taxi companies, operating around 53,000 taxis, and generating sales of 5.3 billion euros (Bundesverband Taxi und Mietwagen e.V. 2019). As in

other countries such as Norway, or cities such as New York, too, the German taxi market is strictly regulated by federal laws and regional restrictions. Regulation relates to quantity and service, as well as price regulation and regulation of the industry structure. To be allowed to establish a taxi company, entrepreneurs must apply for a "Taxikonzession" (in the following referred to as taxi concession), a license that is similar to American taxi medallions, and is intended to regulate the quantity of taxi companies. However, applicants often wait 20 years or longer until they get a taxi concession (i.e. interviewee T06). The approval of a taxi concession is linked to the fulfilment of various admission criteria, which can be classified into subjective (guarantee of the safety and capability of the business, the reliability of the applicant as well as his or her professional background) and objective criteria (viability of the local taxi industry with regard to transport orders in taxi traffic, taxi density, development of the revenue and cost situation). Taxi drivers must hold a passenger transportation license without which she or he is not allowed to transport people commercially.

Traditionally, three main parties are involved in the taxi service: the customers, the taxi drivers and the taxi dispatchers. The taxi dispatchers take over the organization of the taxi ride in their role as intermediaries. Their main task is to optimize taxi availability and customer requests and to broker trips. Other core functions of the taxi dispatchers are administration (e.g. accounting) and representative duties (representation of taxi drivers vis-à-vis institutions). Currently, 80% of taxi drivers are members of regional taxi dispatch services (Deutscher Taxi- und Mietwagenverband e.V. 2016). Most of the taxi companies are additionally organized in the German taxi association BZP (Bundes-Zentralverband Personenverkehr – Taxi und Mietwagen). This institution represents the interests of taxi companies and has repeatedly lodged complaints against different TNCs, putting pressure on the European Court of Justice to reach a decision. However, membership is not mandatory.

The taxi driver is responsible for all executive activities: first and foremost, driving, meaning the execution of the trip but also the route planning, which is why prospective German taxi drivers still have to prove their knowledge of their district by exams. Routing is the first activity that has changed as a result of digitization and has increasingly been carried out by technology in the form of GPS navigation. As most taxi drivers today make use of GPS-supported routing, many consider a mandatory local knowledge exam to be outdated (Cassel and Thomas 2017). The taxi drivers themselves, however, usually consider their knowledge as superior to GPS routing (Girardin and Blat 2010).

2.2. Uber's struggle to gain a foothold on the German market

The entry of UberPop into the German market in October 2014 provoked great resistance from taxi drivers and taxi associations. As in many other countries, action has been brought against the authorization of such transport services (Fleisher 2014). Plaintiffs relied on the strict regulation of the taxi industry to which every lawfully

operating taxi driver is subject. On March 18, 2015, the service was declared anti-competitive by the Frankfurt Regional Court, as Uber drivers were driving without a taxi concession and a passenger transportation license. Even so, because fares regularly exceeded the operating costs of the trips (Bundesgerichtshof (BGH) 2015) (which implies that there is an intention to make a profit and that there is no pure cost sharing between peers). On December 20, 2017 the European Court of Justice (ECJ) ruled that Uber corresponds to a transport service and must be regulated accordingly and thus cannot operate legally with its current business model. Uber reacted to this decision and is now offering UberX in several German cities since May 2019, with a business model with professional drivers that corresponds to the German model of *hired cars with drivers*. Like taxi drivers, these drivers require a passenger transportation license, whereas the companies do not need a taxi concession, making it easier to start a business. However, this service can only take requests at the company's registered office and must immediately return to its registered office after finishing a ride. Thus, hired cars with drivers are neither allowed to be hailed at the side of the road nor to wait for customers at attractive places like airports or train stations, and customers may only book the service via the office. As the Uber App directly matches drivers and customers, the Regional Court of Cologne issued a temporary injunction on July 19, 2019, stating that it is no longer permitted to broker rides via app in Germany. So far, Uber has ignored this ban and continues to offer its service. For an even more detailed comparison of the regulation between taxi and Uber in different countries we refer to (Rienstra et al., 2015) and (OECD 2018).

Contrastively, taxi apps – apps that broker rides with professional taxi drivers of existing taxi business holding a taxi concession – are becoming increasingly popular in Germany, 11.5% of all taxis were ordered via app in 2017 (Statista 2018). The clientele of both TNCs and taxi apps is considerably different from that of traditional taxis: While the average Uber passenger is 32.7 years old with 0.3% being 70 years or older, the average taxi passenger is 47.6 years, with 11.4% being 70 years or older (Young and Farber 2019).

2.3. ICT-based innovations in the taxi industry

E-hailing apps which broker trips with licensed taxi companies are becoming increasingly popular in Germany. Across Europe, over 100,000 taxis can be booked via at least one taxi app (Statista 2018). Offering similar functions to those of TNC apps, e-hailing apps enable professionally employed or self-employed taxi drivers to take over the most important function of taxi dispatchers – the brokerage of rides (Haucap et al., 2017). Customers and taxi drivers can get in touch directly and arrange a trip, instead of going through a classic taxi dispatcher. Recent studies have analyzed how conventional taxi drivers reacted to the advent of e-hailing apps. One study showed that the Ola app has changed existing practices and consequently limited the flexibility and autonomy of auto rickshaw drivers in India while at the same time the use of the Ola app had increased earnings or reduced the number of

working hours only marginally (Ahmed et al., 2016). Similarly, taxi drivers in China who had installed Didi or other taxi-hailing apps, reported a significant decline in their income and an intensification of work stress (Chen 2018b).

While there are relatively few studies that focus on traditional taxi drivers who switched to or adopted e-hailing apps, most of the studies are dedicated to TNC drivers. The aforementioned business models of the TNCs Uber or Lyft are attributed to the so-called gig economy. The gig-economy is 'the sub-form of the platform economy, in which personal contact between client and contractor takes place' (Konrad-Adenauer-Stiftung e. V. 2019). By flexibly matching peers, the digital platform business models are disrupting their respective industries (McGregor et al., 2015) and can replace traditional forms of businesses.

HCI and CSCW Researchers have analyzed how digitally mediated TNC platforms coordinate and organize work, how they influence drivers and how drivers react to their digital 'principals'(Chen 2018b; Marquis et al., 2018; Peticca-Harris et al., 2020). The impact of Uber's algorithm-controlled price system has been the topic of recent research investigating how surge pricing affects workers and consumers (Cachon et al., 2017; Chen and Sheldon 2016). Others have analyzed the drivers' position in relation to earnings, autonomy, and satisfaction (Kim et al., 2018; Ma et al., 2018).

The results of the following studies are of particular interest for our study: Recent work has investigated the motivation to become a Uber driver in India, showing that drivers hope for better lives and respect in their social spheres (Prabhat et al., 2019). Most Uber drivers in India, unlike drivers in the developed Western countries, face the challenge of having to buy their own vehicle first in order to participate in the service. In the study by Peticca-Harris et al. (2020), former and active professional taxi drivers from Canada were interviewed regarding their motivations for switching completely to Uber or using Uber as a supplement to traditional taxis. Results revealed that they worked for Uber to keep up with the changing landscape and mitigate the impact of the high weekly rental fees charged by traditional taxi companies. They considered the increased independence from taxi companies and taxi stands, as well as greater flexibility in working hours, to be a positive.

It is difficult for drivers to unite and assert their interests against the Uber corporation (Alkhatib et al., 2017). Addressing uneven power between gig workers and platforms, some studies have analyzed workers' rights in more detail and shown how workers' rights might be strengthened (De Stefano 2015; Stewart and Stanford 2017). Much work has been done on the pressure that rating systems put on ridesharing drivers, investigating how the strong pressure of the ratings influences the behavior of the drivers and the design of the service (Anderson 2016; Chan 2019; Glöss et al., 2016; Raval and Dourish 2016). Focusing on the high service orientation and how the ridesharing drivers respond to the platforms' rating systems, Glöss et al. (2016) outlined, by interviewing US-American and British Uber drivers, how important new tasks and skills such as empathy and emotional labor in general have come to the fore. In the same way, Raval and Dourish (2016) and Anderson (2016)

have shown how ridesharing drivers try to create a personalized and pleasurable experience for their passengers always having the pressure of the 5star rating system in mind.

2.4. Future technological impacts – shared autonomous vehicles

Gig economy experts Lieber and Puente forecast the end of the gig economy, as understood at present, for low-skilled, commercialized workers, at least as they are currently to be found in the logistics and transport sector:

> 'In the past few years, analysts and reporters have obsessively focused on transportation technology platforms such as Uber and Lyft and delivery technology platforms such as Instacart and the workers needed for these on-demand services. […] these tasks are overwhelmingly likely to be automated over time, performed by selfdriving cars and drones.' (Lieber and Puente 2016)

Other experts go a step further and argue that platform operators are instrumentalizing the gig workers to automate their services. Michael Osborne argues that Uber and Lyft can feed their algorithms with the journey data collected on user demand, traffic and road conditions until the computers are finally smart enough to perform the complete driving task without human intervention (Taylor 2016). In this respect, the era of the human gig worker is seen as a transitional phase for the automated execution of services. Taking up this issue, we contribute to a better understanding of how future technology could change work in the taxi industry. In this respect, we also contribute to the existing literature on the gig economy by analyzing the future of gig work against the background of self-driving technology. In doing so, we expand the scope of previous literature which focuses primarily on current developments and technologies.

Three forms of autonomous driving are conceivable and are currently in different development and test stages: autonomous public transport, private autonomous vehicles, and shared autonomous vehicles (Pakusch 2020; Pettigrew et al., 2018). The first two variants represent further developments of established means of transport. Autonomous driving in the form of autonomous buses, autonomous trains, or automated shuttle buses enriches public transportation. Meanwhile, there is the concept of SAVs, which is the most disruptive of the three and which represents not only a technical innovation (automation), but also a social innovation (sharing). As such, it represents a passenger-centric concept (Stevens et al., 2016). SAVs are thus understood as fully automated vehicles that can be hailed via an app, drive to the passenger to pick him or her up, and chauffeur him or her to the desired destination without the user having to bear the burden of ownership (Fagnant and Kockelman 2014). Often this mobility service is also discussed using the term 'driverless taxi' (Pakusch et al., 2020).

Regarding the future of the taxi business, besides automated routing and brokering, the technology could perform the central task of the ridesharing service: doing the driving itself in SAVs. Aspects of, and possibilities surrounding, the building safe and reliable autonomous vehicles for facilitating innovative and efficient future transportation have recently been investigated (i.e., Agatz et al., 2016; Hima et al., 2011; Leonard et al., 2008; Lutin et al., 2013). For a long time, this has been a predominantly technical discourse that dealt with technological feasibility (Goodall 2014a; Schreurs and Steuwer 2016; Strand et al., 2014), (resource) efficiency (Brown et al., 2014; Greenblatt and Shaheen 2015; Morrow et al. 2014) and ethical issues (Fagnant and Kockelman 2015; Goodall 2014b; Lin 2016) relating to automated driving without taking into account the different roles of humans associated with these vehicles.

Transportation research has focused on the acceptance of semi and fully autonomous vehicles (i.e., Kyriakidis et al., 2015; Nordhoff 2014; Pakusch and Bossauer 2017; Payre et al., 2014) as well as on the use and applicability of fully autonomous vehicles as not privately owned but publicly shared vehicles. In this discourse, the term 'shared autonomous vehicles' (SAVs) has become established (Fagnant et al., 2015; Litman 2017; Pakusch et al., 2018) drafting scenarios with driverless taxi fleets, and indicating 'there will be no more employment for taxi drivers'(Walker and Marchau 2017). In this vein some studies have undertaken simulations of SAV fleets (Burghout et al., 2015; Fagnant et al., 2015; Martinez and Viegas 2017; Spieser et al., 2014) showing that new mobility concepts in public transport based on SAVs can be sustainable solutions and efficient extensions to existing concepts and thus could compete with and endanger the existence of traditional taxis in the future.

HCI research has mainly addressed driver-vehicle interaction especially in handover situations (Gowda et al., 2016; Koo et al., 2015; Meschtscherjakov et al., 2016b; Politis et al., 2015); interaction between drivers or pedestrians and driverless vehicles (Brown and Laurier 2017; Mirnig et al., 2017; Rothenbücher et al., 2015); dashboard design derived from user surveys, and in-car interaction (Meschtscherjakov et al., 2016a; Pettersson and Karlsson 2015; Stevens et al., 2019). These studies, however, do not typically raise the question of ownership or use in shared contexts, and thus can be understood as implicitly focusing on privately-owned vehicles. One exception is the recent study of Kim et al. (2019), who simulated an SAV in a Wizard of Oz experiment that was tested with 43 participants. In their study, the authors created a customer journey for taxi use based on observations and interviews with taxi drivers. This customer journey describes the touch point of the passengers and the classical taxi service, which the authors then use for the further analysis of the service design. Their participants, however, seem to represent the average Uber or taxi-app user regarding age, thus being different from Germany's taxi customers (Young and Farber 2019). Another Wizard of Oz study has simulated an SAV service (Meurer et al., 2020), analyzing a more diverse sample. They identified design themes such as short-term domestication, the active passenger, the passenger experience, and how

breakdowns might be dealt with. However, the effects of an SAV service were not discussed in relation to the influence on the drivers' jobs.

2.5. Research outline

Given this prospect, we wanted to analyze possible future changes to the profession of taxi drivers. To do so, we also considered the social part of the taxi driver profession to be a relevant matter, as this aspect might be the decisive difference between human driven taxis and automated driverless taxis. As outlined before, recent research has begun to investigate the work practices of professional drivers and the experiences of passengers in order to provide a broader context for design in the area of e-hailing apps and mobility services (Ahmed et al., 2016; Dillahunt et al., 2017; Glöss et al., 2016; Kasera et al., 2016; Meurer et al., 2014; Tedjasaputra and Sari 2016). While these provide valuable insights into the working lives of drivers, such as the importance of emotional labor and empathy (Anderson 2016; Glöss et al., 2016; Kameswaran et al., 2018; Raval and Dourish 2016), these works focus on Uber drivers (Glöss et al., 2016; Lee et al., 2015; Ma et al., 2018; Peticca-Harris et al., 2020; Raval and Dourish 2016) or drivers of other TNCs (Zade and O'Neill 2016). That costumer clientele, however, substantially differs from the clientele of the traditional taxis. In particular ridesharing is used less by older people, while traditional taxis are (Young and Farber 2019). Further, all these studies focus on existing technologies and have little to say about future technologies such as driverless taxis.

Therefore, we extend this work by analyzing the perspectives of German taxi drivers on the threat of new forms of competition, especially SAVs. To do so, we focus on a set of research questions to help us assess the consequences of the not-yet-existing technology.

RQ1: How do taxi drivers assess the potential for the automation of their profession by SAVs?

RQ1.1: Based on experiences with recent innovations, how do German taxi drivers perceive the general influence of digital innovations on their work?

Our rationale for focusing on RQ1.1 is that it allows us to understand how taxi drivers experience and generally respond to changes of their work practices. We argue, that this understanding helps to draw conclusions for possible future disruptions.

RQ1.2: What specific working tasks would still require human work in the age of SAVs?

As previous literature has already shown, (professional) drivers can stand out from the competition particularly through their customer orientation and service level (Anderson 2016; Glöss et al., 2016; Kameswaran et al., 2018; Raval and Dourish 2016). The impact on service levels of SAVs and what the role of the human being

might be determined in particular by interaction with the customer. Thus, focusing on RQ1.2 may allow us to learn from the taxi drivers' actual experiences from which we can predict challenges in the context of SAVs.

RQ2: What contextual factors shape the adaptation of the profession to increasing automation and how can those factors inform the design of new technologies?

Onthe basis of the findings of RQ1.1 and RQ1.2, focusing on RQ2, we further analyze how the job of the taxi driver might change if the driving task is completely taken over by the technology. In doing so, we assess to what extent the person of the taxi driver is or may in the future be more desirable than a fully automated taxi.

3. Methodology

We have chosen a qualitative approach towards our open-ended research question and conducted semi-structured interviews with 19 taxi drivers aged 19–65 in Germany (excerpts in this paper have been translated by the authors) (Brumby et al., 2016). Participants were recruited randomly by addressing them at taxi stands in the urban Cologne-Bonn area. We offered the taxi drivers financial compensation based on the length of the interviews, roughly amounting to the same price of a taxi ride with the same duration. Some taxi drivers were willing to do the interview without compensation. We tried to create a typical sample of respondents for the German taxi driver community, which is characterized by male drivers with a migration background. To ensure diversity of opinions, we interviewed one female taxi driver and five who did not identify as having a migration background (see Table 1). The interviews ranged from 15 to 45 min in length (average 27 min).

After we had obtained the consent of the taxi drivers to record the conversations, we conducted the interview in the car, the driver's workplace. We followed a semi-structured interview guideline with open ended questions and encouraged the participants to elaborate on their answers or to report on concrete examples from their daily work. We started with questions about their career and reasons for choosing the profession of taxi driver as an entry point for narrative interviews (Bauer 1996). Then, we continued by asking the drivers to tell us how they typically work, how they see taxi industry changes in recent years and what changes they expect to see in the future. If the drivers did not address it independently until this part of the interview, we enquired about the digitalization of their profession and how that affects their work life, their customer clientele and interaction with them. The last part of the interviews was focused on their expectations regarding the future of their business in the light of innovations such as self-driving vehicles. Depending on how much the taxi drivers knew and could imagine about autonomous driving, we asked more open questions or had to become more concrete with our inquiry.

To avoid influencing our participants, we generally focused on the open questions and waited if the participants mentioned the subtopics (apps, TNCs, autonomous

Table 1. Socio-demographics and background information on participating taxi drivers.

No	Sex	Age	Status	Personal background	Taxi app
1	m	59	Self-employed	Driver for 35 years, immigrated from Afghanistan, could not return home due to war, taxi driving as a compromise	Yes
2	m	65	Employed	Driver for 20 years, immigrant, gave up job for taxi driving to become independent, retired, drives occasionally to increase pension	Yes
3	m	53	Employed	Driver for 29 years, immigrant, switched from courier to taxi driver, appreciates the customer contact	No
4	m	52	Self-employed	Driver for 21 years, immigrant, was printer but lost his job	Yes
5	m	64	Self-employed	Driver for 37 years, immigrant, dropped out of his studies, took a taxi as short-term solution	No
6	m	54	Employed	Started taxi driving as part-time job while studying, more than 20 years ago, 'loves' his job	No
7	m	19	Employed	Started taxi driving a year ago as sideline beside vocational training	No
8	m	62	Employed	Driver for 7 years, immigrant, prior employer shut down factory	No
9	f	61	Employed	Was driver in transportation sector before (school bus, trucks, blood transport), appreciates customer contact	No
10	m	61	Self-employed	Has held taxi concession for 21 years, immigrant, dropped out of studies for financial reasons, became taxi driver	Yes
11	m	48	Self-employed	Has held taxi concession for more than 20 years, dropped out of studies, got stuck in taxi driving	No
12	m	50	Employed	Driver for 23 years, immigrant, no other occupational perspective	No
13	m	51	Self-employed	Has held taxi concession for 23 years, dropped out of studies, got stuck in taxi driving	Yes
14	m	62	Self-employed	Driver for 39 years, became taxi driver after having conflicts with superior	Yes
15	m	50	Employed	Driver for 25 years, was unhappy with former job as educator	Yes
16	m	48	Employed	Taxi driver for 10 years, 4 years self-employed at the beginning, since then only part-time, originally from Russia	No
17	m	44	Self-employed	Taxi driver for 20 years, started in his brother's company, now self-employed, usually at taxi rank at the station	No

(*continued on next page*)

Table 1. (continued)

No	Sex	Age	Status	Personal background	Taxi app
18	m	45	Employed	Taxi driver for 20 years, trained communication electrician, appreciates the communicative aspects of the job	No
19	m	55	Self-employed	Runs a taxi company for 24 years, which exists for over 80 years, with at times more than 50 employees	Yes

driving) themselves. However, if the core topics of our research questions were not covered by the participants in these narrative passages, we asked the more detailed questions that included the above. If a participant addressed a topic on their own, we followed up on his or her comments and changed the order of questions accordingly.

We only provided taxi drivers with additional information on the concept of autonomous driving when it became apparent that they had little or no knowledge of this technology and therefore found it difficult to imagine possible consequences. The information we gave to those participants related to general definitions of autonomous driving (T7, T10, T12) and information about pilot projects to give them a picture of the reality of progress (T3, T7, T10, T12, T15), or to some car manufacturers' announcement that autonomous vehicles will come onto the market in 5–10 years (T10). Finally, in a view of their very personal opinions, we asked the participants how they see their future in the taxi industry and whether they would recommend the profession of taxi driver to their children.

All interviews were recorded, fully transcribed, and analyzed independently by two people following a thematic analysis procedure based on (Braun and Clarke 2006). Thematic analysis is a method for identifying, analyzing and creating topics from datasets (Boyatzis 1998), which is used to meaningfully summarize the key aspects of a large amount of data. Thematic analysis highlights similarities and differences between datasets. It also enables unforeseen new insights to be generated. It is often used for the analysis of qualitative data and is flexible because it is not bound to any theoretical framework as e.g. structuration theory conversation analysis is (Giddens 1984). For our analysis, we first familiarized ourselves with the material. As transcription of the interviews was divided up among the researchers, some familiarization had already been achieved during the transcription, as well as through close reading of the other transcribed interviews. In the next step, we started to code the interviews using MAXQDA software. The interview scripts were coded by two researchers independently. The coders regularly met to compare codes, to resolve coding conflicts and to discuss new codes. For coding, we chose a deductive semantic approach, meaning that coding emanated from the specific research questions that had already shaped the structure of the interviews. We knew, for example, that we wanted to extract the advantages and disadvantages of taxi services, which therefore had corresponding codes. Not only were passages coded that related to our

specific interview questions, but so were interesting passages such as subordinate clauses explaining other concerns. During the initial coding, we began to assign topics and subtopics by making color mappings. Once we had systematically coded the complete data set, we checked the pre-structured codes, searched for topics and combined them into motifs. We then reorganized the code system by grouping the codes into themes and subtopics before finally sorting the themes. In the next phase, we checked whether the topics were consistent with the elaborated, coded passages and the entire dataset. The coding system was then applied to all of the interviews and iteratively refined, extended and adapted as and when new interviews required it. Finally, we selected meaningful examples of the most relevant topics, representing the diversity and breadth of the interviews, prior to working up the analytic results in text form as findings.

4. Findings

In the following we present the findings of our interview study structured according to time: We start with what has happened in the *past* including how our participants came to be taxi drivers and in how far technology has led to changes in existing work practices so far (4.1). Following this we will outline how drivers react to *present* IT-driven innovations within their industry (4.2). Finally, we will present the drivers' attitude towards *future* innovations – particularly SAVs – enriching their personal opinions with examples of scenarios where human interactions might be relevant (4.3).

4.1. General background and experiences of taxi drivers

The professional careers of the interviewed taxi drivers were very different from each other. None of the participants chose the career of a taxi driver voluntarily when they entered the job market. For eight respondents, taxi-driving was more of a sideline during vocational training or retirement. Five taxi drivers made a conscious decision to take up the profession of taxi driver, although they already had other permanent jobs at that time. Nine of the interviewed taxi drivers started driving a taxi only as a temporary solution and then stayed with it due to the lack of alternatives. They had either lost their job, quit their jobs themselves, or had dropped out of their studies. Table 1 gives an overview on the various reasons and backgrounds of our participants.

Fifteen of the respondents reported they had been working as taxi drivers for over 20 years. They described that both the competition and their clientele had changed considerably in recent decades. Increased competition from the expansion of urban public transport in terms of routes and destinations, and new mobility services such as carsharing were seen as main drivers of this change. Customers allegedly changed their habits, particularly in the context of the declining purchasing power of the population and a decline in the urban pub and party culture, resulting in a lower demand for (night) trips.

Many of the taxi drivers' work practices have already changed because of technical progress. Nowadays, taxi companies use digital mobile systems to coordinate their fleets and satellite navigation plays a huge role for the drivers. All surveyed drivers had GPS systems and used them routinely via text or voice commands to plan a ride. As a rule, drivers use the GPS as a supplement to their own local knowledge and planning ability: they describe situations in which the systems were inferior to their own knowledge and recommended longer distances than necessary. Drivers mainly use GPS if they do not know the specified destination well, appreciating the efficiency of these systems in such cases.

Regarding the organization of customer orders, technology has enabled taxi drivers to work more autonomously, as described by T17:

> 'We now have very many small companies that have only one taxi concession or a maximum of two. And there is no point in having a dispatcher, that is the problem. You need to get someone to do the coordination, who costs money, day and night, then you have to rent an office. (...) Since there are mobile phones – everybody [taxi driver] has a mobile phone – with very few exceptions people can call you. In former times it was just that the taxis were not available because the mobile phones did not exist.' (T17)

This respondent observed that taxi companies have become smaller in recent years, and that it is very costly for a single company to have one position only for coordinating the trips, for example to receive telephone calls from customers and then distribute them to the drivers. Since the advent of mobile phones, customers have been able to contact taxi drivers directly in their cars during their working hours and request rides. This was not possible when the drivers could only be reached via radio, so a dispatcher was needed.

Also, new GPS-based systems enable fully automated brokerage of taxi rides. These systems allow taxi drivers to view the locations of other colleagues. This results in a significant improvement in taxi drivers' trip planning, as our interviewees reported: 'you can log into the stopping places online. In the past, you were forced to go there and stand at the back' (T01). Another taxis driver explained what advantage this change has for him in more detail:

> 'Because in the past (…) if you were unlucky, there were already ten taxis there – and you waited endlessly. At another stop there was none at the same time, there you would have been needed. Well, and now you can see everything [points to the app in the smartphone]: there are fewer, then I'm going there now, or here are so many taxis.' (T19)

T19, an experienced taxi entrepreneur, describes how uncoordinated the taxi business was without the digital tools that are common today. In addition to taxi orders that were placed via the taxi dispatchers, they had to wait at stopping points or hope

for being hailed directly by customers on the streets. Without digital systems to provide awareness, drivers had to decide for themselves which waiting area would offer the best chance of finding the next customer. They could rely to a certain extent on their experience, but luck played an important role, especially as other drivers positioned themselves based on similar preferences.

The taxi drivers were generally quite open-minded towards innovations such as e-hailing apps like mytaxi – eight taxi drivers had already been using them and expressed a positive opinion. Only four of them mentioned the negative consequences of increased digitization, especially regarding the reduced contact between colleagues and taxi dispatchers (T01, T05, T06, T19). One of them expressed his frustration with a declining sense of togetherness. He appreciated listening to his colleagues over the radio, even when only small requests were involved:

> 'The contact, that is regrettable. (...) Everything has advantages and disadvantages (...). In the past this was just more pleasant with voice radio. One has heard where things are going on. Ehm, you heard your colleagues. You could only shake your head, why doesn't he know the street? (...) That was easy, it was more communicative.' (T06)

The respondent found it 'more pleasant' to be in contact with his colleagues because it gave him the feeling of being able to get a better overview of the overall situation ('where things are going on"). His comment shows that communication via voice radio was not only about efficient coordination, but that the social aspect played an important role as it was 'more communicative". T01 explains the aspect of social contact further: taxi drivers traditionally used to meet at typical waiting points such as taxi ranks at train stations or tram stops, while waiting for the next passengers or dispatch requests. As drivers are increasingly using e-hailing apps, fewer drivers are to be found at the waiting points:

> 'Nowadays, this social exchange does not take place at all anymore due to the introduction of digital systems, and some of our colleagues can no longer be seen for months. Unfortunately, everything has become anonymous.' (T01)

T01 describes a growing anonymity because of e-hailing apps and expresses the view that his colleagues are no longer as close as they used to be. He deplores this aspect of digitization. Self-organization via the apps thus leads to a transition to a less collegial work environment. T01 thus sees the danger that the drivers' social cohesion will diminish. However, other respondents did not bring up this topic.

4.2. Facing current innovations in the taxi industry

4.2.1. *Usage of taxi apps*

Eight out of 19 interview partners reported that they actively use an e-hailing app. These participants were overly positive about their experience with them, primarily

appreciating advantages that the app offers them as well as their customers compared to using a classic taxi dispatch. Arguments about these benefits included the view that customers would value the additional service features such as tracking the location of the ordered taxi, getting the estimated time of arrival, and paying the fare by cashless payment. One respondent also mentioned the greater field of his service district as a benefit for taxi drivers:

> 'In the past, you could not take trips in Cologne or Düsseldorf [when coming from Bonn]. Today I take a passenger to Cologne and get a new ride via my app. (…) You can log in to the taxi stops online. In the old days, we were forced to go there and get in line.' (T01)

Regarding effects on their work, T01's comment shows that using the apps offers drivers the possibility of getting trips outside their core areas more easily. Regional taxi dispatchers only broker trips in their core areas. If drivers leave those areas, they are on their own. E-hailing apps help taxi drivers to find customers at their current location even when they are outside their normal service area. With luck, they can thus avoid an empty return trip. However, in some German cities some e-hailing apps have been prohibited from brokering trips to drivers who do not have a taxi concession at the starting point of the trip.

T19 reported that he uses a taxi app because he gets additional customers through it. His experience was that foreign customers especially prefer to place orders via the app because they appreciate the easy access without having to place a call to a German dispatch center, and because they can pay directly via the app. These advantages lead T19 to accept the additional costs of order placements via the app.

Three drivers reported that they are no longer members of regional taxi dispatch service. The commission-based costs of the app reduce the financial risk to taxi drivers, as costs are not incurred as fixed monthly fees as in case of the dispatch memberships, but only incur if drivers have actually undertaken trips. T10 told us that his taxi dispatcher demanded a high fee of 800 Euros per month, putting him at great risk if he should become ill or otherwise unable to work. Hence, he cancelled the membership and now exclusively uses a taxi app to get orders or find taxi stands with high demand. Thus, the revenue-dependent costs make taxi apps an attractive alternative to a membership of a taxi dispatch service, especially for occasional drivers:

> 'I'm a member [of a taxi app]. If I have to drive once a week, I use my cell phone. I'm not a professional [fulltime] driver.' (T02)

T02 is a retired driver with more than 20 years of experience who still occasionally drives taxi to supplement his pension. He has a stock of loyal customers who still contact him because of his cleanliness and reliability, he claimed, and he uses an app to get additional orders. Using a taxi app as a complementary channel, he gets

sufficient customers without being a member of a regional taxi dispatch service. T14 highlights another advantage of the taxi app he uses:

> 'Yes, of course, at mytaxi I have now... I've got over 250 regulars already. That means that if these 250 people are in Cologne, or if they are halfway close to me and order a taxi, I'm first in line to get the order.' (T14)

He describes how he benefits from the fact that customers can define preferred drivers within the app, and whose requests are assigned to him and not to other colleagues when he is close to these customers. This customer retention helps him in his independence. Further, T14 reports, he could 'even forego his membership in the regional taxi dispatch service today' as he has these regular customers who book trips via taxi apps. The reason he is still a member of the dispatch service is more out of loyalty than necessity.

For T19, the membership with a taxi dispatcher has other benefits. He also appreciates the advantages of using the app, but he believes it makes sense to make use of both the dispatcher and the app:

> 'I think it is all about the right mix. What a lot of drivers do are patient trips. Chemotherapy and whatever. And that all goes through the dispatcher, because they also settle accounts with the health insurance companies and that can't be done through the app. Not yet. I'm not saying what's in five years, we're always just talking about today. Otherwise, I'd have to settle accounts with every health insurance company, write letters, I could really hire someone in the office who takes care of such things. And that's all done by the dispatcher. Then I just give my receipts and say here, and ten days later I have the money in my account. Collected once a month—and that's it. That's a big advantage.' (T19)

T19 thus points to a special clientele which, according to him, cannot be coordinated via taxi apps. He refers to patient trips which neither fall into the category of business trips nor into the category of private trips. In Germany, health insurances pay for taxi trips if it is medically necessary. This is for example the case when patients are at home but need to go to chemotherapy, irradiation, dialysis, etc. He describes the accounting of patient trips as an important activity, which would cause him a lot of overhead work if he was doing it himself. Since the patient trips are not billed directly to the patients, but to the health insurance companies of the patients, a higher organizational workload arises compared with regular taxi rides. His expression 'I could really hire someone in the office' indicates how much work these billings can actually cause. Thus, when it comes to trips with patient, the dispatchers take over the time-consuming task of billing. The fact that the dispatcher is responsible for invoicing the health insurance companies means that the drivers only have to 'give [the] receipts' to the taxi dispatchers 'once a month'. Interestingly, when T19 declares that these billings cannot be conducted via taxi apps nowadays, he adds

'Not yet. I'm not saying what happens in five years, we're always just talking about today', showing he believes it is possible that the taxi apps will also map such services in the future. These rather open-minded thoughts could probably stem from his status of being a taxi entrepreneur with his taxi company having a more than 90 years tradition, who – as such – might probably be more concerned about the future of the taxi industry than other employed taxi drivers.

So, the taxi drivers who make use of taxi apps in their daily business appreciate the fact that they gain new customers through the app, that the costs are revenue-dependent and not fixed, and that they can build up a regular customer base through the features of the app.

4.2.2. *Reasons for resisting taxi apps*

Eleven taxi drivers in our sample did not make use of e-hailing apps. Some drivers deliberately decided against using such apps as an additional broker next to their usual taxi dispatchers. These drivers have informed themselves about the taxi apps and weighed advantages and disadvantages for their own business. They do not consider the benefits outlined above to be advantageous over the traditional way of using a taxi dispatch service. This was usually explained by the fact that the drivers could get trips via the taxi dispatcher free of commission (T05, T12).

> 'Well, it's a very clever, very sophisticated model. (...) However, for us it is a big competition, so that's what we have to say. Because the people here [taxi drivers using taxi apps], they don't understand, they're now driving doubly. That's the seven percent for the mytaxi that they pay for. If they weren't on mytaxi, they would have had the trip with us [classical dispatcher].' (T05)

T05 argues here that the journeys, which are requested via the app, would otherwise have been requested via the dispatcher. Hence, drivers using the taxi apps pay both the fixed costs for the dispatcher, of which many are still a member, and the turnover-dependent costs of the taxi app. He believes that the costs of the app could be saved. T11 is of the same opinion and considers 'some of the drivers pretty […] stupid' in that they demand tariff increases on the one hand, but on the other hand willingly accept apparently higher costs when using a taxi app. What they do not consider at all is the opportunity of gaining new customers and additional requests, as some of the other drivers have experienced, which might outweigh additional costs.

T17, who is self-employed, prefers to rely on his usual work routines as long as he gets enough jobs without an app:

> 'If nothing was going on at all, then I would also register with mytaxi. But if it works without mytaxi, then gladly without mytaxi. That is my attitude. I also have colleagues who use it a lot. Everybody must know that for himself. And you never know if they will increase the fees, and then you stand there.' (T17)

He raises another point, namely the risk of being dependent on the app operators' decisions, i.e. to raise the fees for the participating taxi drivers. As an entrepreneur who is not a member of a regional taxi dispatcher but who gets his request via direct telephone call or on the street, T17 is not dependent on any brokering institutions, thus does not need to pay these institutions and there is no risk of rising costs caused by these.

T06'decision not to make use of taxi apps is driven by a completely different reason. While he generally likes some of the features of taxi apps, especially the reputation system, his main concern regarding the use of taxi apps is the disclosure of private data. But he seems to generally be sensitive when it comes do privacy, as he refuses to use very widely used apps such as Facebook and WhatsApp.

Three other taxi drivers have not dealt with taxi apps yet as they leave such decisions to their employers (T07, T16, T18). T18 explains this decision with his employer being 'loyal' to the taxi dispatcher although his boss is struggling with the decision to use taxi apps after all:

> 'Yes, if things go on like this (...) he has to think about it. (...) But that hurts when one [app operator] is sitting there earning money and you see, that's your own money going away, and you give it to him, and so far he [boss] has refused to do that, hoping that it will get better, but it won't get better.' (T18)

His boss's thoughts are driven by deteriorating business, and both see from their colleagues that taxi apps can help getting more customers. Nevertheless, they so far have a negative attitude towards the apps, as they only see that they have to pay costs, while the app operators are 'earning money", apparently without doing much for it. Further, they condemn the fact that taxi app operators use the existing infrastructure of the taxi industry without participating in its maintenance (T05, T18) or they didn't like how taxi apps gave discounts to customers in the early days (T09), which led to taxis with taxi apps being preferred to those without. This behavior of taxi app operators seems to have triggered a negative attitude towards taxi apps that lasts.

T03 sees e-hailing apps as similar forms of internal competition in the same category as Uber:

> 'mytaxi and so on (...) Well, if I were a customer, I wouldn't even get in with them. Because they're not insured at all. No exam of the local geography, so as I said, that's just moonlighting. (…) They're not professional drivers – Uber and mytaxi.' (T03)

He is obviously not correctly informed about the business model of these apps and is unaware that taxi apps only broker trips by licensed drivers. His decision not to use such apps is therefore due to his limited information, affecting his judgement.

So, those taxi driver who do not use taxi apps, do so for different reasons. While some just see additional costs but no additional revenue, others fear possible

dependencies or refuse to use apps for privacy reasons. Some have not yet used taxi apps, because they (or their employers) tend to stick to their normal routines. Further, a negative attitude towards taxi apps in general seems to dispose drivers not to use the apps.

4.2.3. *Competition by transportation network companies*

Due to the general ban on Uber, which was imposed on the German market very quickly after its market launch, taxi drivers did not notice any effects on their own business. One taxi driver had not even heard about Uber thus far (T07), while most of the respondents reported a negative attitude towards this competitor. Their criticism included assumptions that Uber would work 'illegally' (T10), drivers would 'go moonlighting' (T11) and work without clear insurance cover for themselves and their passengers. They argued that taxi drivers offered a far more reliable and safe service due to the examinations which they must pass to be licensed.

> 'I've only heard of it from hearsay. I don't find it correct that they [Uber] want to get on the market here. Because you don't know who you're getting in the car with, do you? We have to do driving tests, they don't. We have to undergo our exams every four years. And they don't need to do anything.' (T09)

Contrary to many studies that show the negative impact of Uber on the traditional taxi industry, most taxi drivers interviewed do not consider business models such as Uber as a threat to their own job. Most of the interviewees referred to the strict laws and regulations prevailing in Germany.

> 'I don't think so, in Germany, because the laws are somewhat stricter here.' (T04).

Others trust in bodies representing them such as their regional taxi dispatchers or the nationwide taxi association who have already in the past put pressure on policy and law makers.

> 'The dispatchers will also resist against them [Uber], so that nothing will happen'. (T09)

Those drivers were firmly convinced that these provisions will continue to apply in the future and thus protect their profession.

Regarding the possibility that regulations might be weakened or dropped, one taxi driver in particular argued that customers would remain loyal to taxis because of the high quality of the service. At the same time, his expectation was that no matter how the regulation was changed, Uber drivers and their vehicles would be subject to the same rules as the taxi industry which would then be able to adapt and limit the possibility for undercutting their services with cheaper prices.

> 'My regulars. There's no one to ride with Uber. Certainly not. They know what they get from me, what quality. [...] Then Uber drivers must of course also compete under the same conditions. And if that should happen, I don't have to worry about my colleagues. If they have to do everything the way we do, and they also have to pay tax, etc. Then it won't be so cheap anymore.' (T14)

Only one respondent, T06, feared that the regulation of the taxi industry in Germany could be relaxed, opening the market for competitors such as Uber drivers. He hence expects the competition to get harder and even more difficult times for the classical taxi industry to come.

4.3. Attitudes and expectations towards shared autonomous vehicles

4.3.1. *Perceived impact on the transportation market*

When asked about potential concerns regarding the possible introduction of autonomous cars into their business, most drivers did not feel threatened. Only five drivers brought the topic of autonomous vehicles up on their own during the narrative passages of the interviews (T04, T06, T08, T13, T19), before the interviewers addressed it. These drivers mentioned different expectations regarding market penetration, the use of SAVs, and their impact on private car ownership, or the risks of taxi drivers becoming obsolete.

Most of the respondents in our study (14) did not bring up the topic of autonomous vehicles in the interviews on their own. While some taxi drivers regard the emergence of autonomous vehicles as a given (T04, T06, T08, T11, T19), most of the respondents were generally skeptical about the feasibility of replacing drivers with autonomous cars in the first place. In their view, autonomous driving will have hardly any impact on the taxi industry in particular. Their reasoning for this view was an assumed lack of security and reliability, the expense of buying and maintaining the cars, unsettled liability issues in damage situations, as well as the strict legislation policies of Germany.

Older drivers especially did not usually feel threatened as much as younger drivers, likely because autonomous cars were considered a topic of the future, and most of the older drivers did not expect to experience this innovation in their work life:

> 'I'm very curious about electric cars and self-driving cars. I'm 60 now. That means I may stay here for another three to four years. That means it's not a terrible thing for me when that happens.' (T08)

Other taxi drivers (T02, T19) think that even with the spread of autonomous vehicles, not all population groups will accept them, so they will not use them and will continue to rely on traditional drivers.

> ‘It’s gonna come. It’s already there, but in practice it’s difficult. Not difficult, but people don’t trust.’ (T02)

They see a major hurdle in the fact that customers will not rely on self-driving technology and would therefore not make use of such innovative services in the long term. At the same time, taxi drivers describe different effects for the future scenario with SAVs which would affect them to a greater or lesser extent. When it comes to the question of what the taxi industry could look like in 10–20 years’ time, T06 predicts that the business model of SAVs could have a really fundamental impact on the whole mobility sector:

> ‘I mean, we are at the gateway to autonomous driving where the driver will no longer be necessary. And I can well imagine that if this works properly, then basically there will only be taxis on the road. I mean, why would you want your own car if it drives on its own anyway and you can’t or don’t have to drive it yourself? And if you just walk through the city and somewhere on the corner there is a [shared autonomous] vehicle and you know you can get in there and know the prices and you know that it takes you from A to B.’ (T06)

He fundamentally questions the fact that in the age of autonomous vehicles and SAVs, people still have any interest in owning their own car. He argues here with the fact that it makes no difference whether one uses one’s own vehicle or a vehicle on demand if one does not drive the vehicle in either of the two variants. Hence, he expects that only taxis will be on the road – no more private vehicles. He paints a picture of people who use SAVs spontaneously according to their needs, and expects the future presence of autonomous cars on the roads to improve traffic flow and reduce accidents, as he explained further:

> ‘The sooner and the more interlinked the vehicles are with each other, the faster moving it’ll all be. And even if they can communicate with each other, there won’t be accidents anymore.’ (T06)

The positive-minded taxi drivers generally expect positive effects from the emergence of autonomous vehicles. Regarding the taxi industry, they consider changes to be a realistic possibility but agreed that the taxi industry will change in such a way as to divide the market between traditional and driverless taxis.

> ‘Maybe... there are certain lines that go to the airport or something.’ (T03)

T03 can imagine that there will be taxis that will travel completely without a driver. He does, however, qualify this and does not see this new variant of the taxi service suitable for all trips. Rather, he considers there will be fixed, standardized trips, such

as to the airport, which will be carried out by driverless taxis. In this respect, this idea corresponds to that of T04:

> 'Parallel business to the taxi. Taxis, these classic taxis, I don't think there will be that many anymore. Of course, taxi will always exist because there are elderly people, patients. You can't do anything else. You must take a taxi.' (T04)

In contrast to T03, T04 immediately gives reasons why there will not be exclusively driverless taxis. He names elderly people or patients as two customer groups, who will rely on taxis with a human driver also in the age of autonomous driving. He is convinced these groups do not have a choice but opt for the taxi with a human driver. This opinion might be shaped by the experiences he has gained with these customer groups. He gives similar reasons as to why the taxi driver is needed, as presented in 4.3.2.

T11 expects autonomous taxis to compete less with traditional taxi drivers than with the alternative driving services already available today, such as hired cars with drivers, or shuttle buses. Those differ from taxis in that they can only accept planned driving orders and not spontaneous orders, i.e. they are not allowed to serve customers hailing taxis on the street or at taxi stops. He sees autonomous vehicles as particularly interesting for the operators of such companies:

> 'After all, the competition already exists. That will be the operators who, for example, previously offered only airport transfers. There are also travel agencies that offer this, or entire tour operators. Or companies that offer shuttle services because they are remote and take their guests to the airport by company car. They could say: We save the chauffeur and use an autonomous vehicle instead. That would really pay off for them.' (T11)

In summary, while some drivers question a successful implementation of SAVs due to a lack of trust, others see great potential in autonomous driverless taxis in terms of fewer accidents, an improved traffic flow and reduced personnel cost. They expect that some routes and customers could be served with SAVs while they mention specific customer groups they consider could not be served with SAVs. However, most taxi drivers do not regard SAVs as a threat to their own person as they are in a late phase of their career.

4.3.2. *Limitations of SAVs regarding customers' needs*

While the previous section highlighted that taxi drivers expect certain trips and services could be taken over by SAVs, they are sure that even in the age of autonomous taxis they will still be needed by their customers. Their argumentation is based on the customer structure of taxi services. T11 and other interviewees mentioned specific services that they provide, which are requested by many of their

customers. In the following, we will provide quotes that illustrate how frequent and diverse these interactions and supports are:

> 'I see the proportion of people in need of help and that is pretty substantial. That's why you call a taxi because you can't drive yourself. If people could drive themselves, they would also use an autonomous vehicle.' (T11)

According to T11's experience, there is a large proportion of customers who need help with the transportation—because they could not be able to for example board the vehicle on their own. T11 emphasizes that many customers request a taxi because of additional services. For example, he points out that the actual trip also includes the way e.g. from the apartment to the vehicle and from the vehicle to the destination, e.g. the entrance area of a doctor's surgery. Other drivers also argue that human assistance will still be required for certain services which cannot be easily offered by SAVs. As an example, several taxi drivers mentioned the needs of elderly people or persons with physical disabilities which make up a significant proportion of their passengers and regular customers.

> 'We have to go up sometimes, sixth floor. Need to help bring a patient or elderly person down. There must be a taxi driver. Cannot be abolished completely.' (T04)

These customers need support when walking and climbing stairs, and the drivers say that they pick them up at their front door and accompany and support them all the way to the car. The assistance ranges from helping to get in and out of the car, storing bulky objects such as wheelchairs, walkers, or luggage for them in the vehicle or running errands for their customers. T11 also explains he has customers who need additional support:

> 'I have regular customers who can't do it alone. They can't drive to the doctor with an autonomous vehicle because they can't get into a car on their own. They don't come down the stairs alone, they don't get their shopping bags carried alone. Nobody folds the walker when it is an autonomous vehicle. Yes, so there will always be a segment where this support is present.' (T11)

He also refers to activities that in his opinion autonomous vehicles would not be able to conduct. However, this statement refers to a specific customer 'segment": of people requiring assistance. T18 also sees some disadvantages in transporting this clientele in need of help, as these orders require ('incredibly") more time to be spent without any extra compensation for this time and service. Yet he explains, these services are inseparably linked to the profession of taxi driver:

> 'It takes an incredibly long time for them to come. You ring the bell, many have no elevator, have to come down the stairs – you can understand it all, that's, one day it

> happens to us too, we will also depend on others for help – they come with their rollator, very heavy, so you take a little time, take them by the hand, take them to the car, some also need help to fasten the seat belt. But that's just part of it. Sometimes you have to have nerves for such things.' (T18)

For this segment of customers, such situations where supportive services are demanded occur regularly. More than that, the close interactions he mentioned ('takes them by the hand'when the situation demands it; fasten the seatbelt, etc.) are not mere optional services, but central requirements for those customers. Like T18, other taxi drivers are also very service-oriented. For them, it is a matter of course that they take their customers' wishes and needs into account. T19 runs a third-generation taxi family business and attaches great importance to customer satisfaction:

> '(…) taxi is a service business. Service means I open the door for the passenger, I ask if I can help, and if there is a little old mother, it goes without saying that I bring the bags at least to the front door. Or if we bring ladies home in the dark at night, it goes without saying that I wait in front of the door. I wait until she is through the door.' (T19)

He also helps elderly people by bringing their bags to their front door without being asked to. If he drives women home in the evening or at night, he waits until the women have arrived safely in their apartment before he drives to his next customer. He points out that some customers are particularly happy about this help and attention and show their gratitude which is 'reflected in the tip". He emphasizes that this service orientation is decreasing more and more with other colleagues.

Furthermore, taxi drivers also see communication as an important topic. Some passengers cannot articulate themselves clearly, either because they do not speak the language, or because they are permanently or temporarily disabled (e.g. because they are drunk), which makes it difficult for the taxi driver to find out what the taxi customer's destination is. T01 reports on his experiences:

> 'There are guests who can't speak and only have a note that says where they want to go.' (T01)

Communication with customers also plays an important role in other respects: In addition to knowledge of location and routes, customers also rely on the drivers' knowledge of other infrastructure-related tips, such as restaurants or specialized clinics and doctors:

> 'Some people come: 'I need a good doctor for this or that', and then we know that this clinic is specialized for that, and that clinic is specialized for that. The very fact that you give the impression of giving information often makes them feel better.

> Or words of consolation, we sometimes drive mourners, or I don't know. Even if the content is completely irrelevant or just empty words, but if the passenger feels good, that's basically the goal. That he says: 'Geez, taxi driving in Cologne – the taxi driver was nice'.' (T19)

T19 has the impression that what is said is not especially meaningful, but that 'the impression of giving information makes [the customers] feel better". Rather, in some situations it is more about the driver radiating competence or sometimes also acting as an interlocutor, listener, or comforting person. T13 also sums up these functions as follows: '[A] taxi driver is sometimes like a psychologist". For T19, being there for customers on an emotional level too, so that customers can pour out their hearts, is an important part of the overall service. He wants his customers to leave the taxi in better shape than they entered it. This is illustrated by T19's the statement 'if the passenger feels good, that's basically the goal", making it clear again that one of his job goals is to satisfy his customers.

Two taxi drivers do not use a taxi dispatch service or an e-hailing app but place themselves in busy locations such as train stations and mainly serve walk-in customers (T16, T17). Although they also report on occasional trips in which they have to help older passengers carry and stow their shopping and help them get in the car, their clientele consists mainly of mobile, rather young passengers, often business customers, who travel with little luggage and therefore do not need any additional support and services. In this respect, they describe their regular trips as exactly those that could simply be replaced by SAVs.

> 'I guess the problem is a lot of people just look at the price. And if the car drives by itself and is – so autonomous taxis will be considerably cheaper than taxis where someone is sitting in it, that's clear – maybe half the price. Yes, and the business customers and the young people anyway. They will take their app and order the thing and ... I don't think taxi drivers will die out, there will be a lot less use, I guess.' (T17)

T17 thus describes his customers as being very price-sensitive, especially his business and young customers, and as he expects autonomous taxis to be able to offer their services much more cheaply than human-driven taxis. This will mean substantially fewer taxi drivers will be needed in the future. Confronted with this scenario, they see their future tasks primarily in vehicle maintenance such as cleaning and reconditioning the vehicle for customers.

T09 thinks that SAVs may be able to replace traditional taxis, and she becomes particularly concerned when she thinks of her young passengers:

> 'They are all just texting and looking at their smartphones. There are no more nice conversations. Then we won't need a [human driven] taxi anymore. Do we?' (T09)

She describes the interaction with many young customers as minimal. Just like the customers of T16, her customers often neither ask for support e.g. for stowing objects is necessary, nor do they linger for conversations. As she is not using a taxi app, there is still a verbal exchange to communicate the destination and to process the payment.

Thus, the taxi drivers agree that there will still be human drivers in the future, as there remains a substantial proportion of their customers who are in need of assistance. However, taxi drivers do consider the probability high that their rather young, fit and cost-sensitive customers will prefer SAVs in the future.

5. Discussion

Our study expands the discussion on the future of the gig economy in the mobility sector by analyzing the perspective of taxi drivers on SAVs as well as on innovations in the field of transportation apps and associated services as a means to understand better the effects of a future with SAVs on their working lives. Additionally, we highlight the role of the specific local context for designing successful mobility services as proposed by (Raval and Dourish 2016).

5.1. Adapted work practices today and in the future – comparing Germany to Northern America, China and India

5.1.1. *The impact of recent technological innovations on taxi drivers and industries*

Even though Germany represents a specific case, with a stronger regulated market, specially regarding the market entry of new business models, liberating technology has taken its tolls. We can observe that the traditional German taxi industry is developing towards a gig economy, while there still are some differences remaining. We will elaborate on commonalities and differences and work out in how far the attitude and reasonings of the German taxi driver differ from their international colleagues.

Our findings indicate a growing mismatch between traditional service structures in the German taxi industry (client, dispatcher, driver) and new informal practices that are enabled by mobile tools. By directly connecting driver and customer, the need for the customer to search for nearby taxis is redundant, thereby changing the way taxi services operate, especially with regard to spontaneous trips. In the past, central stopping places such as airports, train stations, bus stops or event locations were only to be used by licensed taxi drivers in order to simplify this (analogue) search. So far, these locations have represented a structural advantage for taxi drivers over competitors such as hired cars, as the drivers meet a high demand at these locations, and thus are protected from these competitors. Yet, this structural advantage loses importance due to the presence of e-hailing apps in Germany. Instead, it is more important for the drivers to be available within the different apps to reach out to potential customers regardless of location.

The increased transparency afforded by e-hailing apps has led to a shift in power from the dispatcher to the drivers themselves, allowing taxi drivers to operate more independently since processes such as coordination, localization of passengers, and payment can be carried out by themselves. Taxi drivers appreciate the fact that they can acquire new customers and that they can be chosen as their customers' regular driver with the help of the app functions. The drivers consider the revenue-based variable costs incurred when using the apps to be an important advantage over the high fixed costs incurred by the dispatcher in terms of their independence and flexibility.

The work of those drivers who now almost exclusively receive their driving orders via a taxi app in particular is very similar to gig economy work in the Northern America or Asian markets: they receive the driving orders – the gigs – via smartphone and do not necessarily need to go to common taxi stands anymore.

Even so, the German taxi industry slightly differs from the gig economy as observed i.e. in Northern America or UK in five essential aspects: First, even when making use of e-hailing apps, German taxi companies are subject to a duty to operate in order to ensure mobility at all times. Those working for Uber in Northern America and India can flexibly choose when and how much they work (Glöss et al., 2016; Kashyap and Bhatia 2018; Ma et al., 2018; Peticca-Harris et al., 2020). Secondly, German taxi drivers are subject to an obligation to carry and are not allowed to refuse trips. This is different with gig drivers, who are basically free to either accept or refuse orders. However, Uber driver in North America and Ola drivers in India feel a pressure to carry, as they have to expect a negative evaluation or even account deactivation when refusing trips (Lee et al., 2015; Ma et al., 2018). Many Chinese taxi drivers have as a consequence installed bot apps that help drivers automatically bypass the app's rules and algorithms (Chen 2018b). Thirdly, Uber offers dynamic pricing while the German taxi industry strictly applies tariff regulations. Further, gig economy platforms do not regard their drivers as employees but as independent contractors, whereas in the German taxi industry 86% of taxi companies have employees to whom they pay a fixed monthly salary (not just on a commission basis) (Frentzen et al., 2018). And finally, so far, there remains a lively social exchange between the taxi drivers, especially when waiting at taxi stands. In contrast to what is usual in many gig economies, the contractors (taxi drivers) know each other due to their regular proximity to each other at the stands.

The development of the adoption of e-hailing apps by German taxi drivers is most comparable to the cases in India and China, where initially only traditional licensed taxi drivers could offer their rides (Chen 2018b; Kashyap and Bhatia 2018). As with some of the German taxi drivers, drivers from India and China reported that the additional use of e-hailing apps helped them attract more customers, have fewer empty trips, gain greater visibility into taxi stand occupancies and customer-intensive hotspots, and have adopted the app in the first place in response to the changing landscape. Just like their Asian counterparts, most traditional taxi drivers use the app as a supplement to their existing business.

Those German taxi drivers who decided against continuing to be members of a taxi dispatch service and now get their orders only through the app give similar reasons and advantages as their colleagues from North America and India who switched to Uber or started their transportation careers without prior experience with transportaion services: They value having control and flexibility over their schedule (Peticca-Harris et al., 2020), and the freedoms of self-employment (Kashyap and Bhatia 2018; Ma et al., 2018; McGregor et al., 2015). Some former taxi drivers see Uber as having the great advantage of removing the financial burden of the high monthly fees that come with the traditional taxi business (Peticca-Harris et al., 2020). This bears a resemblance to the reasoning of some German taxi drivers, who have terminated their membership with a taxi dispatcher in order to save on the fixed monthly costs, and who also see the advantage of revenue-based costs when it comes to e-hailing apps.

Similar to some of the German taxi drivers who are rather critical of e-hailing apps, drivers from India argue that by opening the e-hailing apps to private drivers, others now get the rides that the traditional taxi driver would otherwise have obtained (Ahmed et al., 2016). Similarly, Chinese drivers felt betrayed by the app operator when it opened the app to private drivers as well, after a large proportion of traditional taxi drivers had registered and customers had become accustomed to use e-hailing apps (Chen 2018b). This also reflects the displeasure of Chinese taxi drivers, who opined that the app operator has led them into a kind of dependency – similar reservations were also expressed by some taxi drivers in our study.

Another reason for rejection among German taxi drivers was a generally negative attitude toward the business model of the app operators. Similar attitudes were shown by Uber drivers from California, who criticized the fact that Uber as a company uses the existing infrastructure without investing in it themselves (Glöss et al., 2016).

In terms of revenue, some German taxi drivers expressed the view that, because they did not expect additional income from using e-hailing apps, there was no reason to use them. The study on e-hailing in China showed that taxi drivers' income did in fact decrease after adopting the e-hailing app Didi (Chen 2018b). Rejectionist arguments, especially among older taxi drivers, were similar in Germany and India in that drivers criticized technology use as a prerequisite for e-hailing use, especially reliance on GPS navigation – which, from the taxi drivers' perspective, speaks to the inexperience and professional inferiority of their app-using colleagues (Kashyap and Bhatia 2018).

Unlike TNC drivers, especially in North America (Anderson 2016; Glöss et al., 2016; Marquis et al., 2018; Raval and Dourish 2016), the rating systems of the e-hailing apps do not seem to put German drivers under pressure. The topic of ratings hardly played a role in our interviews (but was also not pushed on the part of the interviewers), unlike studies with Uber drivers which show the great pressure drivers feel due to customer ratings (Anderson 2016; Chan 2019; Glöss et al., 2016; Raval and Dourish 2016).

A significant difference can also be seen in the change of working conditions due to the introduction of e-hailing apps in a more regulated market like Germany, in contrast to a scarcely regulated market like the auto-rickshaw market in India. While in Germany the flexibility and autonomy of taxi dispatchers increased through the use of taxi apps, the Ola app has seemingly changed existing practices and consequently limited the flexibility and autonomy of auto-rickshaw drivers (Ahmed et al., 2016).

To summarize, the views of German taxi drivers with regard to e-hailing apps are similar to those of traditional taxi drivers in other countries who prevented TNCs from entering the market by strictly regulating their entry. Taxi drivers from countries where the barriers to entry for competitors such as Uber were lower, such as in North America and the UK, not only recognized these TNCs as a threat, but have already experienced the impact on demand for their services and engaged with and in some cases adopted the new competing apps in response. The fact that German taxi drivers hardly see the potential competition from TNCs such as Uber as a threat might be due to the fact that Germany's state protection of the taxi industry has so far averted this threat. Taxi drivers in Germany have not yet had the need to deal with this competition unlike taxi drivers in North America or India, for example, have. Their attitudes may be more rosy as a result, which poses a risk in that they may not be well prepared for the competition should legislation in Germany no longer prevent TNCs.

As an additional result, we can observe these changes affecting the role of taxi dispatchers in Germany: Acting as an intermediary, bringing together demand and supply in a bundled way, was classically one of the most important functions of taxi dispatchers. Yet, this intermediary role is exactly the kind of function that is suitable for replacement by e-hailing apps and has also informed the development of apps in the taxi industry (Dawes 2016). However, the tasks of taxi dispatchers go far beyond simply arranging trips: they take over negotiations with health insurance companies, accounting for patient trips and advance the driver's travel expenses, which gives those drivers a liquidity advantage, as e.g. T19 mentioned. In addition, they deal with municipalities and authorities when it comes to organizing major events and coordinating the overall use of taxis if individual taxi drivers or taxi operators do not offer their services around the clock. Such representative tasks are clearly less prominent in the gig economy (Friedman 2014; Minter 2017) making it hard for i.e. Uber drivers to unite (Alkhatib et al., 2017).

5.1.2. *Taxi drivers' anticipated impact of autonomous vehicles on their profession*
With a view to the further development of the gig economy, the influence of automation is controversial. Many experts and scientists make the claim that taxi drivers are no longer needed in the age of autonomous vehicles (Alessandrini et al., 2015; Chou 2017; Madrigal 2018; Walker and Marchau 2017). This argument has, as yet, few detractors. So far, a deeper and more nuanced examination and discussion about the role of taxi drivers in the age of autonomous cars is lacking. Few of the

existing studies, if any, address the impact of autonomous driving on the driver's profession.

These experts consider taxi trips to be work that could be automated particularly well, since they are often commoditized and not particularly differentiated (Lieber and Puente 2016). However, our participants strongly argue against this description of their profession. In fact, the taxi drivers reported varied personal experiences from their everyday professional life, demonstrating in what respect they consider the human driver to be indispensable. They describe different situations that occur regularly, in which they need to interact closely with their customers – not only in terms of communication and service but also physically. Social competence and service orientation play a decisive role in this context. The views of taxi drivers provide a subtle rejoinder to those studies which argue that the profession of taxi drivers will become obsolete (Walker and Marchau 2017).

Our drivers highlight that their profession will rather transform with regard to its core focus and work practice. Although many studies predict that demand could be met by fewer and therefore more efficient SAVs in the future (Bond 2014; Lewis and MacKenzie 2017; Sun et al., 2017), and although many taxi drivers consider SAVs to be generally feasible, they are convinced that their jobs will not be replaced by automation. The respondents expressed the opinion that their job would entail more than the driving itself, highlighting other aspects such as the trust of their clients as well as the provision of additional services accompanying the transportation that SAVs and to certain extent even existing TNCs would not be able to provide (Brereton et al., 2009; Meurer et al., 2014; Ozenc et al., 2011). In fact, they described to be largely dealing with a loyal clientele, which regularly requests a service from taxi drivers that goes beyond transport from A to B. As those customers specifically appreciate the physical assistance and social contact, our drivers expected them to be reluctant to change the mode of transportation.

While previous studies from the US have already identified the importance of the aforementioned social connection between driver and passenger (Anderson 2016; Chan 2019; Kameswaran et al., 2018; Raval and Dourish 2016), and emphasized the importance of emotional labor (Glöss et al., 2016; Marquis et al., 2018; Raval and Dourish 2016), our study highlights how this emotional labor extends to additional, not-transport-related tasks that are required when dealing with certain customer groups, e.g. with physical or age-related impairments which leave those people unable to physically perform certain activities. Talking to traditional taxi drivers whose clientele differs significantly from that of TNCs led us to understand this important difference and the need for additional services to inform the design of new tools and services in the taxi market following the emergence of the envisioned SAVs. So far, special needs have not yet been discussed in recent studies regarding SAVs. For example (Kim et al., 2019), conducted a Wizard of Oz study in Korea and have drawn up the customer journey of a taxi customer in detail. They identified which touch points should be considered in the transition to autonomous taxis. However, their customer journey did not cover supportive services as outlined by

our taxi drivers. As our investigation shows, these are important aspects to consider in the design of SAVs and supportive service models.

It is possible that, in the long term, the so far loyal clientele could be replaced by a cohort that is more open and used to self-service models such as SAVs (Krueger et al., 2016). The effect of an ageing population remains an open question. Based on our findings regarding these uncertainties, we argue that it is likely that the taxi business will be differentiated into a personal-service infrastructure and a self-service infrastructure (Walker and Marchau 2017), as i.e. T04 suggested or T11 described implicitly. Consequently, future design research should consider both forms.

The personal-service infrastructure would then address special target groups and cover trips such as patient trips or trips where the passenger requires special individual support or physical assistance, e. g., if he or she is carrying luggage, or if he or she needs help with getting in and out of the vehicle or if social interaction plays a special role. This part of the taxi industry requires a very close interaction between passenger and taxi driver, flexible support as well as social skills, as i.e. T05 or T18 have pointed out (section 4.3.2). In this segment of the population, taxi drivers might continue to play a role. However, the activity of driving will become less and less important, while at the same time the demands for customer and service orientation will continue to rise – also against the background of ageing societies.

Thus, based on the data we gathered, it is reasonable to expect a change in task priorities within the taxi industry, such that assistive and social functions will make the former taxi driver into a taxi trip attendant or trip steward. Of course it is arguably the case that this shift in function might require new forms of professional training. This kind of change in working practices will certainly only be of interest to taxi drivers who already enjoy the social part of their work and who have a strong service orientation, such as T19. Those drivers, who like their job mainly because of the driving task, might not be satisfied with this kind of change. In the argumentation of the taxi drivers regarding their right to exist, it is very interesting that they always equate the role of the assistant with the role of the driver. Nowadays, of course, these two roles are inseparable.

The self-service infrastructure, on the other hand, is particularly suitable for trips that can be standardized and carried out without fulfilling special requirements, and whenever lower prices or special circumstances (such as trips between remote locations that are not well serviced by classic means of transportation) make such offers more viable (Litman 2017). For instance, T09 has outlined how little importance young customers attach to interaction or communication with taxi drivers, and T17 has described how business customers and young costumers in particular act very autonomously and even today make very little use of supplementary taxi driver services such as helping with luggage. No human driver will be needed for the execution of these journeys. Analogous to the user groups of taxi apps and TNC apps, one can assume that the target group for these trips will probably consist of rather young, pragmatically thinking, digitally affine and mobile users who need no additional service (just as T17 predicts).

Trying to forecast the market shares of the two services is certainly difficult and of course highly speculative. The current figures for taxi journeys (section 2.1) can only provide an indication. In particular, journeys for medical reasons (12%) are among the journeys that are likely to require human assistance. In addition, the journeys in which goods and objects are transported (2%) and minor parts of the remaining journeys in which passengers wish to be assisted by a human driver may also be counted. That leaves the conclusion that in the age of AVs, only a small fraction of today's workforce would be needed to accompany passengers.

For those drivers who are less engaged in the social aspect of their work, other professions could emerge. Their future role could for example focus on car care and maintenance. This could be interesting for those drivers who generally like to work with cars and are more interested in the technical part of the job. For some self-employed drivers, it might be particularly interesting to coordinate their own fleet of SAVs and take more care of the business aspects of taxi driving, including billing, valeting and marketing. One could argue that this would be in line with the previously seen extension of autonomy (and liberation from dispatchers) provided by e-hailing apps. For other drivers, it might be appropriate to work as a teleoperator. A teleoperator is a person who remotely controls one or several (semi-)automated vehicles (Neumeier et al., 2018). Currently, the potential of teleoperating (semi-)automated vehicles is being tested with regard to its technological feasability (Hosseini and Lienkamp 2016; Neumeier et al., 2019; Shen et al. 2016). In the transitional phase especially, SAVs will need remote control in case of traffic jams or blockages, road works or occasional interruptions such as festivals and sporting events. Such problems, in the urban context, are unlikely to go away. Drivers could deploy existing knowledge of alternative routes or shortcuts to resolve problematic scenarios of this kind.

5.2. Comparing how context shapes taxi drivers' practices, beliefs, rationale and outlook onto the future of their profession

It is noteworthy how few taxi drivers regard an internationally successful business model such as Uber as a threat (i.e. P06, P09, P14). Taxi drivers refer to the protectivist and regulated system in Germany on the one hand, but observe a shift to less regulated work practices as well. We draw the conclusion that the legal, social and cultural context not only shaped the beliefs and rationales of the taxi drivers but that such constraints also matter for the success of a business model and/or technological disruption.

5.2.1. *Legal and economic context*

In contrast to TNCs, the example of regulation-compliant e-hailing apps such as mytaxi show how the socio-cultural conditions in a country can be successfully dealt with. Mytaxi, one of the market-leading taxi apps in Europe, is an application that nowadays offers the same functional concept as Uber concerning the matching of

driver and passenger, live tracking and interaction with the driver, payment, reviews, etc. In contrast to Uber, however, the app has taken the regulatory framework as well as prevailing rules, values and practices into account and successfully integrated it into their business model. As a result, in Germany, taxi drivers gain flexibility and autonomy from the use of legal taxi apps with none of the costs reported elsewhere. Taxi drivers, as we have seen, are able to reduce their dependence on regional dispatching through their use of the apps. This is in stark contrast to markets with little or no regulation, such as India, where the Ola app has changed existing practices and consequently limited the flexibility and autonomy of auto-rickshaw drivers (Zade and O'Neill 2016). Thus, while taxi apps enable drivers in highly regulated countries, they have a restrictive effect in less regulated markets.

The failure of Uber in connection with the simultaneous success of mytaxi, which promotes similar work practices but takes into account existing legal and power structures, suggests a more contextualized or staged introduction of technology even when it comes to potentially disruptive innovations. Studies on the adoption of new mobility services such as Uber have so far been strongly influenced by an Anglo-American perspective (Kasera et al., 2016), but have hardly reflected the socio-economical context in which those innovations have been implemented.

5.2.2. *Social and cultural context*

In the case of Uber in Northern America, the situation could be characterized as entailing a liberal market economy, which allows new companies to enter and operate in (thus far) largely unregulated markets. While strict regulations apply regarding the number of concessions and the suitability of potential taxi drivers, competing services such as Lyft or Uber can access the market and operate legally in the USA, as can Ola in India and Didi in China respectively. In this respect, it is not just regulation but also a question of representation and organization. In Germany, trade unions play a major role, representing the taxi driver community and negotiating with policy makers when there are changes in the market. Thus, German unions and interest groups repeatedly lodged complaints against different TNC thereby putting pressure on the European Court of Justice to reach a decision. As a result, UberPop's service with private drivers was defined as a transport service and thus equated with taxi services along with its other divisions, UberX and UberBlack. The result of Uber's non-compliance is a renewed ban on the ride brokerage in Germany. In our case, the strong employee protection that is embedded in the German labor market, successfully prevented new TNCs from taking hold in Germany. As a consequence, drivers such as T01, T04 and T09 indicated, they feel nurtured and protected by German laws, unions and dispatch services.

Social factors are of particular relevance for the successful implementation of a business model as well. As the taxi drivers have reported, their clientele is characterized by regular customers and also by those customers who not only need social interaction but also physical support to complete the taxi ride. The latter customers in

particular do not seem to belong to the clientele of TNC apps and e-hailing apps, and their needs have seldom been reflected in previous studies on the gig economy.

Regarding mobility services based on SAVs, then, it is crucial for such service infrastructure to be embedded in the respective country-specific regulatory framework and services aligned with the interest of affected stakeholders. As the regulatory framework sets out who can be the operator of such an SAV fleet, taxi drivers or dispatchers may be the ones who will be (legally) responsible for managing SAV-fleets, further shifting their role. On the other hand, there might also be a free, unregulated market in which everyone can operate his or her own SAV (Martinez and Viegas 2017).

6. Implications for design

From the conversations with taxi drivers we learned that the profession has evolved and consists of more than just driving. The job also encompasses logistical as well as communicative tasks and often enough requires empathy and other social skills. Those supplementary services are unlikely to be replaced by technology as they are situated, customer-specific and in continuous flux. For exactly that reason, these supplementary services could provide new business opportunities for taxi drivers even when SAVs become fully available. On the other hand, there is a specific proportion of rides where the utilitarian aspect of getting from A to B matters most.

At this point it is important to highlight that from the taxi drivers' perspective the adoption of technology in the German taxi industry has streamlined coordination tasks and made finding customers or drivers for both parties respectively more flexible. Yet, by doing so, the social and supplementary services provided by drivers have gotten out of the picture and led to interactions between driver and passenger but also the interactions between drivers being reduced.

In summary, regarding the design of future mobility services, we suggest considering these two aspects: (1) Design for utilitarian interaction with SAVs and (2) Design for supportive services and social exchange.

6.1. Design for utilitarian interaction with autonomous vehicles

If we consider the following insights, (1.) that all organizational activities such as ordering, destination determination, and payment can be handled through an app, (2.) that there is a segment of passengers that does not require supportive services or other interactions with the driver, and (3.) that in the future vehicles may be able to operate automatically, we conclude that this particular segment of passengers can probably be well served by SAVs in a self-service infrastructure. As Meurer et al. (2020) point out, however, there are some other unresolved issues, including the suitability of pick-up and drop-off points. Here, the design of utilitarian SAV services may focus on positive usability and a good user experience for the passenger while

autonomously using an SAV as analyzed in various studies (Fagnant et al., 2015; Stevens et al., 2019).

This is quite different to a future in which SAVs will replace *all* taxi drivers and trips – even those trips with passengers that nowadays need assistance. This is not a scenario we consider realistic after talking to drivers, but it is the scenario assumed in the majority of previous studies (see Kim et al., 2019; Stevens et al., 2019; Fagnant et al., 2015; Krueger et al., 2016). High demands, given the nuances of market segmentation, will be placed on the design of SAVs. SAVs will not only have to support the standardized self-service trips, as i.e. recently worked out by Kim et al. (2019), but also attention will have to be paid to the value-added services. Communication must be possible exclusively via the vehicle and its technology. Although data concerning passenger needs can, in principle, be easily transmitted to the SAV, one cannot assume that all relevant data will be. Passengers change their minds, and sometimes have little knowledge of their destination such as a precise address. Currently, as soon as the passenger has entered the vehicle, there is usually a verbal exchange and further information can be given. T01 reported experiences with passengers who used notes to communicate their destination because they could not communicate in any other way. For those people who fail to articulate all relevant matters before the journey starts, the system will need to incorporate flexible and dynamic communication methods, such as voice commands and touch displays (Brewer and Kameswaran 2018).

To make the taxi driver completely redundant, additional logistical services that the drivers would otherwise have taken over would have to be able to be carried out automatically by the vehicles. This requires, for example, support to load and unload the vehicle (e.g. shopping baskets and trolleys) or to assist passengers getting in and out of the vehicle. These possibilities could be realized by ramps or chairlifts. In addition, SAVs would also have to offer the possibility of automatic seatbelt fastening and securing of passengers in order to serve the needy customer clientele described by taxi drivers. However, where the assistance concentrates on activities outside the vehicle (e.g. help with walking stairs), we assume that the technology will reach its limits when trying to replace these kind of services.

As long as technology cannot map these value-added services, we believe the profession of taxi driver will continue to exist, and below we outline how SAV services including supportive services and social exchange could be designed.

6.2. Design for supportive services and social exchange

While decreasing interaction and communication is accepted by younger customers for standard trips and resembles themes known from other areas of the gig economy (Pakusch et al., 2020), our interviewees emphasized the crucial nature of supplementary services for specific situations or individual needs. Taking the taxi drivers' arguments seriously, new transportation service applications could further focus on extending the services provided by taxi drivers, moving the focus away from the

organization of routes and trips to include further service offers that are tailored to special needs. As literature (2.1) and empirical data have shown, taxi trips can be classified according to types of people or trip purposes. New apps could support such a distinction by client and by driving purpose (Carmien et al., 2005; Stein et al., 2017). If the application passes on the type of customer, whether he or she is mobile, physically or communicatively restricted, or ill, the taxi driver can prepare his services accordingly and adapt them for his or her next customer.

At present, patient trips or trips with passengers that are restricted in their mobility are among those that cannot be automatically coordinated and executed with the currently available technologies and applications. Patient trips still offer room for design, particularly regarding the tasks that are currently provided by the dispatchers. Patient trips could, for example, be coordinated and billed directly between the health insurance company, hospital, customer, and driver via an ICT enabled application. If the patient passes on special requirements via the application, the taxi driver can equip the vehicle accordingly before starting the journey; perhaps adjusting the seats or the temperature in the vehicle.

If the application supports the transmission of the journey purpose, the driver can offer his customers special experiences and thus increase his customer loyalty. If a customer, for instance, orders a taxi for a trip to a party, the number of people or requests for food and drinks could be transmitted via an app. The driver can then equip his vehicle with snacks or sparkling wine, for example, in order to generate additional income.

Our study showed that drivers have already started to shift their core tasks and take over new responsibilities, thereby slowly advancing the mobility services by providing a better experience to the passenger. Even though the introduction of taxi apps had smaller effects in Germany than in other countries, a change in the work culture was clearly articulated.

Many of these services, such as equipping the vehicle with snacks, adjusting the seats or regulating the temperature, could undoubtedly also be performed automatically by SAVs. It is possible, however, that for some customers it may be a kind of luxury to have a human companion while driving, or that companies may offer their customers the special service of a human attendant, as is the case with elevators in hotels, for example.

6.3. Enriching design through workers participation

Taking a step back, what our study also shows is that there are opportunities for CSCW and HCI research to have a positive impact even on technologically-driven innovations such as SAVs. As our research shows, giving drivers a voice can open up interesting implications for the design of better workplaces or a more socially responsible and proactive development of jobs. In this sense, we follow the tradition of participatory European CSCW research promoting the development of technologies and work processes that enhance workplace democracy (Harmon and Silberman

2019). Without the involvement of taxi drivers, important aspects of taxi services are not considered at all and not-needing-a-driver-anymore is assumed as a given, as previous studies on the service design of SAVs have shown (Kim et al., 2019; Stevens et al., 2019). As a consequence, these studies disregarded the fate of the taxi drivers, and those of the vulnerable group of people with restricted mobility, missing important opportunities for service design and future research.

The findings of our study can be interpreted in different ways. On the positive side, it shows that even with advances in automation, the need for having human workers does not necessarily go away. New tasks and even new job definitions may evolve. On the negative side, there is the risk that the profession will change in a direction that will not satisfy the taxis anymore. Whether drivers will be willing or able to redefine their roles remains unknown. Opportunities exist for work such as car maintenance, coordinating SAV fleets, etc., but we cannot say how this will affect their level of autonomy and work satisfaction. As with other gig economy jobs, the question is who benefits and remains in control of the work: the taxi drivers, or a platform service provider.

As researchers, we cannot prevent the loss of a large number of jobs or the development of their profession in a direction that may no longer satisfy them. There even is a risk, that involving taxi drivers in the analysis and design of new technologies and services can contribute to their jobs becoming obsolete even faster. By including the taxi drivers themselves in the analysis of their activities, we reveal unique selling points elating to innovation considered as a socio-technical matter – for example, for passengers with particular needs, or in respect of journeys with unusual characteristics. However, giving taxi drivers a voice in the design of new mobility services offers the opportunity for shaping said systems in a way that is more positive for those involved, asking questions about how automation can be done in a way that at least recognizes flexible pathways. Involving taxi drivers in the research and design of SAVs may help them to proactively identify their role in the future and to shape the changes in their profession that are on the way. We cannot, of course, guarantee their future but we can empower them to reflect upon and possibly embrace new possibilities. When planning and conducting co-design studies of this kind, we as researchers have an obligation to consider the design of these workshops not only with a view to immediate, tangible returns but also with regard to possible long-term benefits to the participating drivers. Certainly, future workshops of this kind could involve an explicit orientation to the long-term.

Our insights provide a wide scope for further studies: (How) can taxi drivers be part of the service design of either “self-service” or “personal-service” infrastructures? How would taxi drivers feel about their work being focused on specific activity, for example, being a kind of mobile care service in the future? What are the impacts on the service when there are no people, and does this really matter? And what are the social elements of this type of work, and how can it be supported in a positive way for workers? And if thus changes are implemented, how can we make sure that new types of work provide the same level of satisfaction, or at least preserve

the autonomy of the people that are most affected by this type of change? Answering these questions is out of scope for our study, but we think that our findings provide ample insights into opportunities for future research, and thus provides first steps towards the design of a more positive future of mobility.

7. Limitations and future research

The selection of study participants is certainly a limiting factor that determines the generalizability of the results. However, we have tried to select taxi drivers in such a way that they well represent the diversity and composition of taxi drivers in Germany. Contextual qualitative work can contribute in significant ways in HCI, even when grounded in a particular context as it is the case with the study at hand. Further, the region and circumstances addressed in this study are comparable to other metropolitan areas across Europe which make our findings transferable to some extent. However, it would be enriching to conduct a subsequent quantitative study, that would involve participants with more geographic diversity, and to contrast it with the study at hand.

Another limitation is how we tackled the topic of autonomous driving in this study. As we at most provided general information about autonomous driving, pilot projects, or market introduction announcements during the qualitative interviews, the answers of the participants refer very much to their limited knowledge and imagination. Basically, the question of the threat of autonomous driving serves here as a motivation to talk about why or why not autonomous driving is a danger to their profession. From our point of view, it is not absolutely necessary for the participants to have a detailed picture of the technical possibilities of autonomous driving in order to talk about how they as a human being are advantageous to a robot. Nevertheless, this methodological aspect must of course be taken into account when reviewing the results.

In view of the narrow focus of our study and the specific framework conditions, we wish future research to conduct contrasting studies with additional drivers. While there are already many contrasting studies with drivers with respect to TNCs (section 2.3), there is a lack of studies with TNC drivers or traditional taxi drivers concerning their attitude towards SAVs. It would thus be particularly interesting to include drivers from countries where business models like Uber are already working very successfully. From them one might be able to learn whether and how they position themselves, or what assistance they offer to passengers. In addition to this, further research into specific stakeholders will be needed to get a more detailed picture. For instance, by including other professional taxi drivers, or assistance drivers, we could enrich the picture that we have drawn in this article. As we have also worked out, dispatchers are particularly affected by recent IT-driven changes. It is of particular interest to investigate the future role of dispatchers within the taxi industry and what their stance on SAVs might be. Analyzing their tasks and working practices could as well inform the design of future applications and business models. Further, we have

now discussed the perspective of professional taxi drivers and the risk of them becoming obsolete in the age of AVs. However, it will for sure be the customers who will decide between human-driven taxi or automated taxi in the end. Thus, including taxi customers into the analysis is necessary. While many studies have researched taxi und TNC customers in HCI, they have as well not yet discussed the customers preferences in the light of autonomous driving. Investigating customers should thereby cover the range of taxi customers including business customers, healthy customers, but also those with special needs such as patients or elderly (Stein et al., 2017) and possibly also other service providers such as from the field of care giving. This is in line with recent calls to practice-based research (Wulf et al., 2015) towards a more open, ethically, socially and legally circumspect design practice, which has recently been suggested in other domains and would also be important to consider in the design research on automation in mobility (Liegl et al., 2016).

8. Conclusion

The gig economy is disrupting the traditional taxi industry worldwide (Borowiak 2019). Undifferentiated and commoditized kinds of work are most likely to be automated over time, and maybe performed by automated vehicles as some experts predict (Lieber and Puente 2016). Simulations of SAV fleets have shown that the profession of taxi driver could become obsolete in the future (Burghout et al., 2015; Burns 2013; Fagnant et al., 2015; Martinez and Viegas 2017; Spieser et al., 2014). The aim of our study was to shed light on the perceptions of taxi drivers towards future forms of mobility such as SAVs to extend the discussion on the future of the gig economy and to whether the work of taxi driver really becomes obsolete with the advent of autonomous vehicles or how it might adapt in response. For doing so, we interviewed taxi drivers who have so far been underrepresented in the ongoing discourse and who have not actively been involved in research of such innovations in the area of novel mobility concepts – specially in the discussion about SAVs. Since taxi drivers cannot base their views on actual observations, as SAVs are not yet ready for the market, we have expanded the discussion to include the influence of current innovations in the area of mobility apps and services on the drivers' job to approach the topic of the impact of emerging technologies from several perspectives.

Results show that the drivers are already redefining their relationships with regional taxi dispatchers and having their relationships with other redefined for them. E-hailing apps enable them to plan and manage their own travel services. Changes in population profiles are impacting on their interactional work. With their common functions (searching, booking, tracking, communicating, paying, rating) current taxi apps support the standard trips from A to B. However, the less common, sometimes unpredictable and specifically situated nature of both passenger and journey profiles imply opportunities around support of social and physical interaction between taxis drivers and passengers in this area.

Thus, it seems reasonable that special trips including additional supportive services that go beyond pure transportation have not been, and may not be the core focus in the design of SAV services in the near future. In this respect, our study has shown how important it is to consider taxi drivers in the co-design of future taxis and SAV services precisely to take account of the special circumstances that still intervene in the lives of drivers and passengers. Unlike a number of previous studies (Alessandrini et al., 2015; Chou 2017; Madrigal 2018; Walker and Marchau 2017) we do not feel the taxi driver is going away any time soon, although the work may become more of a niche. Consequently, a division of the market between manned autonomous taxis serving a service-oriented infrastructure and driverless taxis that are aimed at customers that prefer a self-service infrastructure can be expected, which is in line with some suggestions (Litman 2017; Walker and Marchau 2017). Our study has shown that working with those whose work is being disrupted can help us to build systems or services in a responsible way, and moreover build in such a way as to reflect the heterogeneous needs of workers and passengers.

Acknowledgments

We thank the anonymous reviewers whose valuable feedback and helpful comments helped improve and clarify this manuscript.

Funding

Open Access funding enabled and organized by Projekt DEAL.

References

Agatz, Niels; Ana L. C. Bazzan; Ronny Kutadinata; Dirk Christian Mattfeld; Monika Sester; Stephan Winter; and Ouri Wolfson (2016). Autonomous Car and Ride Sharing: Flexible Road Trains: (Vision Paper). In *SIGSPATIAL'16: Proceedings of the 24th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems*, *Burlingame, California, 31 October – 03 November 2016.* New York: ACM Press, pp. p. 1–4.

Ahmed, Syed Ishtiaque; Nicola J. Bidwell; Himanshu Zade; Srihari H. Muralidhar; Anupama Dhareshwar; Baneen Karachiwala; Cedrick N. Tandong; and Jacki O'Neill (2016). Peer-to-peer in the workplace: A view from the road. In *CHI 2016: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, San Jose, California, 7 – 12 May 2016*. New York: ACM Press, pp. 5063–5075.

Alessandrini, Adriano; Andrea Campagna; Paolo Delle Site; Francesco Filippi; and Luca Persia (2015). Automated vehicles and the rethinking of mobility and cities, *Transportation Research Procedia*, vol. 5, pp. 145–160.

Alkhatib, Ali; Michael S. Bernstein; and Margaret Levi (2017). Examining Crowd Work and Gig Work Through The Historical Lens of Piecework. In *CHI 2017: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, *Denver, CO, USA, Colorado, 6–11 May 2017.* New York: ACM Press, pp. 4599–4616.

Anderson, Donald Nathan (2016). Wheels in the head: ridesharing as monitored performance, *Surveillance & Society*, vol. 14, no. 2, pp. 240–258.

Arntz, Melanie; Terry Gregory; and Ulrich Zierahn (2016). The risk of automation for jobs in OECD countries: A comparative analysis. *OECD Social, Employment, and Migration Working Papers*, no. 189.

Autor, David (2015). Why are there still so many jobs? The history and future of workplace automation, *Journal of Economic Perspectives*, vol. 29, no. 3, pp. 3–30.

Barro, Josh (2014). Under pressure from Uber, taxi medallion prices are plummeting. *The New York Times,* 27 November 2014.

Bauer, Martin (1996). *The narrative interview: Comments on a technique for qualitative data collection*. Methodology Institute.

Bond, Andrew T. (2014). An app for that: Local governments and the rise of the sharing economy, *Notre Dame Law Review Online*, vol. 90, pp. 77–96.

Borowiak, Craig (2019). Poverty in Transit: Uber, Taxi Coops, and the Struggle over Philadelphia's Transportation Economy, *Antipode*, vol. 51, no. 4, pp. 1079–1100.

Boyatzis, Richard E. (1998). *Transforming qualitative information: Thematic analysis and code development*. Thousand Oaks, California: SAGE Publications.

Braun, Virginia; and Victoria Clarke (2006). Using thematic analysis in psychology, *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77–101.

Brereton, Margot; Paul Roe; Marcus Foth; Jonathan M. Bunker; and Laurie Buys (2009). Designing participation in agile ridesharing with mobile social software. In *OZCHI '09: Proceedings of the 21st Annual Conference of the Australian Computer-Human Interaction Special Interest Group: Design: Open 24/7*, *Melbourne, Australia, 23–27 Nov 2009*. New York: ACM Press, pp. 257–260.

Brewer, Robin N.; and Vaishnav Kameswaran (2018). Understanding the power of control in autonomous vehicles for people with vision impairment. In *ASSETS 2018: Proceedings of the 20th International ACM SIGACCESS Conference on Computers and Accessibility*, *Galway, Ireland, 22–24 October 2018*. New York: ACM Press, pp. 185–197.

Brown, Barry; and Eric Laurier (2017). The trouble with autopilots: Assisted and autonomous driving on the social road. In *CHI 2017: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, *Denver, CO, USA, Colorado, 6–11 May 2017*. New York: ACM Press, pp. 416–429.

Brown, Austin; Jeffrey Gonder; and Brittany Repac (2014). An analysis of possible energy impacts of automated vehicle. In *Road vehicle automation*, Springer, pp. 137–153.

Brumby; Duncan P.; Ann Blandford; Anna L. Cox; Sandy J. J. Gould; and Paul Marshall (2016). Research Methods for HCI: Understanding People Using Interactive Technologies. In *CHI 2016: Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, *San Jose, California, 7–12 May 2016*. New York: ACM Press, pp. 1028–1031.

Bundesgerichtshof (BGH) (2015). *AZ: 3-8 O 136/14*.

Bundesverband Taxi und Mietwagen e.V (2019). Geschäftsbericht 2018/2019. p. 154, Berlin: Bundesverband Taxi und Mietwagen e.V. https://www.bzp.org/Content/INFORMATION/Geschaeftsbericht/_doc/AUSZUG-GB-KOMPLETT-kl.pdf. Accessed 27 January 2020.

Burghout, Wilco; Pierre Jean Rigole; and Ingmar Andreasson (2015). Impacts of shared autonomous taxis in a metropolitan area. In *Proceedings of the 94th annual meeting of the Transportation Research Board, Washington DC, 2015*.

Burns, Lawrence D. (2013). Sustainable mobility: a vision of our transport future, *Nature*, vol. 497, no. 7448, pp. 181–182.

Cachon, Gerard P.; Kaitlin M. Daniels; and Ruben Lobel (2017). The role of surge pricing on a service platform with self-scheduling capacity, *Manufacturing & Service Operations Management*, vol. 19, no. 3, pp. 368–384.

Carmien, Stefan; Melissa Dawe; Gerhard Fischer; Andrew Gorman; Anja Kintsch; and James F. Sullivan (2005). Socio-technical environments supporting people with cognitive disabilities using public transportation, *ACM Transactions on Computer-Human Interaction (TOCHI)*, vol. 12, pp. 233–262.

Cassel, Susanne; and Tobias Thomas (2017). Mehr Wettbewerb auf dem Taximarkt zulassen. In *List Forum für Wirtschafts-und Finanzpolitik*, Vol. 43, Berlin Heidelberg, Germany, Springer, pp. 185–187.

Chan, Ngai Keung (2019). The rating game: The discipline of Uber's user-generated ratings, *Surveillance & Society*, vol. 17, no. 1/2, pp. 183–190.

Chen, Julie Yujie (2018a). Technologies of control, communication, and calculation: taxi drivers' labour in the platform economy. In *Humans and Machines at Work*, Springer, pp. 231–252.

Chen, Julie Yujie (2018b). Thrown under the bus and outrunning it! The logic of Didi and taxi drivers' labour and activism in the on-demand economy, *New Media & Society*, vol. 20, no. 8, pp. 2691–2711.

Chen, M. Keith; and Michael Sheldon (2016). Dynamic Pricing in a Labor Market: Surge Pricing and Flexible Work on the Uber Platform. In *EC*, p. 455.

Chou, Chih-Yuan (2017). A Lie on Sharing Economy: Solutions for Uber Drivers' Dilemma When Self-Driving Cars Arrive. In *DIGIT 2017: Proceedings of the Twenty-Second DIGIT Workshop. Seoul, South Korea, December 2017.*

Davidson, Peter; and Anabelle Spinoulas (2015). Autonomous vehicles: what could this mean for the future of transport?, Presented at *AITPM 2015: Australian Institute of Traffic Planning and Management National Conference, 2015, Brisbane, Australia*.

Davidson, Peter; and Anabelle Spinoulas (2016). Driving alone versus riding together-How shared autonomous vehicles can change the way we drive, *Road & Transport Research: A Journal of Australian and New Zealand Research and Practice*, vol. 25, no. 3, pp. 51–66.

Dawes, Margo (2016). *Perspectives on the Ridesourcing Revolution: Surveying individual attitudes toward Uber and Lyft to inform urban transportation policymaking*, PhD Thesis, Massachusetts Institute of Technology.

De Stefano, Valerio (2015). *Comparative labor law and policy journal*, vol. 37, pp. 471.

Deutscher Taxi- und Mietwagenverband e.V (2016). BZP Geschäftsbericht 2015/2016. http://www.taxi-lvs.de/images/1481208729_BZP_Report_2016_Heft_7.pdf. Accessed 20 January 2020.

Dillahunt, Tawanna R.; Vaishnav Kameswaran; Linfeng Li; and Tanya Rosenblat (2017). Uncovering the Values and Constraints of Real-time Ridesharing for Low-resource Populations. In *CHI 2017: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, *Denver, CO, USA, Colorado, 6–11 May 2017.* New York: ACM Press, pp. 2757–2769.

EU Commission (2016). *Study on passenger transport by taxi, hire car with driver and ridesharing in the EU – Final Report*, EU Commission.

Fagnant, Daniel J.; and Kara M. Kockelman (2014). The travel and environmental implications of shared autonomous vehicles, using agent-based model scenarios, *Transportation Research Part C: Emerging Technologies*, vol. 40, pp. 1–13.

Fagnant, Daniel J.; and Kara Kockelman (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations, *Transportation Research Part A: Policy and Practice*, vol. 77, pp. 167–181.

Fagnant, Daniel J.; Kara M. Kockelman; and Prateek Bansal (2015). Operations of Shared Autonomous Vehicle Fleet for the Austin, Texas Market, *Transportation Research Record: Journal of the Transportation Research Board*, no. 2536, pp. 98–106.

Fleisher, Lisa (2014). Thousands of European Cab Drivers Protest Uber, Taxi Apps: Protesters in London, Madrid, Milan Say the Apps Skirt Regulations. *Wall Street Journal.*

Ford, Martin (2015). *Rise of the Robots: Technology and the Threat of a Jobless Future*, Basic Books.

Frentzen, Kathrin; Martin Beck; and Jonas Stelzer (2018). Beschäftigungswirkungen des Mindestlohns, *Wirtschaft Und Statistik*, vol. 1, pp. 35–51.

Frey, Carl Benedikt; and Michael A. Osborne (2017). The future of employment: how susceptible are jobs to computerisation?, *Technological Forecasting and Social Change*, vol. 114, pp. 254–280.

Friedman, Gerald (2014). Workers without employers: shadow corporations and the rise of the gig economy, *Review of Keynesian Economics*, vol. 2, no. 2, pp. 171–188.

Giddens, Anthony (1984). *The constitution of society: Outline of the theory of structuration*, University of California Press.

Girardin, Fabien; and Josep Blat (2010). The co-evolution of taxi drivers and their in-car navigation systems, *Pervasive and Mobile Computing*, vol. 6, no. 4, pp. 424–434.

Glöss, Mareike; Moira McGregor; and Barry Brown (2016). Designing for labour: Uber and the on-demand mobile workforce. In *CHI 2016: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, San Jose, California, 7 – 12 May 2016*. New York: ACM Press, pp. 1632–1643.

Goodall, Noah J. (2014a). Ethical decision making during automated vehicle crashes, *Transportation Research Record*, vol. 2424, no. 1, pp. 58–65.

Goodall, Noah J. (2014b). Machine ethics and automated vehicles. In *Road vehicle automation*. Springer International Publishing Switzerland 2014, pp. 93–102.

Gowda, Nikhil; David Sirkin; Wendy Ju; and Marcel Baltzer (2016). Tutorial on Prototyping the HMI for Autonomous Vehicles: A Human Centered Design Approach. In *AutomotiveUI '16: Adjunct Proceedings of the 8th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, *Ann Arbor, Michigan, 24–26 October 2016*. New York: ACM Press, pp. 229–231.

Greenblatt, Jeffery B.; and Susan Shaheen (2015). Automated vehicles, on-demand mobility, and environmental impacts, *Current Sustainable/Renewable Energy Reports*, vol. 2, no. 3, pp. 74–81.

Gwilliam, Kenneth M. (2005). Regulation of taxi markets in developing countries: issues and options. https://openknowledge.worldbank.org/handle/10986/11780. Accessed 18 September 2018.

Harmon, Ellie; and M. Six Silberman (2019). Rating working conditions on digital labor platforms, *Computer Supported Cooperative Work (CSCW)*, vol. 28, no. 5, pp. 911–960.

Haucap, Justus; Ferdinand Pavel; Rafael Aigner; Michael Arnold; Moritz Hottenrott; and Christiane Kehder (2017). Chancen der Digitalisierung auf Märkten für urbane Mobilität: Das Beispiel Uber – The prospects of digitalization in markets for urban mobility: The case of uber. In *List Forum für Wirtschafts-und Finanzpolitik*, Springer, vol. 43, pp. 139–183.

Hima, Salim; Benoit Lusseti; Benoit Vanholme; Sebastien Glaser; and Said Mammar (2011). Trajectory tracking for highly automated passenger vehicles. In *IFAC World Congress 2018: IFAC Proceedings Volumes*, *Milano, Italy, 28 August – 2 September 2011*, vol. 44, no. 1, pp. 12958–12963.

Hosseini, Amin; and Markus Lienkamp (2016). Predictive safety based on track-before-detect for teleoperated driving through communication time delay. In *2016 IEEE Intelligent Vehicles Symposium (IV)*, *Gothenburg, Sweden, 19–22 June 2016*, pp. 165–172.

IFAK (2014). Kundenzufriedenheit mit Taxiunternehmen in Deutschland 2014 – Tabellenbericht. http://www.lvsh-taxi-mietwa-gen.de/files/pepesale/content/pdf/IFAK_Tabellenbericht_Anl.pdf. Accessed 24 September 2019.

Kameswaran, Vaishnav; Lindsey Cameron; and Tawanna R. Dillahunt (2018). Support for social and cultural capital development in real-time ridesharing services. In *CHI 2018: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, *Montréal, Canada, 21–26 April 2018*. New York: ACM Press, pp. 1–12.

Kasera, Joseph; Jacki O'Neill; and Nicola J. Bidwell (2016). Sociality, Tempo & Flow: Learning from Namibian Ridesharing. In *AfriCHI'16: Proceedings of the First African Conference on Human Computer Interaction*, *Nairobi, Kenya, 21–25 November 2016*. New York: ACM Press, pp. 36–47.

Kashyap, Rina; and Anjali Bhatia (2018). Taxi drivers and taxidars: A case study of Uber and Ola in Delhi, *Journal of Developing Societies*, vol. 34, no. 2, pp. 169–194.

Kim, Sangmi; Elizabeth Marquis; Rasha Alahmad; Casey S. Pierce; and Lionel P. Robert Jr (2018). The Impacts of Platform Quality on Gig Workers' Autonomy and Job Satisfaction. In *CSCW 2018: Companion of the 2018 ACM Conference on Computer Supported Cooperative Work and Social Computing*, *Jersey City, New Jersey, 3–7 November 2018*. New York: ACM Press, pp. 181–184.

Kim, Sangwon; Jennifer Jah Eun Chang; Hyun Ho Park; Seon Uk Song; Chang Bae Cha; Ji Won Kim; and Namwoo Kang (2019). Autonomous Taxi Service Design and User Experience, *International Journal of Human–Computer Interaction*, vol. 36, no. 5, 429–448 pp. 1 429–448.

Konrad-Adenauer-Stiftung e. V (2019). Gig-Economy: Chance oder Gefährdung für den Arbeitsmarkt?, Analysen & Argumente No. 349, Konrad-Adenauer-Stiftung e. V. https://www.kas.de/documents/252038/4521287/AA349+Gig+Economy.pdf/2df45fcf-6634-7ab5-0657-4e6dfaa12f12?version=1.0&t=1556609593640. Accessed 07. January 2020.

Koo, Jeamin; Jungsuk Kwac; Wendy Ju; Martin Steinert; Larry Leifer; and Clifford Nass (2015). Why did my car just do that? Explaining semi-autonomous driving actions to improve driver understanding, trust, and performance, *International Journal on Interactive Design and Manufacturing (IJIDeM)*, vol. 9, no. 4, pp. 269–275.

Krueger, Rico; Taha H. Rashidi; and John M. Rose (2016). Preferences for shared autonomous vehicles, *Transportation Research Part C: Emerging Technologies*, vol. 69, pp. 343–355.

Kuutti, Kari; and Liam J. Bannon (2014). The turn to practice in HCI: towards a research agenda. In *CHI 2014; Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, *Toronto, Canada, 26 April – 01 May 2014*. New York: ACM Press, pp. 3543–3552.

Kyriakidis, Miltos; Riender Happee; and Joost CF de Winter (2015). Public opinion on automated driving: Results of an international questionnaire among 5000 respondents, *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 32, pp. 127–140.

Lee, Min Kyung; Daniel Kusbit; Evan Metsky; and Laura Dabbish (2015). Working with Machines: The Impact of Algorithmic and Data-Driven Management on Human Workers. In *CHI 2015: Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, *Seoul, Korea, 18 – 23 April 2015*. New York, ACM Press, pp. 1603–1612.

Leonard, John; Jonathan How; Seth Teller; Mitch Berger; Stefan Campbell; Gaston Fiore; Luke Fletcher; Emilio Frazzoli; Albert Huang; Sertac Karaman; and others (2008). A perception-driven autonomous urban vehicle, *Journal of Field Robotics*, vol. 25, no. 10, pp. 727–774.

Lewis, Elyse O'C.; and Don MacKenzie (2017). UberHOP in Seattle, *Transportation Research Record: Journal of the Transportation Research Board*, vol. 2650, pp. 101–111.

Lieber, John; and Lucas Puente (2016). *Beyond the Gig Economy – How New Technologies Are Reshaping the Future of Work|2016*, San Francisco. http://alanbweaver.com/yonkers/beyond_the_gig_economy.pdf. Accessed 02. April 2019.

Liegl, Michael; Alexander Boden; Monika Büscher; Rachel Oliphant; and Xaroula Kerasidou (2016). Designing for Ethical Innovation, *International Journal of Human-Computer Studies*, vol. 95, no. C, pp. 80–95.

Lin, Patrick (2016). Why Ethics Matters for Autonomous Cars, in M. Maurer; J. C. Gerdes; B. Lenz; and H. Winner, (eds), *Autonomous Driving: Technical, Legal and Social Aspects*, Berlin, Heidelberg: Springer, pp. 69–85.

Litman, Todd (2017). Autonomous vehicle implementation predictions, *Victoria Transport Policy Institute*, vol. 28.

Lutin, Jerome M.; Alain L. Kornhauser; and Eva Lerner-Lam MASCE (2013). The revolutionary development of self-driving vehicles and implications for the transportation engineering profession, *Institute of Transportation Engineers. ITE Journal*, vol. 83, no. 7, pp. 28.

Lutz, Christoph; Gemma Newlands; and Christian Fieseler (2018). Emotional labor in the sharing economy. In *HICSS 2018: Proceedings of the 51st Hawaii International Conference on System Sciences*, *Waikoloa, Hawaii, 3 – 6 January 2018*. New York: ACM Press, pp. 638–645.

Ma, Ning F.; Chien Wen Yuan; Moojan Ghafurian; and Benjamin V. Hanrahan (2018). Using Stakeholder Theory to Examine Drivers' Stake in Uber. In *CHI 2018: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, Montréal, Canada, 21–26 April 2018*. New York: ACM Press, pp. 1–12.

Madrigal, Alexis C. (2018). *Could Self-Driving Trucks Be Good for Truckers?* https://www.theatlantic.com/technology/archive/2018/02/uber-says-its-self-driving-trucks-will-be-good-for-truckers/551879/ Accessed 03 September 2019.

Marquis, Elizabeth B.; Sangmi Kim; Rasha Alahmad; Casey S. Pierce; and Lionel P. Robert Jr. (2018). Impacts of Perceived Behavior Control and Emotional Labor on Gig Workers. In *CSCW '18: Companion of the 2018 ACM Conference on Computer Supported Cooperative Work and Social Computing, Jersey City, New Jersey, 3–7 November 2018*. New York: ACM Press, pp. 241–244.

Martinez, Luis M.; and José Manuel Viegas (2017). Assessing the impacts of deploying a shared self-driving urban mobility system: An agent-based model applied to the city of Lisbon, Portugal, *International Journal of Transportation Science and Technology*, vol. 6, no. 1, pp. 13–27.

McGregor, Moira; Barry Brown; and Mareike Glöss (2015). Disrupting the cab: Uber, ridesharing and the taxi industry, *Journal of Peer Production*, no. 6.

Meschtscherjakov, Alexander; Alina Krischkowsky; Katja Neureiter; Alexander Mirnig; Axel Baumgartner; Verena Fuchsberger; and Manfred Tscheligi (2016a). Active Corners: Collaborative In-Car Interaction Design. In *DIS 2016: Proceedings of the 2016 ACM Conference on Designing Interactive Systems, Brisbane, Australia, 4–8 June 2016*. New York: ACM Press, pp. 1136–1147.

Meschtscherjakov, Alexander; Manfred Tscheligi; Dalila Szostak; Sven Krome; Rabindra Ratan; Bastian Pfleging; Ioannis Politis; Sonia Baltodano; Dave Miller; and Wendy Ju (2016b). HCI and autonomous vehicles: Contextual experience informs design. In *CHI EA 2016: #chi4good – Extended Abstracts, 34th Annual CHI Conference on Human Factors in Computing Systems*, *San Jose, California, 7 – 12 May 2016.* New York: ACM Press, pp. 3542–3549.

Meurer, Johanna; Martin Stein; David Randall; Markus Rohde; and Volker Wulf (2014). Social dependency and mobile autonomy: supporting older adults' mobility with ridesharing ICT. In *CHI 2014: Proceedings of the 32nd annual ACM conference on Human factors in computing systems*, *Toronto, Canada, 26 April – 01 May 2014*. New York: ACM Press, pp. 1923–1932.

Meurer, Johanna; Christina Pakusch; Gunnar Stevens; Dave Randall; and Volker Wulf (2020). A Wizard of Oz Study on Passengers' Experiences of a Robo-Taxi Service in Real-Life Settings. In *DIS 2020: Proceedings of the 2020 ACM Designing Interactive Systems Conference*, *Eindhoven, Netherlands*, *6–10 July 2020.* New York: ACM Press, pp. 1365–1377.

Minter, Kate (2017). Negotiating labour standards in the gig economy: Airtasker and Unions New South Wales, *The Economic and Labour Relations Review*, vol. 28, no. 3, pp. 438–454.

Mirnig, Nicole; Nicole Perterer; Gerald Stollnberger; and Manfred Tscheligi (2017). Three Strategies for Autonomous Car-to-Pedestrian Communication: A Survival Guide. In *HRI 17: Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction*, *Vienna, Autria, 06-09 March 2017*. New York: ACM Press: pp. 209–210.

Mönch, Alexander (2018). Wir machen das Taxigeschäft effizienter. https://www.zeit.de/mobilitaet/2018-03/mytaxi-zukunft-taxi-app-kunde-carsharing. Accessed 11 September 2018.

Morrow, William; Jeffery Greenblatt; Andrew Sturges; Samveg Saxena; Anand Gopal; Dev Millstein; Nihar Shah; and Elisabeth Gilmore (2014). Key Factors Influencing Autonomous Vehicles' Energy and Environmental Outcome. In *Road Vehicle Automation*, pp. 127–135.

Neumeier, Stefan; Nicolas Gay; Clemens Dannheim; and Christian Facchi (2018). On the way to autonomous vehicles teleoperated driving. In *AmE 2018: Automotive meets Electronics; 9th GMM-*

Symposium, *Dortmund, Germany, 07–08 March 2018*. VDE Verlag GmbH Berlin/Offenbach: pp. 1–6.

Neumeier, Stefan; Ermias Andargie Walelgne; Vaibhav Bajpai; Jörg Ott; and Christian Facchi (2019). Measuring the Feasibility of Teleoperated Driving in Mobile Networks. In *TMA 2019: 2019 Network Traffic Measurement and Analysis Conference (TMA), Paris, France, 17–21 June 2019*. IEEE, pp. 113–120.

Nordhoff, Sina (2014). *Mobility 4.0: Are Consumers Ready to Adopt Google's Self-driving Car?* Master Thesis. University of Twente.

OECD (2018). *Taxi, ride-sourcing and ride-sharing services - Background Note by the Secretariat*,. https://one.oecd.org/document/DAF/COMP/WP2(2018)1/en/pdf. Accessed 06 December 2019.

Ozenc, Fatih Kursat; Lorrie F. Cranor; and James H. Morris (2011). Adapt-a-ride: understanding the dynamics of commuting preferences through an experience design framework. *In DPPI'11: Proceedings of the 2011 conference on designing pleasurable products and interfaces*, Milan, Italy. New York: ACM Press, pp. 1–8.

Pakusch, Christina (2020). *Technology assessment of autonomous driving–are shared autonomous vehicles ecologically and socially sustainable?*. Doctorial thesis. University of Siegen, Germany.

Pakusch, Christina and Paul Bossauer (2017). User Acceptance of Fully Autonomous Public Transport. In I*CETE 2017: Proceedings of the 14th International Joint Conference on e-Business and Telecommunications. Madrid, Spain, 24–26 July 2017.* Portugal: Scitepress, pp. 52–60.

Pakusch, Christina; Paul Bossauer; Markus Shakoor; and Gunnar Stevens (2016). Using; Sharing, and Owning Smart Cars. In *ICETE 2016: Proceedings of the 13th International Joint Conference on e-Business and Telecommunications*, *Lisbon, Portugal, 26–28 July*. Portugal: Scitepress, pp. 19–30,

Pakusch, Christina; Gunnar Stevens; and Paul Bossauer (2018). Shared Autonomous Vehicles: Potentials for a Sustainable Mobility and Risks of Unintended Effects. In *ICT4S: 5th International Conference on Information and Communication Technology for Sustainability, Toronto, Canada, 14–19 May 2018*. EPiC Series in Computing, vol. 52, pp. 258–269.

Pakusch, Christina; Johanna Meurer; Peter Tolmie; and Gunnar Stevens (2020). Traditional Taxis vs. Automated Taxis – Does the Driver Matter for Millennials?, *Travel Behaviour and Society*, no. 21, pp. 214–225.

Payre, William; Julien Cestac; and Patricia Delhomme (2014). Intention to use a fully automated car: Attitudes and a priori acceptability; *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 27, pp. 252–263.

Peticca-Harris, Amanda; Nadia de Gama; and M. N. Ravishankar (2020). Postcapitalist precarious work and those in the 'drivers' seat: Exploring the motivations and lived experiences of Uber drivers in Canada, *Organization*, vol. 27, no. 1, pp. 36–59.

Pettersson, Ingrid; and IC MariAnne Karlsson (2015). Setting the stage for autonomous cars: a pilot study of future autonomous driving experiences, *IET Intelligent Transport Systems*, vol. 9, no. 7, pp. 694–701.

Pettigrew, Simone; Lin Fritschi; and Richard Norman (2018). The Potential Implications of Autonomous Vehicles in and around the Workplace, *International Journal of Environmental Research and Public Health*, vol. 15, no. 9, 1876.

Politis, Ioannis; Stephen Brewster; and Frank Pollick (2015). Language-based Multimodal Displays for the Handover of Control in Autonomous Cars. In *AutomotiveUI '15: Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, *Nottingham, United Kingdom, 01–03 September 2015.* New York: ACM Press, pp. 3–10.

Prabhat, Shantanu; Sneha Nanavati; and Nimmi Rangaswamy (2019). India's "Uberwallah profiling Uber drivers in the gig economy. In *ICTD '19: Proceedings of the Tenth International Conference on Information and Communication Technologies and Development*, *Ahmedabad, India, January 4–7, 2019.* New York: ACM Press, pp. 1–5.

Raval, Noopur; and Paul Dourish (2016). Standing out from the crowd: Emotional labor, body labor, and temporal labor in ridesharing. In *CSCW '16: Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing, San Francisco, California, 27 February – 2 March 2016*. New York: ACM Press, pp. 97–107.

Rienstra, Sytze; Peter Bakker; and Johan Visser (2015). International comparison of taxi regulations and Uber, *KiM Netherlands Institute for Transport Policy.*

Rothenbücher, Dirk; Jamy Li; David Sirkin; Brian Mok; and Wendy Ju (2015). Ghost Driver: A Platform for Investigating Interactions Between Pedestrians and Driverless Vehicles. In: *Automotive UI '15*: *Adjunct Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, Nottingham, United Kingdom, 01-03 September. 2015 New York: ACM Press, pp. 44–49.

Schreurs, Miranda A.; and Sibyl D. Steuwer (2016). Autonomous Driving—Political, Legal, Social, and Sustainability Dimensions. In *Autonomous Driving*, Springer, pp. 149–171.

Shen, Xiaotong; Zhuang Jie Chong; Scott Pendleton; Guo Ming James Fu; Baoxing Qin; Emilio Frazzoli; and Marcelo H. Ang (2016). Teleoperation of on-road vehicles via immersive telepresence using off-the-shelf components. In *Intelligent Autonomous Systems 13*, Springer, pp. 1419–1433.

Spieser, Kevin; Kyle Treleaven; Rick Zhang; Emilio Frazzoli; Daniel Morton; and Marco Pavone (2014). Toward a systematic approach to the design and evaluation of automated mobility-on-demand systems: A case study in Singapore. In *Road Vehicle Automation*, Springer, pp. 229–245.

Statista (ed) (2018). Deutsche nutzen Online-Mobilitätsdienste vergleichsweise wenig. https://de.statista.com/infografik/13586/nutzung-online-mobilitaetsdienste-in-china-und-deutschland/. 18 September 2018.

Stein, Martin; Johanna Meurer; Alexander Boden; and Volker Wulf (2017). Mobility in Later Life: Appropriation of an Integrated Transportation Platform. In *CHI 2017: Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems, Denver, CO, USA, Colorado, 6–11 May 2017*. New York: ACM Press, pp. 5716–5729.

Stevens, Gunnar; Johanna Meurer; Christina Pakusch; and Paul Bossauer (2016). From a Driver-centric towards a Service-centric lens on Self-Driving Cars. In *CHI 2016: CHI Extended Abstract HI 2016 Workshop "HCI and Autonomous Vehicles: Contextual Experience Informs Design. San José, California, 07–12 May 2016.*

Stevens, Gunnar; Paul Bossauer; Stephanie Vonholdt; and Christina Pakusch (2019). Using Time and Space Efficiently in Driverless Cars: Findings of a Co-Design Study. In *CHI 2019: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, *Glasgow, United Kingdom, 4–9 May 2019*. New York: ACM Press, pp. 1–14.

Stewart, Andrew; and Jim Stanford (2017). Regulating work in the gig economy: What are the options?, *The Economic and Labour Relations Review*, vol. 28, no. 3, pp. 420–437.

Strand, Niklas; Josef Nilsson; I. C. MariAnne Karlsson; and Lena Nilsson (2014). Semi-automated versus highly automated driving in critical situations caused by automation failures, *Transportation Research Part F: Traffic Psychology and Behaviour*, vol. 27, pp. 218–228.

Sun, Zhentian; Mingyuan Yu; Jing Zeng; Hao Wang; and Yishun Tian (2017). Assessment of the Impacts of App-based Ride Service on Taxi Industry: Evidence from Yiwu City in China. *Transportation Research Board 96th Annual Meeting.* Washington DC, United States. January 2017.

Taschler, Erica (2015). A crumbling monopoly: the rise of Uber and the Taxi Industry's struggle to survive, Chicago: Institute for Consumer Antitrust Studies. https://pdfs.semanticscholar.org/4880/5bb421a1c4e96285aaeb060c41e1193006cb.pdf. Accessed 15 September 2019.

Taylor, Harriet (2016). How robots will kill the 'gig economy'. https://www.cnbc.com/2016/03/09/how-robots-will-kill-the-gig-economy.html. Accessed 12 December 2019.

Tedjasaputra, Adi; and Eunice Sari (2016). Sharing Economy in Smart City Transportation Services. In *SEACHI 2016: Proceedings of the SEACHI 2016 on Smart Cities for Better Living with HCI and UX*, San *José, California, 08 May 2016.* New York: ACM Press, pp. 32–35.

Walker, Warren E.; and Vincent AWJ Marchau (2017). Dynamic adaptive policymaking for the sustainable city: The case of automated taxis, *International Journal of Transportation Science and Technology*, vol. 6, no. 1, pp. 1–12.

Wulf, Volker; Kjeld Schmidt; and David Randall (2015). *Designing Socially Embedded Technologies in the Real-World*, 1st ed., London: Springer Publishing Company, Incorporated.

Young, Mischa; and Steven Farber (2019). The who, why, and when of Uber and other ride-hailing trips: An examination of a large sample household travel survey, *Transportation Research Part A: Policy and Practice*, vol. 119, pp. 383–392.

Zade, Himanshu; and Jacki O'Neill (2016). Design Illustrations to Make Adoption of Ola Technology More Beneficial for Indian Auto-Rickshaw Drivers. In *CSCW '16: Proceedings of the 19th ACM Conference on Computer Supported Cooperative Work and Social Computing Companion*, *San Francisco, California, 27 February – 02 March 2016*. New York: ACM Press, pp. 453–456.