Research in Transportation Economics
Available online 30 July 2018
In Press, Corrected Proof

Implications of ride-sourcing and self-driving vehicles on the need for regulation in unscheduled passenger transport

Jørgen Aarhaug, Silvia Olsen
Show more

https://doi.org/10.1016/j.retrec.2018.07.026

Abstract

The recent emergence of large-scale ride-sourcing services, such as Uber and Lyft, is a major development in passenger transport. By utilizing fleets of private cars and app technology, these services call into question the definitions of private and commercial transport and challenge the existing transport framework in multiple ways. By operating between commercial and private services, they are partly outside the control of governments and, to some extent, contravene current regulations.

In this paper, we combine the literature on regulation and economic properties of the unscheduled passenger transport markets with scenario analyses for examining how ride-sourcing and automated vehicles affect these markets.

Our main findings are that the underlying economic mechanisms faced in markets dominated by ride-sourcing and automated vehicles have similarities with traditional markets. Hence, regardless of how the services are offered, some need for regulation will remain. However, as the market segments are different and a shift in their relative importance is likely, the possible and suitable forms of regulation will change.

Keywords

Regulation; Taxi; Ride-sourcing; Scenarios; Unscheduled passenger transport

JEL classification

D23; D43; D72; J00; K00; L00

1. Introduction

Since the arrival of ride-sourcing services in 2009, the availability of door-to-door transport in many cities has changed radically. Schaller (2017) has recently described how the habits of New Yorkers have changed in this regard, with enormous growth in market size and loss of market shares for both taxis and transit. Similar developments have been observed in many other cities, including London (Dudley, Banister, & Schwanen, 2017) and San Francisco (Rayle, Dai, Chan, Cervero, & Shaheen, 2016). Although there is still debate around whether ride-sourcing is a substitute for or supplement to public transit (cf. Hall, Palsson, & Price, 2017; Sadowsky & Nelson, 2017), ride-sourcing is a new and significant mode of travel in many cities and around the world—at the time of this writing, ride-sourcing companies are still growing rapidly.

Although automated vehicles operate with a combination of technologies that already assist the task of driving (Baker, Wagner, Miller, Pritchard, & Manser, 2016), autonomous self-driving vehicles as a commercial option in most cities are still a long way off. By autonomous self-driving vehicles, we are referring here to vehicles operating at levels 4 or 5 within the SAE International (2016) taxonomy.[1] Self-driving technology has seen rapid development, with some major companies—e.g. GM, BMW, Ford and VW—aiming to achieve level 4 automated vehicles (full self-driving automation within a defined area) as early as 2020–2024. Tesla, and Google through their subsidiary Waymo, have suggested that they will operate level 4 vehicles on the market even

earlier, based on their ongoing pilots. If—or when—this is achieved, it will likely have a significant impact on the way cars are used and owned, including implications for the kinds of door-to-door services offered to the travelling public in cities, both how they are offered and who is offering them.

In this paper, we describe and discuss the implications of ride-sourcing and self-driving vehicles on regulations within the unscheduled passenger transport markets. We begin with our theory section, presenting some of the economic mechanisms that point towards regulation in these markets. Recognizing both the global scope of these innovations and the European and North American focus in current theory and literature, we have conducted expert interviews and an expert survey to create alternative scenarios—our aim is to add robustness to the discussion on how ride-sourcing and self-driving is likely to affect the markets for unscheduled passenger transport. We therefore focus on the changes in the market structures and how these influence the economic reasons for regulation. We do not wish to contribute to the long running academic and political debate on 'regulation' vs 'deregulation' of the taxi market which focuses on quantitative restrictions, as we observe that current events with respect to the arrival of ride-sourcing companies have rendered this debate largely obsolete. Instead, we wish to contribute to the broader regulatory discussion as summarised by Bray et al. (2017). By 'unscheduled passenger transport', we mean services that provide door-to-door passenger transport for one or a few persons, i.e., services using a small vehicle, such as a taxi, private hire vehicle, black cab, limousine, and so on. Unscheduled passenger transport may also include vans and minibuses—traditional actors in these markets include taxis, limousine services and adjacent services such as demand-responsive-transport (DRT), inside or outside the organized public transport realm.

In line with Rayle et al. (2016), we use the term 'ride-sourcing' to describe app-based, on-demand ride services that are provided commercially by companies like Uber and Lyft. These services match supply and demand dynamically, by allowing a person using a smartphone app to request and accept a trip with a private vehicle in real time from potential suppliers. The distinction between 'ride-sourcing' and 'ride-sharing' is that the former is operated by drivers motivated by profit, and the latter by drivers who have an independent transport requirement but offer spare capacity in their vehicles on a non-commercial basis. As ride-sharing is not the focus of this paper. We use the term 'ride-hailing' solely with the meaning to provide the connection function between passenger and driver (i.e. the 'hailing'), regardless of how payment is handled. Ride-sourcing apps include a ride-hailing function, as do apps that use regular taxis or ride-sharing services. We use the term Mobility-as-a-Service (MaaS) to describe actors that position themselves between transport providers and customers by providing coordinating services for different transport providers, including public transport, taxis etc., as described by Kamargianni et al. (2016), Wong, Hensher, and Mulley (2018) and Smith, Sochor, and Karlsson (2018), among others.

The rest of this article is structured as follows. We begin by presenting a theoretical framework in section 2 for understanding the markets for unscheduled passenger transport. In section 3, we present our data, methods and analyses, including how the scenarios have been established. This is followed by a discussion in section 4, where we discuss how the different scenarios have an impact on both the need for regulation and the tools available. We conclude this discussion in section 5.

2. Theory

This section briefly presents existing theories for market mechanisms in the different market segments of unscheduled passenger transport, grouped as *street segments* in the Osland, Aarhaug and Longva (2010) framework. This segment is the traditional realm of the taxi industry and different *pre-book* actors. Within this analytical framework, the term 'pre-booking' means any booking through a third party, from near-immediate service to ordering a service days in advance. The key distinction between pre-booking and street segments is that a third party, i.e. a dispatcher, is involved. In these segments, various actors have traditionally been involved, including taxis, private-hire vehicles, limousines and so on, depending on context. Pre-booking is also where new entrants—such as ride-sourcing and autonomous vehicles in taxi services—are establishing themselves. In this section, we focus on the link between economic mechanisms in these segments and issues that call for regulatory intervention or non-intervention, such as public safety and security, fair treatment of passengers with respect to quality and price, environmental concerns, congestion, working conditions, city image and competition. These issues are all affected by ride-sourcing services and will be affected by the commercial arrival of automated and autonomous vehicles operating on-demand services in fleets.

A complicating factor relating to the unscheduled passenger transport markets is their inclusion of a series of partially interlinked market segments that have different economic properties; the most important distinction is between the street segments, including *street hailing* and *taxi ranks*, on the one side, and pre-booking on the other. Focusing on private, single-trip travel, we present different theories explaining the mechanisms that justify different forms of regulation in these market segments.

Traditional taxi market segments with street hailing and taxi ranks

The earliest documented regulatory interventions in taxi market segments date back to the 1630s (Gilbert & Samuels, 1982), but the topic received little academic attention until 1960–1990, when a series of academic discussions on the properties of taxi market segments took place. There have been few empirical studies on taxi regulation, however—though there are many theoretical studies reflecting the political views of the authors (Bekken, 2007; Cooper, Mundy, & Nelson, 2010). When discussing from an economics point of view whether to have quantitative regulations (typically capping the number of entrants), Moore and Balaker (2006) pointed out that studies were equally split for and against deregulation (removal of restrictions, mostly quantitative). These studies include model-building theoretical studies as well as empirical studies. However, the theoretical

studies were mostly in favour of not enforcing quantitative restrictions, pointing towards rent-seeking behaviour associated with these restrictions. The longstanding debate on quantitative restrictions in the taxi industry has largely become irrelevant with the arrival of ride-sourcing. Still, taking a more general look at the economics of unscheduled passenger transport (i.e. not limiting it to the taxi industry), the underlying economic properties of the unscheduled passenger transport market segments are often poorly understood and communicated. Only to a limited extent are the different properties of these segments included in discussions about whether, how, and why these markets should be regulated.

2.1. Street segments

The economics of the street hail (a.k.a. cruising) sub-segment have been examined in several empirical and theoretical studies (Aarhaug & Skollerud, 2014; Schaller, 2007; Shreiber, 1975), which largely agree that some regulation is needed as the customer is faced with a temporary monopoly of supply when hailing a taxi (Dempsey, 1996). For the customer, choosing to wait means uncertainty regarding when the next vacant taxi will come along or what the driver will charge. This uncertainty hands the bargaining power to the driver; in an unregulated market, one would consequently expect prices to rise, resulting in a suboptimal solution with high prices and low quality. As an alternative, it is possible to focus the analyses on the atomistic nature of the encounters between driver and passenger, which point towards arbitrary combinations of price and quality as a result of the absence of continuous supply and demand curves. Adding to this uncertainty in market outcome is the fact that there are few or no economies of scale and limited capital requirements for operating taxis in this market segment—the only capital needed is a car. All other capital requirements are induced by regulation. Consequently, in an un-regulated market, one would expect a high number of vehicles, high or arbitrary fares, low salaries, and poor quality and profits. These undesired externalities therefore warrant some form of regulations, to be enforced by the authorities, the industry or a third party.

The taxi rank sub-segment has some similarities with the street hail segment, with respect to information asymmetries and temporary monopoly. These effects are often created by the existence of a taxi rank with a strong tendency towards first-in first-out arrangements. They are enforced by either physical design or social norms resulting in an observed tendency for prices to be high or arbitrary in a free market situation, i.e. from customers being faced with a monopoly supplier in most cases. Even if there are taxis from different companies at the same rank, the relationship between driver and passenger is ‘peer-to-peer’, with the driver having an information advantage—this is in contrast to the ‘business-to-consumer’ relationship indicated by the brand on the taxi vehicle and uniform. As with the street hailing, there are few or no economies of scale in offering the service. Also, requirements are low with respect to driver skills, as the ranks are usually clearly marked at transport hubs. The barriers to entry are therefore also low, or induced by regulation. In an unregulated market, this would result in a high number of vehicles, low wages, low profits and, accordingly, a push towards cutting cost and reducing quality. These market properties thus typically result in some regulatory intervention with respect to the same issues as those in the street hail segment.

Government concerns providing arguments for regulation in the street hail and taxi rank sub-segments relate to public safety and security, fair treatment of passengers with respect to quality and price, environmental concerns, congestion, working conditions, city image and competition, and so on. If the industry or a third party[2] enforces the regulations, while their motivations may not primarily be altruistic, outcomes will largely be similar. The regulations can come in the form of quantitative restriction (a limited number of licenses), qualitative entry restriction (like ‘the knowledge’ in London), price regulation (setting compulsory fares), or other forms of market intervention, such as safety and environmental minimum standards, and technical requirements such as colour schemes, taximeters, etc. In the empirical evidence, there is no clear or obvious relationship between the regulatory approach chosen and a successful outcome (Bekken, 2007). Further, the evidence from changing regulations is mixed (Bekken & Longva, 2003). In other words, there are economic rationales for regulatory intervention in these market segments—particularly related to information asymmetry—but no clear best-practise solution.

2.2. ‘Pre-book’ segments

Mechanisms for the pre-book market segments are different. There is no need for the vehicle and passenger to be at the same point in space and time prior to the trip; rather, it is up to a dispatcher to match the supply and demand. In a way, this market segment is ‘business-to-consumer’ rather than ‘peer-to-peer’ as it is for the street segments.

Matching supply and demand in this segment is a process that has traditionally required a great deal of local knowledge and coordination. However, since the 1990s, the pre-book segment has benefited greatly from the use of computers. It is also the segment that has been influenced the most by the arrival of new communication technology—one result of which is that pre-booking can now be done instantly. Even so, there are still economies of scale with respect to fixed costs, as well as economies of density, with the vehicle closest to the customer typically being the most attractive option. In this market segment, however, a potential customer can quite easily contact several different companies and compare prices and availability, provided that they are available in the market. It is also relatively easy to build up experiences with different companies. These market properties reduce the need for regulatory intervention, as the market incentives point towards fair treatment of passengers, even for a single purchase. In an unregulated market, scale and density effects point towards either a monopoly or a dominant actor with a competitive fringe, as found by Arnott (1996), Cai (2011) and others. However, both a monopoly and a dominant actor with a competitive fringe can be undesirable market outcomes from a societal point of view. If one assumes the regulated, subsidized monopoly as a non-realistic solution, the regulatory discussion can focus on the relation between the efficiency gained from competition on the one hand and the economies of scale and density on the other. This discussion need not result in the same conclusion regardless of context. In summary, within the pre-book market, the principal need for regulatory intervention is not

linked to the needs of the passenger—which are solved by the market—but rather to societal policy objectives. These objectives are related to the allocation of the benefits these services provide (between labour, dispatcher and government), and the allocation of city space (related to desired modal split, environmental standards etc.).

In addition to the single-trip market segments, many public authorities and private companies have a demand for unscheduled passenger transport. These services are not necessarily conducted by the same actors who provide the services to the public; however, there are no technical reasons why a vehicle used for single trips cannot also be used for multiple trips. This is a 'business-to-business' market segment for services that can be provided by various actors. Who provides these services depends more on existing regulation, both governmental and company, than on the properties of the market (cf. Aarhaug, 2015). From an economic perspective, there are few arguments for regulatory intervention in this segment, aside from societal arguments such as promoting mass transit use and limiting congestion.

2.3. Consequences for regulation

As the markets in the street and pre-book segments have different properties, they require different regulations: This has commonly been addressed through the use of a two-tier system with different regulations for the street and pre-book segments. In addition, as unscheduled passenger transport is inherently flexible, the ways in which these market segments are regulated will influence how they evolve. A summary of the challenges for regulation in this context is presented in Table 1.

Table 1. Summary of regulatory issues and solutions in the existing literature.

	Hail segment	Rank segment	Pre-booked segment	Contract segment
	Street segments			
Challenges that may call for regulation	Maintaining quality of service; maintaining efficient prices, roadworthy vehicles, qualified drivers.		Market forces should keep supply, quality and price efficient. Maintaining competition is a major issue, due to network economies. Balancing economies of scale against benefits from competition, preventing monopolies.	
Theoretical solution	Regulated price, quality regulations, and (for social reasons, i.e. congestion and operator economy) quantity restrictions may be called for. However, quantity can also be regulated through quality or economic regulation.		Subsidized monopoly can maximise social welfare.[a] Market solutions should be efficient. Regulation on externalities.	Market solution regarding price, supply and quality.

[a] Market solution for price and supply is realistic; minimum standards for quality are called for, as well as regulations to limit the market power of the dominant actor.

Principal reasons for regulation in street markets include public safety and security, fair treatment of passengers with respect to quality and price, environmental concerns, congestion, working conditions and city image. Many of these are also relevant for pre-book segments. For pre-booking, as defined above, the market has properties that should resolve issues related to passenger interest without the need for government intervention. Issues related to density and network economics, and the abuse of market power by the large actors, additionally call for different regulatory approaches than those for the street segments. As pointed out by studies of taxi market regulation, deregulation is often *re*regulation. Deregulation, in the form of removing quantitative restrictions or price caps—which have been prominent in many taxi markets—is often followed by regulation along other dimensions, particularly quality and price information (Aarhaug, 2016; Bekken, 2007; Cooper et al., 2010). In the following section, through a scenario analysis, we look at how this framework is affected by the introduction of ride-sourcing and automated vehicles.

3. Data and analyses

Taxis, ride-sourcing and autonomous vehicles are global issues. However, the theory presented in the literature has primarily been developed in European or North American contexts. Recognizing this potential shortcoming in our study and the need for a broader framework for discussing its implications, we conducted expert interviews and an expert survey at a global level to create alternative scenarios. We have also had the opportunity to consult an international expert panel. These scenarios are used to add robustness to our discussion and to provide a potential correction for any eurocentrism in our conclusions.

3.1. Review of the literature and expert interviews

In order to create a business-as-usual scenario (BAU), a review of the literature was conducted with a focus on describing projections for the future, up to 2030. This was supported by a series of interviews with 10 experts representing the traditional taxi industry, ride-sourcing services, MaaS operators and representatives of regional and national regulators. The actors interviewed represented businesses operating on all continents. However, interviews with actors representing regulating authorities were only conducted in Europe, Asia and Australia. The interviews were semi-structured and conducted predominantly by telephone, but

also face-to-face whenever possible. The authors constructed a series of projections from these sources that forms the basis of the BAU scenario. This is based on the 'dominant view' of the informants and the literature.

The BAU scenario projections include:

- A smaller share of the population in major urban areas owns their own car, but the total number of cars still increases (the population in major urban areas grow faster than the number of cars in these areas).
- A smaller share of young people owns a private car, while car ownership in other groups continues to increase.
- Urban congestion is in part addressed by increased use of congestion charging schemes.
- The cost of using taxis is the same as today, as is the cost of using public transport.
- Zero or low emission vehicles are gradually utilized.
- Self-driving automated vehicles are not replacing the traditional car in the short term.
- Low-income groups increase in size.

The BAU scenario points to an increased use of non-personal vehicles—ride-sharing, ride-sourcing and public transport—on trips both within and between cities. This is a consequence of an increased availability of alternatives to the private car and an increased demand for these services. However, there are few or no radical changes in terms of new technology within this scenario; rather, technological development is a slow but continuous process.

In order to develop alternative scenarios to BAU, a set of projections for the future (presented in Table 2) was formulated based on key uncertainties identified in the literature, in interviews conducted as part of creating the BAU scenario, and in panel discussions. 'The future' was defined as the period between 2017 (when the survey was distributed) and 2030. These projections formed the basis for statements that were used in the subsequent expert survey.

Table 2. Factor loadings based on principal component analysis of the two most important components.

Rotated Component Matrix[a]	Component	
	1	2
The sharing economy flopped and does not affect travel mode choice.	0.320	−0.189
A larger share of the population in urban areas owns a car.	0.547	−0.243
The middle-income group has declined; a polarization of labour has taken place.	0.118	0.616
Self-driving vehicles have replaced the traditional car.	−0.614	0.237
The cost of using a taxi is higher than today.	0.508	−0.110
The cost of using ride-sharing services is higher than today.	0.349	0.174
The cost of using public transport is higher than today.	0.641	0.143
Urban congestion is worse than today.	0.517	0.224
The different transport modes will be more integrated than today.	−0.053	0.415
The cost of using private vehicles is higher than today.	−0.111	0.246
A larger share of the urban population chooses walking and cycling as its main mode of travel.	−0.277	0.274
The problem of transport sector emissions has been resolved by technological advancements.	−0.403	0.392
There has been a considerable automation of labour.	−0.243	0.514
Low-income groups cannot afford to live in central urban areas.	0.418	0.105
The trend of urban population growth has declined.	−0.175	−0.177
The population has an increased environmental concern.	−0.199	−0.186
The share of the population working in high-tech industries is considerably larger than today.	−0.378	0.044
Mobility-as-a-service will be provided.	0.218	0.694
The economy is marked by rapid growth.	0.369	0.374
The population values experiences and recreation higher than purchases of goods and services.	0.031	0.510
Your day-to-day transport activities are safer.	−0.342	0.195

Rotated Component Matrix[a]	Component	
	1	2

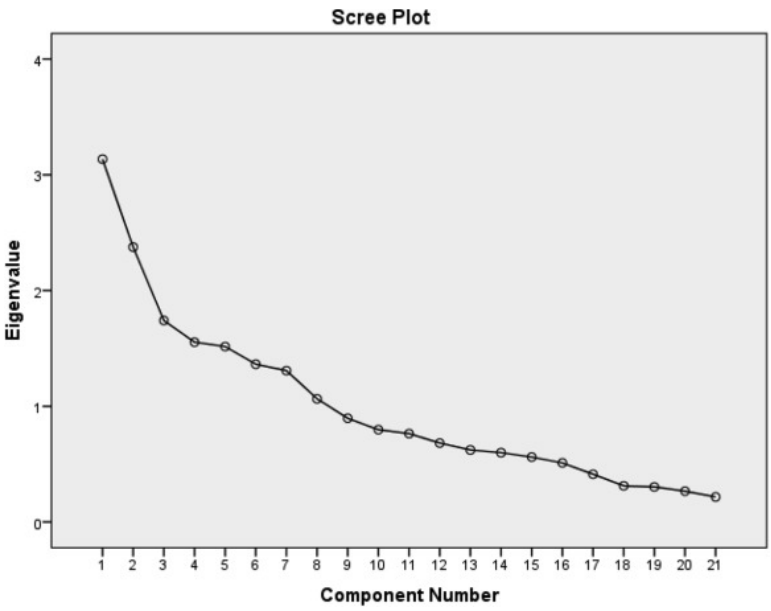
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a Rotation converged in 11 iterations.

3.2. Expert survey and alternative scenarios

The projections were used in an expert panel survey that was sent to 218 respondents representing cities in all parts of the world. The panel consisted of representatives from taxi, government, research and interest group organizations who held senior executive positions. The survey had a 35 percent response rate (n = 76) and respondents represented all continents. Europe was slightly oversampled and had a much higher response rate compared to other continents, as a consequence, Europeans are accounting for approximately 60 percent of responses.

We used a principal component analysis with varimax rotation. This methodology is used to convert possibly correlated variables into a set of variables that are linearly uncorrelated. This transformation is defined so that the first principal component accounts for as much of the variability in the data as possible. Each succeeding component accounts for as much variability as possible given the constraint that it is orthogonal to the preceding components. The eigenvalue screen plot is shown in Fig. 1. The initial analysis indicated that seven factors had an eigenvalue higher than 1, and could explain 67 percent of the variation in the different projections. As illustrated in Fig. 1, the inflexion point in the plot of eigenvalue vs number of factors point to three factors for further analysis. After an analysis of the data material, we used an eigenvalue of two as our cut-off point, leaving us with two components instead of three. This is because the projections derived from component 2 and 3 ended up being rather similar and is in line with praxis. In the expert survey, we also attempted to further differentiate between different ways of promoting MaaS and automated vehicles. However, these attempts yielded little variation to give meaningful differences; consequently, the projections were joined in the factor analyses and a discussion of different MaaS models was dropped.



Download high-res image (169KB) Download full-size image

Fig. 1. Scree plot from principal component analysis.

We base our analysis on two factors. The two factors together explained 35 percent of the variation in the different projections.

Two alternative scenarios were constructed on the basis of these factors. *The conservative car-oriented scenario*, based on the projections loading into factor 1, and *the technology and innovation scenario*, based on the projections loading into factor 2.

The conservative car-oriented scenario has the following characteristics in terms of factors that influence travel mode choice and cost.

- A larger share of the population in urban areas own a private car.

- Self-driving vehicles have *not* replaced the traditional car.
- The relative cost of using a taxi is higher than today.
- The relative cost of using public transport is higher than today.
- Urban congestion is worse than today.
- The problem of transport sector emissions has *not* been resolved by technological advances.
- Low-income groups cannot afford to live in central urban areas.

Subsequently, the increased share of the population owning a private car, coupled with more expensive taxis and public transport, results in an increase in urban congestion in this scenario.

The conservative car-oriented scenario includes characteristics opposed to projections on technological advances. This means that the conservative car-oriented scenario rejects the notion that technological advances will remove transport sector emissions and that self-driving vehicles will replace the traditional car.

The technology and innovation scenario has the following characteristics in terms of factors that influence travel mode choice and cost.

- The middle-income group has declined; a polarization of labour has taken place.
- The different transport modes will be more integrated than today.
- The labour market has been considerably affected by automation.
- MaaS has taken off.
- The population values experiences and recreation higher than purchases and consumptions of goods.

These factors are related to a belief in the impact of automation on the labour market, consequently resulting in a polarization of labour and decline of the middle class.

This scenario includes projections such as the introduction of MaaS, and a subsequent belief that different transport modes will be more integrated than today.

3.3. Likeliness of the alternative scenarios

The conservative car-oriented scenario deviates significantly from the BAU scenario, which represents the mainstream literature on future trends and projections. The technology innovation scenario, however, may be seen as a faster-paced version of the BAU scenario, where some of the observed and/or predicted trends have had a greater impact on society than expected.

Table 3 shows the expert panel's response to the different projections. The responses have been sorted in accordance with the mean score, and are marked in colour to illustrate the factor each projection is loading into. The standard deviation illustrates the degree of consensus among the panel on the mean response; low standard deviation means high consensus.

Table 3. Panel's assessment of projections on a scale from 1 (strongly disagree) to 6 (strongly agree); the shades mark the factor each projection loads into: Dark = Factor 1, Light = Factor 2, White = Does not load into the two factors; N = 76.

	Minimum	Maximum	Mean	Std. Dev.
The different transport modes will be more integrated than today.	3	6	5.32	0.594
The cost of using private vehicles is higher than today.	2	6	5.14	0.828
The population has an increased environmental concern.	1	6	5.12	0.864
There has been a considerable automation of labour.	2	6	5.09	0.769
Your day-to-day transport activities are safer.	1	6	4.78	0.903
Low-income groups cannot afford to live in central urban areas.	1	6	4.75	1.156
The share of the population working in high-tech industries is considerably larger than today.	1	6	4.74	0.971
Urban congestion is worse than today.	2	6	4.39	1.047
Mobility-as-a-service will be provided.	1	6	4.25	1.113
A larger share of the urban population chooses walking and cycling as their main travel mode.	2	6	4.21	1.037
The population values experiences and recreation higher than purchases of goods and services.	1	6	4.21	1.330
The problem of transport sector emissions has been resolved by technological advancements.	1.	6	4.11	1.090
The middle-income group has declined; a polarization of labour has taken place.	1	6	4.05	1.496
The economy is marked by rapid growth.	1	6	4.01	1.113
The costs of using public transport are higher than today.	1	6	3.84	1.132
The costs of using ride-sharing services are higher than today.	1	6	3.82	1.262
Self-driving vehicles have replaced the traditional car.	1	6	3.72	1.078
The costs of using a taxi are higher than today.	1	6	3.70	1.108
A larger share of the population in urban areas own their own car.	2	6	3.51	1.281
The trend of urban population growth has declined.	1	6	3.32	1.073
The sharing economy flopped, and does not affect travel mode choice.	2	5	3.24	0.964

We can see from Table 3 that the projection rated with the highest mean result is for the belief that different transport modes will be more integrated than today. We can also see that the panel finds the projection 'The sharing economy flopped, and does not affect travel mode choice' as the factor with the lowest mean.

We checked the data for geographical differences on views about the likelihood of the conservative car-oriented scenario. European respondents were least likely to give this scenario a likely rating. They believed most in self-driving vehicles replacing the traditional car, and that technological advancements would solve the problems of transport sector emissions. At the opposite end of the spectrum, respondents from Sub-Saharan Africa were more in favour of the conservative car-oriented scenario. This may well have been a reflection of divergent paths of development with respect to these factors, in these two very different settings. We also acknowledge the limits of this survey, as it does not address all aspects we find relevant in this discussion and there is some ambiguity in the answers given. However, we find that the survey has been a helpful tool for identifying systematic variation that would possibly be otherwise ignored in the discussion, particularly with regards to responses from non-developed countries.

4. Discussion

4.1. Implications for regulation in the business-as-usual scenario

The BAU scenario points to ride-sourcing becoming increasingly dominant in the segments for unscheduled passenger transport. This is the main change affecting regulation in this scenario. Ride-sourcing gains market shares from private cars, scheduled public transport, and newly generated traffic. In terms of traffic volume, ride-sourcing increases, which is in line with the findings of Schaller (2017) and Rayle et al. (2016). It is primarily the increased role and volume of ride-sourcing that has implications for regulation. In this scenario, autonomous vehicles are not important in the market, at least not until after 2030. Self-driving vehicles retaining the driver changes the skill set required for driving, but not the economics related to having a driver in the vehicle. It is therefore treated as a minor development within this scenario.

As far as street segments are concerned, the main effect of ride-sourcing is increased competition from the pre-book market segments, of which ride-sourcing services are a part. From the passenger's point of view and a regulatory perspective this is a positive, as the street segments require the least regulation. A transfer of passengers from street to pre-book reduces the number of actors who face the information asymmetry that creates mechanisms calling for strict regulation of prices and quality.

The arrival of low-cost ride-sourcing, as observed in many cities, means that large parts of the established taxi industry need to change their business model, accept being side-tracked or get a form of regulatory protection. A key point in ride-sourcing is the increased social control created through the rating systems. This social control, together with increased accessibility through denser networks of available vehicles, increases the utility of the passengers using ride-sourcing compared to passengers using the street hail and taxi stand markets. Although Schaller's (2017) evidence points to street market segments becoming less important, they do not disappear from within this scenario, at least not in the short term. As it is recognised that there still is a demand for vehicles at key transport nodes, such as airports and stations, and events that may at least to an extend be difficult to

serve using ride-sourcing. Also, as long as street hailing or taxi ranks are not eliminated, it is an easy and intuitive way to match transport supply and demand.

From a theoretical point of view, ride-sourcing is a part of the *pre-booking* market segment, as there is no need for both the vehicle and passenger to be at the same point in space and time when the trip starts. Ride-sourcing has the same economic properties as traditional actors in this segment (PHVs, taxis, limousines etc.). The main difference is that the supply side has received a major shock, as ride-sourcing has made it much easier to enter as a driver/operator and to up-scale the market for the dispatchers (ride-sourcing companies). Similarly, the transaction costs created by dispatching have presumably been reduced, as the connection between driver and passenger is increasingly automated and scalable with an app-based dispatching system. This has allowed dispatching to move from a city scale to a global scale, increasing concerns in relation to network economics.

A consequence of transferring traffic from the street market segments to various forms of pre-booking is that maintaining competition between actors becomes a key issue for the regulatory authorities to address, replacing issues of information asymmetry and an atomistic market. In this scenario, the questions of how to ensure continued competition within the unscheduled passenger transport markets—where the network economics point in the direction of a monopoly—and how to direct intermodal competition in a way that will not result in an undesirable modal split become key.

Questions related to regulation of labour are also a concern in this scenario. It is not that issues related to labour are easily solved in the before situation, but rather that they are a reflection of the role of ride-sourcing companies compared with more traditional dispatchers. With ride-sourcing, traditional working relations and regulations are bypassed by using self-employed drivers. This is not a radical difference compared to traditional operation in the sector (see Cooper et al., 2010), but it is a shift bypassing intermediaries and changing incentive structures, in line with other activities labelled part of the ‘collaborative economy’.

An important point is the shift in focus from efficiency to redundancy, highlighted by Rolandsson (2016) in a more general note on the ‘collaborative economy’—in which he states that an advantage of platform technology is the possibility of scaling—and by Leiren and Aarhaug (2016) regarding ‘crowd-taxis’, a term introduced to link ride-sourcing to the literature related to the concept of ‘crowd-working’ used in other sectors. Platforms can handle huge volumes of small contributions and can result in a shift in focus, on the production side, from cost efficiency to redundancy. A traditional pre-booked transport dispatcher has direct cost from owning and operating the vehicles, which means that the actors have incentives to operate these efficiently. A platform-based ride-sourcing actor does not own or operate the vehicles (as that is done by the drivers), so their incentive is therefore only related to the transport network; this points towards having as many vehicles on the streets as possible, a point that, again, has significant impact on urban planning, and not just within the transport sector. Production efficiency points in the direction of high rates of vehicle utilization, while redundancy points to having large fleets of vehicles available. Rolandsson (2016) identifies certain characteristics of the collaborative economy, where the focus has shifted to underutilized resources and where innovation no longer occurs in terms of new services but in new ways of starting and running a business. This has regulatory implications: When efficient vehicle utilization is less important than having access to many vehicles, important regulatory issues centre around working conditions, where this shift points to lower revenue per vehicle kilometre and thus lower earnings and congestion—as access to more vehicles means that more vehicles are on the streets, as noted by Schaller (2017) with regards to New York.

In this scenario, possible new ways of regulating include a focus on creating standards for minimum wages and maximum working hours. Plausible approaches for the issues in the BAU scenario are to regulate congestion by taxing empty vehicle-kilometres or by using toll schemes or road pricing. With regards to issues of local pollution, setting and enforcing environmental standards in terms of vehicle technology is a possible solution.

4.2. Implications of regulation in the conservative car-oriented scenario

In this scenario, private car use increases, while car-sharing, taxi-use, ride-sourcing and public transport all lose ground.

For the street segments, higher prices on the use of taxis and public transport, together with higher modal share of private cars, points towards less use. Still, there is no indication that this market segment will disappear. As a result, traditional issues—such as regulation for public safety, information asymmetry and atomistic markets—will still be relevant (to a greater extent than the case in the BAU scenario).

Predictions for the pre-book segments are very hard to make within this scenario, as it is unclear from the factors specified above if ride-sourcing will gain or lose ground. The main prediction is on the increased use of private cars and the decreased use of public transport. This could both stimulate increased use of ride-sourcing, as it utilizes the increased private car fleet, or it could reduce it (i.e. if people choose to drive privately using their own car, instead of using both PHVs, limousines, and ride-sourcing). However, compared to the BAU scenario, the conservative car scenario points to less change in the requirements for regulation than is the case today.

As the main development in this scenario is increased car use, congestion becomes increasingly worse in the major cities, impacting regulation in relation to the use of city space and environmental concerns.

However, the direction of the effect of increased congestion is not obvious. On the one hand, congestion points to the potential for increased use of congestion charging for private vehicles to make their use less attractive in peak hours. On the other hand, the

alternatives to private car use become less attractive, and therefore regulation to replace private car use becomes less relevant. The question arises: To what extent will regulation target commercial passenger transport vehicles? Similarly, congestion caused by increased use of private cars points to the use of city space being changed, while the use of other modes and ride-sharing are promoted as alternatives. Promotion of non-personal vehicle use may be relevant through better taxi stands and providing access to priority lanes for high occupancy vehicles (among others). However, it is doubtful that these measures would be as effective in alleviating congestion as some form of conventional public transport use. Alternatively, a likely political implication of the conservative car-oriented scenario is that private car use is increasingly supported by the government at the expense of other modes. If car use dominates, one would expect that the interests of private car users would be given priority in political processes—thus pointing to an uphill battle for non-personal vehicles in all market segments and tighter competition for use of city space, an already scarce resource.

Furthermore, an increasing share of the population will move to the suburbs in this scenario (i.e. urban sprawl), with private-car-based commuting. From a regulatory perspective, this again points to congestion charging and promotion of scheduled public transport, rather than regulatory measures that directly affect the market segments for commercial unscheduled passenger transport. It is assumed that car-pools and ride-sharing will not continue to grow. This is opposed to a continuation of the rapidly increased car-sharing and related services described by Bert et al. (2016, pp. 1–13) and the developments in the BAU scenario. On the one hand, this scenario plays well with increased use of ride-sourcing, with a more car-centric culture and use of space, together with an increased share of the population being more cost-aware. On the other hand, the scenario is focused on the use of private cars rather than taxis and ride-sourcing.

In the conservative car-oriented scenario, environmental concerns are not addressed with the arrival of new technology, which means that they have to be addressed through policy measures, very likely at city level. How these policies are shaped will influence how the different industries within unscheduled passenger transport evolve.

Compared to the BAU scenario, there is less need for new regulatory approaches in this scenario. That said, congestion and environmental concerns become more pressing. This again points towards pricing in the negative externalities associated with congestion in the regulation of unscheduled passenger transport markets. This could take the form of a general move towards road-pricing or congestion charging: for example, a tax levied on vehicle-kilometres used and taxes on vehicles with high levels of local pollution. Alternatively, funding schemes, or direct regulation, for promoting vehicles with lower negative externalities. The issues related to labour that were key in the BAU scenario become relatively less important in this scenario, compared to the traditional concerns for passenger safety, information asymmetry, and the increased issues related to congestion and environmental factors.

4.3. Implications of regulation in the technology innovation scenario

The technology innovation scenario is different in that autonomous vehicles become available commercially within the scenario. This situation will radically affect the market for unscheduled passenger transport as labour costs are reduced. Consequently, one would expect passenger fares to fall and usage to increase. Using a Norwegian example (Aarhaug, Hagman, & Skollerud, 2013), labour costs constitute about 60 percent of total costs in taxi operations. Consequentially, we expect the introduction of automated vehicles for commercial applications, both scheduled and unscheduled, to precede the introduction of such vehicles for private use; this is in line with the projections presented in Kristensen et al. (2018). In extension, we expect the market segment—unscheduled passenger transport with autonomous vehicles—to both induce new demand and take other modes' market shares, possibly from private cars but particularly from scheduled public transport; this latter may become largely irrelevant as a mode, with the exemption of heavily trafficked corridors. In this discussion, we do not address issues related to the transition period in the introduction period for automated vehicles. Rather, we focus on the regulatory impact of having level 4 or5[3] autonomous vehicles available for commercial passenger transport on the road, either in limited areas or in full deployment.

Autonomous vehicles require a booking through a third party, as there is no driver to do the transaction directly. Therefore, issues related to information asymmetry and the atomistic market found in the traditional street segments become irrelevant. Only congestion at key transport hubs remains relevant as an aspect requiring regulation.

Autonomous vehicles will merge street segments with pre-booking segments, creating a new service that contrasts with traditional scheduled public transport, as opposed to today's market segments within unscheduled transport. Lower operating costs would point towards increased demand, both in the form of induced demand and transfers from other modes. Consequently, one would expect a move towards higher density in supply—which again, through network externalities, would result in higher welfare and further increases in supply. However, this increase in demand points towards a new set of challenges for regulation. The distinction between scheduled and unscheduled transport become blurred. This may very well also be the case with the distinction between private and public transport, and is also a temporal efficiency issue (cf. Wong et al., 2018). Within this scenario, autonomous vehicles are shared more than conventional cars. However, it is unclear that this is an obvious market solution. Is there a qualitative difference between an autonomous vehicle and a non-autonomous vehicle that points to the one being more suited for sharing than the other? It is clear that unregulated use of autonomous vehicles points towards increased use, and consequentially increased welfare. How this welfare increase is to be distributed is a question—one where regulation may have a substantial influence. Key issues become regulating congestion and ownership/usage patterns. This may take the form of regulation that favours joint or fleet ownership of autonomous vehicles, as opposed to private personal ownership.

When we examine ownership, we are looking at how this market is organized. If organized in a way that the vehicles are owned by a public entity (as opposed to private individuals), or by a company acting on a public entity's behalf, one would expect larger vehicles for joint ridership to be given priority, and that the number of passengers per vehicle-kilometres can substantially increase. A fleet or joint ownership solution points towards shared or differentiated use, not necessarily that each trip will be shared between individuals but that each vehicle will transport more than just its owners. All other things being equal, this would increase the vehicle-kilometres provided.

Given some form of common ownership, one would expect that the market structure of today's pre-book segments would prevail, based on network effects. Possible regulatory solutions are 1) to auction the operation of such vehicles as a private monopoly, as in the bus sector today (following the Scandinavian model) (Bekken, Longva, Fearnley, Frøysadal, & Osland, 2006)—this has been the main direction across all public transport modes over the past 30 years (Wong & Hensher, 2018); or 2) to enforce a competitive solution using regulation similar to some pre-book markets today, with licenses and regulation regarding the maximum market shares that each operator can have in each region.

With individual ownership of automated vehicles, the regulatory context would be very different, i.e. more like that for private cars. Consequently, instruments such as congestion charging and vehicle standards for environmental regulation would become more appropriate policy measures. Network effects resulting in concerns for lack of competition would not be an issue, beyond what is covered by ordinary competition laws. However, the need to regulate the use of city space would be substantial, as one would expect vehicle mileage to increase and the number of passenger-kilometres per vehicle-kilometres to drop from 1) lower occupancy, as the vehicles can be used to drive back empty to park; 2) dead running, with autonomous vehicles roaming the network with no one on board, to avoid the need for parking; 3) induced demand; 4) lower generalized cost associated with each trip; and 5) transferred demand from other modes—particularly public transport, as the cost and disutility of using a private vehicle is reduced. These effects points towards an increase in congestion as a negative externality.

All effects taken together, the technology and innovation scenario points towards reduced need for regulation. That is not to say that regulation in all forms should disappear, but rather that today's distinctions between street and pre-book segments become irrelevant. Also, autonomous vehicles may blur the distinction between scheduled and unscheduled transport, and between private and public transport. Together, this points towards rethinking regulation, a key part of which is identifying the issues that call for regulation in this setting. In our opinion, this may include: 1) *congestion*, which can either be addressed through regulation ownership (promoting joint ownership) or usage (taxing empty/underutilization of capacity); 2) *environmental impact*, which can be addressed by regulating vehicle technology and usage; and 3) *social inclusion*, which can be addressed by providing a service for those who are unable to use autonomous vehicles on their own, through fleet-level regulation (requiring a certain proportion of vehicles to have an assistant on board or similar), taxation and transfers (taxing the use of autonomous vehicles), or direct subsidies to persons who require assistance.

4.4. Summary discussion

Unscheduled passenger transport has properties that call for more regulation than is necessary in other markets and market segments. However, some of these properties are likely to change, through societal and technological shifts. The expected direction of these changes is summarised in Table 4.

Table 4. Changing regulatory requirements in the three scenarios.

	Business as usual (BAU)	Conservative car-oriented	Technology and innovation
Street segments (hail and rank)	These segments lose importance to pre-booked segments; reduces the need for regulation on safety, quality and price.	As BAU	Will disappear
Pre-book segments	Segment increase, both through new traffic and as a result from transfers from other modes and segments.	As BAU	Much cheaper
Concerns	Changes from concerns based on information asymmetry to competition between networks Competition Labour Efficiency and congestion	Congestion Environment	Change in intermodal spit PT => Autonomous vehicles Ownership structure

Both the business-as-usual scenario created from the literature and the alternative scenarios created from the expert survey point to a direction where the street market segments become less important. However, only in the technology and innovation scenario—where autonomous vehicles dominate—will the issue of information asymmetry between transport provider and passenger be fully addressed by technology and make regulation of these issues superfluous. As information asymmetry and passenger safety are the major rationales for regulatory intervention in this market segment, there is still a need for regulation in the short and medium future, regardless of scenario.

In pre-book market segments, there are issues outside information asymmetry and the fair treatment of passengers that are more important. As this segment gains in terms of its share of the transport market—in both the business-as-usual and car-oriented scenarios—regulation of the pre-book market segment becomes more important than today. In particular, issues related to network economics, and congestion must be taken into account, especially with regards to ride-sourcing.

Aspects made more important by network economics include limiting the largest operator's potential to use its market power to curb competition. In this, we assume that the theoretical first-best solution of the subsidized monopoly, as described by Arnott (1996), is not an option. This situation also points towards a need for research on what the relevant markets are, in terms of both intermodal competition and geographical scope. A monopoly in a market segment is an issue if the monopolist has the potential to extract monopoly rents. The question of to what extent the private car and scheduled public transport are viable options for pre-booking unscheduled services will determine the degree of importance of market power within the pre-book segments. Still, a monopoly as the best solution is doubtful, as one could readily imagine a monopolist creating situations where rent can be extracted—especially since such an actor could combine being a monopolist towards consumers with being a monopsonist towards suppliers.

Congestion remains an issue in all scenarios, but the regulatory options addressing congestion will depend upon which business models are allowed in the technology innovation scenario: i.e., limiting empty vehicle mileage—either in the form of a tax on empty driving or as part of a general congestion pricing scheme not limited to commercial transport—remains options for regulation. In the technology and innovation scenario, with autonomous vehicles, regulation related to ownership can become an option as an alternative to congestion pricing. The need for environmental regulation will remain, regardless of development scenario, but the toolbox available will depend on the market structure. One particularly interesting aspect in the technology and innovation scenario is that the distinction between private and public transport, and between scheduled and unscheduled transport, become blurred. The distinctions which are obvious today may no longer be relevant, if both shared and exclusive automated vehicles are available through the same intermediary. This points towards a need for a totally new set of thinking about transport.

In summary, changes in the available technology, together with new ways of utilizing existing technology, point towards new issues that need to be addressed by regulation. Using the framework presented by Bekken and Longva (2003), the issues that are used to justify a combination of strict qualitative and price regulation become less important or lose their relevance altogether. This is a consequence of moving from the direct relation between passenger and driver to booking through an intermediary. This also means that these intermediaries become more powerful, both in relation to the drivers/operators and the passengers, and that this relation becomes key in future regulation, as suggested by Leiren and Aarhaug (2016). The present and—within our scenarios—future situation calls for regulation to address the issues related to the increasingly blurred distinction between public and private transport, as described by Feigon, Murphy, and McAdam (2018) and Enoch (2015), particularly related to conflicts over city space and effects on total vehicle miles driven. This can be solved by either creating new regulation for each new form of transport that appears or—as is currently being attempted in Finland—by creating a new framework law that is mode-agnostic[4], to address overall issues such as access to markets. There will probably be a need for local or regional regulation to supplement the mode-agnostic laws and to address issues that arise at specific locations, such as congestion and inter- and intramodal competition.

5. Conclusions

In this study, we have argued that both ride-sourcing and autonomous vehicles will influence the need for the regulation of unscheduled passenger transport. In the business-as-usual and conservative car-oriented scenarios, it is not so much that we see a reduction in the need for regulation compared with today's situation, but that these developments point towards changing which parameters are used in regulation. Regulation focused on tackling street segment issues, such as passenger safety and information asymmetry, becomes less important while regulation towards congestion, competition and labour issues become more important. Although there is much uncertainty with regard to the future, some common ground has been found.

In all the scenarios discussed, street market segments currently dominated by taxis lose out either to private cars or to pre-booked trips (ride-sourcing, taxi-use, ride-sharing or similar services) or automated vehicles. The need for regulation to ensure fair treatment of passengers is reduced and, in contrast, congestion and competition become more important. As long as the playing field is divided between actors following different rules, it will be difficult to enforce proper competition regulation. This can be addressed either by creating a framework regulation, addressing what is different about transport markets today, or by enforcing regulation along the strictest criteria for all actors who offer unscheduled passenger transport. In addition, issues related to information asymmetry and fair treatment of passengers on street segments may not disappear, as long as vehicles with drivers accepting cash payments are an option. In other words, suitable regulation of these segments must be found, even if the relative importance of these market segments decrease.

In the scenario with autonomous vehicles, the key question influencing the regulatory options at a city level centres around how the market will be organized. Will the vehicles be owned and operated by private individuals/companies operating them as taxis, or will the vehicles be operated as part of public transport? In the first case, congestion and environmental issues may call for substantial regulation (cf. Wong et al., 2018); in the latter, they may be dealt with in contracts between the authorities and operators, without the need for much explicit regulation in addition to of these contracts (cf. Hensher, 2017).

Acknowledgements

The research leading to the publication of this paper was financed in part by the Strategic Research Programme (SIS) "Competition in Passenger Transport: Governance, Regulation and Efficiency" and the following projects: SHIFT—Sustainable Horizons in Future Transport, a flagship Nordic Energy Research project supported by the Nordic Council of Ministers (www.nordicenergy.org/flagship/project-shift/); CLIMAMOB—Climate change and everyday mobility: social impacts, adaptation and mitigation strategies, funded by the Norwegian Research Council through the Climate Research Program KLIMAFORSK (project no. 244137); and DIGMOB—Digitalization and mobility: Smart and sustainable transport in urban agglomerations, funded by the Norwegian Research Council (project no. 283331).

Appendix A. Supplementary data

The following is the supplementary data related to this article:

Recommended articles Citing articles (0)

Research data for this article

Data not available / The data that has been used is confidential

About research data

References

Aarhaug, 2015 J. Aarhaug
Competitive tendering in an entry regulated market—an accident waiting to happen?
European Transport Research Review, 7 (2015), p. 17
Google Scholar

Aarhaug, 2016 J. Aarhaug
Taxis as a Part of public transport
(2016)
Sustainable urban transport technical document #16
http://sutp.org/files/contents/documents/resources/B_Technical-Documents/GIZ_SUTP_TD16_Taxi_EN.pdf
Google Scholar

Aarhaug et al., 2013 J. Aarhaug, R. Hagman, K. Skollerud
Drosjer i Østfold – et marked i utvikling
(2013)
TOI-report 1256/2013
Google Scholar

Aarhaug and Skollerud, 2014 J. Aarhaug, K. Skollerud
Taxi: Different solutions in different segments
Transportation Research Procedia, 1 (2014) (2014), pp. 276-283
Article Download PDF View Record in Scopus Google Scholar

Arnott, 1996 R. Arnott
Taxi travel should Be subsidized
Journal of Urban Economics, 40 (1996), pp. 316-333
Article Download PDF View Record in Scopus Google Scholar

Baker et al., 2016 R. Baker, J. Wagner, M. Miller, G. Pritchard, M. Manser
Disruptive technologies and transportation
Final Report. Texas A&M Transportation Institute (2016)
Google Scholar

Bekken, 2007 J.T. Bekken
Experiences with (De-)regulation in the European taxi industry
(De)regulation of the taxi industry, round table, 133, OECD (2007)
Google Scholar

Bekken and Longva, 2003 J.T. Bekken, F. Longva
Impact of taxi market regulation - an international comparison
Institute of Transport Economics, Oslo (2003)
TØI report 658/2003

Google Scholar

Bekken et al., 2006 J.T. Bekken, F. Longva, N. Fearnley, E. Frøysadal, O. Osland
Procurement and contracts for local bus services
(2006)
TØI report 819/2006
Google Scholar

Bert et al., 2016 J. Bert, *et al.*
What's ahead for car Sharing? The new mobility and its impact on vehicle sales
Boston Consulting Group, Inc. (2016)
2/16
Google Scholar

Bray et al., 2017 Bray, D.D. Hensher, Y. Wong
Thredbo at Thirty: Review of past papers and reflections
Competition and Ownership of Land Passenger Transport, Stockholm (2017)
2017
Google Scholar

Cai, 2011 H. Cai
Competition in the Bergen taxi market. Model simulations
(2011)
SNF rapport 14/11
Google Scholar

Cooper et al., 2010 J. Cooper, R. Mundy, J. Nelson
Taxi! Urban economies and the social and transport impacts of the taxicab
Ashgate (2010)
Google Scholar

Dempsey, 1996 P. Dempsey
Taxi industry regulation, deregulation & reregulation
Transportation Law Journal, 24 (73) (1996), pp. 73-120
HeinOnline
View Record in Scopus Google Scholar

Dudley et al., 2017 G. Dudley, D. Banister, T. Schwanen
The rise of uber and regulating the disruptive innovator
The Political Quarterly (2017)
May 2017
Google Scholar

Enoch, 2015 M.P. Enoch
How a rapid modal convergence into a universal automated taxi service could be the future for local passenger transport
Technology Analysis & Strategic Management, 27 (8) (2015), pp. 910-924, 10.1080/09537325.2015.1024646
CrossRef View Record in Scopus Google Scholar

Feigon et al., 2018 S. Feigon, C. Murphy, T. McAdam
Private Transit: Existing services and emerging directions
TCRP Research Report 196 Pre-Publication Draft (2018)
January 2018
Google Scholar

Gilbert and Samuels, 1982 G. Gilbert, R.E. Samuels
The taxicab. An urban transportation survivor
University of North Carolina Press (1982)
Google Scholar

Haakaas and Sæter, 2011 E. Haakaas, K. Sæter
Svindel uten grenser: en reise I svart drosjeøkonomi
Aschehaug, Oslo (2011)
Google Scholar

Hall et al., 2017 J.D. Hall, C. Palsson, J. Price
Is Uber a substitute or complement for public transit?
October 27. 2017
http://www.palssonresearch.org/Uber_and_Public_Transit.pdf (2017)
Google Scholar

Hensher, 2017 D.A. Hensher
Future bus transport contracts under a mobility as a service (MaaS) regime in the digital age: Are they likely to change?
Transportation Research Part A: Policy and Practice, 98 (2017), pp. 86-96
April 2017
Article Download PDF View Record in Scopus Google Scholar

Kamargianni et al., 2016 M. Kamargianni, W. Li og, M. Matyas
A comprehensive review of "mobility as a service" systems"
TRB 2016 (2016)
Google Scholar

Kleemans and Van de Bunt, 2008 E.R. Kleemans, H.G. Van de Bunt
Organised crime, occupations and opportunity
Global Crime, 9 (3) (2008), pp. 185-197
CrossRef View Record in Scopus Google Scholar

Kristensen et al., 2018 N.B. Kristensen, A. Enemark, K. Hauxner, M. Wass-Danielsen, M. Fosgerau, O.A. Nielsen, *et al.*
Mobilitet for fremtiden
The Danish expert group on future mobility (2018)
March 2018
https://www.trm.dk/da/temaer/mobilitet-for-fremtiden
Google Scholar

Leiren and Aarhaug, 2016 M.D. Leiren, J. Aarhaug
Taxis and crowd-taxis: Sharing as a private activity and public concern
Internet Policy Review, 5 (2) (2016)
2016
Google Scholar

Moore and Balaker, 2006 A.T. Moore, T. Balaker
Do economists reach a conclusion on taxi deregulation?
Econ Journal Watch, 3 (1) (2006), pp. 109-132
View Record in Scopus Google Scholar

Osland et al., 2010 O. Osland, J. Aarhaug, F. Longva
Drosjetilbudet i distriktene etter omleggingen av pasienttransporten i 2004
TØI-rapport, 1086/2010
Transportøkonomisk institutt, Oslo (2010)
Google Scholar

Rayle et al., 2016 L. Rayle, D. Dai, N. Chan, R. Cervero, S. Shaheen
Just a better taxi? A survey-based comparison of taxis, transit, and ride-sourcing services in San Francisco
Transport Policy, 45 (2016), pp. 168-178
Article Download PDF View Record in Scopus Google Scholar

Rolandsson, 2016 B. Rolandsson
The sharing economy in Sweden
Paper presented at "Delingsøkonomien møter den nordiske modellen" Fafo 27th September 2016 (2016)
Google Scholar

Sadowsky and Nelson, 2017 N. Sadowsky, E. Nelson
The impact of ride-hailing services on public transportation use: A discontinuity regression analysis. Bowdoin working paper 5-26-2017 (2017)
https://digitalcommons.bowdoin.edu/econpapers/13/
Google Scholar

Schaller, 2007 B. Schaller
Entry controls in taxi Regulation: Implications of US and Canadian experience for taxi regulation and deregulation
Transport Policy, 14 (2007), pp. 490-506
Article Download PDF View Record in Scopus Google Scholar

Schaller, 2017 B. Schaller
Unsustainable? The growth of app-based ride services and traffic, travel and the future of New York City
Schaller Consulting, New York (2017)
Google Scholar

Shreiber, 1975 C. Shreiber
The economic reasons for price and entry regulation of taxicabs
Journal of Transport Economics and Policy, 9 (1975), pp. 268-279
View Record in Scopus Google Scholar

Skaperdas, 2001 S. Skaperdas
The political economy of organized crime: Providing protection when the state does not
Economics of Governance, 2 (2001) (2001), pp. 173-202
CrossRef View Record in Scopus Google Scholar

Smith et al., 2018 G. Smith, J. Sochor, M. Karlsson
Mobility as a Service: Development scenarios and implications for public transport
Research in Transportation Economics (2018)
https://doi.org/10.1016/j.retrec.2018.04.001
Google Scholar

Wong and Hensher, 2018 Y.Z. Wong, D.A. Hensher
The thredbo story: A journey of competition and ownership in land passenger transport
Research in Transportation Economics (2018)
https://doi.org/10.1016/j.retrec.2018.04.003
Google Scholar

Wong et al., 2018 Y.Z. Wong, D.A. Hensher, C. Mulley
Emerging transport technologies and the modal efficiency framework: A case for mobility as a service (MaaS)
ITLS-working paper ITLS-WP-18-04
(2018)
Google Scholar

[1] https://www.sae.org/standards/content/j3016_201609/.

[2] Traditionally, organized crime has had close links to (parts of) the taxi industry (see Skaperdas, 2001; Kleemans & Van de Bunt, 2008; Haakaas & Sæter, 2011; etc.), and acted in a regulatory role.

[3] https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety#issue-road-self-driving.

[4] https://www.lvm.fi/en/home.

View Abstract