TAXIcouncil QUEENSLAND
8/96 Cleveland St
PO Box 290
Stones Corner QLD 4120
[redacted]

Ms Deborah Jeffrey
Committee Secretary
Transport and Public Works Committee
Parliament House
George Street
Brisbane, Queensland, 4000
By email: tpwc@parliament.qld.gov.au

Dear Ms Jeffrey

RE: Inquiry into Transport Technology

The Taxi Council of Queensland (TCQ) is the peak representative body for the taxi services industry and more broadly, the personalised transport sector, in Queensland. TCQ's members participate in the sector as –

- Authorised Booking Entities;
- Taxi licence owners;
- Taxi fleet operators; and
- Taxi/booked hire drivers.

Relevantly, TCQ represents the interests of approximately 20,000 small, medium and large businesses. We are also a member of the national industry body, the Australian Taxi Industry Association (ATIA), and through the ATIA, indirectly members of international bodies including the North American based Taxicab, Limousine & Paratransit Association (TLPA) and the European based International Road Transport Union (IRU).

TCQ has an obvious interest in the Transport and Public Works Committee's (the Committee's) Inquiry into Transport Technology (the Inquiry). We offer the following comments specifically in relation to the Committee's consideration of connected and autonomous vehicle technologies for personal and public transport[1]. In regard to other technologies, including electric vehicles (EVs), we supply the paper prepared for the IRU by the Institute of Transport Economics, "*Taxi of the Future – Towards fully sustainable and innovative taxi operations*" as Attachment A for consideration by the Committee for the Inquiry[2].

Autonomous Vehicles

TCQ considers that the introduction of Autonomous Vehicles (AVs) will likely constitute the most significant disruption to prevailing operational and business paradigms that

[1] TCQ position on connected and autonomous vehicles adopts the ATIA's position.
[2] TCQ was involved in the preparation of this paper through ATIA and its membership of the IRU's TOF working group.

stakeholders within the personalised transport sector will have ever experienced. It will prospectively comprise both challenges and opportunities for all sector participants.

As the artificial intelligence (AI) innovations underpinning AVs advance, it will be especially important that the transition phase from wholly human driven vehicles to wholly driverless vehicles is managed proactively to avoid adverse market distortions and minimise unintended social dishevel. In TCQ's view, there will be a real and necessary role for Government interventions that prioritise and protect safety, as well as promote level playing fields conditions for new and existing market competitors. Moreover, TCQ expects that it will likely be appropriate and efficient for State and Commonwealth Governments to consider interventions directed to preserving fair and vigorous competition by diverse private sector suppliers within the personalised transport sector, and protecting the huge amounts of personal data associated with AV usage.

On-road trials and simulations of AV technologies are occurring in many jurisdictions around the world. These trials are supported by huge investments from virtually all of the global vehicle manufacturers, as well as giant software and hardware suppliers. In TCQ's view, the progression to full automation (or Level 0-5 of SAE J3016[3]) can be considered inevitable and it will likely occur at an accelerating pace notwithstanding some disjointedness. TCQ expects that consumer acceptance and the adaptation of the legal, regulatory, and insurance environments are more likely to slow or impede progression (i.e. cause disjointedness) rather than obstacles associated with development of AV technologies.

TCQ holds an optimistic view of the potential for AVs to beneficially:

- improve road safety (e.g. by reducing crashes caused by human error);
- increase transport efficiency (e.g. by maximising road carrying capacities through cooperative connected vehicle operations such as platooning);
- decrease transport costs (e.g. by removing/avoiding driver related costs); and
- reduce vehicle emissions (e.g. by promoting alternatives to the single occupant private vehicle travel mode).

Notwithstanding those benefits, it may also be case that the transition to AV negatively:

- triggers large scale job losses as driving roles across the transport sector become redundant, and without commensurate numbers of new opportunities emerging in ancillary support and carer roles;
- meets with consumer and community resistance, if safety concerns are not adequately addressed.
- raises concerns for data security and data ownership, especially from the perspective of personalised transport providers;
- raises concerns for privacy protection from the perspective of personalised transport consumers;
- raises concerns for legal and insurance liabilities, as well as service responsibility, especially as control of material elements devolve to entities estranged and far removed from the physical supply chain for transport services; and

[3] The international standard, SAE J3016, defines Level 0: No automation | Level 1: Driver assistance (*feet off*) | Level 2: Partial automation (*hands off*) | Level 3: Conditional Automation (*mind off*) | Level 4: High Automation (*body off*) | Level 5: Full Automation (*driver off*).

- risks being delayed or diverted by policy settings of Government that misalign with the contemporary or future good of the community.

TCQ Position

The taxi services industry in Australia has a long and proud history of being early adopters of technological innovations and accordingly supports an orderly transition to deploying autonomous vehicles for mobility service delivery. TCQ's position on AVs focusses on the key elements of safety, security and sustainability (i.e. a 3 "S" strategy)[4]:

Safety

- Technical standards for AVs must be harmonised and interoperable across all Australian jurisdictions.
- AV technologies must be proven safe through open and publicly reported, exhaustive trials replicating a comprehensive range of all conceivable real world conditions, before progressing to commercial release.
- During the transition phase, trials should involve professional personalised transport sector taxi operators.

Security

- The risk of cyber-attacks on AVs must be minimised, data security must be ensured, and privacy must be protected through sophisticated encryption with ongoing monitoring and development, and mandatory public disclosure of all material breaches and failures.
- Ethical questions of road safety crash avoidance systems must be resolved before progressing to commercial release.
- The ownership of data related to transport operations should remain with the respective transport provider.

Sustainability

- As the roles of professional drivers change, it will be important for industry and Governments to work together to encourage new drivers to enter the personalised transport sector all the way up to Level 5 AVs (full automation) becoming ubiquitous. The sector will need a clear vision for the future of its human resources and how professional driving roles may be successfully promoted in the context of their foreseeable future redundancy.
- Public and shared use of AVs, especially utilising private sector operators in the personalised transport sectors, must be put in place to promote efficient use of scarce public road and off-road (parking) space and prevent inefficient AV applications promoting otherwise avoidable congestion.
- As higher levels of autonomy are progressed to commercial release, the balance of liability logically shifts from human drivers to vehicle manufacturers and component technology providers. The regulatory and insurance environments must adapt in lockstep as the technology evolves in real world marketplaces to ensure personalised

[4] *Informed by, and consistent with, the 3 "S" strategies promoted by the ATIA and also the IRU.*

transport providers can operate with legal certainty in regard to their Workplace, Health and Safety obligations and liabilities for property damage and personal injury.

- Governments should materially support local businesses, especially small and medium-sized enterprises, to better understand and adapt to the challenges associated with AV technologies.
- A level and fair playing field for all personalised transport providers must be maintained so that AVs do not lead to particular market dominants being able to exercise excessive and exploitative powers to the detriment of the public good.

Conclusion

The transition to fully autonomous vehicles presents as a huge disruption to the personalised transport sector that is full of both opportunities and threats. TCQ, and the Queensland taxi industry more broadly, are approaching the changes that will flow from AVs optimistically, confident that we can rise to any and all challenges while beneficially leveraging the new opportunities. Consistent with that forward looking philosophy, TCQ through the ATIA, joined the Australian Driverless Vehicle Initiative (ADVI) back in 2016 because we recognised AVs as a technological development that demanded attention and support. TCQ continues to stand ready to engage with all relevant stakeholders and Governments, both within and without the ADVI community, in the development and implementation of plans for the successful deployment of AVs within the personalised transport sector.

Lastly, TCQ would of course also welcome the opportunity to discuss prospective advances in any non-AV related technologies, including any matters raised in the attached "Taxi of the Future" paper, with the Committee.

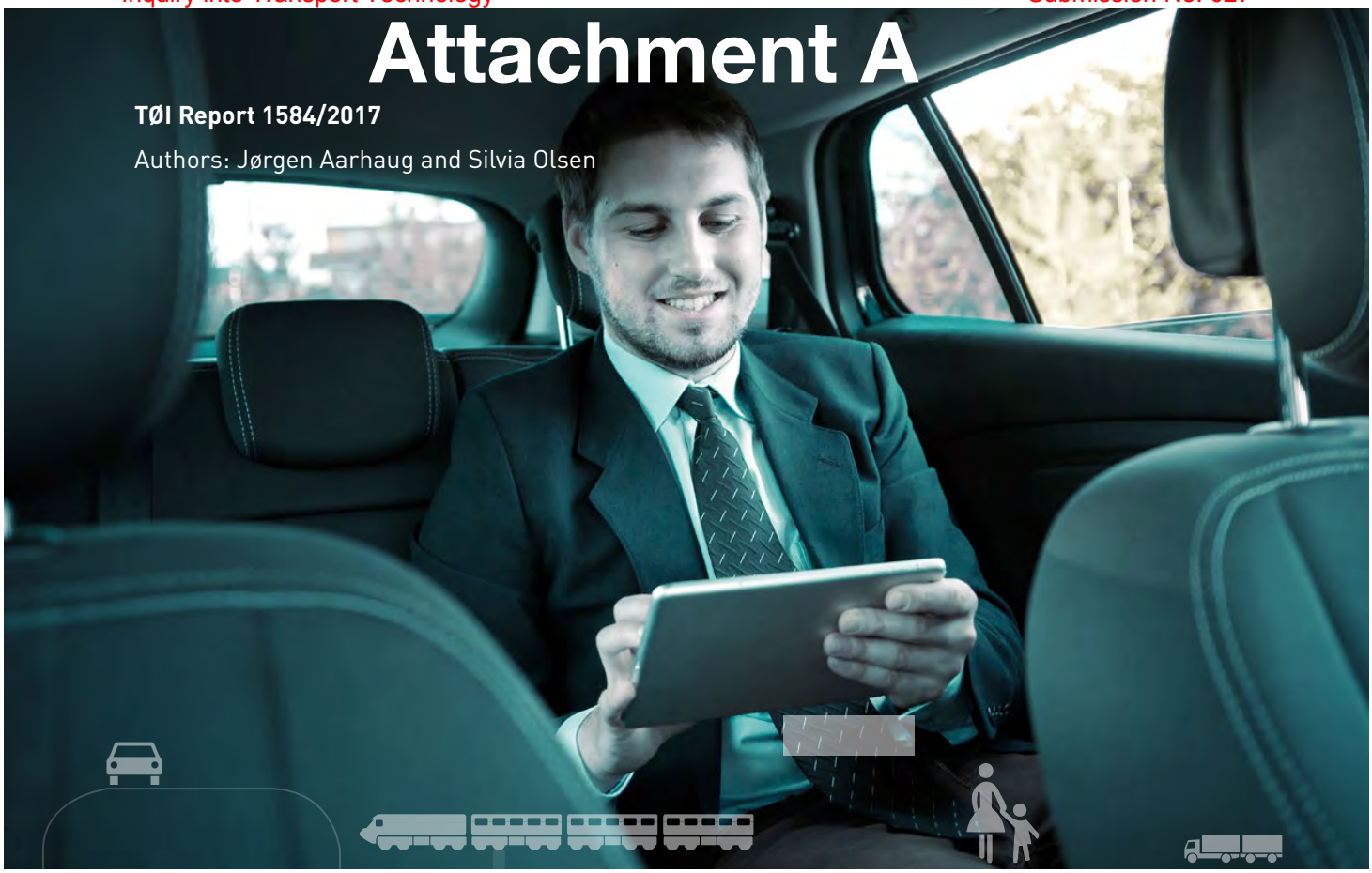
Yours faithfully

Blair Davies
CEO
Taxi Council of Queensland

Attachment A

TØI Report 1584/2017

Authors: Jørgen Aarhaug and Silvia Olsen



Transportøkonomisk institutt
Stiftelsen Norsk senter for samferdselsforskning

Taxi of the Future

Towards fully sustainable and innovative taxi operations

Title: Taxi of the Future
Authors: Jørgen Aarhaug and Silvia Olsen
Date: 10.2017
TØI Report: 1584/2017
Pages: 70
ISBN Electronic: 978-82-480-2078-3
ISSN: 0808-1190
Financed by: IRU – International Road Transport Union
Project: 4397 – Taxi of the Future
Project Manager: Jørgen Aarhaug
Quality Manager: Nils Fearnley
Research Area: 7 – Markets and governance
Keywords: Taxi, Future, Scenario
Language of report: English

Oslo, October 2017

Summary:
This report presents the findings from a study conducted as part of the 'Taxi of the Future' (TOF), initiative by the 'International Road Transport Union' (IRU). The study examines the present developments in the markets for unscheduled passenger transport and points at developments expected towards 2030. The report concludes by pointing out possible directions for future developments and possible points of action for influencing the future. This report has been written using a mix of expert discussions and interviews, reviews of literature, and scenario analyses.

Preface

This report presents the findings from a study conducted as part of the 'Taxi of the Future' (TOF) initiative by the 'International Road Transport Union' (IRU). The study examines the present developments in the markets for unscheduled passenger transport and points at developments expected towards 2030. The report concludes by pointing out possible directions for future developments and possible points of action for influencing the future. This report has been written using a mix of expert discussions and interviews, reviews of literature, and scenario analyses. The project has been commissioned by the IRU. Oleg Kamberski and Sonila Metuchi have been the project's contact persons at the IRU.

Senior research economist Jørgen Aarhaug has been project manager at Institute of Transport Economics, and has cooperated with Silvia Olsen in writing this report. Tanu Pirya Uteng and Frode Longva have commented earlier drafts of the report. The present report has been quality checked by Nils Fearnley. The study has benefited from the expert inputs from the TOF meetings, chaired by Mary Crass. In particular inputs and comments given by Richard Darbéra, Vinny Kearns and Ray Mundy are highly appreciated.

Oslo, October 2017

Institute of Transport Economics

Gunnar Lindberg
Managing director

Ove Langeland
Ass. head of department

Contents

Summary

Taxi of the Future – Towards fully sustainable and innovative taxi operations

Taxis provide a flexible mobility option. This flexibility comes with the cost of being exposed to and easily affected by challenges from new market entrants or from other sectors. The most important innovation in the transport sector the last decade has been the adoption of innovations facilitated by the large scale availability of the smart-phone. Looking towards 2030, the underlying mega-trends put pressure on the taxi industry but they also creates options. There are questions both relating to how fast markets will change and, in which direction. This study emphasises both modal convergence, modal divergence and multimodality as possible future developments. Such developments will affect the taxi sector differently and the study presents three alternative scenarios for the developments towards 2030. Regardless of how the future evolve, the following key policy issues need to be addressed: how to create regulations that facilitates an even playing ground for unscheduled passenger transport, how to promote green transport and how to design vehicle restrictions on private cars and road taxes.

Taxis constitute the most adaptable mobility option within the publicly available transport modes. Taxis provide the means necessary for public transport to compete successfully with the private car, in terms of offering a flexible door-to-door service and thereby make up the most flexible form of public transport available. Taxis are accessible for most people in most communities, in both rural and urban areas. As such, taxis carry a great responsibility to provide mobility services in an efficient, reliable, safe and sustainable manner. It is difficult to give an exact definition of taxis and the industry are also changing. In this study, we use the definition "unscheduled professional passenger transport with a small vehicle".

This report presents the findings from a study conducted as part of the 'Taxi of the Future' (TOF), initiative by the 'International Road Transport Union' (IRU). The study examines the present developments in markets for unscheduled passenger transport and points at expected developments towards 2030.

This initiative starts with the identification of some underlying broad societal trends which will affect the transport markets, markets in adjacent sectors and the society as a whole. The report applies a theoretical framework for understanding innovation processes and the adoption of new technology. It gives a description of characteristics of the taxi markets and discusses how the mentioned trends may change the game and result in new challenges for the future of taxi operations. To give a wider scope, two alternative scenarios, based upon an expert survey, are created. The scenarios are used as a basis for identifying alternative policies which can be promoted in order to secure a future where taxis are utilized as a tool for creating a better mobility future, rather than being a hindrance for that future to emerge.

Trends

The following trends are identified as the most relevant for the taxi markets:

Transport sector trends

- ICT and transport
  - IT-companies expand into the transport market (and other markets)
- Transformation of mobility: Changing relation between different modes
- Reduced car dependency
- Autonomous vehicles

Multi sector trends

- New business models
- Sharing/collaborative economy
- Changing macroeconomic environment
- Increasing inequality
- Automation of low and semi-skilled labour

Global societal megatrends

- Aging population, in the developed world, continued population growth in the developing world
- Urbanization
- The transformation towards a 'smart' society
- Increased environmental focus – 'zero impact' targets

These trends occur in combinations and create a setting where passenger transport as a phenomena is bound to change. As the most flexible link in the public transport system, the taxis are, and will continue to be the mode that probably is most affected by these trends. Taxis both meet challenges in the definitions of the mode with new varieties, such as ridesourcing[1] and ridesharing emerging at its fringes but also for its role in the transport system, where Mobility-as-a-Service (MaaS[2])may create new market opportunities, delivering first and last mile services in a combined mode travel chain.

Future mobility

The increasing use of information and communication technologies (ICT) in the transport and taxi market involves a socio-technical transition[3] that poses several challenges. Firstly, transitions are never solely about technical developments but encompasses social aspects, embeddedness in governance systems, adjustments from the public and so forth. Secondly, social acceptance and the public's adjustment and preferences will have impacts on the future transport and taxi market. This complexity of challenges calls for a theoretical approach that considers macro level perspectives as well as determinants for individual attitudes and behaviour. New transport and cross-sectorial trends which have emerged the last decades have demonstrated , the powerful transformative capacity of some of these trends. This is particularly visible in the introduction of new transport modes (such as ridesourcing and autonomous vehicles) and new ways of perceiving transport (with concepts such as MaaS). These trends may have disruptive impacts on the classical model of technology adoption.

One of the key questions asked but so far not answered, is the question if these trends end up creating modal convergence, modal divergence or multi-modality. Modal convergence is proposed as the final outcome of a development where cars increasingly are both owned and used less exclusively. This implies increased use of ridesharing which reduces the gap between the private car and coach services, and ridesourcing reducing the distance between the private car and taxi services and, peer-to-peer car rental and so forth. Similar developments comes from the other modes. Busses are offered on demand and taxis are shared. The proposed outcome of

1 Ridesourcing is a term used for services such as UberPop, ridesharing services offered by companies similar to BlaBlaCar see glossary for full definition.

2 The term Transportation as a Service, has been used with the same or similar meaning.

3 Socio-technical transition is a concept used for comprehensive structural changes in societal systems, such as the transport system, see Geels, F., Kemp, R., Dudley, G. and Lyons, G., Automobility in Transition? A Socio-Technical Analysis of Sustainable Transport. New York. Routledge.

this development is that all these modes meet in the middle with the 'dial-a-pod' as the ultimate solution. Modal divergence, on the other hand, is the process where new modes are introduced as innovation comes a long, with the electric bike filling a gap between the bike and the car and flexible minibuses between the bus and the taxi. These are essentially the same observations as the one noted in modal convergence but they are interpreted differently. The development of these new, in-between modes may represent the start of a future with more modes available. Instead of converging into a future common mode the development may continue towards modal plurality. A further possibility is that ICT creates the possibility for combining modes in intermodal journeys where the person who travels switch effortlessly between modes. Common for all these models is that autonomous vehicles primarily will have the effect of reducing costs, and thereby increasing the use of transport and the relation between the modes. It will not bring about a totally alternative development.

The taxi passenger

There are few studies looking at the taxi passengers. However, the studies that do exist illustrate that the taxi passengers do not make up a homogenous group. Both high-income groups and persons without private cars are overrepresented. Studies of ridesourcing services also indicate that their typical passengers are different from the typical passengers of the traditional taxi industry. Interviews with ridesourcing actors conducted as part of this study point in the direction of younger passengers, often "millennials", and of more recreational use.

The key question related to who the future taxi user is, is to what extent the different suppliers (or modes) can reach different market segments. The total demand from transport is increasing and more options appears. If young people opt for something different than the traditional taxi industry can offer they may choose other transport modes or new entrants and, accordingly be a lost market segment for traditional taxi actors. In principle, any innovation that reduces the cost (disutility) of mobility, will increase demand but it is very difficult to predict to what extent.

Scenarios

To provide a framework for discussing future developments in the taxi markets we have created three scenarios. These are a main scenario, which we call a business as usual (BAU) scenario. This scenario is derived from literature and information from the main points of view expressed during the taxi of the future meetings. This scenario is contrasted with two alternative scenarios - the conservative car-oriented scenario, and the technology and innovation scenario. Both these scenarios are based on factor analyses of an expert survey conducted as part of the taxi of the future study. The scenarios present a framework of possible developments with implications for the taxi market. This framework is further used for discussing the possible directions of the taxi market towards 2030. Projections feeding into the scenarios are:

The Business as Usual Scenario

- A smaller share of the population in major urban areas own their own car but the total number of cars increases
- Self-driving automated vehicles are not replacing the traditional car in the short term
- The costs of using taxis are as today as is the cost of using public transport
- Urban congestion is partly addressed by increased use of congestion charging
- Zero or low emission vehicles are gradually taken into use
- Low-income groups increase in size
- Fewer young people own private cars while car ownership in other groups continue to increase

The factors included in the BAU scenario point toward increased use of non-personal vehicles, both for trips within and between cities. However, there are few or no radical changes in terms of new technology in this scenario. The technological development is rather a slow and continuous process.

The Conservative Car-oriented Scenario

- A larger share of the population in urban areas owns their own car
- Self-driving vehicles have NOT replaced the traditional car
- The costs of using a taxi is higher than today
- The costs 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 advancements
- Low-income groups cannot afford to live in central urban areas

These factors concern travel mode choice and costs, including an increased share of the population owning their own car, more expensive taxi and public transport and, subsequently a negative effect on urban congestion.

The conservative car-oriented scenario also includes characteristics that are contradictory to the projections on technological advancements. This means that the conservative car-oriented scenario rejects the notion that technological advancements will solve transport sector emissions, and that self-driving vehicles will replace the traditional car.

The Technology Innovation Scenario

- The middle-income group has declined; a polarization of labour has taken place
- The different transport modes will be more integrated than today
- There has been a considerable automation of labour
- Mobility-as-a-service will be provided
- People value experiences and recreation higher than consumption of goods and services

These factors concern a belief in automation of labour and its subsequent consequence; a decline of the middle class and a polarization of labour.

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

Geographical differences and likelihood in the scenarios

In creating the alternative scenarios, the survey data revealed significant geographical differences, particularly with respect to views on the likeliness of the conservative car-oriented scenario. European respondents were most likely to rate the innovation and technology scenario as probable. They highly believed that self-driving vehicles would have replaced the traditional car, and that technological advancements would have solved the problems of transport sector emissions. The conservative car-oriented scenario was on the other hand dominated by respondents from Sub-Saharan Africa.

With respect to likelihood, the highest scores were achieved for statements such as 'The different transport modes will be more integrated than today', 'The cost of using private vehicles is higher than today', 'The population has an increased environmental concern' and 'There has been a considerable automation of labour'.

The highest uncertainty was reached on statements such as 'The middle-income group has declined; a polarization of labour has taken place' and 'The population value experiences and recreation higher than purchases of goods and services'. Here respondents differ greatly in their perception of the likelihood of these development characteristics coming thru.

The lowest probabilities were reached for statements such as; 'The sharing economy flopped, and does not affect travel mode choice', 'The trend of urban population growth have declined', 'A larger share of the population in urban areas own their own car'.

With respect to autonomous vehicles, the experts rate this as 'mid-level' probability, with a relatively small deviations. Indicating that there is significant uncertainty, but that this uncertainty is shared among most experts.

Business models

The product offered by a taxi company is quite uniform, traditional and simple. It is to move a person from point A to point B. However, when it comes to customer interfaces things quickly get more complicated. Here, there are different market segments and these are related both to whom the target customer is and, what is the way of reaching this customer and the relationship between the taxi company and the customer. This is further discussed under the regulations section. With respect to the value configuration and business infrastructure management there is great variation between how taxi companies operate.

We argue that the traditional model for categorizing taxi firms falls short when ridesourcing is introduced. We do not know which technological changes will occur in the years leading up to 2030. We do, however, know that the technology that has become available the last five to ten years has changed the possibilities for doing business in the market for unscheduled door-to-door passenger transport.

Technological change is linked to the coupling between passenger and driver. The coupling functions are now readily available, through existing code and high levels of smart phone availability. As a consequence, it is much easier to develop a business compared to earlier times, for connecting taxis with passengers. It is also technically much easier to up-scale this business.

Funding is also readily available because of the availability of venture capital. As a consequence of this competition is increasing. Although you may have a sound business model and a good product, it is not straightforward to get at good customer basis. There is a new barrier represented by the share volume of offers available. To get a new app to the market there is a need to create a brand and, because of this, there is a need for a much larger marketing budget compared to earlier when markets were local. The question is whether this develops into a "winner takes all" situation as predicted by Metz (2017) and others, with short term losses and long term profits to one or a few multinational companies or, if it result in a situation of increased competition. This is still unknown.

Further, there is a market development on the "platform" level in which platforms, such as Facebook or Alibaba, increasingly add new services to their products. This reduces the possibility for an app-based actor to penetrate the market on its own but it increases the business possibilities for taxi operators with fleets who can (at least potentially) shop between different platforms.

This means that the taxi industry having the possibility to move in different directions. One direction is to focus on the delivery of transport as the core element where the provider offer fleets of cars with drivers to platforms that have the networks and consumer interfaces. To be an attractive partner for the platforms, there is a need for the taxi industry to create big fleets of professional actors and move away for single vehicle actors.

Regulation
Taxi services are an old invention. They go back to long before the invention of the automobile. Similarly, taxi regulation also has a long history. Some point to the 1630s for the origins of modern taxi regulation, when cities experienced problems with horse carriages plying for hire in public spaces. Regulation was introduced to abate these problems. While a lot has changed since then, some of the fundamental issues has not. On the contrary, city space is scarce, consumers' interests are not always the priority of the service provider, there are market failures in several market segments served by vehicles defined as taxis in this study, all of which point toward some form of regulation. However, the present developments with new services, such as the introduction of hailing apps and ridesourcing services – both dependent upon the smartphone – and the emerging possibilities of self-driving vehicles, makes this a very interesting time to study taxi services and the regulation of these.

One of the important issues raised in this report is the danger of new global ridesourcing companies emerging as Global-level monopolies. If a company reach this situation and no longer fears competition, this company may charge the customer the price that maximizes its monopoly rent. At the same time this company will become the only buyer which allow a similar bargaining power against the drivers or providers. An even more challenging issue is related to the anti-competitive effects of dynamic pricing schemes, increasingly employed in the taxi service markets.

Discussion
The BAU scenario is driven by the developments that are observed in society today. In particular, that there is increased automatization of low and semi-skilled labour which together with reduced economic growth rates may increase the economic inequality. Relating to the taxis markets, the major development is the introduction of new business models, resulting in a ridesourcing sector taking an increasing part of the transport market. If these companies are included within the definition of the taxi, the taxi market will increase its market share, if not it will lose its share. The major gain in market shares for ridesourcing companies is not from existing taxi operators, although that should not be dismissed. Equally important, however, or even more important is newly generated traffic and market shares gained from mass transit. Accordingly, the total market for taxis and ridesourcing will together increase, in part at the cost of mass transit.

Within the conservative car-oriented scenario, the demand for taxis and taxi services is reduced. The main reason for this is that the relative cost differences between taxis and other modes will move further in favour of other modes. The cost of car ownership will decrease (relatively) and car use is not facing the full extent of the negative externalities it produces, where taxi use to a much larger extent faces the cost of these externalities. The main group still using taxis will be more affluent people living in the city centres.

Within the technology innovation scenario there are many possibilities for several different chains of events, with different technologies taking front row. There are many different forms of automated vehicles that can influence the taxi industry and, if they reach large a market segments before 2030 this can happen in several ways, with respect both to ownership and usage. They can be owned by private individuals as an alternative to conventional private cars but also be part of different schemes of joint ownership where the user pays for usage. The vehicles can take different forms, both as self-driving versions of today's cars but also as automated minibuses or busses. These options will have different consequences both for the society and the taxi industry.

If Mobility-as-a-Service catches on, empirical evidence point toward increased demand for taxi services. In the experiments with MaaS that has been conducted so far, doing away with the private car has been one of the major conditions for participating.

Increased environmental awareness should result in more demand for taxi services. This may seem like a paradox but there are several factors or chains of events which would have this outcome. First, increased environmental awareness is likely to result in restrictions on the use of private cars, in particular within urban areas and also as long as private cars are predominantly fuelled by fossil fuels. Increased restriction on private vehicles should result in increased use of shared modes, such as mass transit and taxis, as well as walking and cycling.

Conclusions

There are regional variations with respect to what is seen as a likely development. Elements from the conservative car-oriented scenario is seen as more likely by the respondents from developing countries. This may reflect a correct estimate of the future development in their setting and not necessarily being at contrast with a BAU or the technology and innovation scenario which is coming through in a developed world setting. There is also, diverging opinions on the likelihood of whether automate vehicles will become a full scale reality before 2030. A possible scenario in-between the BAU and technology and the innovation scenario is that there will be regional or city level introduction of self-driving vehicles.

The overall conclusion in this report is that the markets for unscheduled passenger transport will evolve and expand, at least within the short and medium time horizons. This is not the same as to say the taxi industry in its present form will be booming. Taxis are filling gaps in the transport systems by providing links and possibilities not offered by other modes of transport. As a consequence, taxis are both exposed to changing market possibilities but also to threats as other modes and scenarios evolve. However, our conclusion is that the demand for on-demand and flexible transport services will increase.

Some of the policy measures that can be taken to promote taxis as a mode to fill this increase in demand, will differ slightly between the different scenarios.

- Create a level playing field for unscheduled passenger transport.

This include establishing a common legal framework for unscheduled passenger transport which satisfies the regulatory objectives in promoting passenger safety, both with respect to criminal activities but also against predatory behaviour; promoting traffic safety; providing necessary conditions for taxi companies to be able act on changing market conditions; prevent monopolies and monopsonies, both at the local, regional, national and international levels; provide secure working conditions for drivers and establish an international standard for calculating the relevant geographical scope of an unscheduled passenger transport service.

- Promote green transport, vehicle restrictions on private cars, road taxes etc.

Reduced car dependency is linked with increased use of taxis and public transport services.

This is also relevant in the conservative car-oriented scenario. Policy restrictions towards private car use which would increase the demand for taxis in this scenario, are mostly similar to that in the BAU scenario. However, promoting restrictions on private car ownership would be more important. Policies / regulation related to emission standards and so on, will promote the use of taxis, as taxis in general use a newer car fleet and is therefore in a better position to take

new technology into use, compared with private cars.

A key question in the innovation and technology scenario is how to organize taxis as part of different transportation regimes. In this scenario, taxis or similar services will have a more important role in the larger transport system. The question is who should own and operate the vehicles and who is going be the key part of the value chain. This raises a series of organisational issues in which the taxi industry can have a significant influence on the new transportation regime.

Possible policy measures within this scenario are:

- Creating a set of regulations that facilitate Mobility-as-a-Service provision.

This is in order to give a predictable service that can function as a partner service with international platform companies.

- Create a set of regulation that promote automated vehicles in ways that allow the taxi industry to take advantage of these services.
- Safety, security and infrastructure.

Automation is changing the role of the taxi driver, like the freight driver, from being a driver to become a system monitor and a service person. In a future where automated vehicles dominate, the service aspect offered by the taxi industry could in fact be its unique selling point.

Some potential policy points come to the forefront, regardless of scenario. This includes not least to promote a level playing field which creates a set of regulations for the taxi industry and adjacent industries and ,which gives similar rules and regulations to similar services. These regulations need to adopt both to changing technology and to secure the passenger and prevent unregulated monopolies from evolving.

On a more practical term, this means promoting transparency and auditability in all levels of operation. It can also imply to create or promote new “third party” platforms that offer the economies of scale and scalability, not usually offered by local or regional actors.

1 Introduction

1.1 About the initiative

Taxis constitute the most flexible mobility option that can empower the public transport to compete successfully with the private car. Taxi's door-to-door mobility is the most flexible form of public transport available, for all social classes and communities, in rural and urban areas. As such, taxis carry a great responsibility to provide mobility services in an efficient, reliable, safe and sustainable manner.

This report presents the work of the Reflection Group on the Taxi of the Future (TOF), which held sessions during the second semester of 2016 and the first semester of 2017, as part of an IRU initiative. A public-private group of mobility stakeholders, the Group's objectives were to develop medium- and long-term policy and business recommendations, to propose an action plan on how to reach a 30 percent reduction in CO2 emissions by 2030 and to draw up the framework conditions needed to significantly increase the safety, accessibility and efficiency of taxis (in both new and existing fleets), operations and infrastructure within this time frame.

During the TOF Reflection Group meetings, different ways of meeting the targets were discussed at length, supported by documentation provided by the participating stakeholders themselves, input prepared by the Institute of Transport Economics (TØI), an independent consultant, and IRU. In addition, several other researchers, in particular Richard Darbéra, were invited to present the results of their findings on similar topics.

For each of the targets mentioned (CO2 emissions, road safety, accessibility and operational efficiency), the present report initially discusses what the objectives are and seeks to sketch out a scenario in which the TOF expected to be in operation by 2030. Subsequently, the different options are presented, along with an assessment of their potential contribution to each of the targets. The results of the many different kinds of measures are brought together in an integrated approach. The report's final section presents a roadmap containing the important steps needed in each of the future decades to meet the long-term targets for a taxi system that emits little to zero CO2, causes a minimal number of accidents and does so at the highest possible level of operational efficiency.

1.2 The IRU targets

CO_2 emission reduction target

The (IRU Reflection Group on the Taxi of the Future) was asked to examine a specific emission reduction target:

- Achieving a 30 percent reduction in CO2 emissions by 2030 (compared to 2007).

The 2030 target is based on the "30-by-30 Resolution" adopted by the IRU General Assembly in 2009. The Resolution is a voluntary commitment to reduce CO2 emissions by 30 percent by 2030, as compared to 2007 values. The Resolution indicates that investments in the latest innovative engines and vehicle technologies could contribute 10 percent, driver training could contribute another 10 percent, and innovative mobility concepts could contribute a further 10 percent, towards reaching this target.

Road safety target
The reference safety target for this project is in line with the target set in the 2015 UN General Assembly Resolution on "Improving global road safety". The target is to reduce global road traffic deaths and injuries by 50 percent by 2020 and provide access to safe, affordable, accessible and sustainable transport systems for all by 2030.

Assuming a proportional effort across different modes of transport, this translates into the following targets for taxis:

- halving fatalities from accidents involving taxis by 2020,
- (close to) zero fatalities from accidents involving taxis by 2030.

Accessibility target
The reference accessibility target for this project is in line with the target set in the 2030 Sustainable Development Agenda and in particular with the Sustainable Development Goal 11.2: "By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all".

Other targets
There are also other targets regarding, amongst others, efficiency that have not yet been translated into policy objectives for the taxi industry.

1.3 Approach and methodology

This final report of the Taxi of the Future study is based on the discussions and documents prepared for the different TOF-meetings, as well as a review of literature, a series of expert interviews, and an expert survey which has been used to create scenarios that form the basis of our scenario analysis.

1.4 Structure of the report

The next section covers the overall societal trends that we consider. This is followed by a presentation of the theoretical framework, the Multi-Level perspective and technology adoption that we use to analyse innovation and changes in the transport markets. This is further followed by a description of some of the current developments affecting the markets for unscheduled passenger transport. Sections 2.2-2.4 present trends. In section 2.5 we ask who the future taxi passenger is. In section 2.6 we present some insights in vehicle technology development. 2.7 concludes the chapter by wrapping these subsections into a business as usual scenario (BAU) i.e. the most probable course of events. Section 3 presents alternative scenarios to this BAU scenario, using factor analysis based upon an expert survey. Section 3.4 presents the implications of the conservative car-oriented scenario, while 3.5 presents the implications of the technology and innovation scenario. Section 4 presents background for and alternative ways for the taxi industry to adapt to the changing contexts. Section 5 presents a discussion of potential future roles for taxis in alternative future scenarios and concludes the report by presenting a roadmap for the taxi industry, in light of the alternative future scenarios.

2 Trends towards 2030

As a starting point for compiling a base scenario for this study, we define 'taxis' as "unscheduled professional passenger transportation with a small vehicle".

Below, we first describe the main trends along three tiers: socio-economic, cross sectoral and sectoral trends.

2.1 Taxis and trends

2.1.1 Trends

We have identified the following three relevant categories of trends. Transport sector trends, multi sector trends and global societal megatrends. Within this document, we use the following definition of a megatrend (from the EC FP7 OPTIMISM project[4]):

"Megatrends are fundamental, long lasting (more than 10 years), global (or at least international) transformation processes leading in a certain direction. Megatrends are characterised by their broad scope affecting multiple aspects of life. They are stable over time or at least over years and decades."

We do not describe all megatrends. Instead, we focus on the trends that we think are most relevant for the taxi markets. This is not an exhaustive list, but it includes some of the main trends that we expect will influence the taxi markets. This list draws on some elements from the similar list presented by Akkermans and Maerivoet (2017).

Transport sector trends

- ICT and transport
- IT-companies expand into the transport market (and other markets)
- Transformation of mobility: Changing relation between different modes
- Reduced car dependency
- Autonomous vehicles

Multi sector trends

- New business models
- Sharing/collaborative economy
- Changing macroeconomic environment
- Increasing inequality
- Automation of low and semi-skilled labour'

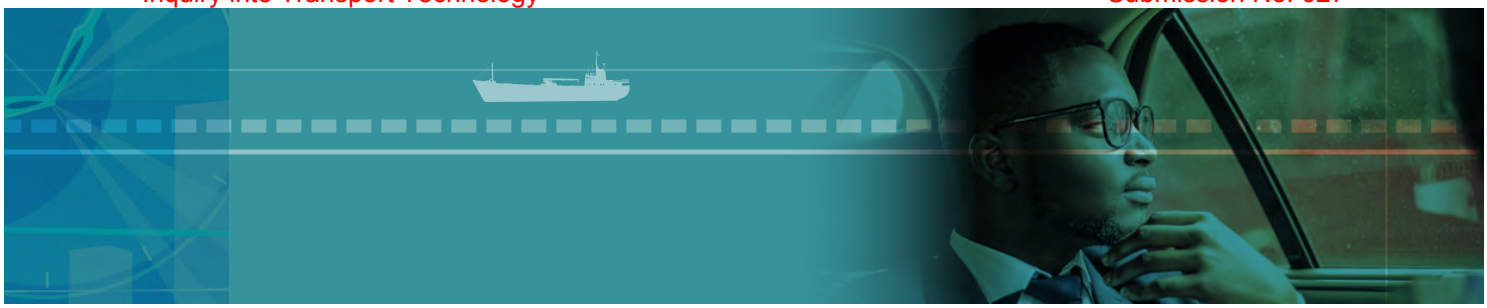
Global societal megatrends

- Ageing population in the developed world and continued population growth in the developing world
- Urbanization
- The transformation towards a 'Smart' society
- Increased environmental focus – 'zero impact' targets

These trends combine in creating a setting where passenger transport as a phenomena is bound to change. As the most flexible link in the public transport system, the taxis are, and will continue to be the mode that is most affected by these developments. Taxis both meet challenges in the definitions of the mode, with new varieties, such as ridesourcing and ridesharing emerging at its fringes, but also for its role in the transport system, where Mobility-as-a-Service (MaaS[5])may create new market opportunities, delivering first and last mile services in a combined mode travel chain.

4 Optimism Deliverable 3.2: http://www.tmleuven.be/project/optimism/Deliverable-3.2-List-of-potential-megatrends.pdf

5 The term Transportation as a Service, has been used with the same meaning.



2.1.2 Theory

The new uses of information and communication technologies (ICT) in the transport and taxi market involve a socio-technical transition that poses several challenges. Firstly, transitions are never solely about technical developments, but encompass social aspects, embeddedness in governance systems, adjustments from the public, etc. Secondly, social acceptance and the public's adjustment and preferences will impact on the future transport and taxi market. This complexity of challenges calls for a theoretical approach that considers macro level perspectives as well as individual attitudes and behaviour. Additionally, interesting aspects of the new transport and cross-sectorial trends that have emerged in the last decades is, the experienced or potential, powerful transformative capacity of some of these trends, in particular the introduction of new transport modes (such as ridesourcing and autonomous vehicles) and new ways of perceiving transport (with concepts such as MaaS[6]). These trends can disrupt the classical model of technology adoption as presented by Rogers (1962).

Multi-level perspective (MLP)

The multi-level perspective (MLP) on socio-technological transitions conceptualizes overall dynamic patterns in socio-technical transitions (Geels 2010, Kern, 2012). It combines concepts from evolutionary economics (trajectories, regimes, niches), science and technology studies (social networks, innovation as a social process shaped by broader societal contexts), structuration theory and neo-institutional theory (rules and institutions that structure actions). Within the MLP perspective, three analytical dimensions are essential in the analysis of transition processes: regimes, niches and landscapes. The landscape level refers to slowly changing external factors that cannot usually be directly influenced by individual actors (Kern, 2012; Whitmarsh, 2012). Avelino and Rotmans (2009) have described the landscape dimension as "the surroundings of a particular societal system under study, where one sees trends with a relatively slow progress and/or developments with a high autonomous character". This is parallel to the concept of megatrends. The regime level refers to a "'dominant' configuration of actors, structures and practices" that preserves the functioning of a societal system (ibid., p. 545). In other words: an institutional setting which usually provides stability but which may also cause a "lock-in" by defending the status quo. For a transition process to become successful, it always needs to involve a transformation of the regime (ibid., cf. Kern, 2012). The niche level refers to a space where "non-conformism and innovation can develop" (ibid., p. 545). These "protected spaces" provide room for (radical) innovation to occur, evolve and eventually start affecting the dominant regime and, in the end, perhaps even overturn it (Kern, 2012; Whitmarsh, 2012). Transitions are dependent on developments on all three levels (Kern, 2012; Rip & Kemp, 1998; Avelino & Rotmans 2009).

This study will start by addressing how the taxi regime is challenged at the niche level; where a wide range of new services are currently developing (see sections on technological and economic trends). We will then move on to outlining the landscape level; changes in demography and urbanisation, as well as cultural developments such as an increased environmental focus. Finally, the regime level will be addressed, studying regulatory impacts at national and international level.

Technology adoption

According to Rogers (1962) technology is adopted following a normal distribution pattern. A small fraction of the population; Rogers stipulate 2,5 percent of the population, categorized as innovators, is leading the way. These are followed

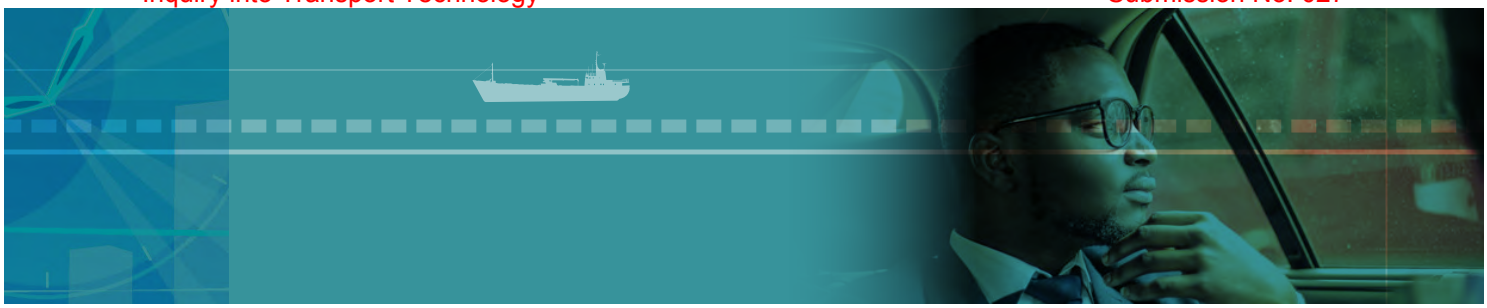
6 Mobility-as-a-Service, Sochor (2015).

by the early adopters, who are high status users, then by the early and late majority, and finally the laggards, who are the last to adopt an innovation. His categories are presented in table 2.1 and figure 2.2.

Table 2.1: Definition of the different categories of technology adopters (Rogers, 1962).

Adopter category	Definition
Innovators	Innovators are willing to take risks, have the highest social status, have financial liquidity, are social, and have closest contact to scientific sources and interaction with other innovators. Their risk tolerance allows them to adopt technologies that may ultimately fail. Financial resources help absorb these failures.
Early adopters	These individuals have the highest degree of opinion leadership among the adopter categories. Early adopters have a higher social status, financial liquidity, advanced education, and are more socially forward than late adopters. They are more discreet in adoption choices than innovators. They use judicious choice of adoption to help them maintain a central communication position.
Early Majority	They adopt an innovation after a varying degree of time that is significantly longer than the innovators and early adopters. Early Majority have above average social status, contact with early adopters, and seldom hold positions of opinion leadership in a system.
Late Majority	They adopt an innovation after the average participant. These individuals approach an innovation with a high degree of scepticism and after the majority of society has adopted the innovation. The Late Majority is typically sceptical about an innovation, has below average social status, little financial liquidity, in contact with others in late majority and early majority, and little opinion leadership.
Laggards	They are the last to adopt an innovation. Unlike some of the previous categories, individuals in this category show little to no opinion leadership. These individuals typically have an aversion to change-agents. Laggards typically tend to be focused on 'traditions', lowest social status, lowest financial liquidity, oldest among adopters, and in contact with only family and close friends.

This model is presenting a 'typical' pattern of innovation adoption. It is also frequently presented using the Bell curve (figure 2.1).



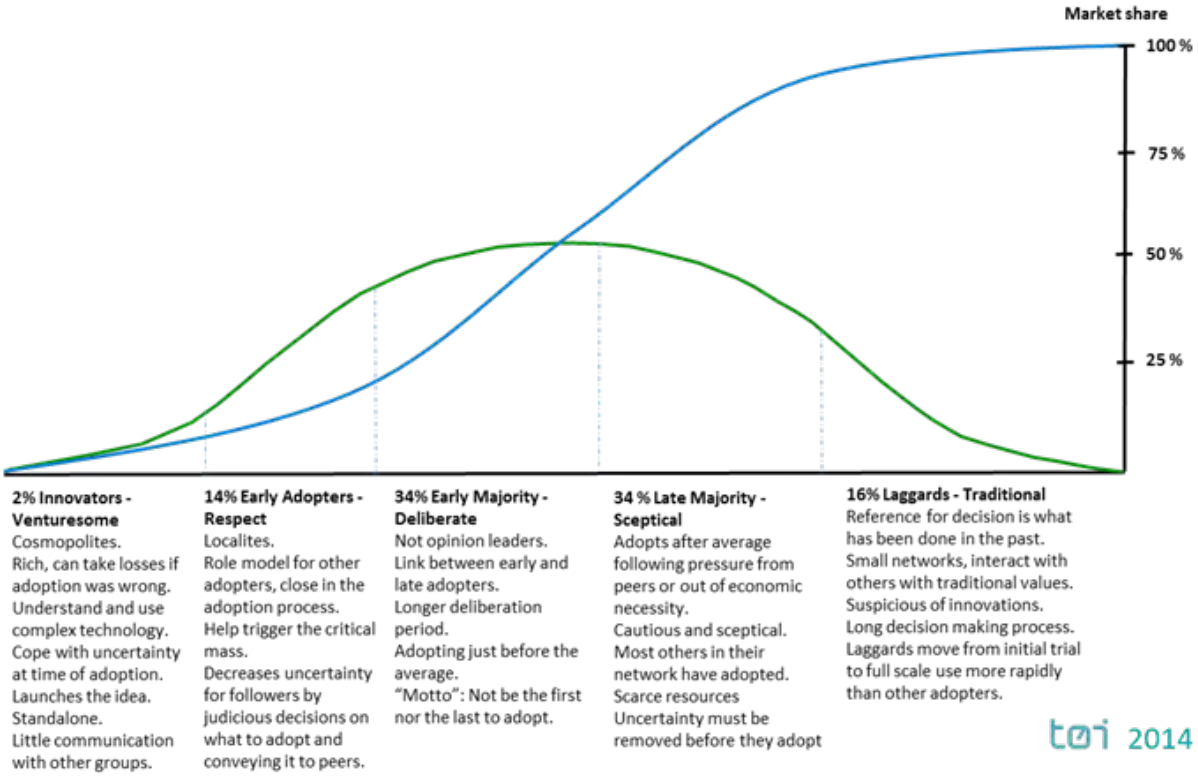


Figure 2.1: Adoption curve for innovations and the typical role of different user groups, adopted from Rogers (1995 and Figenbaum and Kolbenstvedt 2015).

However, some market changes occur along different patterns, (See Bower and Christensen, 1995 etc.) characterized by changes that are initiated by actors that traditionally have not been in the market. Also, adoption is rapid, and does not necessarily follow the same path. Ridesourcing, autonomous vehicles and MaaS-concepts could be examples of such disruptive technologies, that spread rapidly, and has profound impacts on the existing markets, by creating new products and new markets. However, in discussing the use of 'disruptive innovations' as a term, Christensen et al. (2015) point to the changes in the taxi sector following the arrival of the ridesourcing companies and argue that these are not disruptive innovations per se. However, to what extent these developments are different from rapid conventional technology adaptation, can be further discussed. It is also important to note that while certain technologies have evolved and operate outside the regulated markets, and to a large extent illegally. Many innovations have also been accepted and developed by dispatch operators. This links to Christensen et al's.(2015) presentation on how incumbents respond to disruptive innovations.

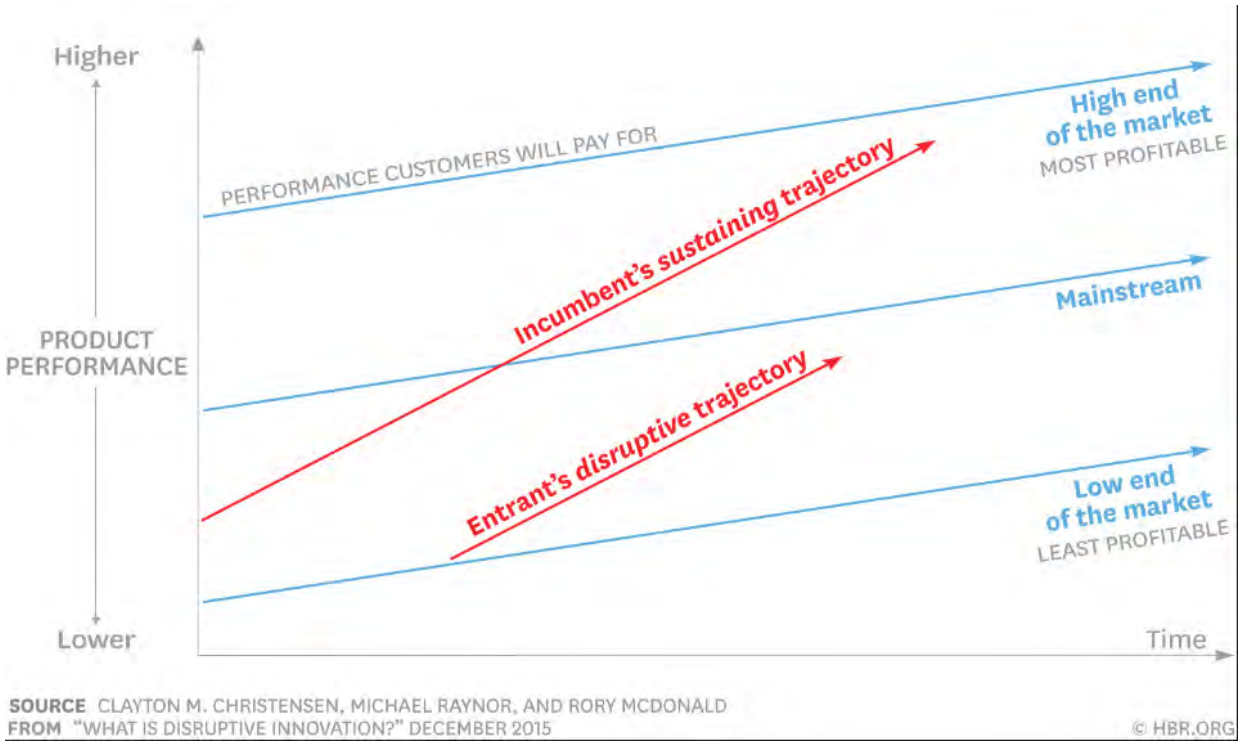


Figure 2.2: The disruptive innovation model (Christensen et al. 2015).

The diagram (figure 2.2) contrasts product performance trajectories with customer demand trajectories. As incumbent companies introduce higher-quality products or services to satisfy the market segments with highest profitability, they overshoot the needs of the low-end spectrum. This leaves an opening for entrants to find a foothold in the market and challenge the dominance of the incumbents. This is similar to the concept in the Multi-Level perspective presented earlier.

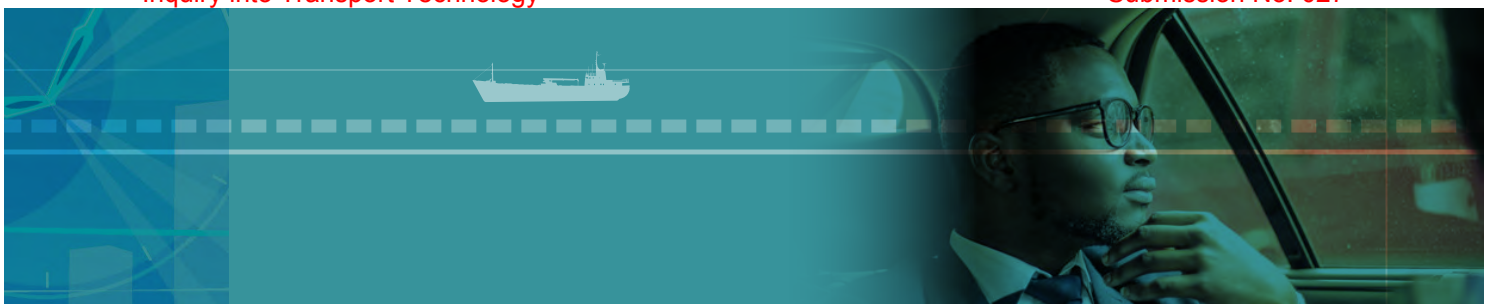
The presented theories on market adoption of new technologies point towards at least two key insights relevant for this industry: 1) that innovation and change is constant, but that it is only a few of the ideas that reach market dominance and change the dominant market regime. 2) that existing market actors are well placed to take new technology into use.

2.1.3 Taxi market developments

In addition to being a distinct mode of transport that is difficult to give an exact definition of, taxis are also evolving. In this study, we use the definition "unscheduled professional passenger transport with a small vehicle". The new services being developed reach new market segments. Two of these include shared taxis, which is in no way a new service, but a service that has gained a revival, and taxis as a public transport solutions for rural areas.

Shared taxis

The concept of sharing a taxi is an intuitive and simple solution for a complex set of challenges. It is also a segment that has received increased attention in the past few years, both as an alternative to mass transit and to taxis. Looking at the phenomenon from a taxi perspective, shared taxis reduce the cost per person and increase capacity; from a transit perspective, shared taxis provide the opportunity for



transport on routes without sufficient traffic for conventional mass transit; and from a city perspective shared taxis offer better utilisation of road capacity. From the user perspective, shared taxis can provide a cheaper and better transport service compared to the alternatives, given a set of condition with respect to the alternative modes. The academic literature using the term 'shared taxis' is limited and dominated by cases in developing countries, where shared taxis in many cases represent a dominant transport mode on city level. In developed countries, other, often concept specific terms are used, but with 'para-transit' being used as an umbrella term.

Shared taxis are a form of public transport somewhere between ordinary taxis and mass transit systems. In some places, typically in developing countries, they operate along pre-defined lines, as an unscheduled bus service; in other places the shared taxi picks up passengers along the way with the first passenger giving directions. A variation is the dispatcher-controlled shared taxi, as the "Kutsuplus" which operated for a period in Helsinki.

As a mode, shared taxis have long traditions in particular Africa (with 'bush taxis', 'tro-tro's etc.) and Asia (Songthaew in Laos and Thailand, Dolmus in Turkey etc.), where minibus based services have operated both within and outside the formal economy. But also in eastern Europe, with 'Marshrutkas' entering as a commercial 'shared taxi' -alternative to mass transit following the collapse of the communist regimes (Kuznetsov, 2015). There are also examples from North-America.

With increased focus on sustainability, both environmental and economic, shared taxis have gained increased attention and recognition as a flexible transport solution, both in developed and developing parts of the world. Different shared taxis are being presented in settings ranging from rural areas in Canada and Norway to the larger cities of Africa. Shared taxis, organised by commercial transport intermediaries (CTIs) have also gained popularity as an alternative to mass transit in the US. In Europe, there are schemes, such as Kutsuplus, organized by public transport authorities. There are also several examples of the taxi industry coming up with similar products on a commercial basis.

Taxis as public transport in rural areas

Taxis solve different needs in different regions and market segments. While taxis are often viewed as an urban mode, dispatcher controlled taxis can offer demand responsive services for lower cost than scheduled transport, in rural areas. Consequently, the taxi industry can offer a public transport option for rural areas that can be an attractive solution for their communities. A major advantage of a taxi service over a mass transit service is that a taxi vehicle is smaller, more flexible and less costly, per kilometre, than a bus. This gives the potential for a door-to-door service in markets that typically will be underserved by scheduled public transport (ITF, 2015). However, as the labour component of a taxi service is high, and the vehicle capacity is low, the cost per passenger for rural taxi services can be substantial. This can result in either the private car being a preferred solution for most potential travellers, in a setting without subsidies, or a requirement for substantial per passenger subsidies, if the service is to be an alternative to private vehicles. Experience from Norway (Leiren and Skollerud, 2016), indicate that taxis, operating as demand responsive transport (DRT), can provide a very popular service in rural areas, more popular than scheduled bus services, but at a high cost per passenger. This results in requirements for a high level of subsidies, in line with Mulley and Nelson (2009) but, potentially with a higher value for money, compared with scheduled public transport options. Automation can change this radically. These DRT services may hence not be sustainable for rural communities without access

to national funding. Mulley and Nelson (2009) also point out that the exact design of the service will determine who uses it. Still, DRTs illustrate the role of taxis in providing transport services in rural areas, also in developed countries.

2.2 Global societal megatrends

2.2.1 Urbanisation

Migration from rural to urban areas is a global trend, and about 75 percent of the EU population currently lives in urban areas (EEA, 2016), while 90 percent of global population growth will occur in cities of developing countries.

In general, the literature on sustainable urban development indicates that there is less car-use and more public transport, walking and cycling in densely populated cities with mixed functions than in cities with more dispersed settlement/location of housing and work (Hagson, 2003). The concept of 'compact cities' is used to show the relationship between density and travel activity (Breheny, 1995; Næss, 2006), the theory being that there is a direct connection between land-use and the inhabitant's activities in time and space (Newman and Kenworthy, 1989). When it comes to the increase in cars, Dargay et al. (2007) have found that the saturation level (of cars) declines with increased population density and urbanisation.

As the developed world is already highly urbanized, the increased urbanisation trend is not radical to its cities. The change is more likely to have impact on rural areas. How this trend affects the taxi markets is unclear. It should reduce demand in rural areas, to what extent is unclear. In the developing world, urban areas continue to grow at a high rate. Together with increased income, this is likely to increase the demand for taxis and similar services. However, the question still remains as to what extent these cities will follow the same path of private car use as the developed cities have. The extent to which mass transit and private car is an option, will influence the demand for taxis and taxi like services.

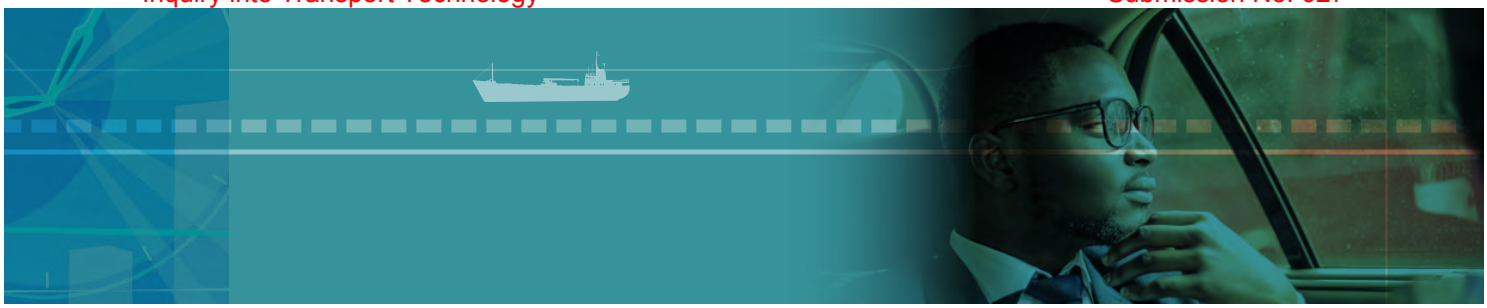
2.2.2 Socio-demographic changes

Developed countries are undergoing significant demographic change involving the ageing of the population. In Europe, the share of people aged 65 years and over in the total population is projected to increase from 17 percent in 2008 to 30 percent by 2060 (Eurostat, 2008). The proportion of people over 65 years is expected to be a heterogeneous group. Understanding the travel needs and travel patterns of these different groups of older people will be a challenge for authorities as well as for private operators.

An ageing population has several implications on the transport and taxi market. Firstly, it is likely that the travel demands of older populations will have an impact on the entire transport system, i.e. in shaping the way transport is planned, organized and managed. Secondly, older populations may form a significant transport resource providing informal transportation to other older persons and grandchildren, for example.

Previous research indicates that these generations will most likely keep their driving licence into old age (Golob and Hensher, 2007; Hakamies-Blomqvist et al., 2005; Hjorthol and Sagberg, 2000; Rosenbloom, 2001; Wretstrand et al., 2009). Improved health, active lifestyles, increased access to a car and, for some groups, higher income have meant more varied activity and extended travel than previous generations had. On the other hand, a large proportion of the new generation of the elderly will belong to the oldest group, i.e. those 85 years of age and older who may have problems related to travelling, walking and use of a car, or getting on and off public transport.

Car-use among the elderly in European countries has also increased over time; for example, in England (Oxley, 2000), Sweden (Kranz, 1999;



Dillen, 2005), Denmark (Magelund, 2001) and Norway (Hjorthol, 2004). Some studies differentiate more between groups of elderly.

2.2.3 Movement towards zero impact society

Increased environmental awareness has been identified as one of the reasons why young people are less interested in obtaining a driving licence and buying a car (Delbosch and Currie, 2013). Whether and how the collaborative economy will contribute to increased environmental sustainability is, however, an object to discussion. According to Fritz (2014), ridesourcing reduces consumer incentives to purchase private cars, hence reducing environmental harms. But, on the other hand, it reduces the cost of getting door-to-door transport by someone else's car, increasing demand, which would have the opposite effect. The economy of scale and capacity utilization (hours per vehicle, seats per vehicle) is important both to bring down the lifecycle environmental impact per passenger kilometre, but also to make the costs of low-emitting or zero-emitting vehicles and fuels more affordable (Eskeland, 2012). In considering environmental effects, Anderson (2014) points out that both traditional taxis and ridesourcing have both additive and subtractive effects on vehicle miles travelled. Both provide increased access to transport (additive effects) and both may reduce vehicle miles of travel (VMT), by e.g. encouraging shared rides, and supplementing fixed-route transit systems by providing multimodal trips. Cramer and Krueger (2016) argue that this is done more efficiently by Uber compared with conventional operators. However, this claim is contrasted by Schaller (2017) who points at the traffic consequences of some of the inefficiencies created by ridesourcing actors' pricing model: In particular, a high number of vehicles cruises empty between surge pricing areas at rush hours. Another important factor is the "spatio-temporal" strategies different types of driver use while driving, and what motivates this, and the environmental impact (Anderson, 2014).

Increased environmental concern is also likely to impact on legal constraints being increasingly imposed on all mobility stakeholders to meet sustainable development goals. In London, the world's first Ultra Low Emission Zone (ULEZ) will be introduced in 2020. Thus, by 1 January 2018, all taxis licensed for the first time must be zero emission capable, and new diesel taxis will not be allowed in London[7]. Such regulations are likely to be introduced in several developed countries during the next decades – and later, also in developing countries. Ridesourcing services may, however, as Anderson (2014) argues, undermine attempts by regulators to promote e.g. "clean taxis".

2.3 Trends affecting several sectors

2.3.1 Macro-economic trends

The latest IMF outlook on the world economy[8] paints a picture where the main macro-economic trend is the slow economic growth in the advanced developed economies, but with signs of recovery in the medium term, with significant uncertainties in both the European Union and USA. Most world growth is predicted to come in the emerging and developing economies in Asia. The developing countries in Africa and South-America have relatively modest economic projections.

In developed economies, the taxi industry has a history of being sensitive to the state of the market with regard to recruitment. Recruitment is typically good in cyclical troughs, when demand for taxi services is low. Similarly, when there are improvements in the economic conditions and demand for taxi services is high, recruitment is more difficult (Buckley 1982 and others). Given this, the immediate outlook is that recruitment to taxi jobs will continue to be good, and demand not so much so, at least in Europe and in the near future. However, as licensing

7 https://tfl.gov.uk/info-for/media/press-releases/2015/october/mayor-and-tfl-finalise-ulez-requirements-for-taxi-and-minicab-trades

8 http://www.imf.org/external/pubs/ft/weo/2016/02/

restricts the entry to the taxi markets, one would expect that much of the demand for jobs will be targeted at non-taxi service providers, rather than the licensed taxi industry. As observed in Ireland, the recruitment of licensed drivers is difficult. Similarly, the drop in demand faced by traditional taxi operators may have several components. Both landscape factors, such as the economic slowdown, and niche factors, such as new service providers, contribute to this.

2.3.2 Automation of low and semi-skilled labour and increasing inequality

In principle, automation of low and semi-skilled labour tasks should result in increased productivity, which with the appropriate policies in place, can result in increased welfare for all. This is a development that affects many sectors, including the transport sector.

Over the last two centuries, there have been numerous movements pointing to a bleak future where human labour becomes superfluous. However, looking back at history, most of these predictions have been proved wrong, at least on a society-level. On an individual level, it has been partially relevant.

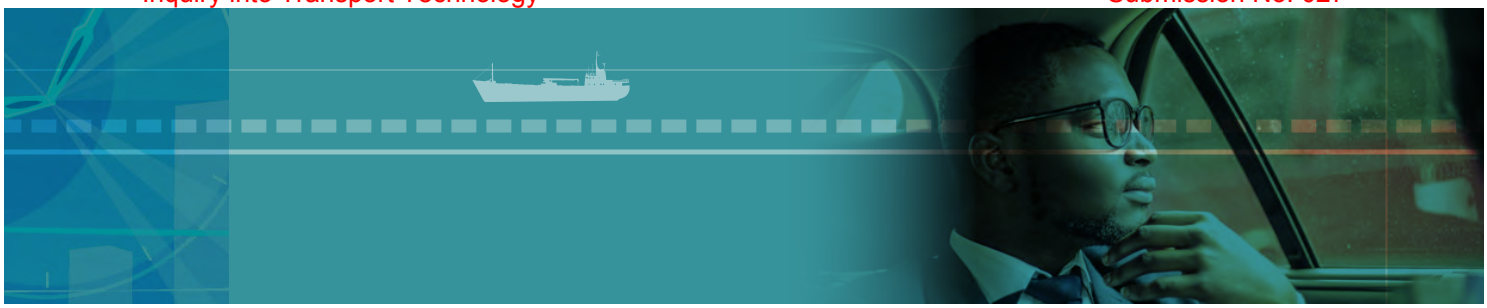
Another trend is the polarisation of labour, with fewer jobs in the middle-income segments. This trend is very relevant for the taxi industry. In the first order of events, one can see the outline of a system where middle income, middle skill, taxi workers being replaced by low income, low skill (but technology assisted) workers. In the second order of events, these workers can be automated away altogether, and replaced by self-driven vehicles, and a few operators managing "unforeseen" events.

For society, this will improve welfare, but who receives the benefits will depend upon the policy approach and the amount of redistribution.

Freight transport experiences many of the same issues relating to autonomous driving as taxis do. Here the Commercial Vehicle of the Future study (TML IRU, 2017) provides some interesting reflections. It points to the likely scenario of gradual implementation of driverless vehicles, by increasing the role of automation of the driving process. This sees the driver evolving from being a controller of the vehicle to become a person who monitors the vehicle, with changing liabilities as a logical consequence. This is discussed more closely under transport sector trends, below.

2.3.3 The sharing or collaborative economy and new business models

The sharing economy as part of a larger digitalisation debate as digital platforms have been used to contract small pieces of labour has existed since the early 1990s. The last decade, these services have evolved from being targeted at high skilled labour (software development, performing arts, design etc.) to low skilled work (cleaning, walking dogs, driving etc.). Similarly, the services have evolved from targeting full-time professionals to target part-time non- or semi-professional workers. The discussion on the sharing economy has several ambivalent aspects, in particular the relation between the concept of sharing, joint consumption and business. It is unclear whether a particular service is peer-to-peer or peer-to-company, whether it is a collaborative process or joint consumption of an underutilized good. One of the advantages of platform technology is the scaling possibilities. Platforms can handle huge volumes of small contributions. This can result in a shift in focus, on the production side, from cost efficiency to redundancy, which is a point that has significant impacts related to urban planning. Production efficiency points in the direction of high rates of vehicle utilization, while redundancy points towards having large fleets of vehicles available. Rolandsson (2016) identifies some interesting characteristics of the collaborative economy, in particular that the focus has shifted



to underutilized resources and that innovation no longer is in terms of new services but in new ways of starting and conducting business.

The dominant mode of transport in terms of passenger kilometres, is the private car. At the same time, a private car is in terms of economic properties an enormous inefficiency. It is a costly asset, which spends most of its time depreciating, without being used. On top of that, it is also an easily taxable object. This is one of the possible points of departure for understanding the attractiveness of the transport sector for business models branding themselves as being part of a collaborative economy.

With respect to the transport markets, the collaborative economy may and does influence many sub segments. Ridesharing is made easier. This is a pure efficiency gain, as it promises to give better utilization of existing vehicle capacity. Joint ownership of vehicles is made easier resulting in joint ownership vehicles becoming far more common now than earlier. This is most likely efficiency improving that a jointly owned vehicle replaces 7 to 15 privately owned vehicles, and that it reduces the number of car kilometres, compared with a before situation where each of the members had a privately-owned car. For users who did not own a car before, the number of car kilometres actually increases (Hållén and Östlund, 2016). It also has the potential to allow under-utilized private vehicles to be utilized better, with peer-to-peer roundtrip car rental. However, the net effect of this, in terms of car usage, is unclear.

Looking at ridesourcing, defined as for profit ridesharing with the passenger deciding the destination and origin of the trip, it is unclear to what extent this can be defined as being part of the collaborative economy, even though many of the most profiled actors claim to be so. The services offered are very similar to taxi services. The efficiency and environmental effects of these services are also unclear. On the one hand it gives access to a large fleet of underutilized vehicles. On the other hand, Schaller's (2017) findings are in line with Rolandsson (2016), pointing at low vehicle utilization rates and therefore less efficiency.

It is likely that these services, if they continue to operate outside the regulated taxi industry, under different regulation, constitute a significant challenge to the taxi industry and to public transport. However, it is also important to note that the impact of these services is not limited to the taxi industry, and that these services can and do reach a demand that the conventional taxi services fail to reach.

Also, it is important to note that the business model central actors, such as Uber and Lyft, have used, so far has failed to deliver significant profits to its owners. Rather, in the case of Uber, it has resulted in enormous losses. Therefore, questions can be raised regarding the economic sustainability of the business model employed by these services. Thus, at present one needs to look at the Chinese and Indian markets to see if there is a profitable business model for CTIs, ridesourcing or ridesharing.

Another development which is closely related to the business models used by taxis, is the development in the information technology sector with platforms becoming more important as nodes in the dissemination of services online. Internet platforms, such as Google and Facebook are offering an increasingly wider array of services, also including transport. This is the case with the Chinese ridesourcing service DiDi. As Metz (2017) pointed out, this is a challenge for the taxi industry since these actors expand into what has previously been the domain of taxi dispatchers.

2.4 Transport sector trends

2.4.1 Connectivity / ICT

The world is changing rapidly, and connectivity is improving. This influences the possibilities for different transport modes. From expert interviews and literature, we have identified three main conflicting ideas on the direction the future transport market will take as ICT improves. That is modal convergence, modal divergence, and multi-modality.

Enoch (2015) questions the common assumption that cars, buses, and taxis will remain the dominant local passenger transport modes in the coming decades. He states that this needs not be the case as new intermediate modes such as shared taxis, lift-sharing schemes, demand-responsive transport and car clubs can grow rapidly and combined with technological and market trends may create a process of 'modal convergence', where he suggests "dial-a-pod" as the ultimate outcome (Enoch, 2015).

Modal Convergence

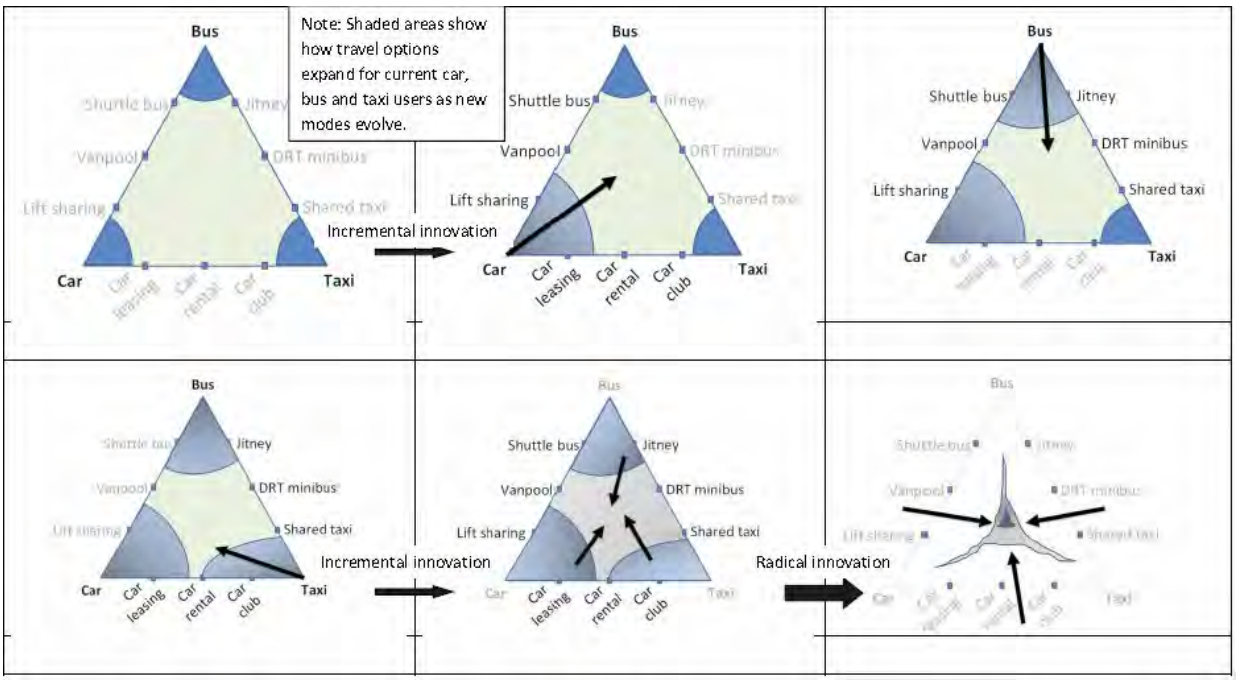
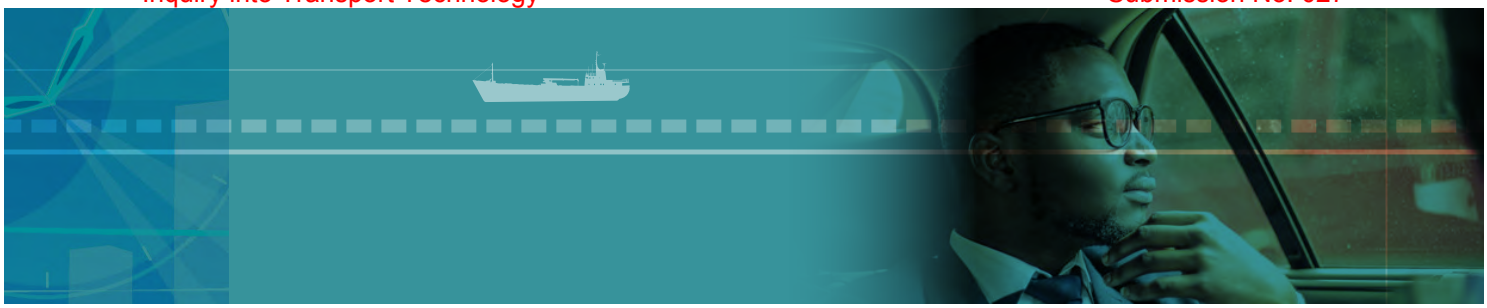


Figure 2.3: The convergence of local passenger transport modes (Enoch, 2015).

Figure 2.3 illustrates Enoch's (2015) four step model for modal convergence. The first step is the traditional market, the second is the expansion towards intermediate modes conducted from car, bus and taxi. In this phase, which he states that we are now within, there is much experimentation with different new modes and service models. In this phase, economic factors will determine which of the new modes will succeed. The third phase is that the surviving in-between modes will mature and begin to replace the traditional options. The fourth is when new automated vehicle technology accelerate modal convergence, and the driver becomes redundant. From model studies, such as presented Petrik (2017), it is possible to see the attraction of this model. It allows a high level of mobility to residents in the city, without much of the city landscape being taken up by parked cars. It also alleviates congestion and is more environmentally friendly, as average vehicle occupancy increases. The questions raised



towards this way of thinking and modelling are linked to it being a mental exercise, and that it hinges on removing private ownership, and that this would be much more difficult to achieve in the real world, where people want to own their own vehicles than in a laboratory setting. There are also questions raised to the financing side of this model.

Modal divergence

From interviews conducted in this study, several of the respondents have pointed to an alternative, and opposite, scenario to the one presented by Enoch (2015). Where Enoch (2015) predicts convergence to follow the present phase of innovation, they point in the direction of modal divergence, where more and more modes appear following innovation, in particular related to the possibilities created with ICT technology. They point to a continuum of new motorised modes between heavy rail and e-bike sharing. According to our informants, these new modes will vary along the sharing - exclusivity spectrum and also with respect to autonomation, creating a more dynamic set of modes, with more modes becoming increasingly tailored to specific market niches. Also, it creates a context where ICT actors can help connect these modes into multi modal travel chains.

Multimodality

Another perspective points to multimodality, with public authorities or public-private partnerships functioning as information hubs. Within this line of thought, Mobility-as-a-Service, or Transport-as-a-Service, is a key concept where people are offered transport services through a platform possibly operated by a third-party actor. Within MaaS the person requesting mobility does not have to make active decisions on modal choice, or rather the mode choice is made for each trip. The most convenient mode will be chosen for the individual by the mobility provider. In this multimodal future, existing modes are not rendered superfluous by new intermediate modes information reduces the friction between modes and new modes appear as complements to the existing modes.

Bustamante (2016) provides a different perspective on the use of ICT in transport pointing to the historical developments of ICT and its long and complex relation to transport. So far ICT has proven to be more of a complement to transport than a substitute. Earlier inventions, such as video-conferencing and e-commerce have gone hand-in-hand with increasing transport volumes. In a similar way, ICT improving efficiency reduces cost and increases transport demand. Looking at the future this position can be summarized as while there is much uncertainty on the relation between ICT and the future transport system, it is very clear that ICT will be an integral part of this.

2.4.2 A wide range of "new" services

Regardless which future developments will come in the relation between ICT and transport, there is a wide range of "new" services being offered at the market today. Ridesourcing services have been high on the public agenda. However, they are only a small part of a large web of transport related services that have reached the market in the last decade or so.

Like the conventional transport / taxi market, where different services and different market segments have different properties, the different services marketed under the collaborative economy label have different properties. Therefore, there is a need to draw up a set of categories to distinguish the services. There are many ways of categorizing these services.

Enoch (2015) uses Vuchic (2007) and draws a distinction based upon what the passenger buys. The categories are a 'common carrier', where the passenger rents a seat/space, the 'paratransit' where the passenger rents the vehicle or 'private' where the passenger owns the vehicle. Using this

definition both 'common carrier' and 'paratransit' are relevant as collaborative economy categories. A different distinction is between 'ridesharing' where the driver sets the origin and destination of the trip, and 'ridesourcing' where the origin and destination is set by the passenger, similar to a dispatched taxi trip. There is also a distinction between services provided by professionals in dedicated vehicles and services provided by non-professionals. Some studies, such as "Shared Mobility" (SUMC, 2016), even include conventional buses as a shared mode by focusing on the non-exclusivity aspect of the vehicle, so that ridesourcing become a shared mode. This definition is in contrast to the actor oriented definitions used, which focus on the peer-to-peer aspect typically associated with the sharing economy, and adopt this meaning of 'shared' into shared mobility.

There are also numerous car-sharing actors such as Zipcar (car-pool/clubs), Nabobil (peer-to-peer car rental) and Car2go (free-floating car rental). These may also have an influence on the traditional taxi-markets, but it is so far very limited and the future of these services are difficult to predict.

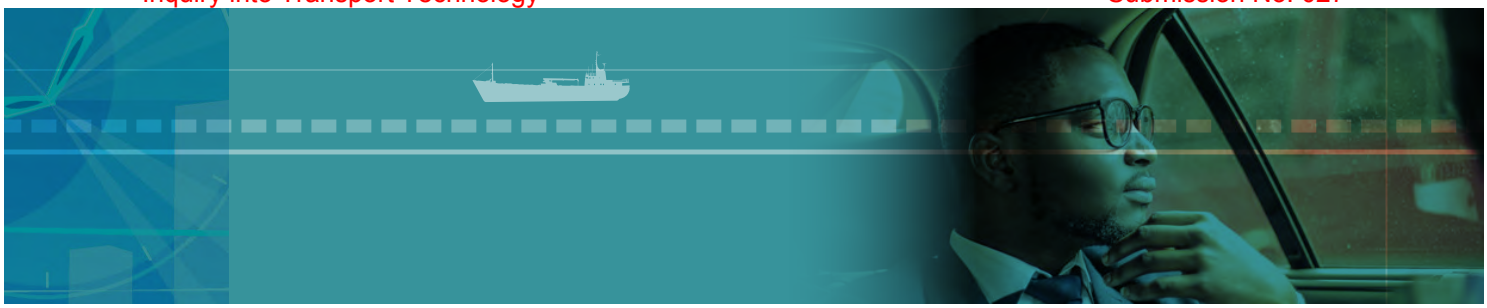
2.4.3 Self-driving vehicles

Automated vehicles consist of a combination of technologies that enable a vehicle to assist in the task of driving (Baker et al, 2016). There has been rapid development in self-driving technology. At present major companies, such as GM, BMW, Ford and VW, are working on reaching level 4[9] automated vehicles in the early 2020s. Tesla and Google are indicating that they will have level 4 vehicles on the market earlier. If /when self-driving level 4 is achieved, it will probably have a significant impact upon the way cars are used. This will also have implications for which services will be offered, and by whom.

9 This is referring to the levels of vehicle automation adopted by NHTSA, (2016). Confusingly, there are several other ways of categorization of different stages of automation. ERTRAC (2017), uses a five level system, where level 5 roughly corresponds to NHTSAs level 4.

Table 2.2 Levels of vehicle automation (NHTSA, 2016).

	Level 1	Level 2	Level 3	Level 4
	Function specific automation	Combined function automation	Limited self-driving automation	Full self-driving automation
	Covers one or more specific control functions	Covers two or more control functions. Driver available and in control most of the time	Vehicle is in control most of the time, but the driver is expected to be able to occasionally retake control with reasonable transition times	Vehicle is in full control and driver/ passenger is not expected to take control at any point
Example	Adaptive cruise control	Adaptive cruise control combined with lane management	Google's self- driving car	None commercialized yet



Fully automated vehicles comprise in-vehicle systems assuming full control of throttle, braking, and steering controls. These vehicles use high-definition maps of the roadway environment, providing a reference point for navigation, and high-accuracy location technology (e.g. obtained from GPS) to determine where the vehicle is. On-board sensors and vision-based systems detect and compile information about the dynamic road environment.

Vehicles that possess high levels of automation can yet only operate in automated mode under certain conditions, and the driver must resume control of the vehicle if a problem is encountered. Automated vehicles are however advancing rapidly, and fully automated vehicles could be on the road anywhere from within the next few years to within a decade.

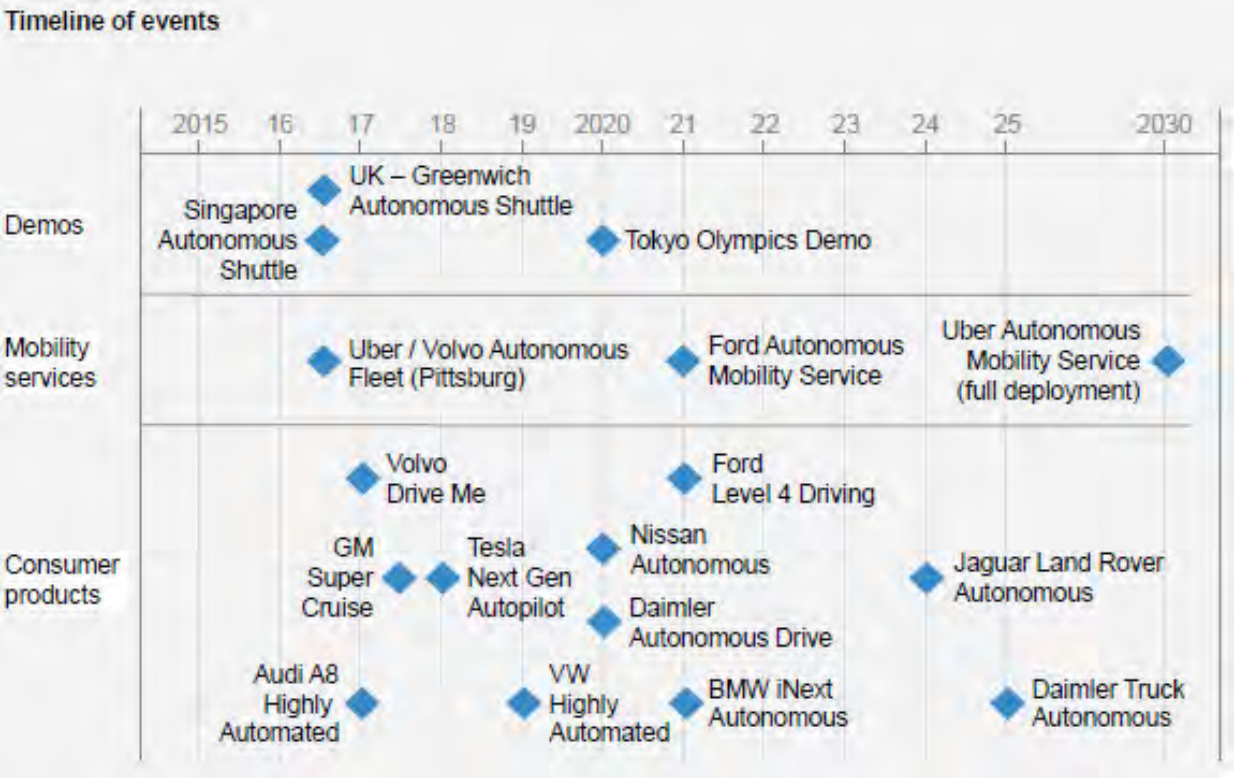


Figure 2.4: Timeline of events for automated vehicles (McKerracher et al. 2016).

The timeline for anticipated deployment of automated vehicle in the taxi industry is unknown. Figure 2.4 is an illustration of possible developments, based upon information from the companies.

In 2015, an Advanced Technologies Centre (ATC) was set up in Pittsburgh by Uber, and the first self-driving Ubers have already been on the road[10]. However, a similar scheme in San Francisco was stopped after a couple of weeks of operation for legal reasons[11]. In Japan, Robot Taxi[12] is planning for deploying autonomous taxis during the 2020 Summer Olympics to be hosted in Tokyo. Robot Taxi adds driverless capabilities to existing cars and will design, create, and market a taxi service. In Singapore, nuTonomy has begun the world's first consumer trial of driverless taxis. Using nuTonomy's ride-hailing smartphone app, select members of the public are being invited to book a free ride in a self-driving car[13]. In Gothenburg, Sweden, Volvo is currently conducting the trial project "Drive Me - Self-driving cars for sustainable mobility". By the end of 2017, 100 self-driven vehicles will be available for lease for customers in the Gothenburg area (Wangsness et al, 2015). Several other manufacturers, such as Tesla, Toyota and Audi have indicated that they will have fully automated vehicles within the near future Google's Waymo was introduced in April 2017[14].

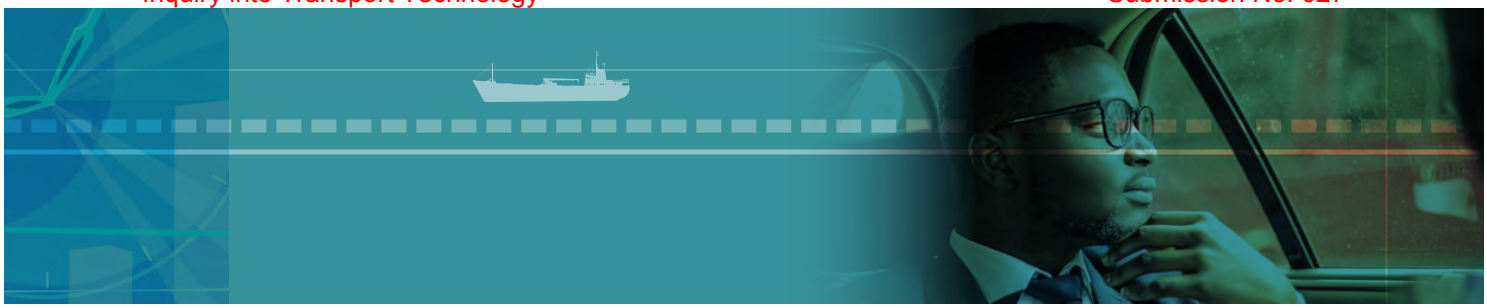
The introduction of self-driving vehicles faces several regulatory challenges, and to date, no country has a complete legislation in place. But this may change soon, as legislation for commercial testing is available in many locations. In Sweden, the vehicle can hold legal responsibility for driving, although a human being must be physically present. If the vehicle is involved in an accident while in self-driving mode, the car manufacturer holds responsibility. This implies that data from self-driving mode must be stored, in order to determine liability (Wangsness et al, 2015). More detailed regulations, e.g. on how and when the vehicle is responsible to inform the driver to take charge, are not yet in place. Self- driving vehicles also represent an example of the societal challenges of automation. For example drivers, who often are independent contractors with few protections and benefits, can lose their employment, if self-driving efforts succeed. However, in the foreseeable future there is still a significant role for the driver.

TML/IRU (2017) points to the likely scenario of gradual implementation of driverless vehicles, for commercial vehicles, by increasing the role of automation of the driving process. This sees the driver as evolving from being a controller of the vehicle to become a person who monitors the vehicle with changing liabilities as a logical consequence.

In the interviews conducted as part of this study there is much divergence of opinion on this topic this ranges from experts who regard self-driving vehicles as unrealistic in real traffic until long after 2030 to experts seeing autonomous vehicles as an obvious next development, ready and implementable on fleet scale within a year. The authors of this report note this difference in opinion and propose that the timescale for implementation is dependent upon three key questions that at present calls for further research. These key questions regarding autonomous vehicles in general, and autonomous taxis in particular include:

1) To what extent will the change from vehicles with a driver to autonomous vehicles change passengers' willingness to accept sharing the vehicle with other occupants? The answer to

10 https://newsroom.uber.com/pittsburgh-self-driving-uber/
11 http://www.theverge.com/2017/2/27/14698902/uber-self-driving-san-francisco-dmv-email-levandowski
12 https://robottaxi.com/
13 Read more from Asian Scientist Magazine at: http://www.asianscientist.com/2016/08/tech/nutonomy-sg-trial-driverless-car/
14 https://www.wired.com/2017/04/googles-finally-offering-rides-self-driving-minivans/



this question is not obvious, and there need not be a single answer either, as differences may occur in different geographical and cultural settings. It may also be influenced by policies. However, the answer to this question will impact significantly on the attractiveness of autonomous vehicles for cities. If they are shared, they will help reduce congestion, if they are not, they will make congestion worse. If usage is exclusive but ownership is organized in fleets, this points toward increased temporal efficiency of the car fleet while the utilization, in terms of passenger kilometres to vehicle kilometres may become worse.

2) To what extent will autonomous vehicles require dedicated or new infrastructure? There is a significant literature stating that connected highway infrastructure is a precondition for fully autonomous vehicles. If this is the case, it may take decades before the driver can be fully removed from the steering wheel (level 4 autonomation).

3) How early will the necessary technology be available? And when will it take significant market shares? On these questions estimates vary from 2018 for the availability of the necessary technology to long after 2030 for implementation. The answers to questions 1) and 2) will influence this to a great extent.

2.5 Who are the future taxi passengers?

There are, in general few studies of the taxi passengers. However, the studies that do exist illustrate that the taxi passenger at present is no homogenous group. Both high-income and persons without private cars are overrepresented[15] (Darbéra, 2010). Also, studies of ridesourcing services indicate that their typical passengers are different from the typical passengers of the traditional taxi industry. Interviews with ridesourcing actors conducted as part of this study[16] point in the direction of younger passengers, often "millennials", and more recreational use. This is in line with the findings in the French study conducted by 6t (2015). The traditional taxi industry in contrast has a more mature clientele. There may also be significant variation of the market segments served by different ridesourcing services[17]. Some have a customer profile closer to that of traditional taxi companies, while others target other types of travel. According to one source, this is a result of company background with companies that have a background in rural areas focus on options available there, companies with a public transport background focus on larger vehicles, and companies with a limousine service background focus on exclusivity. There is an observation that the ridesourcing companies are branching out to target many different market segments with different products, to a much larger extent than what existing taxi companies do.

At present, the ridesourcing companies and traditional taxi companies are reaching different market segments. However, there are several overlaps between these segments (see Rayle et al. 2016). As ridesourcing companies are targeting different market segments compared with traditional taxi operators, they are identifying underserved market segments. This is also in line with the findings in Berthelsen (2011) who compares a travel survey conducted among Norwegian taxi passengers in 1996 with a similar survey conducted in 2011, and finds that the taxi industry has lost market shares in urban and sub-urban settings. Also, he finds that the average taxi user has become older. Fewer persons in their twenties use taxis and they are a smaller part of the demand for taxi services in 2011 than was the case in 1996. As of 2016, these market segments, urban areas and persons under 35, are key segments for ridesourcing companies operating in Norway. Some of the

15 Except in Paris, where only the rich take taxis.

16 Also, supported by interviews.

17 Based upon interviews with Uber, GoMore and Haxi.

possible explanations for this development according to Berthelsen (2011) local, but most can be generalised: Higher youth unemployment; better mass transit; higher cost of taxis; and that the older market segments are more able to get others to pay for their taxi trips (either as social support or as company expenditure). This development can also be relevant in other areas.

The key question related to who the future taxi user is, is to what extent the different suppliers (or modes) reach different market segments. The total demand for transport is increasing, but more options are appearing. If young people opt for something different from the traditional taxi industry, that can be a market segment that is increasingly being lost for traditional taxi actors, to other transport modes or new entrants. In principle, any innovation that reduces the cost (disutility) of mobility, will increase demand. But, to what extent is very difficult to predict. What we do know is that there is a levelling off of car-driving, at least in some developed countries which, creates possible alternative future scenarios for developing nations. Connected to this, there is also a trend that young people are changing their travel habits. In particular, they are reducing their private vehicle ownership, and delaying taking their driver's license (Nordbakke et al. 2016).

Levelling off of car-driving

After decades of steady growth in daily travel and car-use, driving has levelled off in the UK (Metz, 2010), the USA (Puentes, 2012), and The Netherlands (Waard et al., 2013). Analysing trends in passenger transport in the USA, Canada, Sweden, France, Germany, the UK, Japan and Australia, Millard-Ball and Schipper (2011) found that total passenger kilometres by motorized modes of travel have slowed relative to GDP, and, in per capita terms, even declined in a few countries.

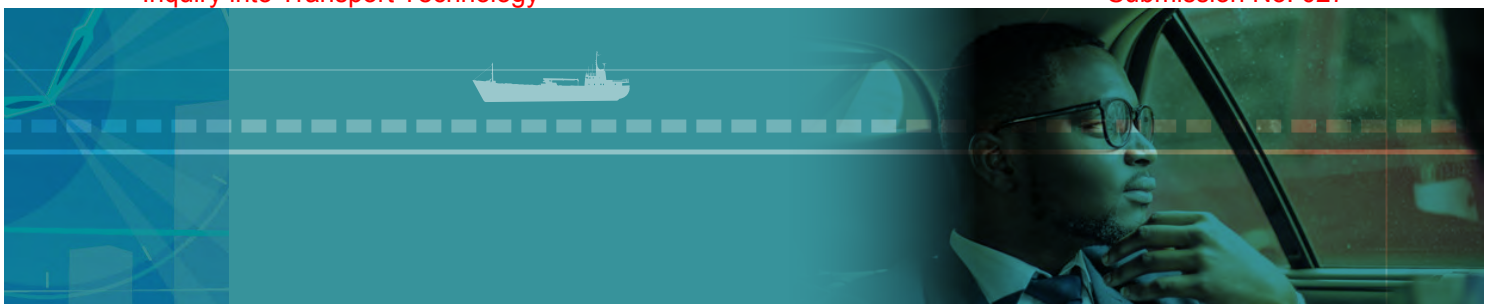
The 'peak car' phenomenon observed in several countries has been linked to aspects of culture. For example, less interest in obtaining a driving licence and in driving a car in general seems related to changed lifestyle among the young generation and in 'car culture'; for instance, the car is less interesting as a status symbol in urban areas in western European countries. At least in some developing countries, there are indications that they may never reach the high level of car use experienced by the developed world. However, at present the development path is still open.

At present, there is a tendency internationally towards stagnation in car-use and travelling (e.g. Metz, 2010), at least in some developed countries. Several reasons for this stagnation have been suggested (Grimal et al, 2013, Goodwin, 2012). Firstly, a saturation of travel demand might have been reached. The saturation phenomenon relates to (the theory of) the process of diffusion of durable goods (car) and innovative behaviour (use of a car). It starts in urban areas and spreads to rural areas, and from the upper classes to the lower. Saturation occurs when society as a whole has 'followed the leader' (figure 2.1). Second, a shift in activity programmes, lifestyles, in the relationship between activity and travel, and therefore in the characteristics of travel as a derived demand. Third, a change in consumer tastes and preferences, more specifically a declining preference for a car compared with other modes of travel. Finally, a downgrading of the relative utility of the car, particularly in the urban environment, either because of less efficiency of the car or of substantial improvements in alternative transport supply.

By itself, the levelling off of car-driving is likely to result in an increased demand for other modes, with taxi travel being especially relevant for first and last miles of the service.

Young people and travel habits

The saturation of travel demand may have its most prominent impact on young people. Young people are very often trend-makers, initiating



new ways of behaving, new ways of dressing, creating music and art with a modern front. Among some of the young urban generation it might not be seen as trendy to buy/drive a car. Since a much larger percentage of the young live in urban areas, especially in larger cities, the need for a car is not so big (Frändberg and Vilhelmson, 2003). The new ways of organizing transport are hence likely to be embraced by the younger generations first; indeed, a US survey showed that about 28 percent of 18- to 29-year-olds and 19 percent of 30- to 49-year-olds have used ride-hailing apps, but just 4 percent of Americans 65 and older have done so.

In several European countries, young people seem less interested in obtaining a driving licence and buying a car (Delbosc and Currie, 2013, 2014; Kuhnimhof et al., 2012, 2013; Forward et al., 2010; Noble, 2005; Hjorthol, 1999, 2012; Nordbakke et al. 2016). The reasons vary. It is not just one single factor suggested, but rather a combination of several factors. In a review of the literature, Delbosc and Currie (2013) classify these into six categories. Life stage: the increasing rate of educational participation, decreasing employment rates, delayed marriage/children, living longer with parents. Affordability: the cost of acquiring a driving licence, fuel and economic recession. Location and alternative transport: relocation to urban areas/accessible areas, better public transport. Driver licensing regulation: stricter regulation, increased minimum age, mandatory driving lessons. Attitudes: acute environmental awareness, car no longer a status symbol (although not in all countries), too busy/other priorities. E-communication: face-to-face contact supplanted, reduced need for physical mobility.

The categories listed above represent variables that may have a significant impact on the inclination to obtain a driving licence. Young people who live outside the larger cities, who have a car(s) in the household, who are in paid work and married/cohabitating, and hold a driving licence to a much greater extent than those living in the larger cities with good access to public transport, students and not married/cohabitating (Hjorthol, 2012). Many of these factors are reported in studies by Kranz (1999) (employment, densely populated areas), Noble (2005) (education), Delbosh and Currie (2012) (education, family and children), Le Vine and Polak (2014) (large city, good public transport, education). In the same 25-year period we have seen that a higher percentage of young people live in the larger cities, spend longer on education and delaying establishing a family and having children (Hjorthol, 2012). These issues lie behind the decline/stagnation of the orientation to have a car, getting a driving licence and owning a car.

The effect of reduced car reliance and a more urban lifestyle among younger people is to increase the demand for taxi services. However, the question remains open as to what extent this development, young people's move away from private car usage, is transferable to other parts of the world, or if it is linked to the economic downturn following the financial crisis, and will reverse also in western Europe.

2.6 Taxis and environmental technology

With respect to creating a better city environment and combat climate change, it is unclear if taxis are a part of the problem or part of the solution. It may also be that taxis can be both part of the problem and part of the solution, depending on how they are organized, as taxis utilize in part "of the shelf" vehicle technology, but often with adoptions for making conventional vehicles more suited to taxi use. In this way, the taxi industry can influence the technology used in taxi vehicles, but a large part of the vehicle technology can also be taken as given. That is, the emissions are given by technological developments taking place outside the control of the taxi industry.

This means that the technology used in taxi vehicles will reflect the general trend of the taxi vehicle fleet. However, taxi vehicles have typically much higher utilization rates, and thus turnover, compared with pure private vehicles. This points in the direction that the taxi industry typically will use newer, and thus cleaner vehicles.

Average energy consumption from a person-kilometre by taxi is typically higher than a similar person-kilometre by private car, as the taxi also drives empty between fare giving trips, and spends some time waiting between trips. During waiting time, the engine is often idling to provide heating/cooling and energy for entertainment systems. Typically,[18] a utilization rate of a taxi vehicle is between 0,5 and 0,7. This means that between a third and half of the vehicle kilometres are driven without a passenger. For a taxi to be a good alternative in an environmental sense, it is necessary for the taxi to, in combination with other modes, reduce the total energy consumption. This can be the case if taxis, in combination with mass transit, replace the private car as main mode of transport. Taxis are not in themselves a solution, but can be part of a solution for greener mobility. The outcome remain dependent upon usage patterns (see Nurhadi et al. 2017).

Most taxis today use a combustion engine, increasingly in combination with an electric engine in a hybrid power train. So far, there are few battery electric taxis. This may change rapidly, as cheaper longer range battery electric vehicles become available. The lower per kilometre cost of battery electric vehicle operations, should give them an advantage as taxis (see Nurhadi et al. 2017).

From a conventional combustion engine private vehicle there are three major emission components. 1) Carbon dioxide CO2 which relates to energy consumption, and is a greenhouse gas. 2) Particulate matter PM and 3) nitrogen oxides, NOx both "local emission factors", and more related to engine technology than energy consumption. Also, diesel engines emit more PM and NOx than petrol engines. In general combustion engine technology is improving and NOx and PM emissions are being progressively reduced, and energy efficiency is also being improved. However, as several studies have found (Weber and Amundsen, 2016, Miller and Franco 2016), there is a difference between type approval emissions and real world emissions. While PM-emission from diesel cars was successfully reduced with the introduction of particle filters, the emission of NOx strongly deviates from the type approval values.

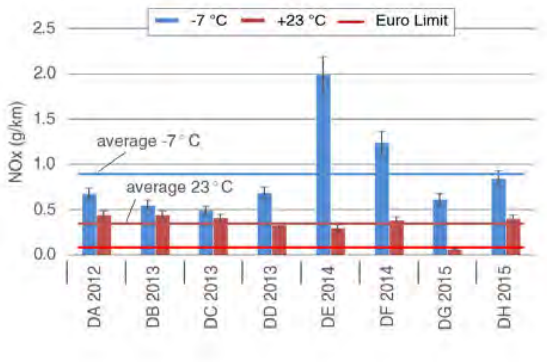
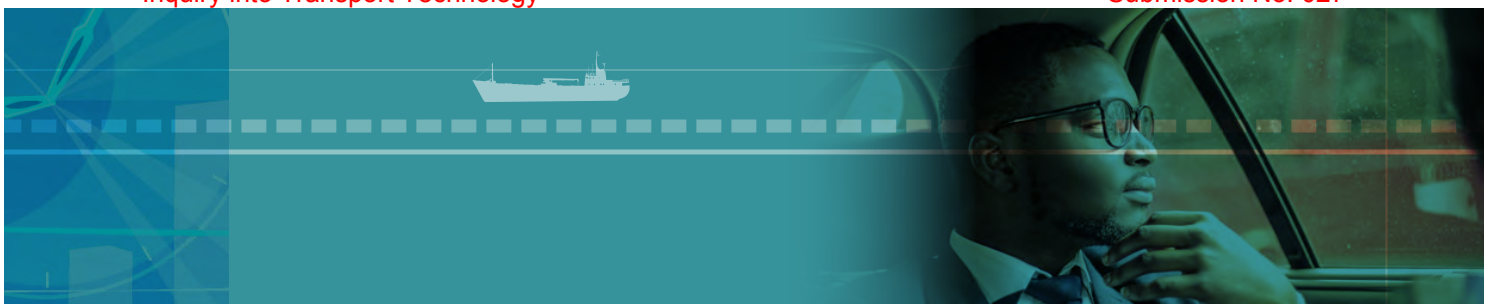


Figure 2.5: Chassis dynamometer results of NOx-emission in g/km for 8 diesel cars with model years ranging from 2012 to 2015. The blue and red bars show laboratory values of the emission during the Helsinki-congested driving cycle at an ambient temperature of -7 and +23 °C, respectively. The aim of this driving cycle is to reproduce realistic driving behavior in the laboratory. The full lines show the average values at the respective temperatures. The light red line shows the Euro 6 type approval limit for diesel cars in the NEDC.

Figure 2.5 illustrates the discrepancy between the nominal limit set by type approval legislation and real driving emissions from a selection of diesel vehicles. The model and brand names of the tested vehicles are anonymised (given letters from A-H). Observations like these are a

18 This is based upon Norwegian experience. From earlier research and public statistics (Statistics Norway, https://www.ssb.no/en/transport-og-reiseliv/statistikker/drosje



driving force behind EU's move towards changing the emissions type-approval procedure for passenger cars. This will also have an impact on the emissions from taxis. Most likely it will have an impact on vehicle technology standards in other parts of the world as well.

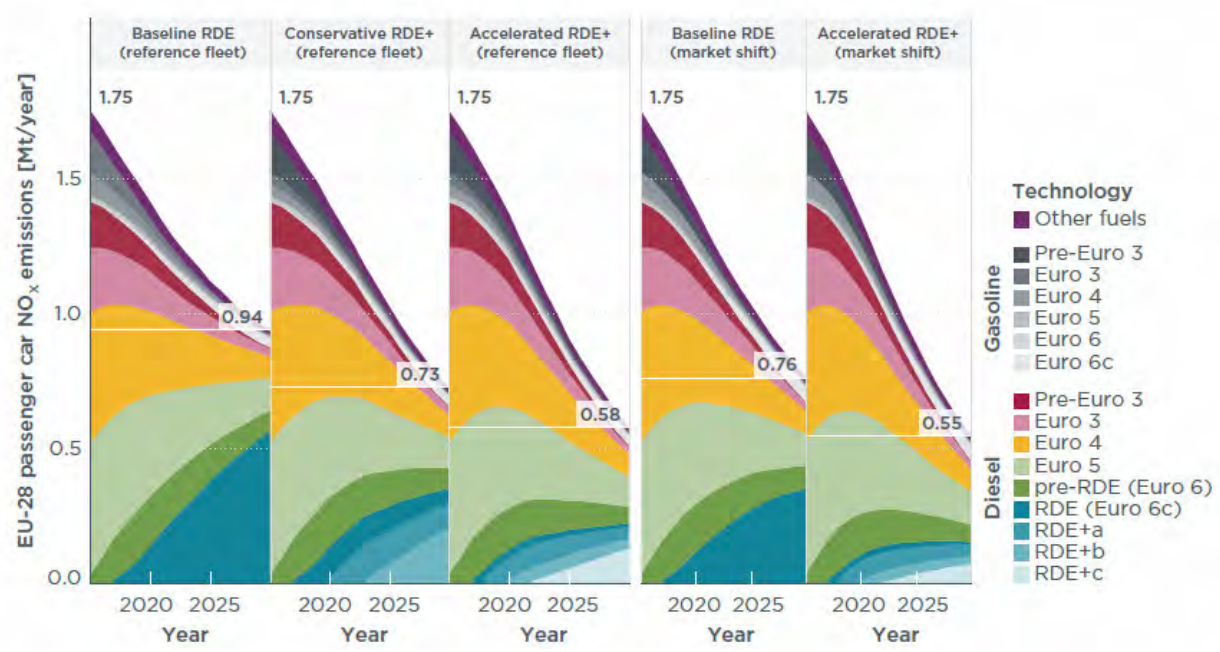


Figure 2.6: Passenger car NOX emissions in the EU-28 by vehicle technology, 2015–2030. The figure compares the outcomes of current ("Baseline RDE") and possible future legislations ("RDE+") (from Miller and Franco 2016).

Figure 2.6 illustrates the composition of NOx emissions from passenger cars in the EU, in the years 2015-2030, within different scenarios with respect to technology and regulation. The main point in having this figure here, is that it illustrates that new technology will take time to implement. Also, different legislation- and market scenarios will result in very different outcomes. The baseline RDE and accelerated RDE cases are the cases most relevant for taxi vehicles, as they typically have a higher diesel share and a higher turnover rate. The current technology, and its associated pollution issues, in terms both of greenhouse gas emissions and local pollutants, will be here for some time, as it takes time for the vehicle fleet to change. This does in turn make local regulation on vehicle technology relevant (e.g. low-emission zones, higher taxes for strongly polluting vehicles).

2.7 Summing up the Business-as-Usual (BAU) Scenario

The purpose of this chapter is to give a general outline of the BAU scenario for the Taxi of the future. This sub-section uses the insights provided in Section 2 to discuss the situation we find most likely to be present at the regime, landscape and niche levels in 2030.

The projections in this scenario include:

- A smaller share of the population in major urban areas own their own car, but the total numbers of cars increase
- Self-driving automated vehicles are not replacing the traditional car in the short term
- The costs to passengers of using taxis are as today, as are the cost of using public transport
- Urban congestion is in part addressed by increased use of congestion charging
- Zero or low emission vehicles are gradually taken into use
- Low-income groups increase in size
- Fewer young people own private cars, while car ownership in other groups continue to increase

These developments will of course vary much between locations. In developing countries the expectation is that more people will own private cars, not fewer. Also with respect to automated vehicles this scenario opens for regional systems of autonomous vehicles, but not market dominance at global level.

2.7.1 The Landscape level

As stated in Section 2.1.2, the landscape level refers to slowly changing external factors. This includes macroeconomic developments, socio-demographic changes, and transport sector trends.

Section 2.3.1 supports that future societies in the developed world as well as in Africa and South America will be experiencing slow economic growth, while the emerging and developing economies in Asia will experience the most growth. Automation of low and semi-skilled labour, and increased economic inequality, also seem likely in 2030. The increased proportions of the higher and lower income classes have several impacts on the taxi market.

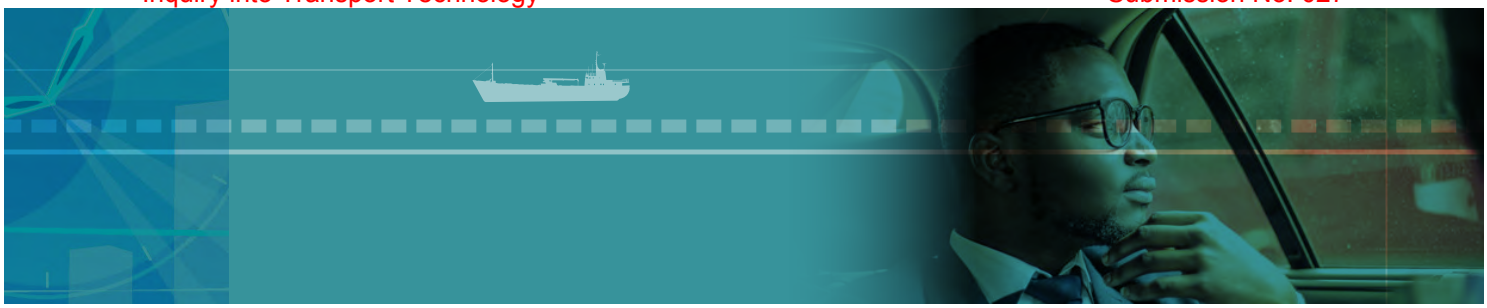
The few studies that exist on taxi passengers suggest that although taxi passengers are no homogenous group, both high-income and low-income groups without private cars are overrepresented (Darbéra, 2010). In addition, studies of ridesourcing services indicate that their typical passengers are different from the typical passengers of the traditional taxi industry. Ridesourcing service passengers are young, often "millennials", and use the services for more recreational purposes (6t, 2015).

A significant variation of the market segments served by different ridesourcing services do hence seem highly likely. Some market segments will have a customer profile closer to that of traditional taxi companies, while others target other types of travel. According to one source, this is a result of company background, although there is an observation that the ridesourcing companies are branching out to target many different market segments with different products. Another source states that the main characteristic of the development is the move toward a more multi-faceted transport system, where it is unclear which mode will represent what offer. This can be made further complexed by the introduction of new "meta"-services, such as MaaS bundling different modes and by doing so creating new options.

2.7.2 The Regime level

The 'dominant' configuration of actors, structures and practices is likely to have changed in accordance with the changes at the landscape level. In line with Rogers' (1962) pattern of technology adaptation, presented in Section 2.1.2, it seems likely that by 2030, the new ridesourcing companies will have made significant changes to today's regime. However, it is not clear if this results in a new alternative regime, or if new hybrid actors, will dominate.

Firstly, the supply structure and mode distribution have changed, not just within "unscheduled" transport, but also between ridesourcing services and scheduled public



transport, private cars and heavy goods vehicles (HGVs). This may particularly be the case when the network densities allow trip-sharing. It does hence seem likely that the new business model will affect incumbents across the economy (Wallstein, 2015).

Secondly, the regulatory regime has changed. While ridesourcing services created regulatory challenges and legal disputes when first entering the transport market, a transition period of implementing new regulations seems likely to have been completed by 2030. New regulations are likely to address problems of monopolies in regions and segments, as well as flows of data, particularly (but not limited to) the transfer of personal data.

We suggest that the new legislation be established through top-down as well as bottom-up approaches. Top- down approaches include initiatives like the EU's stated support towards the collaborative economy, where government banning of services should be a last resort (EU Commission, 2016). Bottom-up approaches include what Cannon and Summers (2014) refer to as initiatives from ridesourcing operators, which includes being responsive to regulators' legitimate concerns, be proactive and explain business models, and promoting transparency, including the sharing of data.

2.7.3 Niche level – what will be the role of taxis in 2030?

The discussion on how the landscape level will look like in 2030 indicates that ridesourcing companies and traditional taxi companies will serve different market segments, although there are several overlaps between these segments.

High-income groups may choose to keep their own car, and may also value (and be served by) the quality of service of traditional taxi incumbents. Traditional taxi incumbents may hence find their competitive advantage being an improved quality of service (Wallstein, 2015). For the (declining) middle-income group, a process of "gentrification" has been taking place, where people from the middle classes has been moving into traditional working class areas in the inner cities (Kasarda et al., 1997; Moss, 1997). With ready access to culture and leisure activities, this income-group may prefer the flexibility and efficiency of reasonably priced ride-sharing or ridesourcing services. Lower-income groups are likely to be most responsive to transport pricing, and are hence the group most likely to be using public transport in the future. The technological progress, particularly relating to ICT, is reducing the cost, and disutility, of transportation which will in itself be a force pushing towards more demand for transport in general.

The application of new technologies may also follow this market segment distinction. However, there are many and conflicting views among the experts who have shared their opinion in this study. This heterogeneity forms the basis for the alternative scenarios discussed in section 3. Consequently; although the technology used in taxi vehicles will reflect the general trend of the vehicle fleet, it may be adopted at different stages. Traditionally, taxi vehicles have much higher utilization rates, and thus turnover, compared with pure private vehicles. This points in the direction that the traditional taxi industry typically will use newer, and thus cleaner vehicles. This trend is further strengthened by the probable customer group these taxis will serve; higher income level groups, with higher demands on comfort and safety. On the other hand, ride sourcing companies operating with low costs seem likely to offer an older fleet of vehicles, thus adjourning the use of new technologies.

This study has shown that the landscape level of the transport system is changing; growing urbanization is coupled with a decreased interest in obtaining a driving license and buying a car

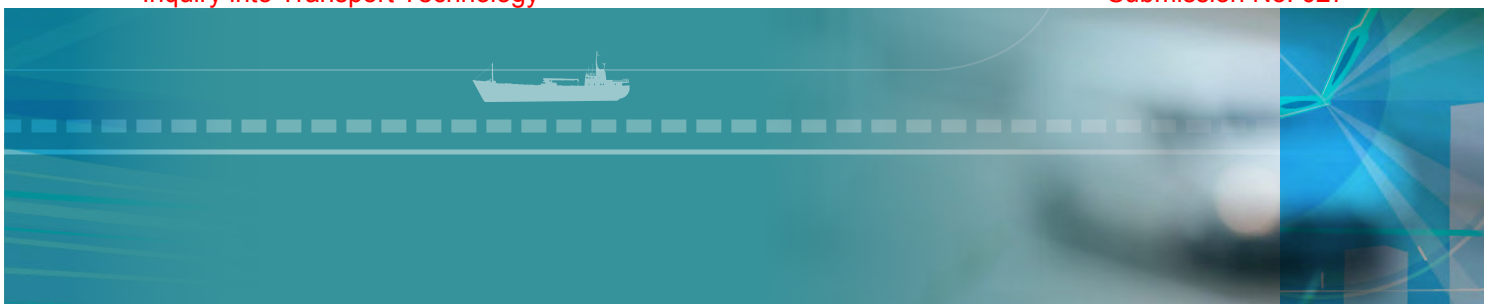
among younger people. Together, these trends increase the market for public transport, taxis and ridesourcing services. At the same time, slow economic growth and increasing inequality may decrease the average individual's travel demand, related to long-lasting degraded economic conditions of households; increasing fuel prices; levelling-off of real income; and increasing costs of other essential expenditure.

A important question is how developments in the niche and regime levels will manifest in such a landscape. At the niche level, the discussion above indicates that the polarisation of labour, with fewer jobs in the middle-income segments, may result in more segmented price elasticities and hence travelling habits among different groups of the population.

At the regime level, the Shared-Use Mobility Centre has observed that public transit agencies can use such innovations in their design of transport policies (SUMC, 2016). This includes collaborating with shared mobility providers, using ridesourcing services and taxis to extend and expand the use of public transit, and letting private providers take the lead in developing customer-facing technologies. Such public-private partnerships may bridge the currently observed fractions between regulators and operators of the new industries. However, bridging these gaps does not solve all issues relating to the new services.

2.7.4 Challenges in the BAU-scenario

A key question in the BAU-scenario is which role the taxi industry will take in response to the challenges presented by the expansion of digital platforms functioning as nodes for transactions that previously were in different and un-related sectors. This trend is affecting both society as a whole, and the transport sector in particular. It challenges the way business is conducted. Therefore, it also strongly influences which business model options will be available for the taxi industry. Business as usual, in terms of business models, may not be an option. Even in the business as usual scenario there are questions on the relationship between supply and demand, both for existing and new services and business models.



3 Alternative Scenarios

3.1 Introduction

In order to develop alternative scenarios to the BAU scenario, a set of projections for the future were formulated. These projections were based on key uncertainties connected to the BAU-scenario.

The projections were used in an expert panel survey, sent out to 218 respondents. The expert panel consisted of representatives from taxi, government, research and interest group organizations. They hold positions such as general manager, deputy director-general, research director, chief executive officer, or the like. The survey had a 35 percent response rate, and respondents represent all regions of the world. European respondents were however clearly overrepresented[19], accounting for approximately 60 percent of the responses.

3.2 Factor Analysis

An Exploratory Factor Analysis was used to examine the panel's underlying attitude structures to the projections. An Exploratory Factor Analysis reveals systematic structures in the data material (Clausen, 2009). The assumption behind this method is that certain sets of projections are being selected simultaneously by the same people, thereby forming factor components.

We used a principal component analysis with varimax rotation. The initial analysis indicated that seven factors had an eigenvalue higher than one, and could explain 67 percent of the variation in the different projections[20]. This is shown in the figure 3.1 below.

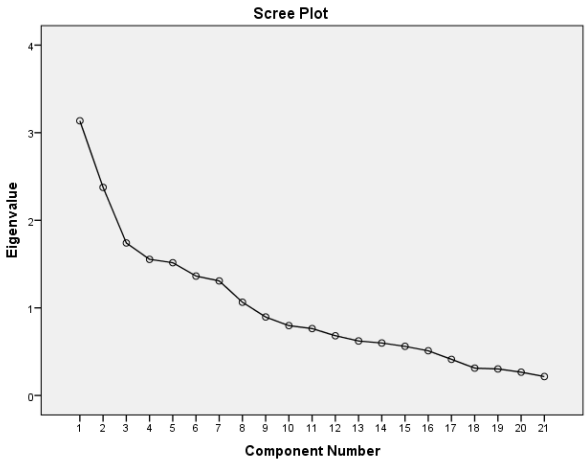


Figure 3.1: Scree Plot from Principal component analysis.

Two factors could together explain 35 percent of the variation in the different projections. We chose to go forward with these two factors.

The results of the analysis are shown in table 3.1, where the projections loading most strongly into the factor is marked in yellow.

19 Europeans were slightly oversampled, and had a much higher response rate compared to other respondents.

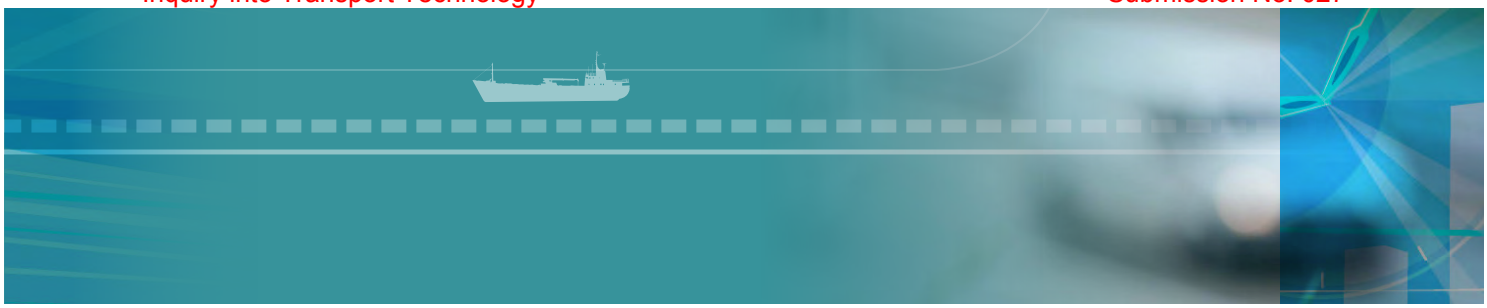
20 We chose to merge the three projections on Maas services into one, since they all loaded into the same factor.

Table 3.1: Factor loadings based on principal component analysis of the two most important components.

Rotated Component Matrixa	Component	
	1	2
The sharing economy flopped, and does not affect travel mode choice	,320	-,189
A larger share of the population in urban areas own their own car	,547	-,243
The middle-income group has declined; a polarization of labour has taken place	,118	,616
Self- driving vehicles have replaced the traditional car	-,614	,237
The costs of using a taxi is higher than today	,508	-,110
The costs of using ridesharing services is higher than today	,349	,174
The costs of using public transport is higher than today	,641	,143
Urban congestion is worse than today	,517	,224
The different transport modes will be more integrated than today	-,053	,415
The cost of using private vehicles is higher than today	-,111	,246
A larger share of the urban population chooses walking and cycling as their main travel mode	-,277	,274
The problem of transport sector emissions has been resolved by technological advancements	-,403	,392
There has been a considerable automation of labour	-,243	,514
Low-income groups cannot afford to live in central urban areas	,418	,105
The trend of urban population growth have declined	-,175	-,177
The population has an increased environmental concern	-,199	-,186
The share of the population working in high-tech industries is considerably larger than today	-,378	,044
Mobility-as-a-Service will be provided	,218	,694
The economy is marked by rapid growth	,369	,374
The population value experiences and recreation higher than purchases of goods and services	,031	,510
Your day to day transport activities are safer	-,342	,195

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

a. Rotation converged in 11 iterations.



3.2.1 The Conservative Car-oriented Scenario

Factor 1 will be termed the Conservative Car-oriented Scenario. The projections loading into Factor 1 include

- A larger share of the population in urban areas own their own car
- Self- driving vehicles have NOT replaced the traditional car
- The costs of using a taxi is higher than today
- The costs 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 advancements
- Low-income groups cannot afford to live in central urban areas

These factors concern travel mode choice and costs, including an increased share of the population owning their own car, more expensive taxi and public transport, and subsequently a negative effect on urban congestion.

The conservative car-oriented scenario also includes characteristics that oppose to projections on technological advancements. This means that the conservative car-oriented scenario rejects the notion that technological advancements will solve transport sector emissions, and that self-driving vehicles will replace the traditional car.

3.2.2 The Technology Innovation Scenario

Factor 2 will be termed the Technology Innovation Scenario. The projections loading into Factor 2 include

- The middle-income group has declined; a polarization of labour has taken place
- The different transport modes will be more integrated than today
- There has been a considerable automation of labour
- Mobility-as-a-Service will be provided
- People value experiences and recreation higher than purchases of goods and services

These factors concern a belief in automation of labour and its subsequent consequences; a decline of the middle class and a polarization of labour.

Factor 2 also 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 two Scenarios

The Conservative Car-oriented Scenario significantly deviates from the BAU scenario. This also implicates that it deviates from mainstream literature on future trends and projections. The Technology Innovation Scenario may on the other hand 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.

3.3.1 The panel's view on likeliness

Table 3.2 shows the expert panel's response to the different projections. The responses have been sorted by mean score, and are marked in colour to illustrate what factor each projection is loading into, respectively. The standard deviation illustrates the degree of consensus among the panel on the mean response; low standard deviation means high consensus.

Table. 3.2. The Panel's assessment of projections on a scale from 1 (strongly disagree) to 6 (strongly agree). The colour marks the factor each projection loads into. Red= Factor 1, Blue= Factor 2, White= Does not load into the two factors. N=76.

	Minimum	Maximum	Mean	Std. Deviation
The different transport modes will be more integrated than today	3	6	5,32	,594
The cost of using private vehicles is higher than today	2	6	5,14	,828
The population has an increased environmental concern	1	6	5,12	,864
There has been a considerable automation of labour	2	6	5,09	,769
Your day to day transport activities are safer	1	6	4,78	,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	,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 value 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 is higher than today	1	6	3,84	1,132
The costs of using ridesharing services is 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 is 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 have declined	1	6	3,32	1,073
The sharing economy flopped, and does not affect travel mode choice	2	5	3,24	,964

As we can see, the projection being rated with the highest likeliness, is the belief that different transport modes will be more integrated than today. We also see that the panel finds the projection "The sharing economy flopped, and does not affect travel mode choice" the least likely.

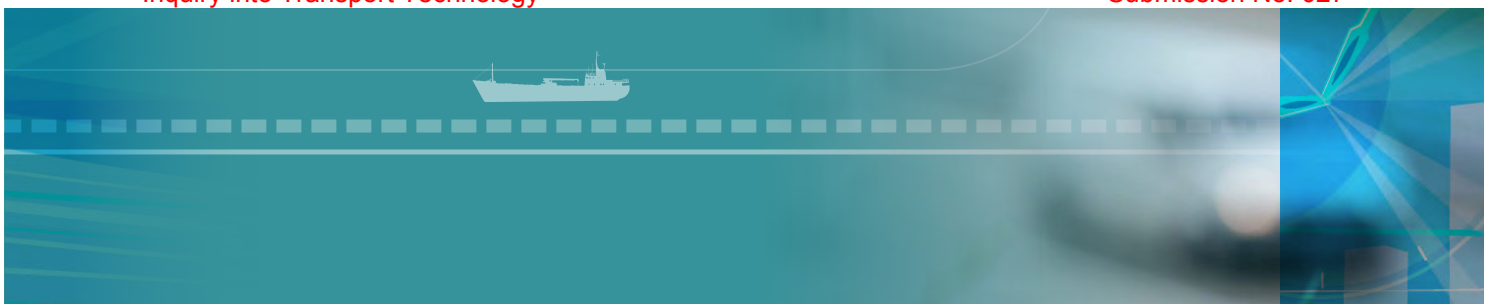


Figure 3.2 below summarizes the panel's response to the projections that form the two scenarios; f1 and f2.

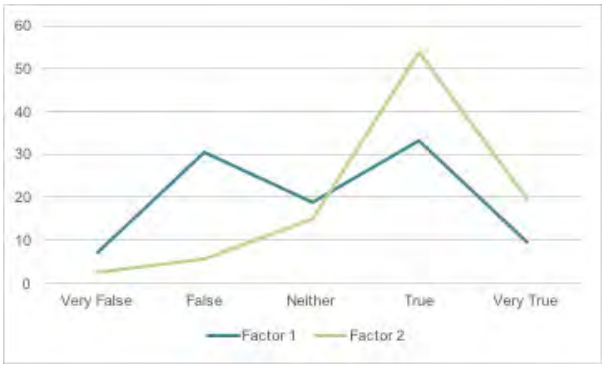


Figure 3.2: Comparison of the panel's response to the projections loading into factor 1 and 2. Percent.

The figure has been constructed by putting together the projections loading into each factor[21]. As we can see, the second scenario, the Technology Innovation Scenario, is viewed as the most likely. This might reflect that the world is already moving in the direction towards this scenario. Scenario 1; the Conservative Car-oriented Scenario, is on the other hand viewed as less likely.

3.3.1 Geographical differences

We also checked the data for geographical differences on views on the likeliness of the conservative car-oriented scenario. As the figure below shows, European respondents were least likely to rate this scenario as likely. Instead, they had the highest belief that self-driving vehicles will have replaced the traditional car, and that technological advancements will resolve the problems of transport sector emissions. The grouping, using Europe, Sub-Saharan Africa and the rest, is due to sample size. The 'rest of the world group' includes respondents from very mixed backgrounds.

21 Since the projections "The problem of transport sector emissions has been resolved by technological advancements" and "The problem of transport sector emissions has been resolved by technological advancements" loaded negatively into factor 1, the scale was reversed for these projections.

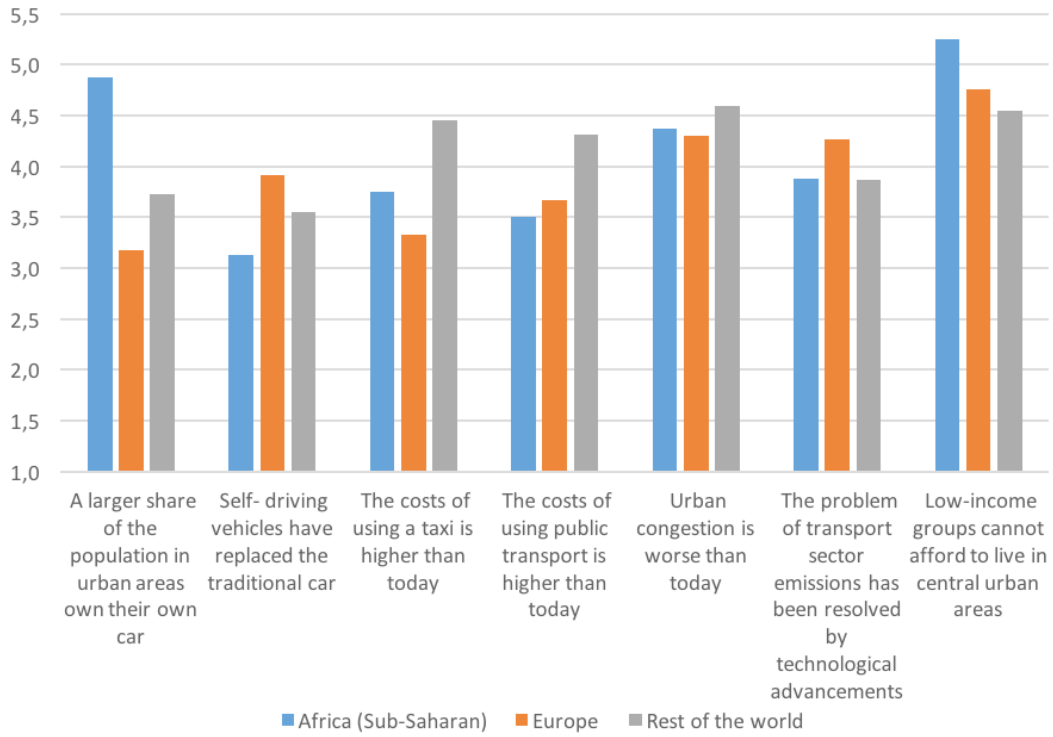


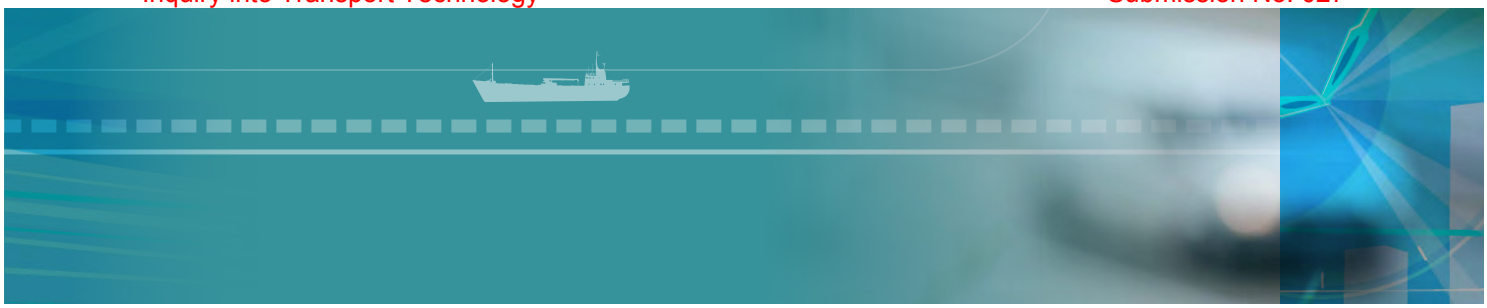
Figure 3.3: Geographical differences on responses to the Conservative Car-oriented Scenario projections average scores (strongly disagree = 1, strongly agree =6).

The figure also show that respondents from Sub-Saharan Africa by far are the ones most likely to believe that a larger share of the population in urban areas will own their own car in 2030. These responses may reflect the relatively low share of the urban population presently owning their own car in these areas.

3.4. Implications of the Conservative Car-oriented Scenario

When an increased share of the population owns their own car, while taxi and public transport have become more expensive, the modal split will turn in favor of private car use. Subsequently, this modal split will have a negative effect on urban congestion. Urban congestion will be further accelerated when low-income groups cannot afford to live in central urban areas. For this group, a likely choice seems to be to move to suburban areas, and commute to work by using their own car.

In this scenario, the role of taxis seems likely to lean toward what is termed the "traditional" taxi industry in section 2.5, mainly directed towards the high-income groups and business segments. But, the lowest income groups, who even in this scenario are unable to own their own vehicles, can, as is the case in many areas today, be partly dependent on taxi services for mobility. This is because the typical clientele of the ridesourcing services; the younger passengers, are more likely than today to be forced to live outside central (expensive) urban areas, and rely on the private car as their main mode of transport. With increased congestion and hence travel time, taxis might also lose market shares to public transport such as metro or BRT. Together, these



trends indicate that a lot of today's emerging ridesourcing services will fail in a conservative car-oriented scenario.

The problems of increased congestion, coupled with a failure of technological advancements to resolve the emissions problems of the transport sector, call for a stronger emphasis on regulatory measures. Relevant measures may include congestion charging, parking regulations and vehicle requirements, and will be discussed in greater detail in chapter 4.

3.5 Implications of the Technology Innovation Scenario

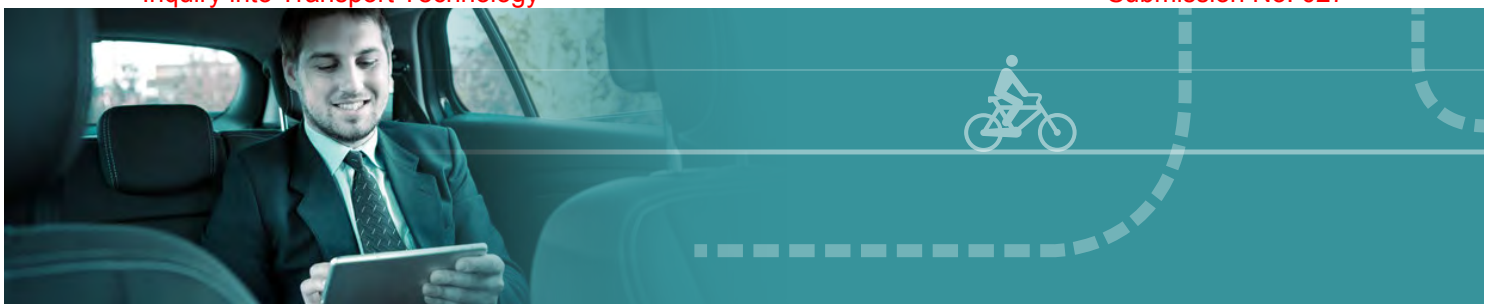
In this scenario, new technologies and new ways of organizing the transport market will impact on the travel mode choice of the public.

Automated vehicles may be introduced through different schemes of joint ownership, where the user pays for usage. The vehicles can take different forms, both as self-driving versions of today's cars, but also as automated minibuses or buses.

The experiments with MaaS that have been conducted so far, indicates that doing away with the private car has been one of the major motivations for participating (Sochor, 2015). MaaS replaces private car ownership with a pay as you go, or a set of allowed quotas, for car use (rental car or taxi) in addition to using public transport as the main mode. Also, using MaaS type services for creating intermodal travel chains point toward increased use of taxis for the first and last mile.

Both automated vehicles and MaaS may contribute to an increased demand for taxi services. In the case of automated vehicles, a less privatized way of organize transport will make the cost of taking a trip visible and closer to the actual cost of taking that trip, increasing public awareness of costs. In the case of MaaS type services, using taxis as an integrated part of a total package for door-to-door transport, the threshold for using taxi on the first and or last mile of a journey should drop. This will result in more, but shorter trips.

As this short presentation suggests, technological advancements in the transport sector will require an increased emphasis on organizational measures. These may appear in the form of private or public initiatives, as will be discussed in chapter 4.



4 Measures to shape the Taxi of the Future

4.1 Business-models

The product offered by a taxi company is quite uniform, traditional and simple. It is to move a person from and point to another. However, when it comes to customer interfaces, things quickly get more complicated. Here, there are different market segments, related both to who are the target customer, what is the way of reaching this customer and the relationship between the taxi company and the customer, as is discussed under the regulations section. With respect to the value configuration and business infrastructure management there is great variation between how taxi companies operate. This is the focus of this business-model section, together with the financial aspects of taxi operation.

4.1.1 Organisation of taxi operators22

There is a lot of variation on how the taxi industry is organised. It varies between countries, regions, communities, even within a community. The way it is organized is a result of a long series of regulation, and greatly affects the incentives for the actors involved. Using a model to illustrate the organisational differences in the taxi industry, Ray Mundy (Mundy 2010, Cooper et al. 2010, etc.) stated that there is considerable confusion as to what defines a taxi company, illustrated in figure 4.1.

22 Draws on Aarhaug (2016).

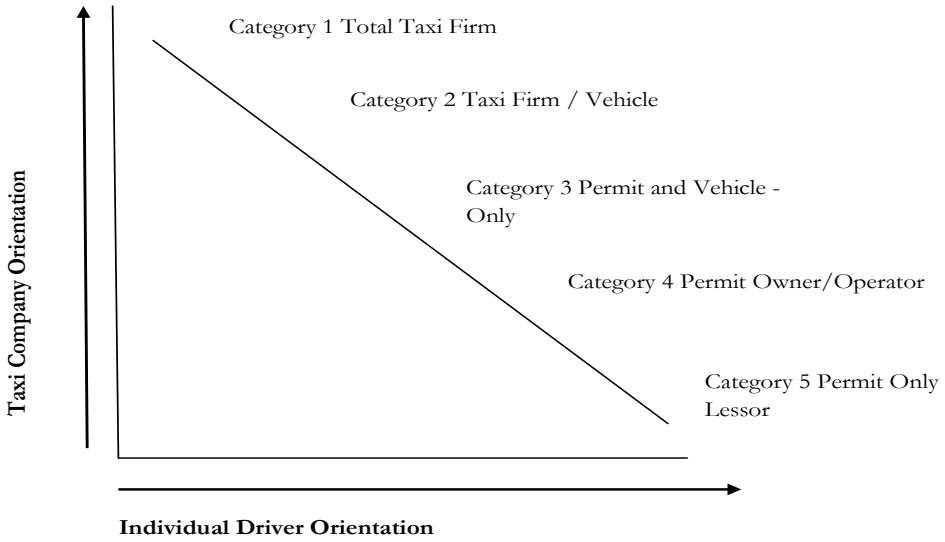
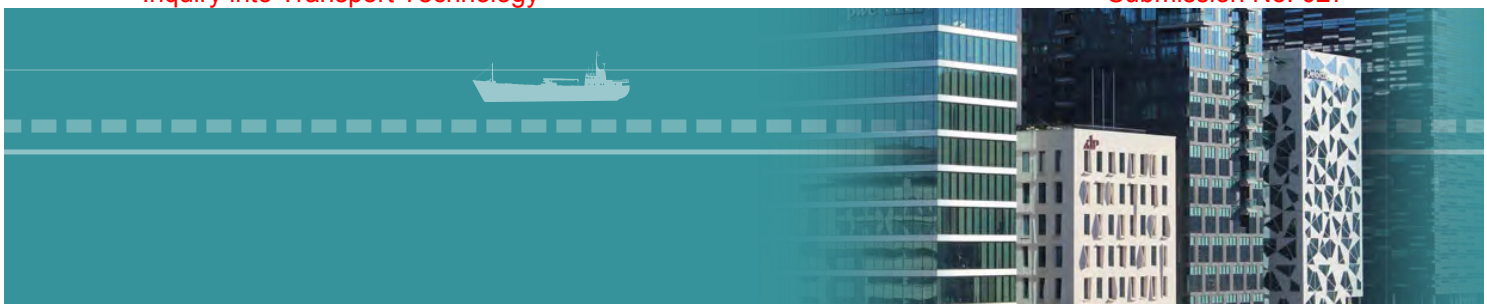


Figure 4.1: Continuum of City Taxicab Firms (Mundy, 2010).



Category 1 is the "total taxi firm," which is a full-service company carrying out maintenance, advertising, insurance and dispatching. Its drivers are employees of firms, many of which have long traditions in the US (see Gilbert and Samuels, 1982), but now operate in only a few cities. The firm sets drivers' shifts (Mundy, 2010). This is a conventional way of organizing business, but has not proven to be the most successful way of doing taxi business. Darbéra (2017b) argues that this is because this model lacks the flexibility necessary to operate successfully.

Category 2 introduces the taxi driver as an independent contractor. For the taxi company, the advantage is that it does not have to pay drivers directly and does not have a tax responsibility for its drivers. A variation within this system is that the vehicle is provided by the driver rather than by the company. The driver will decide whether he or she will or will not take a trip. This type of company provides a range of functions, including marketing, dispatching, credit card processing, corporate work, and so on.

Category 3: The permit and vehicle-only lessor firm provides contract drivers with the vehicle and permits and licences[23], but little or no marketing or dispatching. There are hybrid variants between category 3 and category 2 firms.

Category 4 is a firm in which the permit holder is also the driver. Firms in this category will not usually have a dispatching function or contracts with hotels and such, and are forced to use public taxi ranks and personal clients.

The category 5 firm is the permit-only lessor. These firms only pay annual fees, with the permit holders either driving a single vehicle themselves or leasing the permit to an independent taxi driver who provides the vehicle, the insurance and maintenance.

Ridesourcing companies do not fit into these categories, as they do not necessarily use licensed vehicles. They also always have a dispatching service, in the form of a platform app, usually organized as a separate company from the drivers, who are typically organized as sole proprietorship / individual contractors. However, the sole proprietorships will typically be close to category 4 or 5 taxi company with the platforms providing dispatching and marketing as a separate entity, but the driver is responsible for the vehicle, licenses and insurances and operates as an independent contractor.

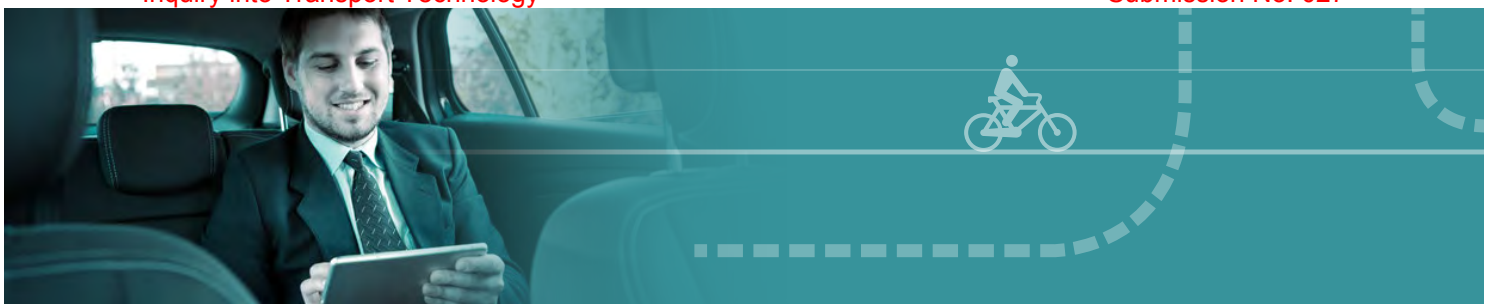
4.1.2 Future business models

We do not know which technological changes will occur in the years leading up to 2030. We do however know that the technology that has become available the last five to ten years has changed the possibilities for doing business in the market for unscheduled door-to-door passenger transport. This involves more of the market being taken by booking, through apps, and less by cruising/curb. This is both a consequence of network economics and a driving force behind this. We also observe that new technologies, such as self-driving vehicles, are coming.

There have traditionally been many different business models in the taxi industry, from the integrated taxi company to the vehicle leaser as described by Mundy (2010). So far, we do not know to what extent technology will change this. However, from the observed technological developments we can point in a few directions.

We will not go into the debate about automation of the drivers' function. There are still issues relating to technological change. A key development over the recent years is the pluralization of possible business-models

23 The definition of the terms "permits" or "licenses" depends upon local legislation. Here the two terms are used synonymously.



enabled by smartphone and app-technology. The major innovation coming from this technological development is not the way of connecting drivers and passengers, although that has become more efficient, it is the scalability of this connection function.

The technological change is linked to the coupling between passenger and driver. The coupling functions are now readily available, through existing code and high levels of smart phone availability. As a consequence, it is much easier to develop a business, compared with earlier, connecting taxis with passengers. It is also technically much easier to scale this business up.

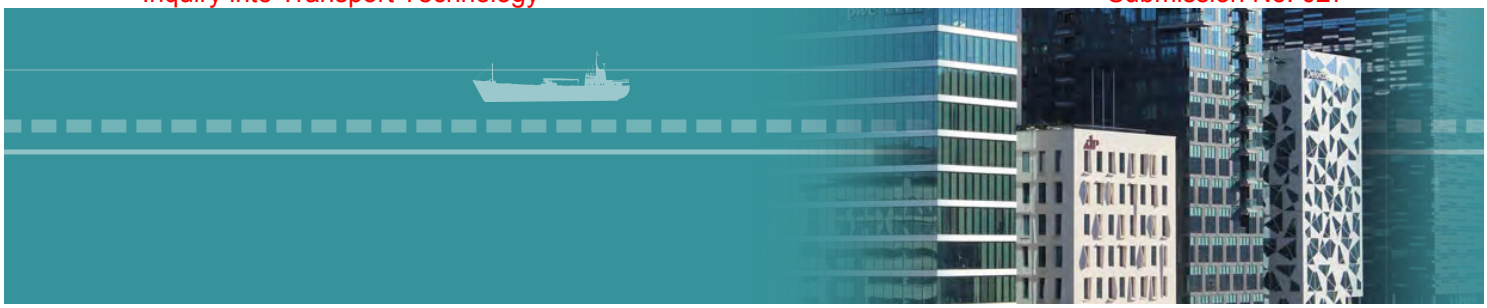
Also, funding is readily available because of the increasing availability of venture capital. A consequence of this is a myriad of offers and although you may have a sound business model and a good product, it is not straightforward to get at good customer base. There is a new barrier presented by the sheer volume of offers available. To get a new app to the market there is a need to create a brand and, because of this, there is a need for a much larger marketing budget compared to earlier, when markets for the connection function were local. The question is whether this develops into a "winner takes all" situation as predicted by Metz (2017) and others, with short term losses and long term profits to one or a few multinational companies or to a situation of increased competition. This is still unknown. But it is known that while the present CTIs (TNC)s dominating in the US market have been successful in being disruptive and in creating a new market, they have so far failed to turn this into profits[24], while Asian actors such as OLA and Didi Chuxing possibly are utilizing more efficient business models. Also, several of our informants, including representatives for ridesourcing companies have pointed towards a future with a plurality of service providers, where more and increasingly diverse products are brought to the market place also within 'door-to-door' passenger service.

Further, there is a market development on the "platform" level. That is that platforms, such as Facebook or Alibaba, increasingly add new services. This reduces the possibility for an app based actor to penetrate the market on its own, but it increases the business possibilities for taxi operators with fleets, who can (at least potentially) shop between different platforms. The bargaining relation in this market is still an unknown. Also, how this market will develop will probably be affected by how the taxi industry is regulated.

This means that we can see the taxi industry as having the possibility to move in different directions. One direction, as suggested by Metz (2017) is to focus on the delivery of transport as the core element. That is to offer fleets of cars with drivers to platforms that have the networks and consumer interfaces. To be an attractive partner for the platforms, there is a need for the taxi industry to create big fleets of professional actors and move away for single vehicle actors. Another future would be for the taxi industry to move into the platform market, with taxi apps and platforms originating from the industry, as there are several approaches. A third, would be that the development of such platforms sidetrack the taxi industry, by using non-professional drivers and vehicles, leaving the taxis to only serve a shrinking street market segment.

From an economist's point of view, the value added from the smart phone based technological development is made in increased connectivity. Therefore, one would expect more of the profits from these markets to move from vehicle provision to the platforms that control or have access to large pools of potential customers, with vehicle provision remain relatively simple.

24 https://www.ft.com/content/09278d4e-579a-11e7-80b6-9bfa4c1f83d2



The difficult task is to generate and maintain the customer base.

The condition for vehicle provision to be profitable would be that the provision of a customer basis is not profitable. That is to say that the bargaining power remains with the vehicle provider, because the different platforms continually compete for the presumably scarce resource of vehicles. This seems unlikely in a setting without a strict cap on the number of vehicles. In most cities, there is an abundance of spare capacity in the vehicle fleet and the low/medium skilled labour markets. All of this point in the direction of increased power to the intermediary. This again points to the intermediary being the most profitable link. Who these intermediaries will be, is still to be seen.

4.2 Regulation

4.2.1 Historical context

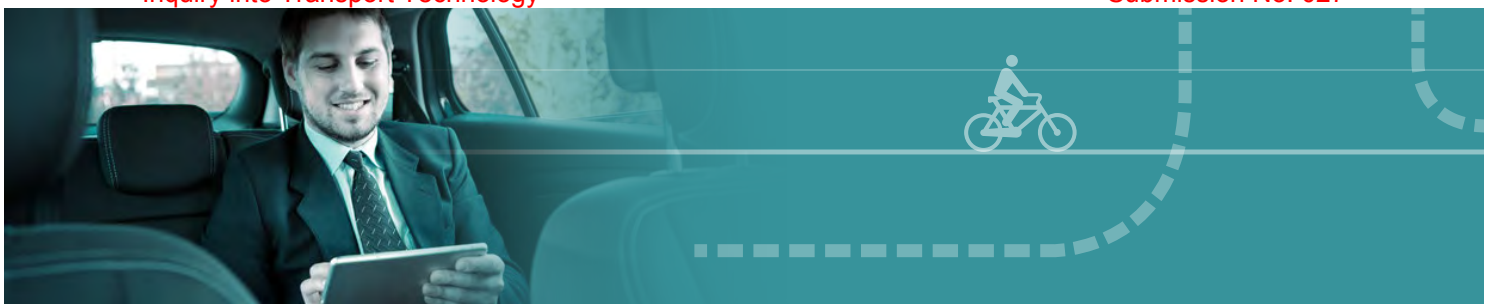
Taxi services are an old invention. They date back to long before the invention of the automobile. Similarly, taxi regulation also has a long history. Gilbert and Samuels (1982) look to the 1630s for the origins of modern taxi regulation, when cities experienced problems with horse carriages plying for hire in public spaces. Regulation was introduced to abate these problems. While a lot has changed since then, some of the fundamental issues have not. On the contrary, city space is scarce, consumers' interests are not always the priority of the service provider, there are market failures in several market segments served by vehicles defined as taxis in this study, all of which point toward some form of regulation. However, the present developments with new services, such as the introduction of hailing apps and ridesourcing services – both dependent upon the smartphone – and the emerging possibilities of self-driving vehicles, make this a very interesting time to study taxi services and the regulation of these.

A frequent point in the debate on taxi market developments over time and regulation, is the so-called regulatory cycle. Dimpsey (1996) points at the developments in American taxicab regulation, stating that American cities began regulating local taxi firms in the 1920s. From the 1970s, more than 20 cities, (his sample), totally or partially deregulated their taxi companies. Further, he states that the experience with taxicab deregulation was so profoundly unsatisfactory that virtually every city that embraced deregulation has since resumed economic regulation, despite strong deregulation ideology.

The background for the taxi regulation in the 1920s was a high level of unemployment combined with the high availability of vehicles. This created a situation with a high level of supply, combined with low demand. This resulted in low quality and poor working conditions. The resulting regulation consisted of municipal fares, licensing (typically with tradable medallions), and quality regulation (such as requiring insurance etc.). These regulations are often very detailed.

A key problem in these regulations is that over time, there are landscape level changes. Demand increases and technology changes, and therefore the outside options changes. Consequently, the rent for being protected, (having a medallion or similar) increases. Resisting change through strong and static regulations create befits for remaining in the status quo for those who are protected by regulation, while limiting the benefits for innovation.

Looking at the situation in the taxi markets in the early 2000s, Bekken and Longva (2003) point to several taxi market regulations, and that it is striking how different regulatory regimes are between the countries and that the paths chosen for regulatory changes vary just as much as the regulations themselves. They also find parallel moves, both toward stricter regulation and towards deregulation. They conclude, from their empirical evidence, that there, was a move away



from direct market access regulation, toward more qualitative regulation, although with much variation. A similar conclusion was found in the UK law commission (2012).

A new major change came from 2009, with the arrival of the app-based ridesourcing companies. Companies we label ridesourcers have operated under different names and with different business-models, but with a common feature that they use smartphone technology to conduct the matching between taxis and passengers. A key difference between these companies and traditional taxi dispatchers is that they are more scalable. And although most of these companies focus on short distance trips, and therefore need to be present locally, the matching process can easily be done at a global scale. The use of this technology is not limited to the new entrants in the taxi markets, but it has been pioneered by them.

Focusing on the history of taxi regulation, the distinction between what is defined into the taxi industry, and what is defined out, is of key importance. The typical distinction is made between single tier and two tier systems (with a distinction between taxis and private hire vehicles). New entrants (ridesourcing companies/ CTIs) challenge this distinction, arguing for a three-tier system (with "transport network companies") being a third category. This development will be discussed in section 4.2.3. A major issue is that how these definitions are made have huge economic consequences for the parties involved. These definitions accordingly represent a target for lobbying.

4.2.2 Taxi regulation – a brief overview

Regulation of taxi services is perhaps the most debated issue regarding taxis. As pointed out by amongst others Dimpsey (1996), Cooper et al. (2010), Bekken (2007), Salanova et al. (2011), it is not a question which has found a single uncontroversial answer. On a general note, when a wide definition of taxis is used (unscheduled professional passenger transport with a small vehicle) it is necessary to introduce the concept of market segments. This is because the different market segments have different properties (in an economic sense), and therefore have different ideal regulations. In order to understand the market, it is important to look into these different properties separately. It is common to distinguish between three or four market segments, depending on context. The first being taxi rank /stand, the second street hail / cruising, the third pre-book[25] (sometimes called telephone, for historic reasons) and the fourth being contract. The key difference between these market segments is how the taxi is hailed, and therefore the relation between passenger and service provider. Table 4.1 summarises the key characteristics of the different segments.

25 The key difference between the pre-book segment and the street segments, is not the possibility to book before the trip takes place, although that is often an option. It is that the hailing goes through an intermediary, creating a business-to-consumer relation rather than a peer-to-peer. In other words, that the consumer is facing an actor other than the driver, who can be identified for future transactions, reducing the information asymmetry problem associated with the street market segments.

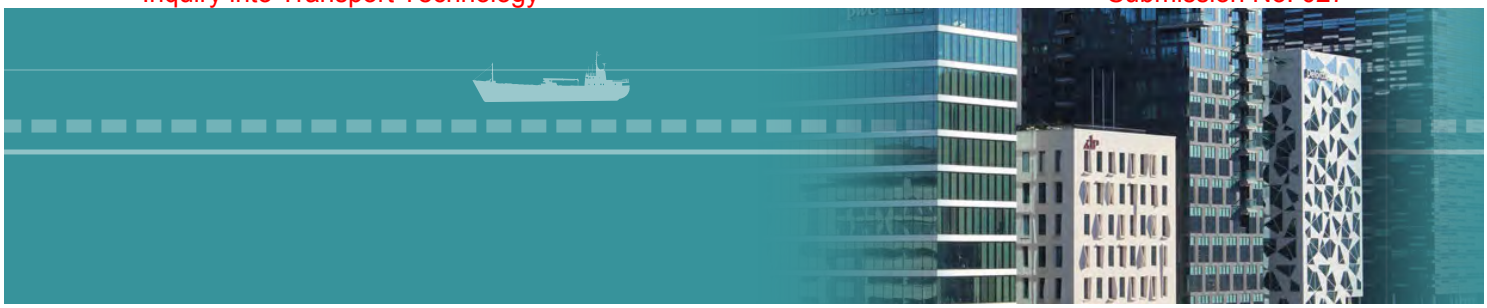


Table 4.1: *Taxi market segments.*

		Hail segment	Rank segment Street markets	Pre-book segment	Contract segment
Engaging		On the street	At a taxi stand	By telephone, (app, call, text message), internet, other	Determined in the contract (usually pre-booked in some form).
Payment	Where?	At destination	At destination	At destination	At regular time intervals
	How?	Cash or card	Cash or card	Cash or card (eventually via smart phone app)	Bank account
	Fare setting?	Metered or negotiated	Metered or negotiated	Metered or negotiated	Negotiated for several trips
Customer-Taxi relation		One customer one taxi	One customer one or more taxis	One customer One or more dispatchers	Several customers Several taxi companies

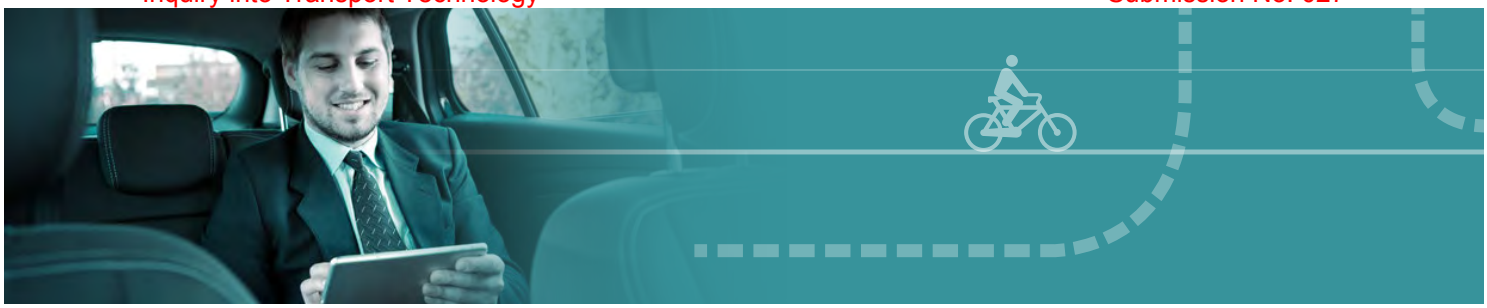
The methods used to regulate the taxi markets can be put into three categories; quantity, quality and economic regulation (QQE). Quality and quantity regulations are sometimes referred to as entry regulations.

- Quantity regulations address the number of vehicles (or licenses) available.
- Quality regulations typically address:
  - the operator's qualifications to operate
  - vehicle standards
  - insurance
- Economic regulation relates to fares.

There can also be additional regulations at dispatcher level. These can range from simple minimum requirements, regulations stipulating minimum or maximum sizes to detailed descriptions of how the dispatcher is to operate. As noted in Bekken and Longva (2003), there is a surprising variety in the form and shape of taxi regulations. A point from this observation is that different forms of regulation may result in similar outcomes through different processes. A "open entry" system with strict quality regulation may limit entry more than a system with quantitative restrictions where new licenses are issued regularly. It is also a general note, expressed by, among others Bekken (2007) and Cooper et al. (2010), that there are few studies on taxi regulation that are based upon empirical experience. Instead there are many theoretical studies reflecting the political views of the author.

One of the major developments on the taxi markets with a direct impact upon regulation is the arrival of the ridesourcing companies. And a major question is how this influences the optimal regulation.

One of the important issues raised is the risk of new global ridesourcing companies emerging as monopolies. Regulating a natural monopoly on city or country level, is relatively straightforward compared to a global monopoly (Darbéra, 2015). If a company reaches this situation, no longer fearing competition, this company may charge the customer the price that maximizes its monopoly rent. At the same time this company will become the only buyer (the monopsonist) which allow a similar poor treatment of the drivers (Darbéra, 2015). Darbéra (2017a) suggests fixed quotas or progressive taxation of market share as possible policy instruments to



address this. This will be discussed in a separate section of this document.

An even more challenging issue is related to the anti-competitive effects of dynamic pricing schemes, increasingly employed in the taxi service markets. Stucke and Ezrachi (2015) describe four ways in which computer enhanced dynamic pricing may result in anticompetitive behaviour of which, at least two of them are relevant to taxi services. One is that actors can present themselves as a "predictable agent", that is to say they can create price increasing cartels by creating an algorithm that credibly changes prices to rapidly changing market conditions, undermining the potential benefit to increase market shares and profits by lowering prices. The other is the "hub and spoke" system where several actors use the same algorithm, which may mimic a perceived competitive price rather than the true market price. Both of the effects identified by Stucke and Ezrachi (2015) present significant challenges to taxi market regulators.

Another question is if the QQE framework still is the right framework for regulation, or if ridesourcing companies require a different framework, as suggested by Harding et al. (2016). Schaller (2017) also ask the question if the growth of ridesourcing services is sustainable, by pointing at their rapid growth and that their growth has resulted in a huge increase in passenger vehicle kilometres. This is contrary to the previous development trends in New York, where passenger transport growth has been taken by mass transit, not cars.

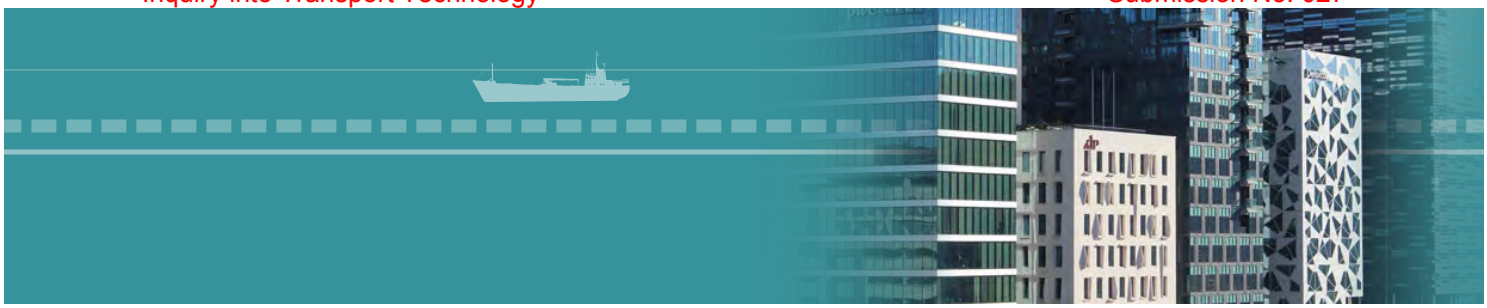
4.2.3 New regulatory challenges? And future regulations

As the previous section illustrates, taxi regulation has a long history, both as a real-life phenomenon and as an academic exercise. However, the changes that have occurred the last five to ten years have changed the context; the main difference is that pre-booking services now are provided by global players rather than players at the city level. Although the transport service offered is local, the provider or facilitator need no longer be so. This has clear implications for regulations, both in terms of at what level regulation is to be, the relative power of the regulator and the regulated, and along which dimensions it is necessary and convenient to regulate.

Darbéra (2017a) points at a matrix of regulation requirements. These are presented in table 4.2.

Table 4.2: Economic issues requiring regulation (Darbéra, 2017a).

	Driver	Vehicle	Commercial Transport Intermediary (CTI)
Safety	"Fit and proper" Overwork	Road worthiness Insurance	
Fair competition	Income tax evasion Social contributions (retirement, health)		Tax avoidance (Dutch sandwich) Natural monopoly
Externalities		Clean vehicle	Congestion
Privacy		On-board camera	Customer protection
Access	Training	Accessible vehicles	Quota or subsidies?
Mobility (night, low density, poor, elderly, etc.)			Subsidies
Planning			Data



In order to enforce this, Darbéra (2017a) suggests that the following information is collected by the relevant authorities:

- The pickup and drop-off date and time
- The driver's license number
- The vehicle license plate
- The pickup and drop-off location names (i.e. postal address)
- The pickup and drop-off longitudes and latitudes

This list is modelled on the information collected by the authorities in New York (from CTIs / ridesourcing actors) and the Netherlands (from taxi vehicles).

The driver[26]

The qualification requirements for the drivers are a very much debated and politically sensitive issue. One must be very careful to distinguish between what is useful for the riders' safety and what is more targeted to prevent new-comers to compete with the established markets.

According to Darbéra (2017) the London regulation could be considered as a benchmark for driver requirements. As stated in its General Guidance for licensed private hire vehicle[27] (PHV) drivers [TfL, 2011b], Transport for London (TfL) may refuse to grant a PHV driver's licence if the "applicant fails to satisfy TfL that: he is at least 21 years of age; he has held a full driving licence for at least 3 years, and; he is of good character and is fit to act as a PHV driver."

The criterion for "good character" is determined mainly on the applicant's conviction history (which is regarded as relevant to the application by the Licensing Authority) derived from the Enhanced Criminal Records Bureau report and other such reports, including police observations and entries made in his Driver and Vehicle Licensing Agency-issued driving licence.

In our opinion, it is important that this vetting should be carried out by government agencies with direct access to the Criminal Records Bureau reports, and not left to the PHV or CTI operators.

An important safety issue is how to prevent drivers from working too long hours. This cannot be left to CTIs since drivers may work for several CTIs during the same day. Here, the only workable solution is for the regulator to centralize all the data transmitted by the various CTIs of its jurisdiction and automatically check drivers' working time.

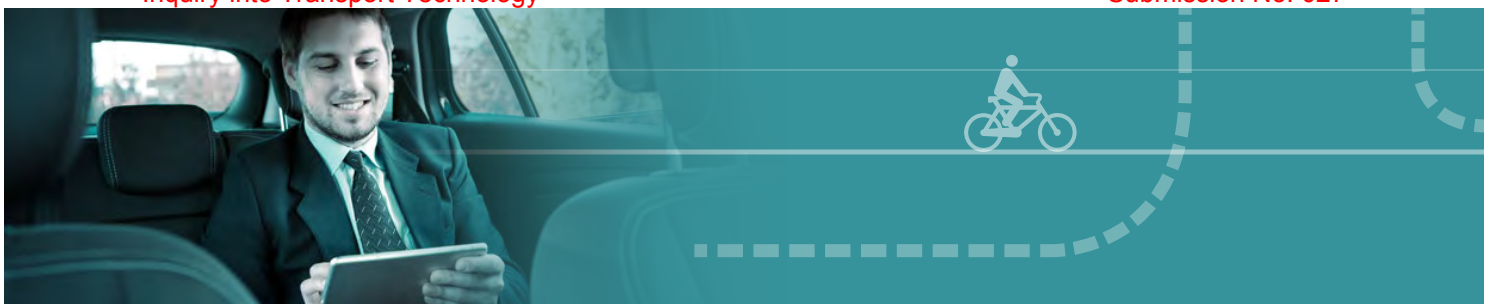
This data could also be used to check drivers' taxation compliance. This can be a very important feature of the regulation, especially in Europe where the welfare state is by and large financed by taxes on employment and on value added, and consequently, incentives for tax evasion and undeclared work are substantial.

The vehicle

The licensing authority must be satisfied that the vehicle is safe, and in a suitable mechanical condition. Any active or passive safety system designed to lessen the risk of injury or death in an accident, such as airbags, seatbelt tensioner etc., must be in good working order.

The vehicle must be inspected periodically to ensure that it conforms to regulations governing safety and emissions standards. Since these vehicles generally are in constant use, these inspections should be more frequent than the ones imposed on other vehicles, i.e. at least every year or even every 6 months. An issue here is to make sure the vehicle used is actually the one that is registered. Here, the Dutch on-board computer system is the most cost effective. Full data transmission from the CTIs is also helpful.

26 Adapted from Darbéra (2017)
27 i.e. UK equivalent to contract only taxi



The Commercial Transport Intermediary (CTI)

To ensure fair competition in the taxi market, it is important to prevent some CTIs from taking advantage of tax avoidance loopholes, such as the famous Dutch sandwich[28]. There is no easy solution to this problem, but one possible option is to raise a specific tax on rides. Another is for the tax system in general to change direction from taxing where the firm is registered to where the economic activity takes place. For this, again, full data transmission from the CTIs is necessary.

As Darbéra (2015) explained in the OECD-ITF discussion paper "Principles for the regulation of for-hire road passenger transportation services" the propensity for CTI to reach a natural monopoly position can be prevented by fixed quotas or by progressive taxation of market share. The first instrument is straightforward. It could however lead to a cartel where the incumbents could collude to prevent new contenders to enter the market. Progressive taxation of market share may be more flexible. But, both of these forms of regulation will be highly controversial.

Mexico City is an example of proportional (not progressive) market share taxation. The city, in July 2015, became the first Latin American city to regulate ride-hailing apps, introducing a 1.5 percent ride levy[29]. In New York City, to close a standoff with the municipality, Uber agreed that summer (2015) to discuss measures such as a surcharge on each fare to help fund the cash-strapped Metropolitan Transit Authority.

To prevent individual CTIs from getting a dominant position in the market, the progressive surcharge should reach punishing rates when the market share gets close to, say, 40 or 45 percent.

Congestion of urban streets caused by the rapid development of app-based taxi services is already a debated issue in cities like New York, London or Amsterdam. This is theoretically identified as an issue where a pre-book dispatcher with a monopoly operates with low fares (in particular if they are below operating costs) in Arnott (1996). Here is an opportunity to implement finely tuned congestion charges based on actual use of public road by time of the day. Here again, this requires full data transmission from the CTIs or installation of a devise which give correct road pricing, based upon GPS, directly in the vehicles (omitting the CTIs as an intermediary). A simplified version of this congestion pricing system is used in São Paulo.

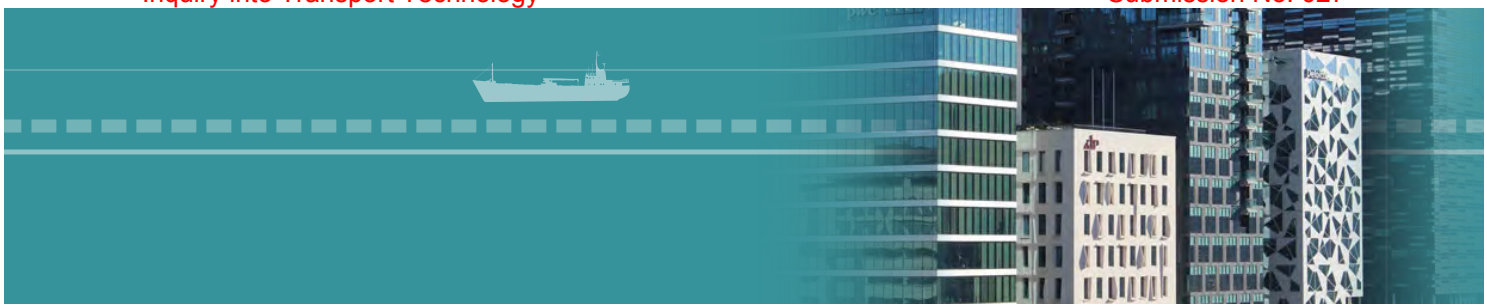
The jurisdiction border issue

Some of the issues above could be regulated at the metropolitan level or at the regional level. There is a problem however when rides cross jurisdiction borders, e.g. when a vehicle registered in one city brings a passenger in another city and takes advantage of the fact that his CTI's platform is present in both cities to pick up passengers in the second city where regulation might be less lenient. This can be prevented by specific signage on the vehicle or by requiring the CTI to transmit their data to a national regulator.

A key question here is the question of the relevant geographical size of the market. Using real data, Aarhaug and Skollerud (2013) calculated this distance to be 20 km in their study of spatial competition in Vestfold county in Norway. This will vary depending upon cost, infrastructure and prices, but will be relevant for calculating market shares.

28 The Dutch Sandwich is a tax avoidance strategies, used by some multinational corporations to lower their corporate tax liabilities. Famously using shell companies registered in the Netherlands to take advantages of the generous tax laws there, relating to the use of royalties.

29 At this date, Uber had 500,000 users and more than 10,000 drivers in Mexico City, with most using Uber X, i.e. the equivalent of Uberpop in Europe.



Is there a need to keep a regulation that is specific to the street taxi?

At a time when e-hailing is a common option for most riders, one could discuss the need to keep a regulatory distinction between street taxis and contract (pre-book) taxis. This distinction may be useful for customers with no smartphone or to avoid congestion at the taxi ranks at airports and train stations. However, other options are available that do not require separated regulations.

4.3 Travel modes

4.3.1 Background:

With increased focus on increasing the use of mass transit / scheduled public transport, there is the associated problem of handling the transport services not provided well by mass transit /scheduled public transport. This relates both to the "first-and-last-mile" problem and the issue of providing transport services to those who are not able to use ordinary public transport. That means to provide a service outside opening hours (at night) and outside the geographical coverage.

Shared taxis as the dominant mode

It can be demonstrated by model studies such as ITF (2016, 2017a,b), that shared modes, in particular shared taxis, have the potential to replace almost all other transport modes. Also, such a solution will reduce the number of vehicles required, compared with today's situation drastically and increase the average occupancy rate, and thereby reduce the CO2 emissions.

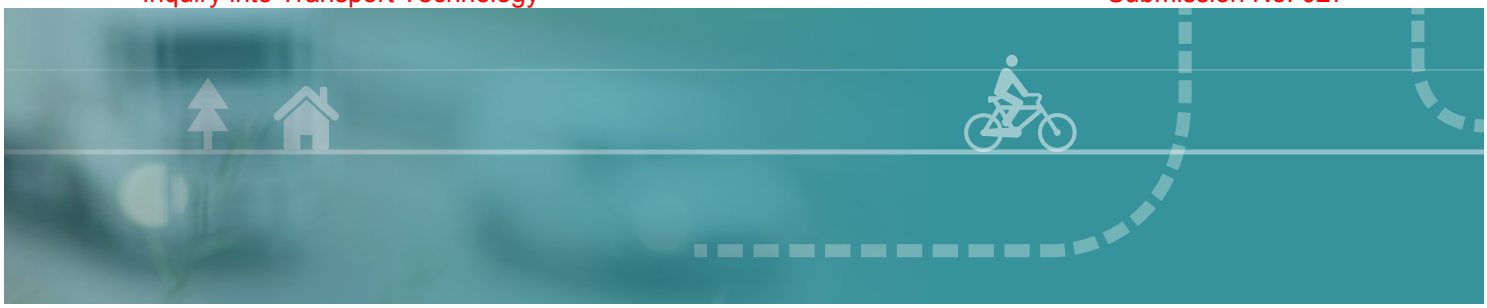
ITF's (2016) study looked at the possibility of replacing all motorised transport in Lisbon with shared services. In this model study the services that were to replace today's variety of largely private motorized transport, was a tri-modal system with shared taxis, taxi-busses and the existing metro. The model result was that today's level of mobility can be provided by using a vehicle fleet only 3 percent of today's fleet, with huge savings in terms of parking, congestion and emissions as a result. Similar studies are being currently conducted for other cities by the ITF.

Studies such as ITF (2016, 2017a,b) can often be dismissed as unrealistic, as the idea is very far from today's reality. However, that does not equate to irrelevant for discussing future mobility. This is in particular so when combined with focus groups that point in the direction of people actually being willing to give up their cars if their mobility is provided by such a system. The difference between the system presented by Petrik (2017), that is dominated by the shared taxi, and the existing system with many different modes filling different niches, is that it also gets around the "first-and-last-mile" problem by using door-to-door transport, although at the cost of a slight time penalty, induced by waiting time, compared with private cars. In the model scenario, this was not an issue, as this was compensated by the elimination of congestion. This may well be an issue in a situation where all existing modes are allowed to operate in parallel with the new shared taxi based system as was commented by several experts.

Taxis within a Mobility-as-a-Service (MaaS) concept

There are many different MaaS concepts that have been tried out in different parts of the world. Looking at the experiences so far from Gothenburg (UbiGo) and Helsinki (MaaS Global), a key change in behaviour that has been observed when people do away with their car, and replace them with a MaaS membership is that taxi usage increases, both as single mode, and in connection with other modes, such as by offering first-and-last mile service extensions to scheduled public transport.

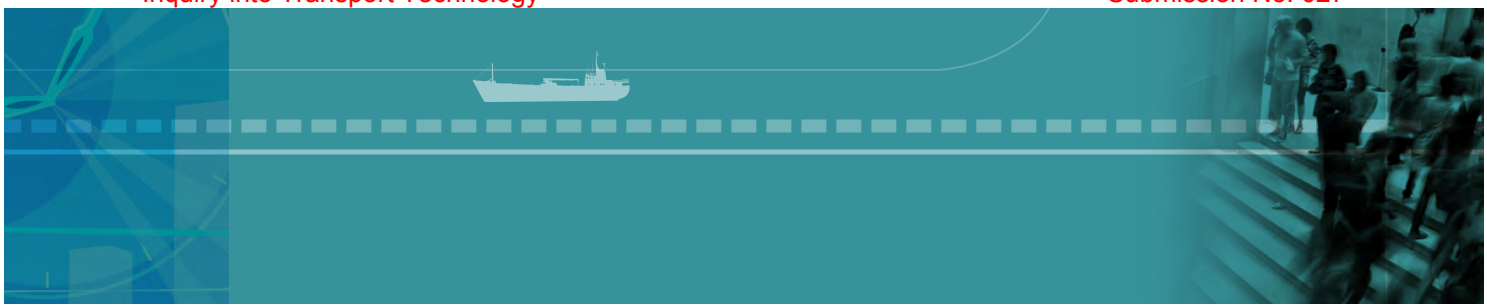
Concepts similar to MaaS is also being discussed and considered both by public transport authorities and by operating companies. The way these evolve will greatly influence the



opportunities for the taxi industry. If they focus on providing shared automatic vehicles as a part of the public transport network, the demand for taxis can possibly drop. If they focus more on integrating existing modes, that would most likely increase the demand for taxis. The question of who will take the lead in this development will probably have a significant influence on which role the taxi industry will assume.

4.3.2 The role of the taxi in the future transport network

A further key question is which role the taxi is to have in the future transport network. Here, the regulatory framework, business model, the initiatives coming from the industry and the definitions used will play critical roles. What is clear is that policy objectives such as increased city mobility and decreased private car ownership both can result in larger transport volumes for unscheduled door-to-door transport.



5 Discussion

This report presents some of the challenges facing the taxi industry in the coming years. These range from changes in technology for connecting drivers with passengers and possibly automated vehicles, to changing macroeconomic climate and increased urbanisation.

As illustrated by the scenario section there are many different opinions on which of these possible future developments will be dominant. Depending on how the future evolves, this gives the taxi industry different options on how to act. This section discusses the possible roles of the taxi in the different scenarios.

5.1 Taxis in urban transport

Taxis exist both in the urban and rural transport environments. In urban environments, mostly as a part of a larger transport system with many different modes. In rural areas, taxis may be the only publicly available motorised transport option. As taxis exist in very different locations and with many local variations, simple generalisations of the future development are bound to fall short. However, we still feel that some overall conclusions can be drawn.

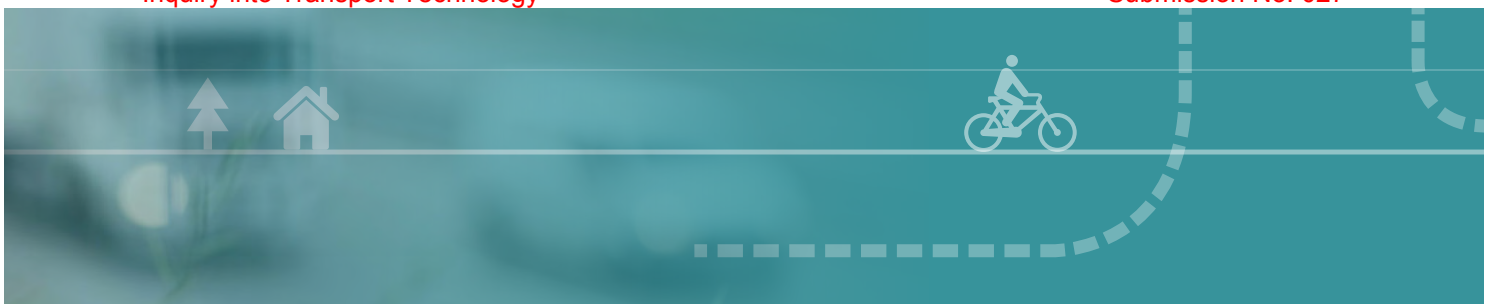
5.1.1 Taxis in an intermodal urban transport system

Within the urban transport system, taxis currently provide a niche service to the public. Taxis combe high flexibility with low cost for the authorities, with relatively low capacity and high user payment (table 5.1).

Table 5.1: Different roles of different modes in an urban setting.

	Capacity	Trip distance	Cost (authorities)	Flexibility
Heavy rail	high	5km+	very high	Low
Metro	high	1km+	very high	low
Light Rail	medium-high	1km+	high	low
BRT	medium-high	1km+	medium	medium
Busses	medium	500m+	medium	medium
Paratransit	low - medium	0+	low	high
Taxis	low	0+	non	high

Compared with other transport modes, taxis have low capacity. In terms of persons per direction per hour it is comparable to private cars. In actual traffic, the capacity utilization is worse, in that occupancy rates drop from an average of about 1,2 (passenger kilometers per vehicle kilometer) in private cars, to somewhere between 0,5 and 1 in taxis. Since much of the driving is done without a passenger on board. This is also true for various ridesourcing products, but not for ridesharing. As a consequence of being car based, taxis and similar services do not have the



necessary capacity to move the major transport flows within cities. Fore line-based shared minibus-taxis this is different.

However, taxis and paratransit can provide a door-to-door service. Conventional buses require suitable streets, and preferably bus stops, which increases the minimum trip distance. Both BRT, LRT and Metro require dedicated infrastructure, but with higher capacity. Heavy rail has even stricter requirements for infrastructure (figure 5.1).

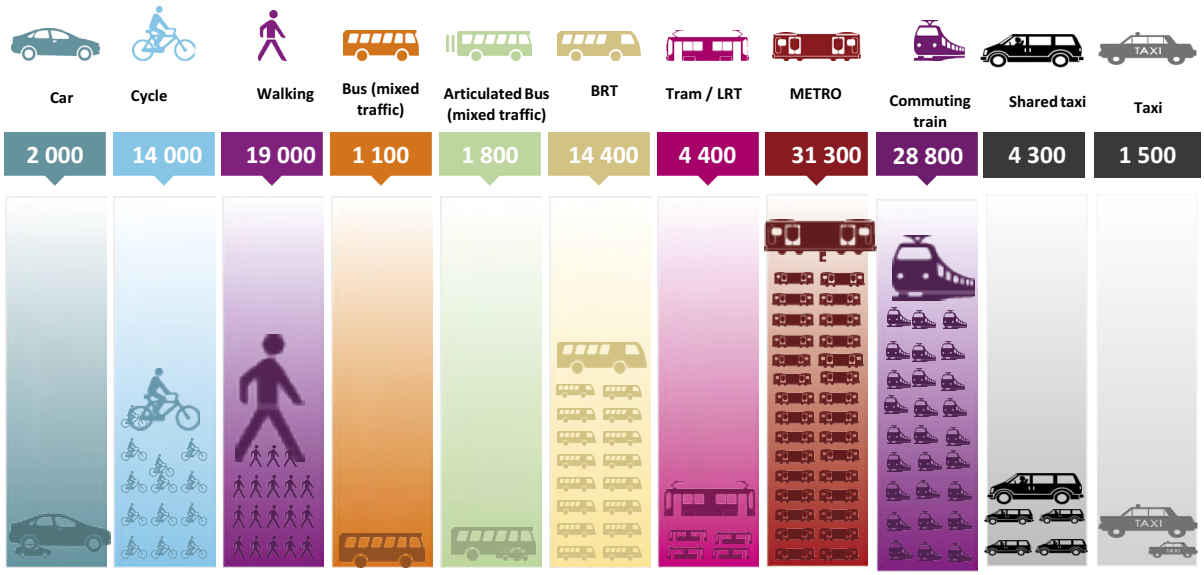
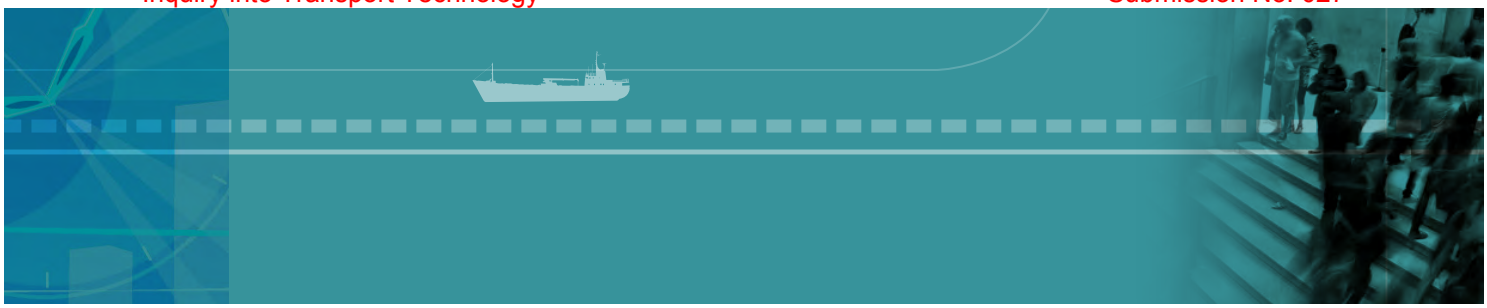


Figure 5.1: Capacity of different transport modes, in a northern European setting of, 2-lane roads.

The capacity of different transport modes is highly context dependent. Figure 5.1 uses a northern European setting[30] with a single lane in each direction. For buses, limited possibilities for overtaking at stops, and sections with road space shared with other lines as well as other traffic is assumed (resulting in 15 vehicles per hour per direction as a limit). The key difference between the bus and articulated bus, and BRT, is that the latter has dedicated infrastructure and the possibility to overtake at major stops. For LRT, there is a limit on length of vehicle (35 meters) and mixed traffic sections. Metro frequency is set at 32 trains per hour per direction, and commuting trains at 24. For cars, taxis and shared taxis it is assumed that pickups and drop offs can be made without disturbing the traffic flow and with a vehicle utilization rate of 0,9 for taxis; 1,2 for cars. For shared taxis, a capacity of 18 per vehicle is assumed and four vehicles per minute[31]. Buses are assumed operate at maximum efficient capacity with 70 persons per vehicle for unarticulated busses and 120 for articulated. Even with these limitations in place, line based scheduled modes have a much higher capacity than taxis, for the same road space. This points towards taxis, and taxi-like minibus services as not being able to provide a viable alternative for the major traffic flows in the foreseeable future.

30 However, it includes modes that are not present in Northern Europe, such as BRT and shared taxis

31 This is close to theoretic maximum capacity, but has empirical evidence from South Africa.



The main advantage of taxis over other modes is its flexibility and the time horizon between identifying a new demand and the implementation of a new service. For rail modes, this includes construction work. BRT will also require construction but can at least partially re-use existing infrastructure. Buses, can reschedule very quickly, provided there is spare capacity in the fleet. If it is not, there is usually a functioning market that allows capacity to be collected within days. For taxis and paratransit, new demand can be met within minutes, or hours if the paratransit is scheduled, subject to the condition that the passenger flows are within the capacity constraints of the taxi network. Taxis also have an advantage in being non-subsidized for most private travel. Other modes, such as buses and metros, usually require a form of subsidizing either for operation or infrastructure or both, to be a commercially viable option.

Compared with other modes, taxis provide high flexibility at the cost of low capacity. This high flexibility is however not only a blessing for the taxi industry, as it is linked with a similar vulnerability, coming from either regulatory, technological or organizational changes. This is made apparent by the arrival of numerous niche inventions wholly or partially having overlaps with the taxi industry.

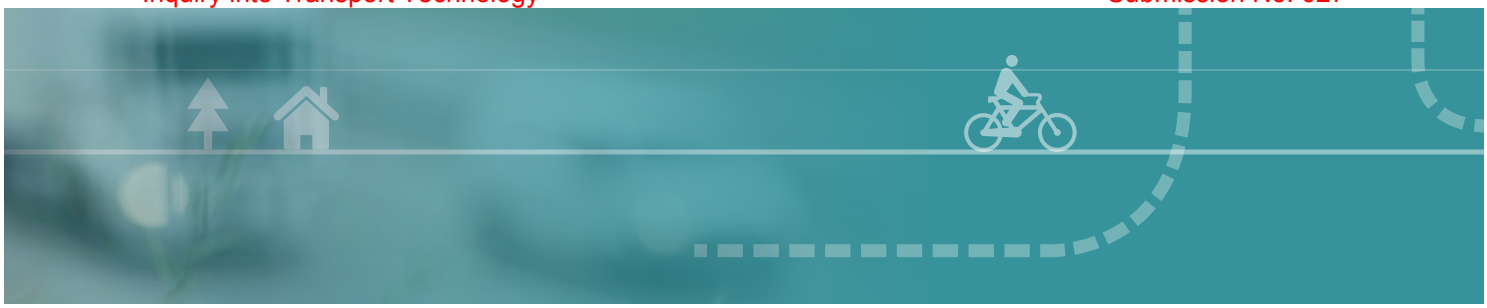
5.2 Taxis in different future scenarios

The business as usual scenario (1) was developed in section 2. This is used together with two alternative scenarios elaborated from the factor analysis of our survey, described in section 3; the conservative - car oriented scenario (2), and the technological innovation scenario (3). These scenarios illustrates that different developments have different implications for the role of the taxi, and the possibilities for the taxi industry looking towards 2030.

5.2.1 Taxis in the business as usual (BAU) scenario

The BAU scenario is driven by the developments that are observed in society today. In particular, that there is increased automatization of low and semi-skilled labour which together with reduced economic growth rates increase the economic inequality. Relating to the taxi markets, the major development is the introduction of new business models, resulting in a ridesourcing sector taking an increased part of the transport market. If this is included within the definition of the taxi, the taxi will increase its market share. If not it will lose. The major gain in market shares for ridesourcing companies is not from existing taxi operators, although that should not be dismissed. Equally or even more important is the newly generated traffic and market shares gained from mass transit.

Within the BAU scenario it is unclear whether or not the taxis will increase or decrease their market shares. On the one hand, it seems obvious that the street hailing and taxi stand market segments will lose out, to pre-booked services, irrespective of whether these services are offered within or outside the taxi industry. This points towards a shift in regulatory focus from the street market segments towards the pre-book segments. Also, as shown by Metz (2017), there is a challenge and opportunity posed by multi industrial ICT-actors, such as Alibaba, Google and Facebook with their consumer network and the development towards buying different services within the same portal. This is a challenge, in that these actors are increasingly entering into markets, including transport and taxi, traditionally served by other companies bringing their network of consumers with them. It is also an opportunity in that the ICT-actors are not going to provide the physical service in the transport market. They will want to remain intermediaries. That means that well-organized taxi operators can reach new markets through these actors. However, it also means



that it is difficult to continue without updating the business model to face these challenges. From the regulatory side this means that new challenges emerge in terms of maintaining a competitive market in the pre-book segments. It will be increasingly important to acknowledge that the main market actor, is not necessarily the driver in the vehicle.

5.2.2 Taxis in the conservative car oriented scenario

This is the most negative scenario extracted from the experts, both from a social, environmental and taxi point of view. However, it was the most dominant scenario given by the respondents in Sub-Saharan Africa. It also has several similarities with the business as usual scenario. Key elements in this conservative car oriented scenario is that there will not be a massive move away from private car ownership. Rather, a larger share of the growing urban population will own their own cars. Self-driving vehicles will not catch on, within the time horizon. The cost of using public transport modes, both mass transit and taxis, will increase. The problems associated with high levels of private car use, such as pollution and congestion will not be solved by technology; such as zero or low emission technology; nor by public policy. Housing prices in central areas will remain high or further increase, driving low-income groups out of central urban areas, increasing commuting by private cars.

Within this scenario, the demand for taxis and taxi services is falling. The main reason for this is that the relative cost differences between taxis and other modes will move further in favor of other modes. The cost of car ownership will decrease (relatively) and car use is not facing the full extent of the negative externalities it produces, where taxi use to a much larger extent faces this. The main group still using taxis will be more affluent people living in the city centers, much like the present-day situation in cities such as Paris, as described by Darbéra, (2017). The poor will increasingly get their own private cars, and use these for most of their transport needs. This points toward a larger market share for services that are more limousine like, and lower demand for cheaper and less luxurious services.

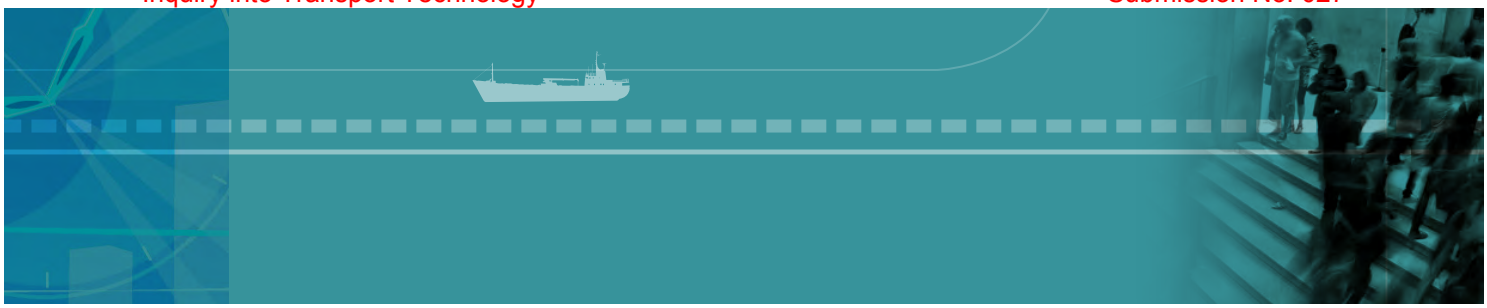
A hinging point for the role of taxis in this scenario is that there are few restrictions on private car ownership, and that owning and operating a private car continues to become cheaper. If this is not the case, taxis or taxi like services may end up reaching a wider demand, even with limited technological change. Increasing parts of the population, in particular within urban areas, will not own their own cars, and from this there will come an increased demand for mobility provided by taxis and similar services, including "budget" taxis. In other words, this will reduce total mobility at societal level, but increase the market shares of taxis and similar service, much as in the business as usual scenario. From a regulatory perspective, the challenges are like the BAU-scenario, but with the added issue of the street-market segments, as the street-market segments will continue to pose challenges for the regulator to address.

5.2.3 Taxis in the technology innovation scenario

Within this the technology innovation scenario there are many possibilities for several different chains of events, with different technologies taking front row.

Automated vehicles

There are many different forms of automated vehicles that can influence the taxi industry, and if they become large a market segments before 2030, this can happen in several ways. Both, with respect to ownership and usage. They can be owned by private individuals as an alternative to conventional private cars, but can also be part of different schemes of joint ownership, where the user pays for usage. The vehicles can take different forms, both as self-driving versions of



today's cars, but also as automated minibuses or buses. These options will have different consequences both for society and for the taxi industry.

A key question is whether persons will be more willing to share a vehicle if it is self-driving than they are for conventional cars. This is important as it is the main condition for making self-driving vehicles more efficient than conventional cars, in terms of passenger kilometers per vehicle kilometer, which is an indicator closely related to both environmental externalities and congestion. If people are willing to share vehicle space more, it is likely that automation will contribute to reducing urban congestion. However, if people continue as today, wanting to own their own vehicles, and have exclusive usage of these vehicles, congestion and emissions will be worse. The road network will in addition to having to cope with the present car traffic, also be required to handle a large number of empty vehicles. Also, looking towards 2030, there will still be many conventional cars on the roads, which will need to be considered. These will limit the possibilities for decreasing the distance between vehicles.

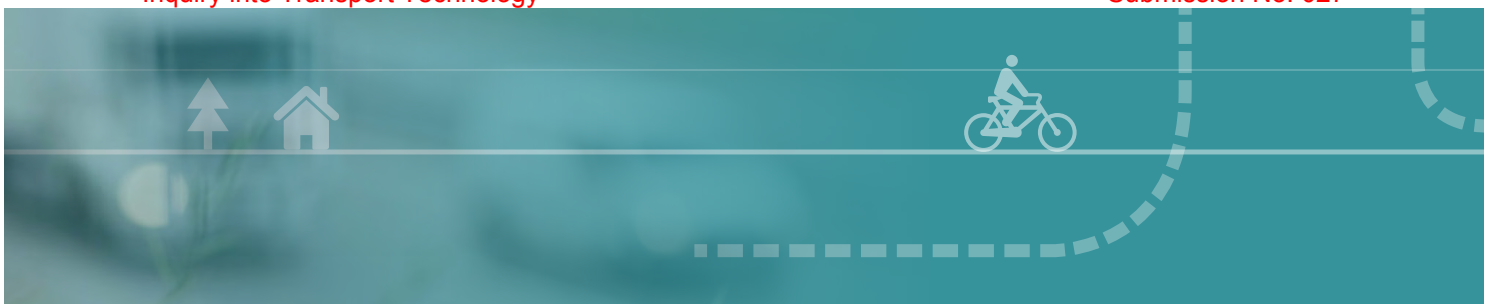
There are two ways in which automated vehicles can contribute to more demand for taxi services. First, if transport become less privatized the visible cost of taking a trip will be closer to the actual cost of taking that trip. This should increase the awareness of the cost of making one extra trip. Also in parallel an increased use of distance dependent tolls for all vehicles should increase awareness of marginal transportation costs from private car use. This will point in the direction of making these costs more like the costs as presented with the use of taxis. And this should increase the demand for taxis. This is because the perceived cost difference between private cars and taxis today is higher than the actual cost difference. People are under estimating the cost of using their private cars and overestimating the cost of using a taxi.

There are several regulatory issues related to automated vehicles. First, regulation will have a role in answering the major question of ownership. Joint ownership or fleet ownership can be promoted by regulation. Second, if fleet or pool ownership of automated vehicles become dominant, regulation will be crucial for how these fleets will be integrated into the wider transport system. Automated vehicles can be used to address first-and-last mile issues, with mass transit. But, automated vehicles can also be in direct competition to mass transit. Third, if private ownership of automated vehicles becomes dominant, this will probably create a market for temporal sharing of vehicle capacity, creating services similar to ridesourcing, without a driver. Fourth, regulation will be key, in drawing the line between taxi services, regardless of ownership, with or without a driver. Automated vehicles can both help alleviate social exclusion, and contribute to it, depending on how these aspects are addressed by regulation.

Mobility-as-a-Service

If Mobility-as-a-Service catches on, empirical evidence points toward increased demand for taxi services (Pyyhtiä, 2016). In the experiments with MaaS that have been conducted so far, doing away with the private car has been one of the major motivations for participating (Sochor, 2015). By replacing private car ownership, with a pay as you go, or a set of allowed quotas, for car use (rental car or taxi) in addition to using public transport as the main mode. In this setup, the demand for taxis will increase.

Also, MaaS type services for creating intermodal travel chains points toward increased use of taxis for the first and last mile. When taxis are no longer being paid separately, but instead are integrated as a part of a total package for door-to-door transport, the threshold for using taxi on the first and or last mile of a journey should drop. From the taxi side, this would result in more, but shorter trips.



From a regulatory perspective, MaaS poses a challenge in that it becomes an intermediary between the taxi and the customer. All MaaS-generated taxi trips will be a form of pre-book, with respect to economic properties. Also, if MaaS becomes a dominant mode it will create an entirely new market structure. The mobility provider / MaaS operator, will have a key function here, but there are many unknowns as to how this will influence the need for regulation.

Increasing green focus

Increased environmental awareness should result in more demand for taxi services. There are several factors or chains of event which would have this outcome. First, increased environmental awareness is likely to result in restrictions on the use of private cars, in particular within urban areas and in particular as long as private cars are predominantly fueled by fossil fuels. Increased restriction on private vehicles should result in increased use of shared modes, such as mass transit and taxis, as well as walking and cycling.

A second mechanism is that the taxi fleet has a higher turnover rate than the general set of vehicles, resulting in greater adoptability to change in vehicle standards. This should result in taxis to being 'greener' than the rest of the car fleet, giving taxis a competitive edge.

If taxis are to lead the way in greener urban mobility, this can materialize in several different ways, both from industry and from the regulatory authorities. Still, as long as more environmentally friendly technology is more expensive than conventional fuels, some form of regulation is needed. Either in the form of subsidies, for cleaner technology, or in the form of protection form competition from less clean vehicles, either by licensing or by geographical restrictions.

Different scenarios in different contexts

As shown in chapter 3, there are regional variations with respect to what is seen as a likely development. Elements from the conservative car-oriented scenario is seen as more likely by the respondents from developing countries. This may reflect a correct estimate of the future development in their setting, while not necessarily being at contrast with a BAU or technology and innovation scenario coming through in a developed world setting. Also, in particular related to automatic vehicles, there are diverging opinions on the likelihood of this becoming a full scale reality before 2030. A possible scenario in-between the BAU and technology and innovation scenario is that there will be regional or city level introduction of self-driving vehicles.

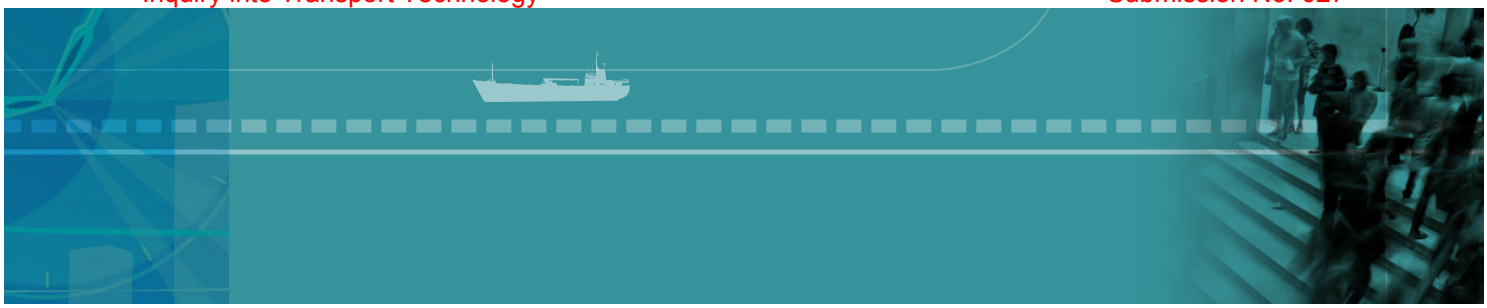
5.3 Policy measures

This section provides a set of possible policy measures that can be used to promote the taxi towards 2030.

5.3.1 Policy measures in the business as usual scenario

- Create an level playing field for unscheduled passenger transport.

This includes establishing a common legal and regulatory framework for unscheduled passenger transport, that satisfies the regulatory objectives in promoting passenger safety both with respect to criminal activities but also against predatory pricing; promoting traffic safety; providing necessary conditions for taxi companies to be able to act on changing market conditions; preventing monopolies and monopsonies, both at the local, regional, national and international level; providing secure working conditions for drivers.



- Promote green transport, vehicle restrictions on private cars, road taxes etc.

Reduced car dependency is linked with increased use of taxis and public transport services.

5.3.2 Policy measures in the conservative car oriented scenario

Policy restrictions towards private car use would increase the demand for taxis in this scenario mostly similar to these in the business as usual scenario. However, promoting restrictions on private car ownership would be more important here.

Promote green transport, vehicle restrictions on private cars, road taxes etc.

Anything that illustrates the actual cost of relying on private cars for transport would point in the direction of increased use of taxis. Policies / regulation related to emission standards and so on, will promote the use of taxis, as taxis in general use a newer car fleet, and is therefore better placed to take new technology into use, compared with private cars.

5.3.3 Policy measures in the technology innovation scenario

A key question is how to organize taxis as part of different transportation regimes. In the technology innovation scenario, taxis or similar services will have an increased, rather than decreased role in larger the transport system. The question is who should own and operate the vehicles, and who is going to play the key part of the value chain. This raises a series of organisational issues, where the taxi industry can have a significant influence on the new transportation regime.

Possible policy measures within this scenario are:

- Creating a set of regulations that facilitate Mobility-as-a-Service provision.

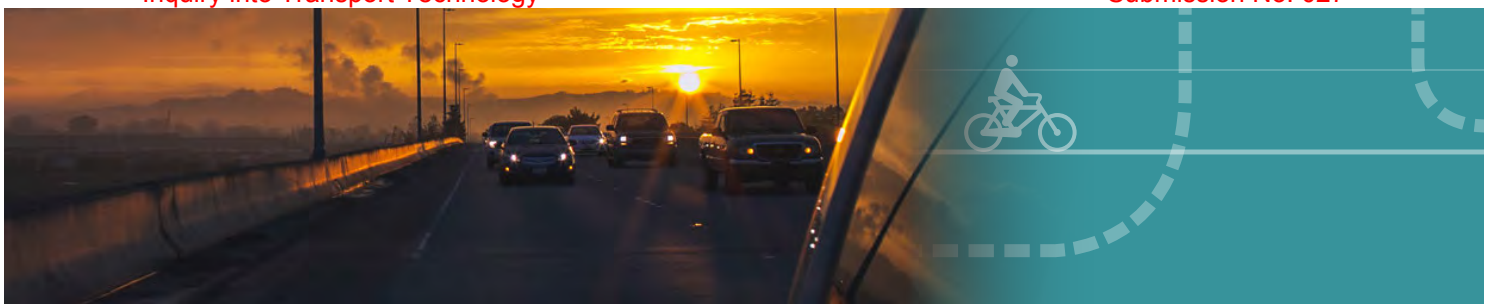
This is in order to give a predictable service that can function as a partner service with international platform companies.

- Create a set of regulation that promote automated vehicles in a way that allow the taxi industry to take advantage of these services.
- Safety, security and infrastructure.

Automation increases the role of the taxi driver, just like the freight driver the role is, changing from being a driver to becoming a system monitor and a service person. In a future where automated vehicles dominate, the service aspect offered by the taxi industry could be its unique selling point.

5.4 Summary discussion

The main weakness of the taxi industry lies in the fact that the taxi industry is facing a rapidly changing world, where its traditional business models are challenged from many different sides. This situation is not unique to the taxi industry, but it may be more severe due to the fact that the taxi industry is very flexible and therefore more exposed to both challenges from new market niches adjacent to the industry, such as ridesourcing services, but also to landscape level megatrends such as automatization and the platform economy. All of these factors are threats to the existing industry. Its flexible nature makes it dependent upon a suitable regulatory regime to preserve its existence. However, this is not the same as saying that there is a bleak future and that the challenges faced by the current transport regime will make the taxi superfluous in the future. There are also many opportunities provided by the same trends and niche developments that



threaten the industry. At landscape level both ICT developments and increased green focus point in the direction of increasing demand for taxi services. Taxi services can be offered over the same platform as scheduled public transport, reducing the "lock in effect" in modal choice. The main strength of the taxi industry is closely related to its main weakness, i.e. that it is flexible. Both the BAU and innovation scenario point in the direction of increased demand for services similar to the services provided by taxis today. The challenge for the taxi industry is in framing these developments in a way in which the industry becomes a part of the solution to the future transport demand, rather than a part of the problem with the existing system. This points in the direction of several key questions that the industry will have to come up with an answer to.

First-and-last mile or an independent travel chain

Which role does the taxi fill? and which should it fill? There are huge differences in the challenges the future may bring for the taxi industry. These depend on if the taxis becoming a part of an integrated multi-modal travel chain (many trips over short distances), versus becoming a separate mode of transport providing door-to-door services. These alternatives are different with respect to who the taxi service competes against. And they call for different regulatory instruments.

Vehicle fleet provider or intermediary with a fleet

Closely linked to the first-and-last mile versus independent travel chain question is the question of who are going to be the taxi industry's customers. Is it going to be businesses, for example ICT-companies, that it offers fleets of vehicles with drivers at a certain price to, or is it going to be the final consumer of the transport services? This require the taxi industry to also have a role in the "platform" segment. The difference is between being a (junior) partner with companies such as Google, or being in competition with these.

The answers to these questions have implications on the way it is suitable to frame the taxi industry, and on the way it should be regulated.

Glossary

Taxi. Taxis are an instantly recognisable form of transport, found in almost every city in the world. However, the role that taxis play varies from city to city – "taxi" does not refer to the same concept everywhere. In this document, the word "taxi" is taken to mean "unscheduled professional passenger transport with a small vehicle" i.e. vehicles that are smaller than buses or coaches and registered for a maximum of nine persons. This definition includes taxi-like services, not provided by licensed taxis. This is not the only definition of taxis, however. Each place typically has its own definition of what a taxi is – properties may vary slightly from country to country and in some cases from city to city. Various definitions have their pros and cons. For example, some definitions exclude the pre-booking market segments (as in the UK). One important starting point for understanding "the taxi market" is in recognising that taxis operate in different market segments and with different properties. We distinguish between four major market segments in the taxi industry: hail, taxi rank, pre-book and contract. The hail and taxi rank segments are unique to the industry, while the pre-book and contract segments overlap to some extent with non-taxi industries. The form and extent of the overlap depend on regulation.

For the "new" companies several terms have been used.

Transport Network Companies, (TNCs) , which is a term focusing on the network provided by the platform (the technology intensive part of the service provision).

Commercial Transport Intermediaries (CTIs), which is a term describing the same phenomena as TNC, but focusing of the characteristics of the companies, that they are both commercial and intermediaries. Which are elements that are not obvious from the TNC term.

Ridesharing, is a traditional term, focusing on the sharing aspect. In terms of companies such as Uber, Lyft and Haxi this is (mostly) a misleading term. But, the term may be appropriate for services such as BlaBlaCar and GoMore. Services where the driver sets the destination, and the other passengers in the vehicle share the ride (and split the cost). Ridesharing can be seen as a shared, but scheduled transport service, as the provision of this service is dependent upon the drivers transport need. Placing it closer to public transport modes, such as coaches, busses and trains, rather than typically unscheduled modes such as taxis.

Ridesourcing, is an alternative term to ridesharing, but without the suggestion that the service is shared. In other words, that the origin and destination of the trip are set by the passenger, and that the driver drives the trip at least in part motivated by money. This is a more appropriate term for services such as Uber, Lyft and Haxi, and MyTaxi, TaxiFix etc within the conventional taxi industry.

Hailing apps, is a term describing services that help passengers hail taxis by using smartphones rather than walking along the street.

Crowd-taxis, is a term which describes services that may be similar to the services described by ridesourcing, but focusing on the "crowdworking"-nature of the services. In other words, focusing on the transport services

provided by unprofessional drivers. UberPop would be a crowd-taxi, UberBlack not so.

Non-taxis, is a term used to describe services that look like taxi services but are provided by operators outside the regulated taxi industry, either companies actively marketing themselves as being something different from a taxi (such as Uber) or as a collective term for illegal taxi operations.

Sharing economy. The term is most commonly used for a range of apps/online platforms that match demanders and suppliers of objects (apartments, cars) and work. Yet, there is, so far, little consensus on how to define the term sharing economy. Researchers, authorities and intergovernmental organizations emphasize different traits and characteristics of the sharing economy when defining the term, and propose numerous alternatives describing the properties they are interested in. The sharing economy can be divided into labour and capital platforms; where the former is a platform where labour is placed at the disposal of others (examples: TaskRabbit[32], Upwork[33]), and the latter is a platform where an underutilized asset (such as a car, boat or an apartment) is put at the disposal of others (examples: Airbnb, Nabobil[34]). Services relevant for the taxi market might include both labour and capital (a car with a driver). Stefano (2016) makes a division between crowdwork «working activities that imply completing a series of tasks through online platforms» (p.1) and «work-on-demand via apps, jobs that are related to traditional activities such as transport, cleaning and running errands» (p.3). Kalleberg and Dunn (2016) argue that the sharing economy is not new, but what we observe is "a digital version of the offline atypical, casual, freelance, or contingent work arrangements characteristic of much of the economy prior to the middle of the 20th century" (p. 2).

Collaborative economy: is a term that is similar to the sharing economy, and to an extent used interchangeably. The exact distinction is debated. However, a distinction can be that the term collaborative economy is more process oriented, suggesting collaboration between peers (in other words a peer-to-peer service), while the sharing economy also include many company to peer services.

32 TaskRabbit is an online marketplace for buying and selling of services between individuals, such as walking the dog, washing the windows etc.

33 The world's largest online platform for intermediation of freelancers and assignments to freelancers, mostly office tasks.

34 Nabobil is an online marketplace where you can rent out or rent a private car (in Norway).

References

6t-bureau de recherche, 2015, "Uses, users and impacts of private hire services. Survey of users of the Uber application", 212p.

Aarhaug, J (2016). "Taxis as a Part of Public Transport", Sustainable Urban Transport Technical Document #16. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) http://sutp.org/files/contents/documents/resources/B_Technical-Documents/GIZ_SUTP_TD16_Taxi_EN.pdf

Aarhaug, J (2015). "Competitive tendering in an entry regulated market - an accident waiting to happen?", European Transport Research Review (166) vol 7 issue 2, DOI: 10.1007/s12544-015-0166-4. http://link.springer.com/article/10.1007%2Fs12544-015-0166-4#/page-1

Akkermans and Maerivoet, (2017). Identified megatrends, workingpaper dated 27/02/2017 (v1.0). Transport and mobility Leuven.

Anderson, D. N. (2014). "Not just a taxi"? For-profit ridesharing, driver strategies, and VMT. Transportation, 41(5), 1099-1117. doi 10.1007/s11116-014-9531-8.

Avelino, F. & Rotmans, J. 2009. Power in Transition: An Interdisciplinary Framework to Study Power in Relation to Structural Change. European Journal of Social Theory 2009 12, 543-569. doi: 10.1177/1368431009349830

Baker, R., Wagner, J., Miller, M., Pritchard, G. and Manser, M. (2016) Disruptive Technologies and Transportation. Final Report. Texas A&M Transportation Institute

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

Bekken, J T and Longva, F 2003. "Impact of Taxi Market Regulation, an international comparison", TØI report 658/2003. Institute of Transport Economics, Oslo.

Bower, J L and C M Christensen (1995). "Disruptive Technologies: Catching the Wave" Harvard Business review January-February 1995, 43-53.

Breheny, M. (1995) The compact city and transport energy consumption. Transactions of the Institute of British Geographers 20, 81-101.

Buckley, P. (1982) "The Deregulation of Urban Taxicab Markes: A Note", The American Economist, vol 26, issue 1, 1982.

Bustamante, F E (2016). "Information and Communication Technologies and Transportation", Chapter 5, in Schofer J.L. and H S Mahmassani (ed.) Mobility 2050 A Vision for Transportation Infrastructure, NWU. June 2016.

Cannon, S. and L. Summers, 2014. "How Uber and the Sharing Economy Can Win Over Regulators," Harvard Business Review, October 13, 2014,https://hbr.org/2014/10/how-uber-and-the-sharing-economy-can-win-over-regulators/

Cramer, J. and A. B. Krueger, (2016). "Disruptive Change in the Taxi Business: The Case of Uber," American Economic Review, vol 106(5), pages 177-182.

Cohen, M., & Sundararajan, A. (2015). Self-regulation and Innovation in the Peer-to-Peer Sharing Economy. The University of Chicago Law Review. 82 U Chi L Rev Dialogue 116, pp. 82- 116.

Cooper J, Mundy, R and Nelson, J 2010. "Taxi! Urban Economies and the Social and Transport Impacts of the Taxicab", Ashgate.

Clausen, S-E 2009. «Multivariate analysemetoder for samfunnsvitere». Oslo: Universitetsforlaget.

Darbéra R 2017a. "What regulation for the taxi of the future", draft paper presented at "Taxi of the future" meeting Brussels March 9, 2017.

Darbéra R 2017b. "Business-models for the taxi of the future", draft paper dated 24th April, 2017.

Darbéra R 2015. "Principles for the regulation of for-hire road transport passenger services", OECD.

Darbéra, R 2010. "Taxicab regulation and Urban Residents' use and perception of Taxi Services: A Survey in Eight Cities", Paper presented at 12th WCTR 2010, Lisbon Portugal.

Dargay, J., D. Gately and M. Sommer, 2007. "Vehicle Ownership and Income Growth, Worldwide: 1960-2030" Energy Journal, Vol 28, No. 4.

Delbosc, A., Currie, G., (2013) Causes of youth licensing decline: A synthesis of evidence. Transport Reviews, 33, 3, 271-290.

Dempsey, P 1996. „Taxi Industry Regulation, Deregulation & Reregulation", Transportation Law Journal 24:73 pp73-120. HeinOnline.

Dillen, J. (2005) Äldre personers resvanor och aktiviteter. Resultat från undersökningar med personer i alderen 65 år och äldre, Transek AB. Stockholm.

EEA, (2011) Urban environment. European Environment Agency Outlook.

Enoch, M P 2015. "How a rapid modal convergence into a universal automated taxi service could be the future for local passenger transport", Technology Analysis and Strategic Management 27:8, 910.924. DOI: 10.1080/09537325.2015.1024646

ERTRAC (2017). Automated Driving Roadmap. Brussel: European Road Transport Research Advisory Council.

EU Commission, 2016. A European agenda for the collaborative economy. Communication from the commission to the European Parliament, the council, the European Economic and Social Committee and the Committee of the regions. Brussels, 2.6.2016. COM(2016) 356 final

Eskeland, G S. (2012:): "Electrification of transport: Which emissions are ours? 2012. Economist (Samfunnsøkonomen, Norwegian, Oktober).

Figenbaum E og M Kolbenstvedt 2015. Pathways to electromobility – perspectives based on Norwegian experiences. TØI-rapport 1420/2015.

Forward, S., Aretun, Å., Engström, I., Nolén, S., Börjesson, J. (2010) Ungdomars inställning till att ta körkort 2002-2009. VTI rapport 694/2010. Linköping: VTI.

Frändberg, L., Vilhelmson, B. (2011). More or less travel: personal mobility trends in the Swedish population focusing gender and cohort. Journal of Transport Geography, 19, 1235-1244.

Fritz, C. (2014). Mobility-as-a-service: Turning transportation into a software industry. Retrieved from http://venturebeat.com/2014/12/13/mobility-as-a-service-turning-transportation-into-a-software-industry/

Geels, F. W. 2010. Ontologies, socio-technical transitions (to sustainability), and the multi-level perspective. Research Policy 39,

Geels, F. W. (2012). A socio-Technical analysis of low-carbon transitions: Introducing the multi-level perspective into transport studies, Journal of Transport Geography24 (2012) 471-482.

Gilbert G and Samuels, R E 1982. „The Taxicab An Urban Transportation Survivor", University of North Carolina Press.

Golob, T. F. and Hensher, D. A. (2007) 'The trip chaining activity of Sidney residents: A cross-section assessment by age group with a focus on seniors', Journal of Transport Geography, 15, pp. 298-312.

Goodwin, (2012) "Peak travel, peak car and the future of mobility: evidence, unresolved issues, policy implications, and a research agenda" Discussion Paper no. 2012–13. Prepared for the Roundtable on Long-Run Trends in Travel Demand, International Transport Forum (2012)

Grimal, R., Collet, R. & Madre, J. L. (2013). "Is the stagnation of individual car travel a general phenomenon in France? A time-series analysis by zone of residence and standard of living". Transport Reviews, 33(3), 291-309.

Hagson, A. (2003) Trafiktålighet: kunskaps- och metidutvikling för at garantera den avsedda miljöns kvalitet på och kring gator i detaljplan. Förstudie: Begreppet trafiktålighet. Chalmers teckniska högskola, Arkitektursektionen, Tema stad & rafik. Göteborg.

Hakamies-Blomqvist, L., Henriksson, P. Anund, A., og G. Sörensen (2005) Fyrtiotalisterna som framtida äldre trafikanter. VTI rapport 507. Linköping: VTI.

Harding S, M Kandlikar and S Gulati (2016). "Taxi apps, regulation, and the market for taxi journeys", Transportation Research Part A, 88 (2016) 15-25.

Hickman, R., Saxena, S., Banister, D., Ashiru O. (2012) Examining transport futures with scenario analysis and MCA, Transportation Research Part A, 46, 560–575

Hjorthol, R. (2012) Endring i befolkningens reisevaner i en 25-årsperiode – trender og drivkrefter. TØI-rapport 1190/2012. Oslo: Transportøkonomisk institutt.

Hjorthol, R. (2004) Kan utviklingen i mobilitet og reisevaner fortelle noe om likestilling? Kvinner, køn og forskning, vol 13, no 1, s 18-30.

Hjorthol, R. (1999) Daglige reiser på 90-tallet. Analyser av de norske reisevaneundersøkelsene fra 1991/92 og 1998/98. TØI-rapport 436/1999. Oslo: Transportøkonomisk institutt.

Hjorthol, R. and Sagberg, F. (2000). 'Introductory report: Norway', in S. Rosenbloom (red.). Transport and aging of the population, Economic Research Centre, Paris.

Hållén C and J Östlund (2016). 'Nya tjänster för delad mobilitet' Rapport 2016:15. Trafikanalys.

ITF/OECD (2015). 'International Experiences on Public Transport Provision in Rural Areas' OECD.

ITF (2016), „Shared mobility: innovation for liveable cities", International Transport Forum Policy Papers, No 21, OECD Publishing, Paris,https://doi.org/10.1787/24108871.

ITF (2017a), „Transition to Shared Mobility: How large cities can deliver inclusive transport services", International Transport Forum Policy Papers, No 33, OECD Publishing, Paris, https://doi.org/10.1787/b1d47e43-en.

ITF (2017b),"Shared mobility Simulations for Helsinki" International Transport Forum Policy Papers, No 39, OECD Publishing, Paris

Kalleberg, A. L. & Dunn, M. (2016). Good Jobs, Bad Jobs in the Gig Economy. The University of North Carolina at Chapel Hill.

Kasarda, J D, Appold, S J, Sweeney, S H, Sieff, E (1997) Central-city and suburban migration patterns: Is a turnaround in the horizon? Housing policy debate, vol 8, no 2, 1997, 307-358

Kern, F. 2012. Using the multi-level perspective on socio-technical transitions to assess innovation policy. Technological Forecasting & Social Change 79,298–310.

Krantz, L. G.(1999) Rörlighetens mångfald och förändring. Befolkningens dagliga resande i Sverige 1978 og 1996 Göteborg: Handelshögskolan vid Göteborgs Universitet.

Kuhnimhof, T., Armoogum, J., Buehler, R., Dargay, J., Denstadli, J. M., Yamamoto, T. (2012) Men shape a downward trend in car use among young adults – ecidence from six industrialized countries. Transport Reviews, 32, 6, 761-779.Moss, M L. (1997) Reinventing the central city as a place to live and work. Housing policy debate, 8, 2, 471-490

Kuhnimhof, T., Zumkeller, D., Chlond, B. (2013) Who made peak car and how? A breakdown of trends over four decades in four countries. Transport Reviews, 33, 3, 325-342.

Kuznetsov, A 2015. "Critiques and Justifications of Urban Mobilities: Marshrutkas as a Matter of Social Justice", Paper presented at the T2M annual conference Caserta, Italy.

Le Vine, S., Polak, J (2014) Factors associated with young adults delaying and forgoing driving licenses: Result from Britain. Traffic Injury Prevention, 15, 974-800.

Leiren M D and K Skollerud (2016). DRT and Citizen Experiences in Rural Norway, in Mulley C and J D Nelson. Paratransit Shaping the Flexible Transport Future. Transport and Sustainability volume 8.

Magelund, L. (2001) Eldres Automobilitet. Transportrådets nyhetsbrev nr. 4. 2001, Copenhagen.

Millard-Ball and Schipper, (2011) "Are we reaching peak travel? Trends in passenger transport in eight industrialized countries" Transp. Rev., 31 (3) (2011), pp. 357–378.

McKerracher C et al. (2016). "AN INTEGRATED PERSPECTIVE ON THE FUTURE OF MOBILITY". Bloomberg – McKinsey, 2016.

Metz, D (2010). "Saturation of Demand for Daily Travel" Transport Reviews vol 30,5, pp 659-674.

Metz, S (2017). "Impact of technological change on future business models in taxi industry". Presentation at the meeting "Taxi of the future", march 9.2017, Brussels.

Miller, J and V Franco (2016). Impact of improved regulation of real-world NOx emissions from diesel passenger cars in the EU, 2015-2030. ICCT-whitepaper, December 2016.

Mulley, C and J Nelson (2009). Flexible transport services: A new market opportunity for public transport. Research in Transportation Economics, 34(1),54-65.

Mundy, R / TTLF 2010. "Saskatoon Taxi Study". TTLF consulting. URL: http://www.taxi-library.org/saskatoon_taxi_study_2010.pdf

Newman, P. W. G., J.R. Kenworthy (1989) Cities and Automobile Dependence. Aldershot: Gower Publications.

Noble, B (2005) Why are some young people choosing not to drive? Department of Transport, London UK.

Nordbakke, S, F Sagberg and F A Gregersen (2016). "Slutt på lidenskapen: Endringer i førerkortandel og bilbruk blant ungdom», TØI-report 1477/2016.

Nurhadi, L S Borén, H Ny and T Larsson (2017). "Competitiveness and sustainability effects of cars and their business models in Swedish small town regions". Journal of Cleaner Production, 340, 333-348.

Næss, P. (2006) Urban Structure Matters. Residential Location, Car Dependency and Travel Behaviour. London/ New York: Routledge.

Oxley, P. (2000) Introductory report: Great Britain in S. Rosenbloom (ed.). Transport and aging of the population. Paris: Economic Research Centre

Petrik, O. (2017) Urban Mobility: How fleets of shared vehicles could change our cities. Presentation at 2nd taxi of the future meeting. Brussels 09.04.2017.

Puentes, (2012) "Have Americans hit peak travel? A discussion of the changes in US driving habits" Discussion Paper no. 2012–14. Prepared for the Roundtable on Long-Run Trends in Travel Demand, International Transport Forum. OECD (2012)

Pyyhtiä, Kaj, (2016). "MaaS" presentation, Helsinki 29th November 2016.

Rayle L, D Dai, N Chan, R Cervero and S Shaheen (2016) "Just a better taxi? A survey-based comparison of taxis, transit, and ride-sourcing services in San Francisco" Transport Policy 45 168-178.

Rip, A., Kemp, R., 1998. Technological change. In Rayner, S., Malone, E. (Eds.), Human Choice and Climate Change, Vol. 2, Resources and technology (pp. 327–399), Columbus, Ohio: Battelle Press.

Rolandsson, B (2016) "The Sharing Economy in Sweden". Paper presented at "Delingsøkonomien møter den nordiske modellen" Fafo 27th September 2016.

Rogers, Everett. (1962, 2003) "Diffusion of Innovations", 5th Edition. Simon and Schuster. ISBN 978-0-7432-5823-4

Rosenbloom, S. (2001) 'Sustainability and automobility among the elderly: An international assessment', Transportation 28, pp. 375-408.

Salanova, J M, M Estrada, G Aifadopoulou, E Mitsakis (2011)."A review of the modelling of taxi services", Procedia Social and Behavioural Sciences 20 (2011) 150-161.

Schaller, B. (2017) "Unsustainable? The Growth of App-Based Ride Services and Traffic, Travel, and the Future of New York City", Schaller Consulting (2017).

Sochor, J, H Strömberg and I C M Karlsson (2015). "Implementing Mobility as a Service; Challenges in Integrating user, Commercial and Societal Perspectives" Transportation Research Record: Journal of the Transportation Research Board, No. 2536, Transportation Research Board, Washington, D.C., 2015, pp. 1–9. DOI: 10.3141/2536-01

Stefano, V.D. (2016). 'The Rise of the "just-in-time workforce": On-demand work, crowdwork and labour protection in the "gig-economy"' in ILO (ed.) Conditions of work and employment series Geneva.

Stucke M E and A Ezrachi (2015). "Atrificial Intelligence & Collusion: When Computers Inhibit Competition" Legal Studies Research Paper Series, Research paper #267, may 2015. The University of Tennessee, Knoxville, college of law.

SUMC (2016). "Shared Mobility and the Transformation of Public Transit", SUMC, March, 2016.

Sundararajan, A. (2016). The Sharing Economy. The end of employment and the rise of crowd-based capitalism. Cambridge, MA. The MIT Press. ISBN 9780262034579.

TML IRU (2017). "Commercial Vehicle of the Future A roadmap towards fully sustainable truck operations". Report January 2017.

Vuchic, V. R. 2007. Urban Transit: Systems and Technology. Englewood, NJ: Wiley. Wallsten, S. (2015). The competitive effects of the sharing economy: how is Uber changing taxis? Technology Policy Institute, Washington DC, June 2015.

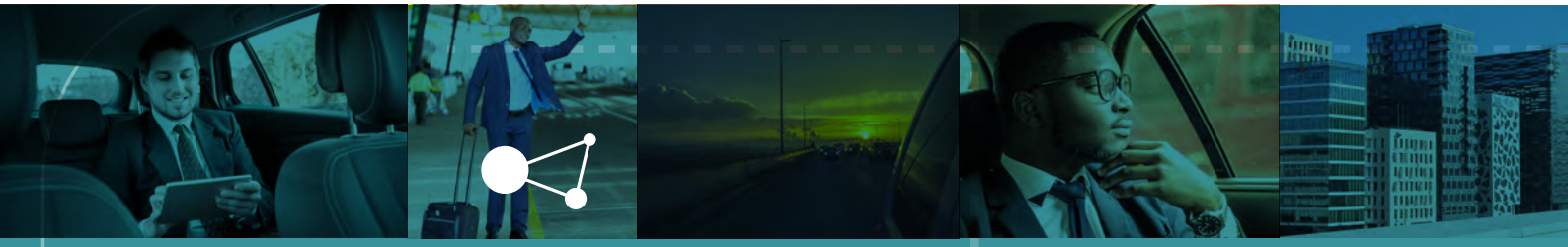
Waard J.v.d.. Jorritsma, B. Immers, (2013). «New drivers in mobility; what moves the Duch in 2012?» Transp. Rev., 33 (3) (2013), pp. 343–359.

Wangsness, P B, H B Sundfør and P Christiansen (2015). "Slipp rattet frigjør tid" Samfersel 2015, 54(2) 14:15.

Weber C and A H Amundsen (2016) Utslipp fra kjøretøy med Euro6/VI-teknologi, TØI-rapport 1506/2016.

Whitmarsh, L. 2012. How useful is the Multi-Level Perspective for transport and sustainability research? Journal of Transport Geography 24 (2012) 483-487. 10.1016/j.jtrangeo.2012.01.022

Wretstrand A, Svensson H, Fristedt S, Falkmer T. (2009). Older people and local public transit: mobility effects of accessibility improvements in Sweden. Journal of Transport Land Use. 2009;2(2):49–65.



www.toi.no

På vår hjemmeside kan du finne mer informasjon om TØI (forskningsområder, ansatte, e-post adresser, nye rapporter, rapportsammendrag).

Institute of Transport Economics
Gaustadalleen 21
NO-0349 Oslo, Norway
Phone +47 22 57 38 00
E-mail: toi@toi.no
www.toi.no

@TOIforsk