GECKO
GOVERNANCE FOR NEW MOBILITY SOLUTIONS

Investigation of main economic, political and social variables

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LIST OF ACRONYMS

C-ITS – Cooperative Intelligent Transport Systems
CCAM – Cooperative, Connected and Automated Mobility
GECKO – Governance principles and mEthods enabling deCision maKers to manage and regulate the changing mObility systems (project)
ICE – internal combustion engine
ICT – Information and Communication Technologies
MaaS – Mobility as a Service
TM 2.0 – Traffic Management 2.0
TMS – Traffic Management System
TNC – Transportation Network Company
UAS – Unmanned Aerial System
UTM – Unmanned Traffic Management

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EXECUTIVE SUMMARY

This report is a deliverable in GECKO project (Governance principles and mEthods enabling deCision maKers to manage and regulate the changing mObility systems) which aims to support authorities with tools and recommendations for new regulatory frameworks required for the transition to the sustainable and interconnected mobility across all modes. To achieve this, it is necessary to understand what are the main disruptive mobility innovations that are to appear in the future and what are the challenges in their implementation that need to be tackled through more holistic and adaptive governance.

Regulating transport goes after several objectives such as safety, for the passengers of the vehicle, for the driver and for the other users, social welfare, and social inclusion. Socio-economic objectives are to ensure fair competition between the various providers of transport services, privacy, accessibility, etc. Then comes mitigating the externalities produced by transport such as pollution and congestions. The report provides an overview and analysis of various economic, political and social variables influencing policies and governance of mobility sector, evidencing barriers and challenges when introducing emerging technologies.

Based on secondary data and research done within GECKO project, 22 such variables were identified and classified in six broader categories: 1) business ecosystem; 2) data management; 3) existing governance structure; 4) environmental impact; 5) social aspects; and 6) customer protection and public safety. The multitude of different aspects need to be governed in order to ensure that the proliferation of disruptive mobility solutions is beneficial for a local or global mobility systems, and that it does not put at risk the safety, security and well-being of the society. The role of governing bodies in such case is to, first, assess the potential of a new mobility solution to solve transportation problems and create benefits for the society. Second, it is necessary to identify what support is required in order to implement the solution successfully and realize the expected benefits. Third, potential negative impacts of a new mobility solution should be assessed and mitigated through various governance instruments.

The final part of the report summarises what is the relevance of each of the identified variables for the different categories of mobility innovations: 1) cooperative, connected and automated mobility; 2) infrastructure, network and traffic management; 3) mobility as a service and platforms; and 4) shared on-demand mobility. The analysis of 22 variables identified in this research provides an overview of which areas might require intervention if a proactive, holistic and adaptive governance model is applied.

Finally, the report outlines the capabilities required from governors and policy makers in order to address various economic, social and political variables influencing successful implementation of disruptive mobility solutions. The capabilities include: 1) institutional power; 2) cross-sector

coordination; 3) data management; 4) technical competences e.g. in relation to autonomous mobility; 5) pro-activeness and experimentation; and 6) innovation.

1. INTRODUCTION

The rapid proliferation of new technologies and disruptive innovations are taking the world by storm, threatening well-established players across many sectors. Technological and business model innovations in mobility sector include autonomous vehicles, shared mobility, Mobility as a Service (MaaS), network and traffic management, and urban air mobility among others. The EC envisages transport systems, which are fully integrated into efficient logistics chains and mobility services for passengers. Embracing digitalisation, emerging technologies and business models could help to achieve benefits to citizens, companies and the environment in rural and urban areas.

While technology and innovation provide an opportunity to turn dysfunctional EU mobility systems into integrated and seamless ones, they could accentuate global challenges rather than solve them, if not managed correctly. Strong integration of these new services could result in a hyper-efficient scenario of future mobility contributing to reducing pollution and energy use, increasing safety, providing resilient services and increasing social inclusion. However, mismanagement and individualisation of services could plunge the sector into chaos.

Regulators and decision-makers at different levels of government seem overwhelmed by the challenge, acknowledging that existing frameworks may be inadequate in terms of protecting society, fostering business development and achieving integrated, accessible and sustainable mobility. Regulating transport goes after several objectives such as safety, for the passengers of the vehicle, for the driver and for the other users, social welfare, and social inclusion. Socio-economic objectives are to ensure fair competition between the various providers of transport services, fair employment conditions, privacy, accessibility, etc. Then comes mitigating the externalities produced by transport, e.g. local and global pollution, noise, and congestion.

This report is a deliverable in GECKO project (Governance principles and mEthods enabling deCision maKers to manage and regulate the changing mObility systems) which aims to support authorities with tools and recommendations for new regulatory frameworks to lead the transition to the new mobility era of cooperative, inclusive, competitive, sustainable and interconnected mobility across all modes, through evidence-based research.

The report provides an overview and analysis of various economic, political and social variables influencing policies and governance of mobility sector, evidencing barriers when introducing emerging technologies. Such analysis is expected to help develop impact-driven institutional and regulatory frameworks to achieve better balance between private and public responsibilities, cooperation and actions for better regulation and resilient governance.

The document is structured as follows:

- Section 2 describes the methodology behind the analysis presented in this report.

- Section 3 provides a brief presentation of disruptive mobility solutions discussed throughout the document.
- Sections 4 and 5 presents the analysis of identified 22 social, economic and political variables categorized in six groups. The description of variables is supplemented with concrete examples of their impact on successful implementation of disruptive mobility solutions. Implications for regulators and decision makers are outlined for each variable category.
- Section 6 discusses the implications for policy-making and governance, including the need for intervention and new capabilities.

2. METHODOLOGY

Policies, regulation and other forms of public governance in mobility sector aims to facilitate safe, reliable and sustainable transportation for people. This requires finding the balance between accessible and convenient mobility, mitigation of its externalities, and facilitation of ‘smart’ mobility innovations. Moreover, mobility sector cannot be seen in isolation from the more complex needs of society as a whole. That is why the effect of mobility on public health, economy, safety, etc. needs to be considered. Yet another challenge relates to the fact that transition of mobility sector is driven by technology sector (vehicles, software, sensors, etc.), which is interested in selling, and thereby creating the market for more mobility in order to maximise the returns, rather than being guided by the societal needs[1].

This creates a complex system of variables that have to be considered when developing governance frameworks for disruptive mobility solutions, which would be inclusive and holistic in order to maximise the benefit of those solutions for the society. The aim of this research has been to identify and categorise such variables and provide recommendations for addressing those variables in governance.

In order to avoid being limited by existing classifications and miss an important emerging issue, a bottom-up approach has been chosen to gather all *relevant* variables that affect governance of disruptive mobility solutions. For that, a desktop study was conducted based on research within GECKO project and secondary information such as industry reports, policy reviews, scientific articles and web articles related to the challenges that the implementation of disruptive mobility solutions have faced or are expected to face. This included both the undesired effects of new mobility solutions on society and the challenges in implementing the solutions, where governance interventions would be needed.

The discovered instances were then classified in 22 variables and six wider categories presented further in Section 4. The classification went through peer review process within the project and was also triangulated with the existing literature about different variables connected to mobility innovations. Finally, the developed classification was verified at a workshop with stakeholders. Workshop participants included around 25 representatives from public and private sector, as well as different research organizations and other actors related to mobility. Based on the results of the workshop a new variable has been added to the list. Otherwise, the proposed variables and categorisation proved to be relevant.

[1] Docherty et al., 2018. The governance of smart mobility

3. OVERVIEW OF DISRUPTIVE MOBILITY SOLUTIONS

This deliverable focuses on social, economic and political variables affecting successful implementation of disruptive[2] mobility solutions. Given the proliferation of digitalization and data-driven models, the research concerns the following three thematic areas:

- technologies
- business models
- data utilisation

The development of new products and services in mobility sector often stem from these areas. For example, the autonomous vehicles are enabled by emerging technologies (sensors, machine vision, etc.), mobility as a service and shared-on-demand mobility are facilitated by innovative business models based on shared economy principles, and network management and optimisation innovations rely on big data analysis. Figure 1 presents the three thematic areas. It has to be noted that most of disruptive mobility innovations rely on several of these innovation areas. For example, drone delivery relies on business innovation, technological innovations and big data analysis.

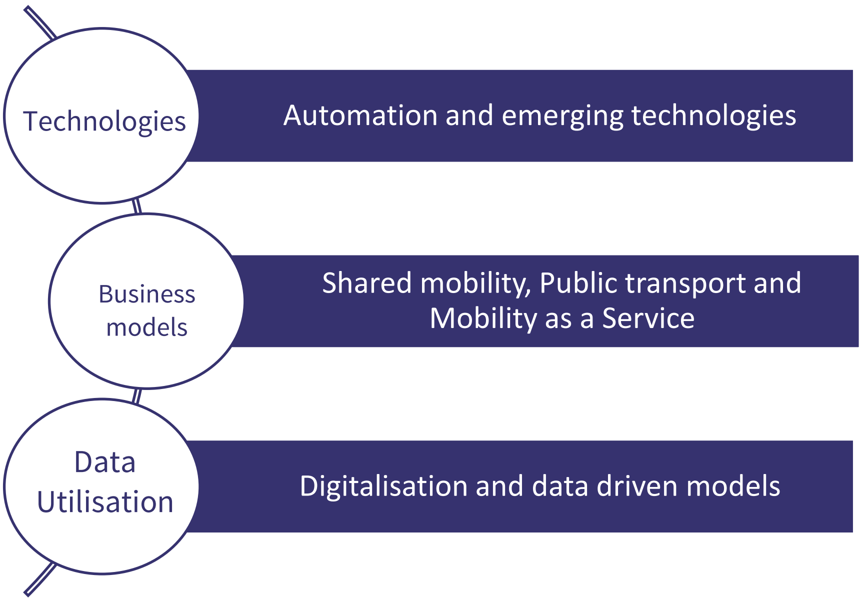

Figure 1: Three thematic areas in GECKO project[3]

[2] Christensen Institute has noted that disruptive innovations involve three elements: the enabling technologies, innovative business models, and coherent value network. See GECKO deliverable D1.1 for further information

[3] Adopted from GECKO deliverable D1.1 'Review of new mobility services and technologies and set-up of knowledge bank'

The project and this deliverable further categorise transport innovations that are most disruptive in today's mobility sector:

- cooperative, connected, and automated mobility (CCAM)
- infrastructure, network, and traffic management
- MaaS and MaaS platform
- shared on-demand mobility

Each innovation category is driven by all three thematic areas to a certain extent. Table 1 shows what is the relevance of the three thematic areas to each mobility innovation category. The innovation categories are described further in more detail.

Table 1: Four innovation categories and their relevance to thematic areas[4]

	Technologies	Business Models	Data Utilisation
CCAM	***high relevance***	*relevance*	***high relevance***
Infrastructure, network, and traffic management	***high relevance***	*relevance*	***high relevance***
MaaS and MaaS platform	*relevance*	***high relevance***	***high relevance***
Shared on-demand mobility	*relevance*	***high relevance***	*relevance*

Cooperative, connected and automated mobility

A connected vehicle is defined as a motor vehicle "that connect to other vehicles and or devices, networks and services outside the car including the internet, other cars, home, office or infrastructure"[5]. In the future, they might directly interact with each other and with the road infrastructure. This interaction is the domain of cooperative mobility, which is enabled by digital connectivity between vehicles and between vehicles and transport infrastructure[6]. An automated vehicle is defined as "a motor vehicle which has technology available to assist the driver so that elements of the driving task can be transferred to a computer system[7]." In contrast, an autonomous vehicle is defined as "a fully automated vehicle equipped with the technologies capable to perform all driving functions without any human intervention[8]." Example of disruptive innovations in this category includes connected and automated vehicles, passenger urban air mobility, and drone last mile delivery.

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[4] Adapted from GECKO deliverable D1.1 'Review of new mobility services and technologies and set-up of knowledge bank'

[5] Gowling WLG, 2016. Are you data Driven?

[6] European Commission, 2019. Intelligent transport systems. Cooperative, connected and automated mobility (CCAM)

[7] European Parliament, Briefing January 2016, Automated Vehicles in the EU

[8] Ibid

Infrastructure, network and traffic management

Mobility innovations regarding infrastructure can be defined as innovations in infrastructure management, pricing, taxation and finance, digitalization and integration[9]. Network and traffic management "provides guidance to the European traveller and haulier on the condition of the road network. It detects incidents and emergencies, implements response strategies to ensure safe and efficient use of the road network and optimises the existing infrastructure, including across borders. Incidents can be unforeseeable or planned: accidents, road works, adverse weather conditions, strikes, demonstrations, major public events, holiday traffic peaks or other capacity overload"[10]. Example of disruptive innovations in this category includes big data for fleet management and logistics, TM 2.0 (Traffic Management 2.0), and Hyperloop.

MaaS and MaaS platforms

"Mobility-as-a-Service is a user-centric, intelligent mobility management and distribution system, in which an integrator brings together offerings of multiple mobility service providers, and provides end-users access to them through a digital interface, allowing them to seamlessly plan and pay for mobility."[11] "The MaaS Platform is the IT structure that is used by the MaaS Operator to provide the final service of mobility to the end-users".

Shared on-demand mobility

Shared mobility and on-demand mobility are two trends that emerged as a response to the change in traveller need for cheaper transport (e.g. sharing the cost of travel) and the need for easy access to a transport (service) at a given moment. Shared mobility can be defined as usage of shared resources, in this case vehicles, which are made available to registered users at various locations in the city. On-demand mobility, on the other hand, is service provided 'on-demand', when requested by the customer, and not based on a fixed schedule. Examples of disruptive innovations in this category include car-pooling, bike sharing, e-scooter sharing or micromobility, ride-hailing and Transportation Network Companies (TNC) like Uber or Lyft.

The wide range of mobility innovations that all have potential to cause major shifts in transportation sector and other areas of social life and business brings up a complex ecosystem of different actors that affect or are affected by the rapidly changing mobility sector. They also have differing interests and motivations as regards the uptake of those innovations, which ultimately needs to be addressed by governance and policy-making (see Figure 2 for a simplified representation of main actors in the mobility sector and their main motivations). For instance, as it was mentioned earlier, the mobility service and technology providers are naturally more interested in profitability of their business and a stable growth potential in the industry. This

[9] European Commission, 2017. Transport Infrastructure Expert Group Report
[10] European Commision, 2019. Intelligent Transport Systems, Traffic Management
[11] Kamargianni et al., 2018. The MaaS Dictionary. MaaSLab, Energy Institute, University College London

means they are interested in 'more mobility' rather than less, which can contradict with the interests of society in general and regulators as the bodies that are supposed to represent it.

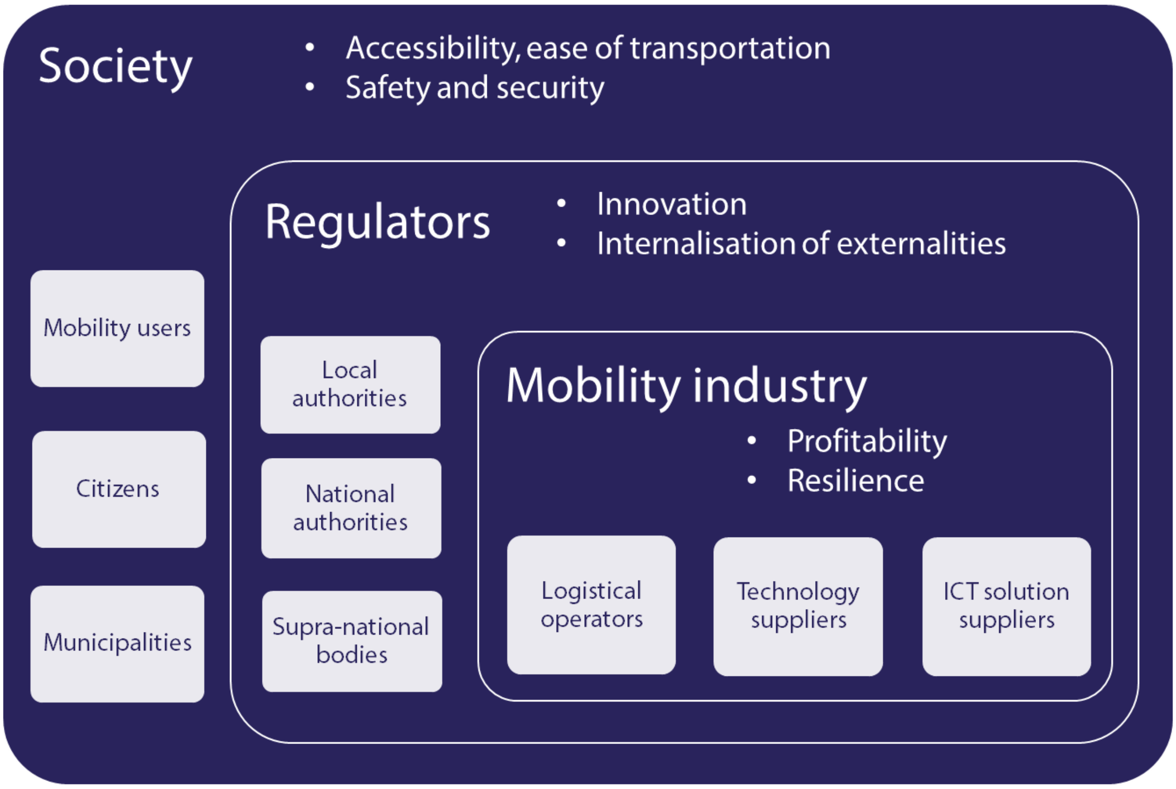

Figure 2: Schematic representation of mobility sector, main influencing and influenced actors and some of their motivations

Further, the variety of disruptive mobility solutions makes it challenging to choose which of them need to be implemented and in what combination, because they are all part of the mobility mix in a location and their benefits cannot be evaluated in isolation from each other and the conditions in the target area.

Finally, mobility sector cannot be seen in isolation from other areas of social activity. Transportation creates positive and negative externalities that affect the environment, job market, public health, concentration of population in certain areas, etc. In order to achieve strong sustainability in transportation sector, it is crucial to find a balance between the impacts of disruptive mobility innovations, social needs and existing conditions (infrastructure, technology, regulations, etc.). This way, the benefits offered by mobility solutions can be realistically assessed and maximised.

4. CLASSIFICATION OF ECONOMIC, POLITICAL AND SOCIAL VARIABLES

When a new mobility solution is introduced, it is expected to bring certain improvements to transportation systems, but also certain variables need careful consideration. For example, safety to the drivers, passengers and public in general need to be ensured. Latest innovations that rely on big data bring a completely new set of critical variables related to data privacy, interoperability, etc. Autonomous mobility raises new type of ethical issues related to the choices a machine would make when driving. The latest trends that pose questions to how disruptive mobility innovations need to be evaluated and implemented can be summarised as follows:

- ***Globalization*** has created a more connected world, where any innovation is introduced in a complex business ecosystem, technology shifts can happen fast, and business model innovations require even less time to change the transportation market.
- Despite the dynamism, ***institutionalization*** is still a limiting factor for maximising the benefits of certain innovations. New technologies or business models face challenges integrating in existing infrastructure, complying with existing legislation, industry standards and norms, and overcoming cultural-cognitive barriers when people's mindset needs to change from e.g. car ownership to car sharing.
- ***ICT technologies and big data*** underpin most innovations and raise issues related to data management.

Due to this dynamism and complexity, it is not immediately apparent what will be the impact of a new mobility solution. This is not defined by the technology or business idea as such, but largely by the way it will be integrated in existing mobility systems. It is possible that the same mobility solution proves beneficial in one location while completely detrimental in another. This depends on the existing infrastructures, local conditions and needs, market and user behaviour. For example, while micro-mobility can be a good solution to force people to make a switch from driving cars, the overcapacity of micro-mobility operators can create problems to user experience and the use of public space. Similarly, the ultimate environmental impact of electric vehicles cannot be assessed without analysing the whole lifecycle of their operation.

It is therefore important to consider various social, economic and political variables attached to any new mobility solution and evaluate its fit for local purposes. Based on that, the governance required for successfully integrating them in the local mobility mix can be designed.

Following the research process described in Section 2, 22 variables that affect the successful implementation of disruptive mobility solutions have been identified. They are classified in six more generic groups as presented in Figure 3. A brief description of the variables can be found in Table 2. Section 5 provides a more detailed description of each variable followed by concrete examples.

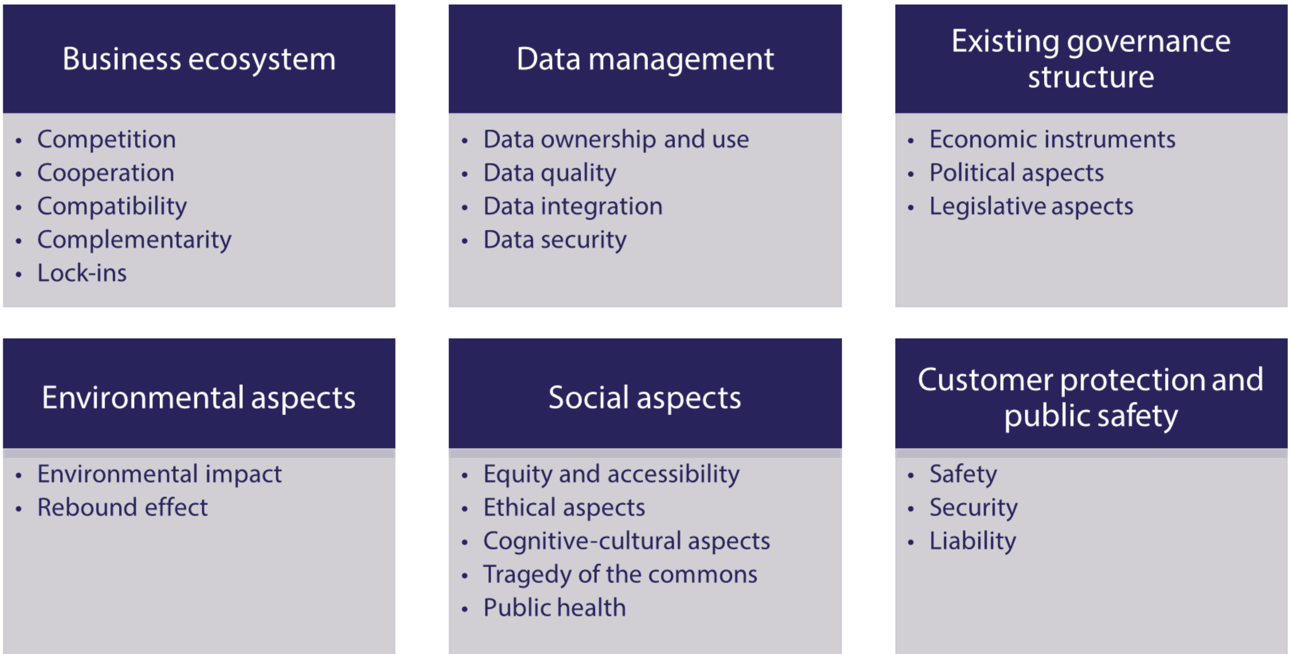

Figure 3: Categorisation of economic, political and social variables influencing governance of disruptive mobility solutions

Table 2: Variables influencing governance of disruptive mobility solutions

Variable name	**Brief description**
Competition	Competition with other mobility solutions within and between business ecosystems
Cooperation	Required cooperation between different private and public parties in order to successfully implement a mobility solution
Compatibility	The need to be compatible with existing technologies, infrastructure and business models
Complementarity	The need for other technologies, infrastructure, business models in order to realize the benefits of a mobility solution – the need for an enabling business ecosystem
Lock-ins	Barriers for implementation of new mobility solutions created by existing technologies, business models, standards and infrastructure
Data ownership and use	Clarity regarding who will own data collected as part of a mobility solution (traffic, payment, personal etc.), how it will be shared and what it will be used for

Data quality	For certain mobility solutions to work it is crucial that the data (e.g. traffic schedules, real-time vehicle locations, etc.) are precise and reliable
Data integration	It is necessary to integrate the data generated by different actors in order for mobility solutions to realize their benefits
Data security	Data required for operation of various mobility solutions contains private information (e.g. credit cards, names, addresses, locations and movements), which needs to be properly protected
Economic instruments	Economic instruments such as taxes, tax reliefs, subsidies, etc. impact new and existing mobility solutions, creating advantages and disadvantages for certain actors
Political aspects	Governmental support, changes in political course, lack of harmonization form political environment that supports or obstructs implementation of mobility solutions
Legislative aspects	Legislation can both support and obstruct implementation of mobility solutions
Environmental impact	The actual environmental benefit of a mobility solution can be only assessed when considering its lifecycle and potential burden shift
Rebound effect	The intended environmental benefits of a mobility solution might not be realised to a full extent. Also, environmental burden can be shifted from one area to another instead of solving a problem
Equity and accessibility	New mobility solutions entail various level of accessibility and their use can be challenging for certain groups of people due to physical, economic or technological limitations
Ethical aspects	Certain new mobility-related technologies or business models bring up ethical issues that are difficult to resolve
Cognitive-cultural aspects	The switch to new mobility solutions often requires a change in people's mindset and revision of what has been taken for granted
Tragedy of the commons	Disregard and vandalism are often observed in relation to objects and infrastructures that are considered to be common or 'no one's'
Public health	While a mobility innovation can make transportation more accessible, it can lead to undesired effect on people's health due to reduced walking
Safety	It is crucial to ensure safety of the users of new mobility solution (passengers) as well as the society in general (pedestrians, local population, etc.)
Security	It is crucial to ensure security of the users of new mobility solutions as well as any affected stakeholders

Liability	In certain cases it is unclear whose liability it is when an accident happens in the context of a new mobility solution

5. ANALYSIS OF ECONOMIC, POLITICAL AND SOCIAL VARIABLES

5.1. Business ecosystem

5.1.1. Background

The advent of ICT industry and globalization have led to disruptions in many industries. It has become difficult to draw industry boundaries as value chains have become highly intertwined. The notion of business ecosystems[12] helps to grasp the fact that industries are converging and constantly evolving, while business actors are parts of complex systems, and their survival depends on the 'health' of the whole ecosystem they are part of.

While business ecosystems are dynamic, they are also inert and institutionalized to a certain extent. Incumbent business models, existing infrastructure, industry standards and norms create a frame for working in such complex environments and facilitate certainty and efficiency. However, such institutional structures can also create entry barriers for technological and business model innovations and limit the potential for ecosystem's self-renewal and increased value creation. Introduction of a disruptive mobility innovation, by definition, requires changing the status quo in terms of the distribution of roles and responsibilities, and appropriately altering the prevailing industry mindset or industry recipe[13]. Meaningful innovations aimed at sustainable development require larger system changes and the development of an enabling business ecosystem.

Market failure normally requires government intervention. Moreover, it is impossible to treat policy-makers and governments as actors independent of markets, because they influence the development of business ecosystems both through the support of certain solutions, technologies and business models, and through creating certain boundaries and even bottlenecks for markets to develop. Thus, in governing disruptive mobility solutions, it is crucial to understand the dynamics of respective business ecosystems and find instruments to support, restrict and guide them in the direction of sustainable development. The changing set of actors involved in transport provision challenge the existing rules of the game, and different types of market failure will emerge and need to be managed.[14]

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[12] Business ecosystem is defined by the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize (See Adner 2017. Ecosystem as Structure: An actionable construct for strategy. Journal of Management, 43 (1), 39-58)

[13] Spender 1989. Industry recipes. An inquiry into the nature and sources of managerial judgement. Oxford, Blackwell

[14] Docherty et al., 2018. The governance of smart mobility

5.1.2. *Variables related to business ecosystems*

Competition

In general, competition has positive effects on the mobility sector, because it increases innovation, diversity of solutions, and drives companies to improve the quality of their products and services. However, there are situations when different aspects of competition lead to unwanted results and may require certain governance. In particular, mobility innovations face competition from existing and established transportation modes, which sometimes leads to strong opposition and the use of resources to fight the status quo. Such competition can also lead to social unease and disruptions in mobility services.

An illustrative example is the competition between traditional taxi services with shared on-demand mobility service providers like Uber. Taxi drivers normally need to acquire licenses for providing taxi services in a municipality, which are recouped after years of operations. Thus, it is often argued that the introduction of TNCs creates unfair competition with average people who did not need to invest into a taxi licence and otherwise follow strict regulations. In several countries, therefore, the requirement to comply with the same process was imposed on Uber drivers[15]. Taxi drivers have also gone on strikes to show their opposition to new ride hailing businesses, creating disruptions in taxi services[16].

Similarly, the introduction of electric cars creates disruptions in incumbent business ecosystems where fossil-fuel driven vehicles prevail. As electric cars will replace more cars with internal combustion engines (ICE), certain maintenance jobs will become obsolete, manufacturing volumes of ICEs will decrease, and second-hand vehicle market will be affected. This will lead to certain social unrest due to jobs cuts and resistance from incumbent firms due to the loss of market share or a role in mobility ecosystem completely.

Such detrimental results of competition between old and new business ecosystems are impossible to avoid when system shifts are happening, but they need to be anticipated, and their negative effects on society can be minimized. Moreover, a too strong opposition of incumbent businesses can prevent potentially more sustainable mobility solutions from entering the market and realizing the expected benefits. Also, too fierce competition leads to overlooking the benefits of cooperation and data sharing.

After a mobility innovation is introduced in the market, multiple service providers appear following the success of the pioneering companies. While a certain degree of 'healthy' competition helps satisfy end-users' needs and develop the services further, there is a potential for quickly reaching market oversaturation.

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[15] Rienstra et al. 2015. International comparison of taxi regulations and Uber. KiM Netherlands Institute for Transport Policy Analysis

[16] Madrid taxi drivers intensify their protest against ride-hailing apps. El Pais, 28.01.2019. Also see the rulings by CJEU related to Uber

For example, when dockless ('floating') shared bikes were introduced in China, innumerable companies joined after the first success of the business model. The market saturation was reached in a short term. As a result, user depreciation towards offered products started to increase. Vandalism forced bike sharing companies to renew their fleet, even to sell old bikes as recyclable iron[17]. Such market oversaturation might require government intervention.

Cooperation

Cooperation factor is especially relevant for the mobility innovations that require the involvement of multiple actors of different nature (public and private), data sharing and coordination of different services, such as, for example, traffic management and MaaS. If cooperation is achieved, it results in market building, interoperability of data and mobility solutions and open innovation.

In order to materialize the benefits of MaaS solutions, it is necessary to attain a critical mass of users. This, in turn, requires orchestration between different modes of transport to provide convenient door-to-door journeys. Lack of cooperation between stakeholders, lack of agreement that could preserve mutual interests can lead to market disequilibrium and the need of authorities to address market failures. For example, transport operators may refuse to adjust their business models to integrate the Cooperative Intelligent Transport Systems (C-ITS) due to the fear to reveal certain internal information, leading to the failure of MaaS introduction.

To enable Traffic Management Systems (TMS) and the attributed benefits, different parties need to share the data for TMS to work. In particular, private and public entities' cooperation is challenging. This also relates to the issue of data ownership and sharing discussed further in this report.

On the other hand, too extensive cooperation can potentially lead to oligopoly, which creates entry barriers for new mobility solutions, and decrease incentives for remaining innovative.

Compatibility

Introduction of mobility innovations requires integration in existing infrastructure, which includes among others road infrastructure, electric grids and ICT infrastructure, which are governed by norms and regulations. For instance, the adoption and development of non-open sourced ICT systems by different automotive manufacturers may cause additional requirements to regulators to ensure compatibility to regulatory schemes. On the contrary, the adoption of proprietary software not compatible with a commonly agreed regulation would cause lobbying against the adoption of common standards.

[17] The Development and Policy Recommendations for Dockless Bike Share (DBS) in China

Another important factor is that city and road infrastructure is planned for long term, and while it is difficult to predict the coming innovations in mobility sector, it is crucial to realize that spatial planning and infrastructure investment decisions of today will significantly affect the ease of introducing mobility innovations in the future. For example, in many cities infrastructure has been developed for cars, pedestrians and bicycles, so introduction of e-scooters faced certain challenges like no designated area for driving them, leading to safety issues.[18]

[18] Yle News 2019. Cities wary of e-scooter risks, prioritise bike schemes

Complementarity

For disruptive mobility innovations to be successfully implemented there is a need for an enabling business ecosystem to exist. For example, e-mobility needs to be conceived as a full ecosystem including manufacturers of electric vehicles and their parts, charging operators, service providers, users, etc. Its economic relevance and environmental sustainability can be analysed only with a systemic perspective. Also, maintenance of electric vehicles requires totally different qualifications compared to traditional ICE vehicles. The use of batteries in electric vehicles involves new raw material value chains into mobility industry, bringing new types of companies as well as economic and political considerations.[19] Another challenge is a big choice of technologies and solutions for charging electric vehicles, such as e.g. battery swapping, charging through an outlet, induction charging, dynamic induction charging etc. This creates an opportunity to adjust charging to local conditions and need, while also creates ambiguity regarding the choice and what actor will be in the business ecosystem for e-mobility.

Similarly, the success of drone transportation depends on the development of other enabling solutions. Drones that travel further than the operator's visual line of sight require unmanned traffic management (UTM), i.e. a system of radar, beacons, flight-management services, communication systems, and servers that coordinate, organize, and manage all unmanned aerial system (UAS) traffic in the airspace. Detect-and-avoid technologies need to be developed to maturity for drone operations to be possible.

Successful implementation of MaaS solutions also requires interoperability of different systems, making sure that all systems such as ticketing and route planning systems can be updated simultaneously.[20]

A specific need for complementarity concerns ICT infrastructure required for implementation of certain mobility innovations. There is a need for adequate telecommunications network that allows the transfer of significant volumes of data. This requirement is especially relevant for data-intensive mobility solutions such as traffic managements systems and autonomous driving. To enable TMS, it is necessary that various complementary technologies are developed to an adequate degree and are available: sensing and surveillance technologies, communication technologies used to transfer data, technologies for data processing and analysis, including machine learning, traffic control systems, etc.

There is a potential for beneficial synergies between various advanced mobility-related technologies as well as with industries outside of mobility industry. For example, investments in advanced technologies are relevant in order to improve shared mobility operational models and meet the expectations of customers, as for example for inductive charging for electric vehicles and autonomous driving technologies; synergies with other industries have to be identified and might require time and negotiations. Moreover, electric vehicles can help accelerate the adoption

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[19] GECKO D2.4 'Regulatory schemes and governance models for disruptive innovation'
[20] Civitas. Innovative ticketing systems for public transport

of mobility services such as shared mobility, because people will want to try an electric car. This can be used to harness the success of innovation adoption and should not be considered in isolation.

An interesting example of complementarity across industries is the use of electric vehicles in electric grids as distributed energy storage. E-mobility has a potentially drastic impact on electric grids, either through increasing the peak loads in the evenings, or through evening the load by shaping EV-charging behaviour. First, it could allow even more effective peak shaving and thus greatly reduce the grid investments discussed. Second, it could allow a reshaping of the load curve beyond peak shaving to optimize generation cost (shifting demand from peak to base-load generation). And, revving charging up at times of excess solar and wind generation or throttling it down at moments of low renewables production could help to integrate a larger share of renewable power production. Finally, by providing demand-response services, smart charging could offer valuable system-balancing (frequency-response) services. A next-horizon refinement of this approach involves vehicle-to-grid plans, which not only shift the power demand from EVs but also make it possible for EVs to feed energy back into the grid under certain conditions.[21]

Lock-ins

The current ways of working and existing relationships between different actors form the structure of business ecosystems and can have a limiting effect on ecosystem development and introduction of disruptive mobility innovations. In particular, existing long-term contracts and framework agreements with suppliers and customers may restrict rapid uptake of innovative technologies.

Industry standards may have a similar effect of imposing barriers for potentially sustainable mobility technologies, though beneficial for ensuring safety and compatibility in mobility industry.

Not all of the lock-ins need to be addressed through governance, but it is necessary to be able to identify them and their potential effect on implementation of disruptive mobility solutions. Such lock-ins can delay market entry or lead to the situation when a potentially beneficial mobility solution remains uncompetitive or does not realize all the expected benefits.

5.1.3. Implications for governance

Variables related to business ecosystem might have positive and negative influence on the development of mobility sector as summarised in Table 3.

Table 3: The influence of variables related to business ecosystem

[21] McKinsey, 2018. The potential impact of electric vehicles on global energy systems

Variable category name	Positive influence	Negative influence
Competition	Improved service quality Increased innovation Lowered service costs Diversity of mobility innovations	Oversupply Price dumping Obstructed cooperation
Cooperation	Market building Interoperability Open innovation	Oligopoly Decreased innovation Heavy administrative process Bureaucracy
Compatibility	Cost reduction due to the use of existing infrastructure Lower entry barriers	
Complementarity	Focused development New competencies and capabilities	Focus on core business only Fixed organizational identities and roles
Lock-ins	Shorter lock-ins create stability and commitment e.g. to environmental goals	Decreased innovation Difficulties to change to new mobility solutions Need to recover sunk costs

The main implication for governance of disruptive mobility solutions are as follows:

- The impact of a new mobility solution can only be assessed taking a systemic perspective of how it fits in existing business ecosystem or can create a new one
- For successful implementation of a mobility innovation and realization of the expected benefits there may be a need to facilitate the integration of a mobility innovation in existing ecosystem or the development of a new business ecosystem
- Support of certain mobility innovation requires support of a whole business ecosystem
- It is necessary to consider the effects on incumbent business ecosystem on introduction of a disruptive mobility solution, and predict and alleviate the negative effects on society (loss of jobs, required training, etc.)
- Control of market saturation might be necessary to avoid market failure
- Policy-makers need to have a long-term outlook in to the future of mobility solutions, because current decisions on infrastructure will affect the introduction of those innovations in the future

5.2. Data management

5.2.1. Background

Transport regulators, transport operators, service providers, and other relevant stakeholders face the trend of big data for the past decade. Big data is critical to the future development of transport industry. Every day big volumes of data are generated about, for example, passenger numbers, vehicle locations and movements, and ticket purchases. However, it will be less valuable if we cannot transform the ubiquitous data into meaningful models and statistics. The output of big data analysis will help all actors to spot patterns, make real-time decisions, and develop innovative offerings to the industry based on understanding customer behaviours, predicting their needs and developing personalized add-ons and enhancements. Therefore, data utilization is another critical area for disruptive innovations.

It brings, however, a completely new set of challenges that need to be addressed in order to realise the benefits of the new mobility solutions. These challenges include unclear ownership of data and sharing practices, requirements to the quality of data in order to be useful and trustworthy, the need for integrating data to achieve the desired outputs, and, importantly, the need for ensuring security of collected private data.

5.2.2. Variables related to data management

Data ownership

Disruptive mobility solutions are offering a new transport paradigm which becomes more and more connected and therefore requires more and more data to be collected, analysed and stored. Such data is generated, for example, through sensors in passenger counting and vehicle locator systems and ticketing and fare collection systems. While it is clear that data-driven innovations in mobility are capable of bringing efficiency to the sector, it also raises a question of how data will flow and will be owned by different parties as it moves through the system.

In a connected mobility ecosystem, data needs to flow between the different actors so that the right services can be offered at the right time. As a result, ownership of the data will also change along the data flow. The question is how data can be shared in a way that also respects the customer's privacy and does not breach their permissions.[22] A related challenge concerns the integration of data owned by public and private actors.

Uncertainty regarding data ownership in mobility solutions brings further concerns about data security and data usage ethics. These implications will need to be addressed in order to gain and keep consumers' trust to collect this data and convert it into successful services and solutions.

In a big data context, different third-party entities may try to claim ownership in (parts of) a dataset, which may hinder the

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[22] KPMG Global Strategy Group, 2018. Mobility 2030 - Data Rules

production of, access to, linking and re-use of big data, including in the transport sector. Currently, no specific ownership right subsists in data and the existing data-related rights do not respond sufficiently or adequately to the needs of the actors in the data value cycle.[23] *As demonstrated in*

Figure 4, such value cycle can consist of a significant number of actors, making it challenging to manage data ownership and use[24].

Figure 4: Potential variety of the actors involved in C-ITS context (source: LeMO deliverable D2.2 'Report on Legal Issues')

Data quality

In terms of big data analytics solutions, one of the main risks is related to the confidence about the data quality and the predictive model a company is producing. The question of data quality is especially relevant for mobility innovations relying on integration of data from different sources. This includes MaaS, network and traffic management systems, and autonomous vehicle operations. In particular, to ensure smooth MaaS experience the data from different transport service providers needs to be of high quality and liability, which would allow for data interoperability. Real-time data sharing is also crucial for the quality of transportation services.

Data integration

High-quality reliable data on traffic, transport schedules, position of vehicles, etc. discussed earlier is a pre-requisite for efficient data integration. Data integration is crucial for such mobility

[23] LEMO project D2.2 'Report on Legal Issues'

[24] There are regulations addressing the reuse of data by the public sector. See, for example, Open Data Directive (2019) and the PSI Directive (2013)

innovations as MaaS, traffic and network management, autonomous vehicle operation, and any other data-driven mobility solutions.

For example, the insufficient coordination and integration of data from different sources can reduce the contribution of connected vehicles to the implementation of innovative mobility schemes by limiting the potential of interactions between vehicles and infrastructure. Then, poor data interoperability can be a barrier for successful implementation of TMS, because the vast amount of data that can even be available for traffic management can be collected and organized according to various principles, making it difficult to compare, combine and use it for traffic management.

Data security

Big data can support people to make smart choices, but it can also lead to data misuse and unfairness. For example, surveillance of transport data, such as traffic data, can facilitate TMS. At the same time, there are challenges of social-ethical concerns, such as possible population-level monitoring and privacy invasion.

When using mobile ticketing or digital transport solutions, most of the time, users need to provide information regarding their credit cards. It is therefore crucial to ensure the security of the users' private and financial information. Other private data includes, for example, geolocation data.

Protection of personal data in shared and on-demand mobility is crucial as well. The GDPR has had a considerable impact in the domains of privacy, transparency, consent, and control in data-driven businesses. The strengthened legal framework is likely to respond to several ethical issues and thus improve end-users' trust in the use of personal data in a big data context.[25]

The question of cyber-security is connected, but is discussed further in section 5.6 devoted to customer protection and public safety.

5.2.3. Implications for governance

Variables related to data management might have positive and negative influence on the development of mobility sector as summarised in Table 4.

Table 4: The influence of variables related to data management

Variable category name	Positive influence	Negative influence

[25] GECKO D1.1 'Review of new mobility services and technologies and set-up of knowledge bank'

Data ownership and use	Clarity and transparency create trust	
Data quality	Data interoperability Reliability of services based on the data	
Data integration	Quality of services relying on data Increased value to the customers (customized offerings)	Predictive models are impacted
Data security	Trust to new mobility solutions	If compromised, drastic safety and security implications possible

The main implication for governance of disruptive mobility solutions are as follows:

- Drastic safety and security implications of insufficiently secure data handling are possible
- New capabilities and expertise is required for governance and policy-making regarding mobility innovations
- Big data might be governed on higher than 'mobility industry' level, because digitalization trend is relevant for many other industries. This means, compatibility with existing and future data management rules (such as e.g. GDPR) is required

5.3. Existing governance structure

5.3.1. Background

This sub-chapter specifically addresses the institutional support but also barriers that are created through policy and current governance structures: politics, legislation, tax, subsidies, etc. While certain measures can promote some solutions over others, they might also restrict the adoption of potentially more beneficial mobility solutions or limit the benefits they are able to deliver to the society.

5.3.2. Variables related to governance

Economic instruments

Economic support plays an important role in successful implementation of disruptive mobility solutions, because it is able to help in breaking status quo and giving the initial momentum to new transportation modes that face significant resistance from incumbent business ecosystem. Such support can be both financial in the form of tax relief or subsidies and non-monetary e.g.

through providing access to restricted areas, reserved lanes and parking areas exclusively to the providers of novel mobility solutions. An example of the latter category is in-kind support in the form of free parking for clean vehicles in city centres provided by certain municipalities. This creates advantages for cleaner mobility compared to gasoline or diesel-fuelled vehicles and serves as yet another incentive for people to switch to cleaner vehicles.

Another way to facilitate successful implementation of disruptive mobility innovations is to provide monetary and in-kind support for the development of respective infrastructure. In certain cases, governmental support might be the only way to overcome barriers to the deployment of necessary resources for the market development of innovative solutions.

While it is clear that economic incentives can give unfair advantage to disruptive mobility innovations against incumbent businesses, the challenge is to define which innovations require this support and to what extent. The multitude of various economic instruments form complex structures on local, national and supra-national level and become an institution on its own. That is, support of one mobility solution can further on create challenges for other more beneficial solutions to enter the market, because the former solutions have an advantage in the form of economic incentives. Moreover, too extensive subsidising of certain technology or business model can obstruct the development of its actual competitiveness against other transportation modes or solutions, i.e. once the economic support is withdrawn, the mobility solution would quickly face low profitability or fierce competition.

It is therefore crucial to carefully consider what is the influence of various economic instruments that are currently implemented on the present-day mobility industry and how it will affect the new-coming mobility innovations. There might be a need to reconsider economic support mechanisms that seemed appropriate earlier as new mobility trends change the business environment. For instance, the implementation of car scrapping schemes supporting car sales and other fiscal incentives, although pursuing social and in part environmental objectives, will conflict with the general objective of fostering the shift from ownership to sharing.

Legislative aspects

A critical variable related to legislation concerns the incompliance of new mobility solutions with existing legislation. This potentially creates entry barriers and prevents new mobility businesses from fully realizing the potential for improved mobility.

For example, there is a growing share of app-based businesses, such as Uber or I Carry It[26], which bring together the users and providers of mobility service via a certain web-based platform. Anyone can apply to become the driver or courier in those businesses respectively. These people, in essence, become self-employed workers. Postal service business in Finland encountered the challenge that couriers working with I Carry It can be considered as entrepreneurs. However, the couriers have expressed the interest in joining Finnish Post and Logistics Union in order to protect

[26] IcarryIt company website

their labour conditions and minimum wages. The government programme, drafted in May, proposes that legislation be altered to better suit the needs of new forms of work, and that the tax authority must provide the necessary means to gather app-based employees' information.[27]

Missing or slowly adapting legislation also has an effect on the implementation of disruptive mobility innovations. It creates uncertainty and slows down user adoption of new mobility solutions. By the time new modes of transportation appear, regulations should also be adapted or relevant new regulations need to be introduced fast. To provide an example, the lack of regulatory environmental standards and the lack of awareness of impact of innovative mobility such as electric cars may cause an overestimation of the attractiveness of the new market, especially in the short run, which might cause environmental negative impact. The latter – once perceived by the society – may slow down the innovation and the public demand that would trigger it. A more dramatic example of how existing legislation creates entry barriers for disruptive mobility solutions is the Highway Act 1835 that prevents people from riding e-scooters on pavements[28].

Another relevant example is the development of Hyperloop. Hyperloop's implementation is especially challenging from regulatory point of view, because this mode of transport has not been yet categorized and standardised, which in turn creates difficulties to get authorizations for the deployment of this transport mode. This case illustrates quite well the necessity to provide a new regulatory framework that will be able to anticipate the advent of future disruptive solutions.[29]

Finally, conflicting interests, lack of recommendations and information, non-inclusion of certain actors in regulation regarding new mobility solutions undermines trust in the new mobility mode. Specifically, the adoption of EU or worldwide environmental standards, affecting mobility but not sufficiently discussed with transport and mobility industry, would be a constraint towards the adoption of regulatory schemes which ensure the market uptake of innovative technologies in mobility. Moreover, the harmonization among the different governance levels (supranational, EU level, national level, regional level, and municipal level) is crucial for achieving sustainability in mobility sector.

Political aspects

Similarly to economic instruments and legislation, current political situation is able either to promote or create entry barriers for disruptive mobility innovations. In general, since such innovations disrupt the current business logics, it is rather natural that political tensions will arise: incumbent business will resist change, lobbying organizations will continue lobbying for status quo, and there will be competition for political support.

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[27] Yle news, 2019. App-based courier service challenges Finland's postal system
[28] BBC news, 2019. Nearly 100 e-scooter users stopped in London one week
[29] GECKO D2.1 'Analysis of regulatory responses and governance models'

Public sector and policymakers influence mobility sector through infrastructure investments, public transport, zoning laws, building standards, and agricultural subsidies. When disruptive mobility innovations are introduced, current public interventions might not optimally steer future outcomes at a system level. Europe faces a real risk that urban planning, mobility systems, and food systems could not integrate the new technologies effectively, with much structural waste remaining.[30]

In particular, geographical competence boundaries and lack of cooperation between neighbouring political agents may hamper the value proposition of seamless and integrated shared mobility services. For example, the persistence of fragmented public ownership of transport services in urban areas may hamper the trend towards data integration, as a key basis for supplying MaaS. A lack of interest in integrating shared mobility services and public transport to increase flexibility and cost efficiency will reduce the potential of co-modality.

Another example concerns autonomous vehicles. Shifts of government responsibilities after elections may cause re-thinking of stops in the implementation of agreements towards common regulation on autonomous driven vehicles. This would lead to uncertainty and prolong wider adoption of the mobility innovation.

Further, micromobility is a potential disruptive transport mode, but its effect depends on how cities react to the service. Cities' support, such as installing intermodal hubs and construction of specific micromobility paths, could facilitate their residents to use micromobility as their "last-mile" solution.[31]

Smart solutions are not enough for changing inefficient transport scenarios. Low utilization rate of vehicles, energy, and infrastructure, cannot be solved only through technological and business model innovation. There is a need for political leadership and suitable economic shifts that can solve current social and structural inefficiencies.[32]

Lastly, global political challenges may also have an effect of mobility solutions. For example, the location of key raw material mines for battery manufacturing is influenced by geopolitical forces and the availability of some metals such as cobalt is limited. This will affect the EV prices and the pace of the growth of their share in mobility sector.

5.3.3. Implications for governance

Variables related to existing governance structure might have positive and negative influence on the development of mobility sector as summarised in Table 5.

[30] McKinsey Center for Business and Environment, 2015. Growth-Within: a Circular Economy Vision for a Competitive Europe

[31] McKinsey Center for Future Mobility. Micromobility’s 15000-mile checkup

[32] The Conversation, 2018. Smart mobility alone is no substitute for strong policy leadership

Table 5: The influence of variables related to existing governance structures

Variable category name	Positive influence	Negative influence
Economic instruments	Support for beneficial solutions in competing with incumbent businesses Help in changing the users' mindsets towards better mobility	Can distort the market, support an ultimately bad mobility solution
Political aspects	Potential to foster collaboration, remove lock-ins	Support of only business needs instead of public needs
Legislative aspects	Certainty for business actors and public	Can create lock-ins and limit innovative solutions Complexity can favour big firms over small ones

The main implication for governance of disruptive mobility solutions are as follows:

- The need to consider carefully which innovations should be economically supported and how
- The need to consider which economic support is actually detrimental for the whole mobility system in a location
- The need for harmonizing legislation, economic instruments, political support in order to ensure the expected benefits of disruptive mobility solutions are realised
- It is important to avoid creating institutional barriers for new disruptive mobility innovations in the form of slowly adapting regulation, economic incentive structure and political situation
- Different levels of governance (from supranational to local) are required for a more efficient institutional framework

5.4. Environmental impact

5.4.1. Background

Transportation creates negative externalities, including unwanted environmental impacts such as pollution, greenhouse gas emissions, noise and congestions. If the whole value chain is considered, there are other environmental impacts related to the production of fuel or mining of non-renewable substances that are required for e.g. vehicle production. In order to assess whether a disruptive mobility innovation is a sustainable option, it is crucial to consider its environmental impact on a system level as well as predict and account for potential burden shifts and rebound effects.

5.4.2. Variables related to environmental impact

Environmental impact

While many mobility innovations claim to be green and sustainable, the assessment of their environmental impact is not a trivial task. Taking the example of autonomous cars, it is not clear how their environmental impact will differ from current transport modes. The potential for reducing environmental impact lies in more even driving, which reduces energy consumption or the preference of electric vehicles for autonomous operations and consequent reduction in noise and direct emissions compared to gasoline-powered cars. The systemic effect of more balanced driving when there are more autonomous and connected vehicles on the streets also adds to reduced environmental impact.

On the other hand, autonomous vehicles confined to a geographical area might be obliged to ride empty to find a passenger or return to base. This causes underutilization and thereby unnecessary energy consumption. Further, the multitude of on board sensors and computers will require additional energy use. Expected lower cost of transportation and potential for new user groups to ride autonomous cars (children, elderly, disabled) can lead to rebound effect[33], i.e. increased use of transportation[34]. This effect is discussed further in this section.

Similarly, the source of energy used for charging electric vehicles (fossil fuels, renewable energy, nuclear energy, etc.) in the end define environmental sustainability of e-mobility. There is a need to assess the full lifecycle of driving an electric vehicle in order to ascertain sustainability of e-mobility in each particular case. There is also a potentially adverse effect on the environment due to extensive use of rare earth materials required for battery production. There is a need to either find substitutes for these rare materials or recycle those metals efficiently in order to ensure that e-mobility is actually a sustainable solution for the future.

Rebound effect

Rebound effect in transportation can be defined as the reduction of expected gains from more efficient transport modes by increased traffic, congestions, and energy consumption because of lower prices or other social effects such as increased usability.

In particular, the prospected cost efficiency and easiness of use associated with TNCs like Uber or Lyft may dis-incentivise sustainable trips and make users prefer ride-hailing and taxi services

[33] Rebound effect is defined as the reduction in expected gains from new technologies that increase the efficiency of resource use because of behavioral or other systemic responses

[34] Forbes, 2019. A green future of transportation: how self-driving cars will be make or break

instead of soft mobility and public transportation in particular. High accessibility and affordability can even make users choose ride-hailing instead of walking or biking very short distances. Research showed that only about 20% of TNC trips replace personal car trips, while 20% of the trips replace traditional taxi services, and the rest 60% replace transit, biking, and walking, or would not have been made without the availability of TNCs[35]. This ultimately leads to more vehicles on the road, congestion and increased pollution.

Even though ride-sharing is still a more environmentally efficient option compared to ride-hailing, shared mobility also has potential to replace journeys that would have been made in soft mobility or public transport by car journeys[36].

5.4.3. Implications for governance

Variables related to environmental impact might have positive and negative influence on the development of mobility sector as summarised in Table 6.

Table 6: The influence of variables related to environmental impact

Variable category name	Positive influence	Negative influence
Environmental impact	If measured holistically can assess various mobility innovations	If not measured correctly, can favour 'wrong' mobility solutions
Rebound effects	Rebound effect can be negative, i.e. environmental benefits of a mobility can exceed expectations	The expected benefits might not be realized

The main implication for governance of disruptive mobility solutions are as follows:

- To evaluate the benefits of new disruptive mobility innovations it is important to consider the whole lifecycle of the service provided
- It is important to foresee and address potential rebound effects when the expected benefits of a mobility innovation are not realised

5.5. Social aspects

[35] Ecolane, 2018. Ride-hailing vs. ride-sharing: the key difference and why it matters
[36] GECKO D2.4 'Regulatory schemes and governance models for disruptive innovation'

5.5.1. Background

Even if a mobility solution promises unquestionable benefits, the local authorities and relevant actors are ready to implement it, the resistance or uncertainty associated with the society can lead to poor realization or failure of any initiative. The way a disruptive innovation is embedded not only in a business ecosystem, but also into social system at large is not evident and bears high level of uncertainty. This concerns the changes in the mindsets of people and public acceptance of innovations, their integration with the newly introduced artefacts be it e-scooters or mobile apps, and the effect those innovations will have at people in general. That is why it is important to acknowledge such potential challenges and be prepared to resolve them. In this report, five variables related to social aspects are discussed. However, there are other factors such as effect on employment, etc. that are not discussed but are also relevant for disruptive mobility solutions as much as for any other disruptive innovations.

5.5.2. Variables related to social aspects

Equity and accessibility

The choice of one mobility solution over another is usually guided by the benefits provided to that part of population that travels more often. These people are also normally having higher income, which means that the interests of lower-income part of population that cannot bear high travel costs is overlooked. It has been argued that accessibility (both financial and physical) should be as important factor to consider when choosing between different transport projects as reduction in travel time or mitigation of negative impacts of transportation[37].

The prevalence of digital access channels and immaterial payment systems within shared mobility or MaaS, for example, can lead in some cases to the partial exclusion of potential users (e.g. elderly or low-income citizens).

Another example is expensive infrastructure projects like Hyperloop that are aiming only high-income travellers.

If urban air mobility is to develop very fast and extensively, the implications on public comfort can be drastic: noise and obstruction caused by many flying vehicles will be significant. It will also affect the non-users of air mobility, i.e. citizens that will be exposed to the noise, pollution and compromised safety from the air mobility. Thus, it might be beneficial to limit the presence of flying vehicles in the sky early on and at the same time address the equity question. For example, the use of air mobility can be specifically dedicated for elderly people. Thereby, the airways will not become congested, and people with special needs can enjoy fast and reliable transportation.

[37] Di Ciommo and Shiftan, 2017. Transport equity analysis

Ethical aspects

As new digitalized, automated and data-driven mobility solutions proliferate, a number of new ethical concerns arise. These include, for example, privacy and cybersecurity concerns or moral dilemmas related to allowing computers make uneasy choices when autonomous vehicles are driven.

The question of data ownership and sharing discussed in section 5.2.2 closely relates to the issue of ethical use of big data generated within mobility sector for optimising and improving mobility services rather than being used for surveillance or discrimination. The main issues related to surveillance using big data include the risks of asymmetries in the control over information and privacy concerns. The former issue concerns the fact that big data can give a competitive advantage to those who own them in terms of capability to predict new economic, social and political trends[38]. The latter issue relates to potential privacy threats due to the wrongful use of data generated in mobility sector.

Yet another concern for privacy comes from transport drone operations. The question of where the drones are to be allowed to fly and how much they would actually invade people's privacy are crucial to resolve in order to achieve public acceptance of urban air mobility.

Autonomous mobility presents a whole set of ethical concerns related to the choices that a machine would need to make when driving. These choices include, for example, running over pedestrians or sacrificing the vehicle and their passengers to save the pedestrians[39]. Such moral dilemmas are difficult to resolve, and one approach has been to launch the Moral Machine[40], an online survey that asks people to make such hypothetical choices and thereby explores moral decision-making regarding autonomous vehicles[41].

Lastly, another set of ethical concerns can arise from the new value chains that follow the introduction of mobility innovations. For example, the production of magnets for Hyperloop would require the use of rare-earth elements like neodymium or samarium, which are significantly more powerful but more expensive than magnets made from iron ore, cobalt and nickel. Cobalt, combined with samarium to create a supermagnet, presents its own challenges given that cobalt mining relies on child labor according to Unicef and Amnesty International.[42]

Cultural-cognitive aspects

The resistance to change due to culture and competence through 'patterning' (forming of fixed ways of behaving) is a very strong barrier to the shift of paradigms towards innovative mobility

[38] LEMO project deliverable D2.3 'Report on Ethical and Social Issues
[39] Bonnefon et al., 2016. The social dilemma of autonomous vehicles
[40] MIT. Moral Machine
[41] Inside Science, 2018. Moral dilemmas of self-driving cars
[42] Rutlan, 2019. What will hyperloop mean for climate, ecosystems and resources?

technologies. The limited perception of the real total cost of ownership (TCO) and of the related economic advantages of sharing leads to subjective decision making. Uncertainties in the generalized cost of transport, which include also the value of time, are a barrier towards the shift from private car use to shared mobility and MaaS for multimodal journeys. The lack of trust, especially in case of peer-to-peer models, reduces the attractiveness of shared options even when perceived as more cost efficient.

People need to change their mindset from owning a car to using shared mobility in order to start actively using the latter. There is a need to ensure that psychological costs related to shared on-demand mobility are not too high and can be overcome: confidence in the driver, fear of lack of security, obligation to talk, insurance etc. Public acceptance of sharing personal data with different stakeholders is also required for MaaS. This means that trust building is crucial in overcoming these barriers.

Another example of cognitive-cultural shifts required for successful implementation of mobility solutions is the willingness to transfer responsibility from a human to the vehicle when it comes to autonomous vehicles. A recent study has shown that even though participants approve of autonomous vehicles that might sacrifice passengers to save others, respondents would prefer not to ride in such vehicles. They would also not approve regulations mandating self-sacrifice, and such regulations would make them less willing to buy an autonomous vehicle.”[43] Another study conducted by MIT in 2017 has found that nearly half of 3,000 respondents said they would never purchase a car that completely drives itself. The respondents said that they feel uncomfortable with the loss of control and that they do not feel self-driving cars are safe[44].

Tragedy of the commons

The tragedy of the commons is a situation in a shared-resource system where individual users, acting independently according to their own self-interest, behave contrary to the common good of all users, by depleting or spoiling that resource through their collective action. This metaphor can be connected to the objects within shared mobility paradigm such as shared cars, e-scooters and bikes. Since they ‘belong to everyone and no one’, users and even passers-by can vandalize and generally treat the object less carefully than required for their efficient use.

Micromobility industry is a good example of ‘tragedy of the commons’. Firstly, fierce competition based on higher presence, i.e. quantity of shared bikes, e-scooters etc. in a municipality leads to oversupply. Such oversaturation of public spaces with e-mobility devices becomes a mobility problem, namely for pedestrians, as well as a sustainability one, given the challenge of dealing with the waste created by thousands of abandoned or damaged bikes or scooters. Thus, micromobility companies use public spaces (streets, sidewalks, parks, plazas, etc.) as a common pool resource trying to maximize their benefit. They ultimately overuse the resource, because

[43] Bonnefon et al., 2016. The social dilemma of autonomous vehicles
[44] GECKO D1.1 ‘Review of new mobility services and technologies and set-up of knowledge bank’

they are able to obtain the benefit of doing so, while incurring no direct cost[45]. Secondly, riders also use the bike fleet as an almost infinite common resource, take poor care of them or using them in such a way that it conflicts with the use of other transport modes (e.g. parking e-scooters on bicycle lanes).

Shared-mobility user misbehaviours is a partial reason for high safety concern of these services. On the one hand, irresponsible user behaviours (driving without helmets, inappropriate physical conditions, etc.) would reduce the lifecycle of equipment, and increases driving risks; on the other hand, the responsibility is later difficult to claim. Dockless e-scooters and bicycles are problematic when these are distributed randomly in cities[46].

Public health

There are many ways in which disruptive mobility solutions can positively affect the public health: through reduction of congestion, improving the quality of the air, etc.

It is important, however, to assess whether a mobility innovation will ultimately have a positive effect on the citizens' health. General safety in a municipality can be compromised by introduction of new unfamiliar transport modes like e-scooters, especially if they are operated unsafely. Then, the development of autonomous mobility can lead to the situation that even children will be riding cars instead of walking or biking over short distances, which can ultimately lead to health concerns on national level. Such long-term effects on society need to be addressed by a holistic policy which defines 'public good' in many dimensions.

5.5.3. Implications for governance

Variables related to social aspects might have positive and negative influence on the development of mobility sector as summarised in Table 7.

Table 7: The influence of variables related to social aspects

Variable category name	Positive influence	Negative influence
Equity and accessibility	Certain innovations would benefit vulnerable social groups	Some mobility innovations are not making transport more accessible physically and economically or even obstruct other existing modes

[45] Blanco, 2019. Beyond avoiding the micromobility tragedy

[46] Holder, 2019. Why Electric Scooters Companies Are Getting Serious About Safety and Ajao, 2019. Electric Scooters And Micro-Mobility: Here's Everything You Need To Know

Ethical aspects		Ethical dilemmas brought by autonomous mobility reduce trust in the solution
Cultural-cognitive aspects		Resistance to adopt potentially beneficial mobility solutions
Tragedy of the commons		Individuals can damage viability for a "common" model
Public health	Reduced air pollution in cities	Mobility innovations can actually have bad impact on public health due to reduced walking even over short distances

The main implication for governance of disruptive mobility solutions are as follows:

- It is necessary to predict and prevent certain unwanted social behaviour in relation to introduction of disruptive mobility solutions
- It is also crucial to work with public acceptance and trust towards new disruptive mobility technologies, because they normally require a critical mass to be successful, and in general it is the society that needs to benefit from those. Such work requires 'soft governance', education, etc.
- Reduction of uncertainty regarding disruptive mobility solutions can create the necessary trust towards them

5.6. Customer protection and public safety

5.6.1. Background

The term safety is broadly used to refer to the protection of individuals, organizations, and assets against threats that can be directed to such entities hence rendering them inactive. Security, on the other hand, mostly refers to the deliberate actions that are geared towards inflicting harm to an individual, organization, or even assets. When a new mobility solution is introduced, one of the key responsibilities of governing organizations is to ensure that the new technologies and business models do not harm people physically, psychologically or financially. It is therefore necessary to identify how safety and security can be compromised due to new mobility solutions. In this section we discuss the safety and security of anyone potentially affected by disruptive mobility innovations: actual users, passengers, and society in general.

The question of liability also arises when disruptive mobility innovations are introduced. Since they often redefine current ways of working and bring novel technologies and business concepts on the market, it is not always clear who is liable for damages in case of accidents, equipment malfunction, etc.

Safety

Some disruptive mobility innovations rely on new technologies that naturally bear risks of malfunction and require certain safety control. These technologies might not be more dangerous than existing alternatives, but due to their novelty, not all of their potential impacts are yet accounted for. For example, electric vehicles are very quiet when driven, especially compared to ICE and diesel cars[47]. While this is a welcome benefit for reducing noise pollution in urban areas, this poses a certain risk to the safety of people, because they can miss an approaching vehicle and be less alert about potential danger. Further, battery technologies currently under development are likely to introduce the need for consumers and EV stakeholders to be informed about personal protection, handling electrical grid voltage under the hood, and fire suppression.

The case of autonomous vehicles is more challenging from safety point of view. On one hand, it is argued that autonomous vehicle operations can be safer because these vehicles have advanced sensors and faster reaction compared to humans. Moreover, as more and more autonomous vehicles enter roads, highly interconnected vehicles will have much better situational awareness than drivers. On the other hand, unforeseen accidents due to autonomous driving vehicles are causing stops in research and testing, and could slow down the related investments by automotive industry. Such events could also cause harsh backlash against the technology from policy makers, preventing further testing.

Some mobility innovations pose even greater safety risks. For instance, single breach in Hyperloop can cause major damage, as air would rush into the tube at about the speed of sound[48]. Other solutions can compromise safety due to misuse and improper human behaviour rather than because of technical faults. For example, e-scooters can cause safety issues when driven both on pedestrian lanes and on roads[49].

Drones pose safety risks both due to potential malfunction of the equipment and human error when operating them[50]. Concerns regarding the technology centre around the battery life, lift capacity, airworthiness, and reliability of the drones. The primary criticism with the flying of commercial drones over public space is that small mistakes could result in crashes that threaten the health, well-being and property of the public. Furthermore, if they crash into public infrastructure such as electricity poles, or wanders into airports and other protected airspaces, it could result in dangerous scenarios that put many lives in danger.[51] This poses the question whether there is a need to regulate who can operate drones, if any licencing is required, impose minimum vehicle requirements, etc.

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[47] GECKO D2.4 'Regulatory schemes and governance models for disruptive innovation'
[48] GECKO D1.1 'Review of new mobility services and technologies and set-up of knowledge bank' and Allied Market Research, 2019. Hyperloop technology market overview
[49] Yle News, 2019. Cities wary of e-scooter risks, prioritize bike schemes
[50] GECKO D1.1 'Review of new mobility services and technologies and set-up of knowledge bank'
[51] Rao et al., 2016. The societal impact of commercial drones

Security

There are different types of security concerns related to disruptive mobility solutions. The more traditional ones include, for example, the security of passengers in ride-hailing and ride-sharing within shared mobility. Those issues include potential mugging, physical abuse of passengers, etc. and apply equally to more established transportation options like taxis and hitchhiking.

There is a set of new security threats related to digitalization as well as remote and autonomous vehicle operation. They can be collectively named cybersecurity issues. One particular problem related to ensuring safety of private and financial data in digital mobility solutions had been discussed earlier in section 5.2. Taking an example of shared mobility, a break-in and or manipulation of data brings severe consequences for the safety of drivers and passengers of a carpool.

Another type of cybersecurity threats relates to the potential of hacking autonomous or remotely operated transportation systems such as drones and autonomous cars. Criminals can take control of such equipment, leading to the consequences described in previous subsection. Drones, for example, can be 'spoofed', i.e. hijacked from their programmed paths. It is difficult to track the signal that overwhelms drones GPS antenna and thereby leads to the loss of control. Thus, the consequences would be attributed to the drone operator. An integrated cybersecurity strategy (e.g., firewalls, encryption support, and network security mechanism) is required to avoid potential cyber-attacks.[52]

The question of privacy related to drone operations can be also related to security and has been touched upon in section 5.5 under ethical issues. In public spaces such as parks or streets, but also in private property that is visible from public spaces, there is no legal basis for submitting a request for infringement of privacy as long as the view is limited to eye level. Drones disregard expectations of reasonable privacy since they are operated in a public place, yet can capture videos and sounds that are not traditionally available to the public.[53]

Liability

While integrating new digital solutions into society, developers may focus on improving the technology. Nevertheless, the question of liability is arguable when an autonomous systems start faulting and cause injuries. It is unclear who will be responsible when an accident involving an autonomous vehicle will happen: will it be the vehicle producer, passenger, operator, or anyone else.

[52] GECKO D1.1 'Review of new mobility services and technologies and set-up of knowledge bank'
[53] Ibid

Following the example of spoofing drones presented above, involuntary and planned collisions seem to be inevitable, especially in an unregulated environment. Several incidents have occurred without the persons responsible being identified.[54]

Yet another example, it is important to identify how liability is shared in case of wrong data provision in MaaS. Clear definition of liability is important because it will also affect insurance.

5.6.2. Implications for governance

Variables related to customer protection and public safety might have positive and negative influence on the development of mobility sector as summarised in Table 8.

Table 8: The influence of variables related to customer protection and public safety

Variable category name	Positive influence	Negative influence
Safety	Ensured safety e.g. through standards can lead to increased trust and faster modal shift	
Security	Ensured security leads to trust and faster adoption of mobility innovations	Too much security e.g. through CCTV can lead to public distrust
Liability	Clear liability sharing creates trust towards new mobility solutions	

The main implication for governance of disruptive mobility solutions are as follows:

- Safety and security of passengers and general public are of utmost importance for governors and policy-makers. It is challenging to identify what are the possible threats when mobility innovations are introduced and what kind of intervention is able to ensure safety and security (Standards on equipment safety, safety rules for operating the equipment, etc.)
- Cybersecurity is a specific concern due to higher digitalization and autonomy in transport, and unknown security threats might arise
- The question of liability is also challenging to address in certain cases due to the novelty of the situation
- If safety, security and clear liability is ensured, it will ultimately lead to higher trust towards disruptive mobility solutions required for their fast adoption

[54] Ibid

6. CONCLUSIONS

6.1. Implications for governance of disruptive mobility innovations

When a disruptive mobility innovation enters the market, there is a variety of social, economic and political factors that need to be considered in order to ensure that its proliferation is actually beneficial for a local or global mobility system, and that it does not put at risk the safety, security and well-being of the society. The role of governance is thus twofold:

- Assess the potential of a new mobility solution to solve transportation problems and create benefits for the society and identify what support is required in order to implement the solution successfully
- Identify potential negative impacts of a new mobility solution and mitigate them through various governance instruments

Disruptive innovations are based on technologies and business models that are capable of drastically changing the current ways of working. Thus, reactive approach in governing their effects is not robust enough. There is a need for more predictive and adaptive governance that can flexibly respond to the challenges in the fast-changing mobility sector. It is difficult to predict all possible innovations developed in the future, but it is possible to understand which factors will be most important to govern given the main innovation trends such as data-driven models, automation and shared economy.

This deliverable outlined 22 variables not connected to any specific mobility innovation, which can inform governance of disruptive mobility innovations yet to come. The factors were divided in six broader categories and analysed. Table 9 summarises what is the relevance of each of these variables for the four categories of mobility innovations.

Table 9: The relevance of identified economic, social and political variables for the four categories of mobility innovations (X –relevant, o – might be relevant)

Variable category name	CCAM	Infrastructure, network and traffic management	MaaS and MaaS platforms	Shared on-demand mobility
Competition	o	o	o	X
Cooperation	o	X	X	o
Compatibility	X	X	o	o
Complementarity	X	X	o	o
Lock-ins	X	X	X	X

Data ownership and use	X	X	X	X
Data quality	X	X	X	X
Data integration	X	X	X	X
Data security	X	X	X	X
Economic instruments	o	o	o	o
Political aspects	o	o	o	o
Legislative aspects	X	o	o	X
Environmental impact	X	o	o	X
Rebound effect	o	o	o	o
Equity and accessibility	X	o	o	o
Ethical aspects	X	o	o	o
Cognitive-cultural aspects	X	o	o	X
Tragedy of the commons	X	o	X	X
Public health	X	o	o	o
Safety	X	X	o	X
Security	X	X	X	X
Liability	X	X	X	X

By taking a more proactive approach to the governance of disruptive mobility solutions, it should be possible to direct innovation in the desired direction. For example, companies developing disruptive mobility innovations can be involved in a dialogue with local transportation authorities in order to ask them to solve the city's problems such as congestion, pollution, poor transportation service in remote areas, etc. This way, the focus shifts from reactively addressing new challenges brought by mobility innovations to more focused search for those that can actually create benefits for the local society rather than only for direct users. In such an approach there is no clear preference for one technology or business model over another, and it is not assumed that any new solution is beneficial by default because it uses latest technologies.

Another important conclusion is that different spheres of social activity are so intertwined that the impacts on and of mobility innovations go beyond mobility sector. For example, city planning, housing construction, general data protection regulations are all influencing the successful introduction of mobility innovations and the extent to which the expected benefits are realised.

The analysis of 22 variables identified in this research provides an overview of where there may be a need for intervention if such a proactive, holistic and adaptive governance model is applied. This is summarised in Table 10.

Table 10: Implications for governance of social, economic and political variables

Variable category name	Need for intervention	Target area for governance
Competition	• Too little competition leads to monopoly or oligopoly • Too much competition can lead to market oversaturation and decreased benefits from disruptive innovation • Tensions between incumbent businesses and disruptors can cause mobility service interruptions and social unease • Unfair competition in terms of regulation and preferential treatment	Mobility service providers' operations
Cooperation	• Too much cooperation – oligopoly and entry barriers for innovations • Inability to deliver the promised value of a mobility solution due to lack of cooperation between public and private parties	Public and private parties and their interaction
Compatibility	• Existing standards and regulations can create entry barriers for new mobility solutions due to incompatibility with existing systems	IT and non-IT infrastructure development
Complementarity	• Support for other complementing solutions or infrastructure is as important as support of a promising mobility innovation • Increased benefits in ensuring complementary of mobility solutions with other sectors	Innovation support; Cooperation with other sectors (e.g. energy)
Lock-ins	• Lock-ins that unnecessarily create barriers for mobility innovations and prevent from realizing associated benefits	Current standards, contractual models, etc.
Data ownership and use	• Unclear ownership, transfer and use of data creates mistrust towards mobility innovations	Data handling rules
Data quality	• If data is not reliable or interoperable, the mobility services relying on it might fail	Data sharing between different parties Data standards Liability schemes in terms of wrong data provision

Data integration	• Lack of trust and cooperation can inhibit proper integration of data required for reliable transportation	Cooperation between various public and private parties
Data security	• If data security is compromised it can lead to abuse of personal information	Data handling rules Legislative framework for sanctions
Economic instruments	• Existing economic instruments create advantages for certain actors and can create entry barriers for innovations	Current economic support
Political aspects	• Political uncertainty, lack of clear course leads to investment uncertainty and slows down adoption of mobility innovations	Political will
Legislative aspects	• Existing legislation can create entry barriers for mobility innovations • Lack of regulation creates uncertainty	Existing and missing legislation
Environmental impact	• The ultimate environmental impact of a mobility innovation can prove to be negative	Assessment of environmental impact
Rebound effect	• The expected benefits of a mobility innovation might not be realised to a full extent • A mobility innovation can lead to negative effects on the environment	Assessment of environmental impact
Equity and accessibility	• Transportation needs of certain groups of people are not addressed by any mobility innovations • Certain population groups are not able to use new transportation solutions	Transportation needs in a given location
Ethical aspects	• New ethical issues arise due to new supply chains • New ethical issues arise due to new technologies and their use	Ethical aspects of new mobility solutions
Cognitive-cultural aspects	• Difficulties in changing human perceptions prevent from realising benefits of mobility innovations	Human behaviour, mindset, trust
Tragedy of the commons	• Inadequate use of shared or unattended equipment in mobility solutions lead to their failure	Human behaviour
Public health	• Too many transportation options may lead to health problems	Effects on public health

Safety	• Potential threats to passenger/user safety in new mobility solutions • Potential threats to citizens' safety in new mobility solutions	Safety of equipment operation
Security	• Potential threats to passenger/user safety in new mobility solution	Security Cybersecurity
Liability	• Unclear liability in case of accidents and disputes prevents from adopting mobility innovations and realizing their benefits	Liability definition in new circumstances

6.2. New capabilities required

Governors and policy makers need the following capabilities in order to address various economic, social and political factors influencing successful implementation of disruptive mobility solutions:

- ***Institutional power.*** It can be argued that the possession of wider institutional power over mobility in a location can facilitate a more holistic and robust approach towards solving mobility challenges through disruptive mobility solutions. Taking the example of Singapore, the municipality controls whole mobility sector: public space, public transportation, permits etc. and thus is able to develop local mobility system in a directed and holistic manner. This is, however, an exceptional case where the city is also the country and thus national power resides on local level.
- ***Cross-sector coordination***. For example, while construction sector and mobility sector are interconnected, but the different planning departments might lack the forum and competence to collaborate.
- ***Data management*** (security, analysis, etc.) capability becomes indispensable.
- ***Technical competences*** related to data management, but also, for example, autonomous operations are required in order to develop governance of technology-driven mobility innovations.
- ***Pro-activeness, experimentation*** in terms of governing new mobility solutions rather than waiting how other municipalities will address this.
- ***Innovation capability***. Innovation can be seen as a process or output; it could be part of transportation policy.

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