Overall Comparison Between Germany and Japan in Relation to Social Impact of Connected and Automated Driving

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Abstract The chapter "Setting the Scene for Automated Mobility: A Comparative Introduction to the Mobility Systems in Germany and Japan" provides an overview of the framework conditions characterizing the transport systems in Germany and Japan. Following two chapters investigate relation of the governance style to regulatory changes and resource allocation in the new technology development in Japan, and a business analysis and prognosis of the ride hailing market in Germany. The chapter 5 discusses the social acceptance of CAD based on the common survey conducted both in Japan and Germany. Following two chapters include the investigations on various parameters of the German transport system applying three consecutive transport models and scenario analyses, and the effects of the diffusion of CAD on the Japanese transport system applying a model developed by the authors in charge. Based on the discussions above, this chapter discuses several points relating to public expectations, touching on the similarities and differences between Germany and Japan; such as public acceptance affecting CAD diffusion, common expectations of groups and individuals, attitude of car industry, mobility services expected to be realized, differences in forms of residence, decision-making toward diffusion, expectations for the type of CAD initially introduced, forming a correct understanding of CAD by citizens, and risks that may affect expectations.

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This volume presents the main results of a bilateral research collaboration on Connected and Automated Driving (CAD) between Germany and Japan, initiated and supported by the German Federal Ministry of Education and Research (BMBF) and the Cabinet Office (CAO) of the Japanese Goverment. Researchers from both countries discussed and examined potential future impacts of CAD on the transport system, resulting in the six chapters discussed below.

Chapter "Setting the Scene for Automated Mobility: A Comparative Introduction to the Mobility Systems in Germany and Japan" provides a broad overview of the framework conditions that characterize the transport systems in Germany and Japan today (2022). It shows that while Japan and Germany are in some ways very different, there are also important similarities, and that these two countries are pertinent comparative case studies for CAD as they represent the prototypical path for mobility development. This chapter lays the groundwork for understanding the context for the introduction of vehicle automation, and provides a framework for interpreting the findings of the subsequent chapters in the overall context of the two national transport systems.

One specific framework condition that relates to the development and deployment of automated driving technologies and services in Japan and Germany are policy processes. Chapter "Governance, Policy and Regulation in the Field of Automated Driving: A Focus on Japan and Germany" investigates in particular how the governance style relates to regulatory changes and resource allocation in the development of new technologies and innovations in the respective society.

Chapter "Business Analysis and Prognosis Regarding the Shared Autonomous Vehicle Market in Germany" analyzes the current shared vehicle service market in Germany, and applies a holistic business analysis to derive future scenarios as to how this ride-hailing market may evolve with the introduction of shared autonomous vehicles (SAVs). The results show that, due to higher utilization rates, if the SAV diffusion rate was 100%, then around one third of the current shared vehicle fleet in Germany would be needed to serve today's demand. However, although a projected SAV service customer price level range of about 0.6 EUR is significantly lower than current cost of use for ride-hailing services, this may not be low enough to convince a considerable number of passengers to switch from their privately-owned car to SAV services.

Chapter "Social Acceptance of CAD in Japan and Germany: Conceptual Issues and Empirical Insights" sets out how acceptance of CAD is key to its diffusion, and looks at ways to conceptually capture and define social acceptance and understand the full scope of the concept. The analysis is enriched with empirical insights based primarily on quantitative research conducted in Japan and Germany. The chapter discusses changes in attitudes towards CAD and explores how automated vehicles (AVs) have been covered in newspaper reporting. It concludes that in order to achieve a "soft landing" for AVs in society, discussions that involve industry, government, academia, the private sector, and citizens will be essential, and further comparisons with countries that have different societal and cultural backgrounds will be important contributions to the discussion.

Chapters "Transportation Effects of Connected and Automated Driving in Germany" and "Transportation Effects of CAD in Japan" address the diffusion of CAD in Germany and Japan. Both analyses assume a wide deployment of CAD in the late 2030s and show model results for the year 2050. Due to different modelling suits and projection methods, the analyses are shown in two distinct chapters. Three consecutive transport models and scenario analyses are used in chapter "Transportation Effects of Connected and Automated Driving in Germany" for the CAD diffusion analyses for Germany. The results show that while privately-owned AVs are likely to increase car density, shared services might reduce the number of cars in 2050. However, the effects are rather limited, with the highest decrease in car density of −4% in a scenario of automated services in both urban and rural areas, and a share of privately-owned AVs of 43–44% in the 2050 passenger car stock. This mixed traffic of automated and conventional vehicles implies that AVs will not be able to realize their full potential regarding safety and efficiency. It also indicates that despite decreasing car density through shared services in urban areas, new transportation modes compensate for this effect by introducing new vehicles. This might attract trips from all other existing means of transportation, thus resulting in an increase of vehicle-kilometers-traveled of about 5%, which might lead to further congestion. The authors argue that in order to cope with the environmental implications, it is necessary to provide a political framework which stresses the advantages of CAD. Chapter "Transportation Effects of CAD in Japan" addresses the effects of the diffusion of CAD on the Japanese transport system by means of a modelling approach. The results show that higher expectations are more effective than lower costs in promoting adoption of the novel transportation paradigm of driverless taxis. This indicates that an appropriate enhancement of consumer expectations will be crucial for ensuring the spread of AVs. The results also show that enhanced expectations regarding AVs are likely to increase total automobile travel distances by inducing a modal shift toward driverless taxis. This may lead to higher energy consumption and more traffic congestion, as well as increased demand for government spending in areas such as road infrastructure.

This concluding chapter presents the issues identified in chapters "Setting the Scene for Automated Mobility: A Comparative Introduction to the Mobility Systems in Germany and Japan–Transportation Effects of CAD in Japan", and in discussions at the joint workshops held in Kyoto in May and October 2022, which researchers from both countries consider to be particularly significant, and identifies those which should be tackled through further joint research activities in close partnership between Japan and Germany.

1 Key Issues Raised Through the Research Collaboration

The following sections discuss the key issues raised through the joint research activities.

1.1 Social Expectations

Social acceptance of CAD will affect its diffusion. To discuss this point, it is necessary to clarify whether the focus is on the expectations of the individuals respectively the expectations and attitudes of a group of individuals, including experts in different fields, that lead their activity coordination. The former is discussed in chapter "Social Acceptance of CAD in Japan and Germany: Conceptual Issues and Empirical Insights", and the latter in chapters "Governance, Policy and Regulation in the Field of Automated Driving: A Focus on Japan and Germany" and "Business Analysis and Prognosis Regarding the Shared Autonomous Vehicle Market in Germany". Chapters "Transportation Effects of Connected and Automated Driving in Germany" and "Transportation Effects of CAD in Japan" include both perspectives.

Each stakeholder should carefully endeavour to understand whether these discussions focus on the individual expectations or group expectations. These two focus points are intended for consideration by Original Equipment Manufacturers (OEM) and governmental activity and inter-organisational coordination, when considering the user expectations of CAD. This expectation can be interpreted as one of the adjustment mechanisms. In fact, the spread of advanced technologies such as CAD requires not only the acceptance of citizens, but also the actions of governments and industries such as OEMs to create a legal framework, develop and sell products, and obtain support from the relevant authorities.

In addition, when discussing the expectations of society, an understanding of the limitations of our knowledge concerning the social learning process that will lead to the diffusion of CAD is necessary. Social learning plays a role in the dissemination of complex technologies in various ways. Expectations and attitudes within the general public may change as people become more accustomed to them. Innovators may change product specifications or deployment strategies after experiencing public reactions to new technologies. Regulators try to balance the interests of different groups and to adapt regulatory frameworks as they learn more about the qualities and limitations of different technologies, as well as about the intended and unintended consequences and implications of their broader use. We do not know when—and exactly how—this will happen; however, we do know that social learning will influence CAD diffusion. It can promote it if adequately understood and organized, or it can hamper it if ignored or mismanaged. Decision-makers need to understand that these processes will evolve in the coming decades.

Before the COVID-19 pandemic, there were many expectations that the new mobility provided by CAD would solve numerous social problems and create new business. However, much has changed compared to the situation before the advent of the COVID-19 pandemic in 2020.0, and the attitude of the car industry and OEMs seems to have withdrawn. As described in chapter "Business Analysis and Prognosis Regarding the Shared Autonomous Vehicle Market in Germany", a number of OEMs had difficulties to determine their own business models to promote CAD, and stopped or slowed down promoting service-oriented business models. To this day, obtaining CAD services or vehicles from major OEMs is difficult in both Germany and Japan, even if local governments are seeking new public transport services. A limited number of companies offer CAD vehicles, with limited levels of technology.

1.2 Commonalities and Differences Between Japan and Germany

In both Japan and Germany, the car industry is a major industry in the national economic system as illustrated in chapter "Setting the Scene for Automated Mobility: A Comparative Introduction to the Mobility Systems in Germany and Japan". But both German and Japanese experts expect Level 4 automated driving of privately-owned cars to be difficult to realize for the time being.

In both Germany and Japan, there is a common understanding that there are two versions of diffusion paths for CAD. One path is the expansion of the current business model of the car industry that promotes personally-owned automated cars with increased safety, higher comfort and increased mobility options, in order to ensure that car owners appreciate the value of the products, thus leading to the diffusion of personally-owned CAD cars. The other path employs CAD as a new mobility service for citizens in both rural and urban environments, and contributes to the provision of minimum mobility service levels and to the reduction of inefficient vehicle travel to support climate change challenge management. Figure 1[1] illustrates these two paths, and shows that automated driving in mobility services, where the Operational Design Domain (ODD) in which automated driving system works can be limited, can achieve Level 4 at an early stage, while automated driving of privately-owned cars, where a wider ODD must be set, will need to wait for technology to evolve.

To ensure that the existing automotive industry successfully realizes the transformation to CAD, two paths of CAD evolution are conceivable. The first path involving privately-owned passenger vehicles is supported by stakeholder groups that prefer to foster support for an improved level of automation, and supply financial support to the existing industry. These stakeholder groups are strong in Germany because of the extensive OEMs. This attitude is thought to be brought about by the belief that the automotive industry supports the countries economy and should be supported by the government. The second process is supported by stakeholder groups that explore ways to transform mobility systems and make them sustainable, more collective, and less energy-demanding. The groups supporting these two different evolution paths compete with each other.

Figure 1 suggests that the required level of automation may vary for different types of mobility service. For privately-owned cars, the expectation is that the automation level should gradually be raised from Level 2 to Level 3, approaching Level 4. Conversely, for mobility services such as public transport, Level 2 is not supported by

[1] These two paths were originally proposed in a SIP-adus project in 2016, and also reported in the 4th SIP-adus workshop in November 2017.

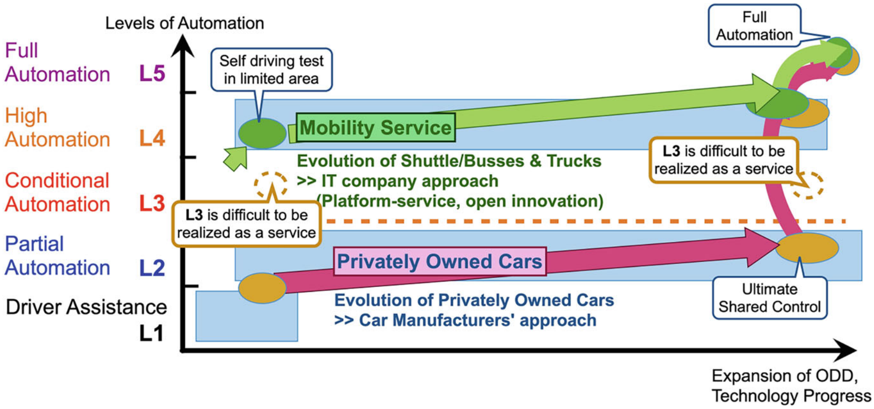

Fig. 1 Overview of the two paths of CAD evolution (modified from Sakai et al. [1])

any stakeholder groups. Although a Level 3 mobility service requires a transitional period, an expectation exists that Level 4 (without a driver), will be significantly appreciated because in addition to the operational flexibility it provides the possibility of considerably reducing the labour costs of human drivers, should the condition of a carefully selected and confirmed ODD be met.

The ODD for the two types of mobility differs completely. Technological, political, and societal expectations differ for different mobility services. However, it is clearly observed that the discussions in the public domain include both types of mobility. As the expectations and assumptions of individuals could differ in discussions or considerations with an unclear definition of mobility, 'mobility' should be defined in advance so that the acceptance or expectations of society can be discussed.

Regarding mobility services expected to be realized, in Japan there are high expectations that CAD will help provide possible mobility to elderly people in rural areas. Although automation itself is not necessary from a user point of view, there is a high expectation of CAD from local authorities and mobility service providers because it is believed that labor costs could be minimized and driver shortages alleviated by introducing CAD. In Japan, public transport services have been stopped in some rural areas, resulting in local governments starting to operate these services as welfare services. In Germany, local governments generally operate the mobility services. But in both Germany and Japan, although it is unnecessary to make a profit from public transport services, a serious concern is the reduction of costs.

In Germany, CAD is expected not only to reduce costs, but also to increase energy efficiency and reduce CO_2 emissions by ensuring a flexible operation of services. Energy conservation has been emphasized from both the environmental and economic perspectives since the oil crisis in the 1970s, and has gained high attention in the course of rising energy costs due to the Russian invasion of Ukraine in 2022.

Conversely, transportation operators and citizens in rural areas in Japan are not seriously considering the reduction of CO_2 emissions, although policymakers request stakeholders to implement steps that may lead to carbon neutrality. In addition, in Japan, there is a high expectation that driverless CAD will solve the driver shortage issue; however, this is not the case in Germany.

Regarding demography and settlement patterns, Germany and Japan have somewhat different forms, as described in chapter "Setting the Scene for Automated Mobility: A Comparative Introduction to the Mobility Systems in Germany and Japan". In Germany, more people live in dispersed rural areas. However, in the rural areas of both Germany and Japan, mobility without a privately-owned car is hard to ensure. From a technical point of view, the introduction of CAD in rural areas is more straightforward where traffic volumes are relatively low, making a consensus for introducing mobility service by CAD easier to obtain. However, the funding resource shortage is a serious issue in most rural areas, except in some wealthy areas where factories of global manufacturers are located and local authorities can secure adequate tax revenue to retain mobility services. In Germany, politicians recognize that one major concern of rural populations s is the lack of options concerning public transport services, although this is not the case in Japan because basic consensus on public transport is different, as described in chapter "Setting the Scene for Automated Mobility: A Comparative Introduction to the Mobility Systems in Germany and Japan". Thus, the improvement of public transport can be politically motivated.

Regarding the expected type of CAD to be initially introduced, as described in chapter "Setting the Scene for Automated Mobility: A Comparative Introduction to the Mobility Systems in Germany and Japan", both Germany and Japan have made a major shift from rail to truck freight. The initial introduction and diffusion of CAD may begin with long-distance truck freight transport. Moreover, with the diffusion of CAD there is the expectation that the understanding and acceptance of society will increase. However, the discussion at the joint workshops in Kyoto reached a conclusion that in last- or first-mile delivery, where drivers are required to fulfil various roles, such as securing and management of loads, loading, and unloading, the introduction of CAD at an early stage from an economic viability point of view may be challenging in both Japan and Germany.

1.3 Decision-Making Toward Diffusion

As described in chapter "Transportation Effects of CAD in Japan", studies in Japan have shown that prior to the actual diffusion of CAD in society, improvement in CAD knowledge and expectations has a greater impact on its projected diffusion than the CAD cost requirement. However, these results should be carefully considered. Once citizens become acquainted with CAD, the cost of CAD will become one of the most important factors affecting its diffusion.

The diffusion of CAD has a complex mechanism. The price of a CAD vehicle could be evaluated by combining the cost with numerous other factors such as the safety level, ease of use of the CAD vehicle, applicability to personal travel needs in a given situation, personal preference between using a privately-owned car or public transport, and electrification levels. These complexities are disjointed and should not be oversimplified, so that an incorrect understanding is not offered by experts to policy makers.

1.4 Possible Risks Arising from the Diffusion of CAD

Discussions in the joint workshops in Kyoto, based on the results of the Chapters, addressed how in order to increase societal acceptance towards the diffusion of CAD, the following risks should be heeded. There are two key points: the use of digital infrastructure, and global supply chains at the manufacturing stage.

Since the realization of CAD is largely dependent on digital infrastructure, resilience against the risk of remote hacking is necessary. Recent geopolitical shifts may lead to the opportunity for citizens to witness digital infrastructure attacks and people may become reluctant to use services using digital infrastructure.

For the manufacture of high-end CAD products by Japanese and German OEMs, materials, semiconductors, parts, and so forth are supplied through the global supply chain. Considering the impact of COVID-19 and economic conflicts between major state powers, the reliance on a single country for any supply is extremely risky. In Japan, where such problems have arisen several times in the past, OEMs have already considered and implemented measures such as diversifying supply bases to Southeast Asian and other countries. Conversely, in Germany, discussions have only just begun on the necessity of dispersing the supply of energy, parts, materials, and so forth.

In addition, the simple replacement of privately-owned cars with CAD, especially in city centers, may lead to serious impacts such as a significant increase in vehicle-kilometers-traveled, as described in chapter "Transportation Effects of Connected and Automated Driving in Germany". Conversely, should citizens change their travel behavior from privately-owned cars to shared services provided by CAD, the total vehicle-kilometers-traveled would decrease. Given the risk that the total number of vehicle-kilometers-traveled will increase, policy efforts are needed to encourage and enable behavior change. It is necessary to clearly indicate the pros and cons of CAD to citizens and promote well-informed understanding of the expected impact for citizens and other stakeholders.

2 Future Avenues of Research

Through the collaborative activities, we were able to answer many of our research questions. At the same time, our joint research activities have led to the emergence of new research questions. These avenues for future research in the field of impact assessment are outlined below.

2.1 Social Acceptance and Adoption

In public and academic debates about the future of CAD, numerous stakeholders (policymakers, industry executives, scientists) stress the importance of "social acceptance" for the successful adoption and diffusion of AVs (chapter "Social Acceptance of CAD in Japan and Germany: Conceptual Issues and Empirical Insights"). This is both encouraging and challenging.

It is encouraging because at least implicitly, this acknowledges that introducing a new mobility technology is also a social program whose outcomes depend on the interplay of three elements:

- the features of the new technology and the mobility services it is intended to enable or improve,
- the regulatory framework (both "hard", i.e. legal, and "soft", i.e. institutional), and
- the attitudes and actions of users and non-users alike.

How these elements and their interdependences are methodologically captured and studied, and how the knowledge gathered by their investigation is translated into action by the variety of innovation actors that take part in CAD development and deployment, is decisive for the actual innovation and diffusion pathways of CAD. It also plays an important role in how these elements contribute to achieving the promises of CAD, as well as to wider societal goals for future mobility systems.

At the same time, the importance and complexity of "social acceptance" in an innovation network create substantial challenges for communication and cooperation between innovation actors, especially across different domains. Within science, there is so far no broadly-shared definition of "acceptance" in general, or "social acceptance" in particular. In substantial parts of the scientific literature, under the umbrella term of "acceptance", at least three phenomena are investigated that could be more precisely described as three different foci of "user acceptance" or "citizens' acceptance":

- the perceptions of and attitudes towards certain products or services,
- the (stated) intention to use them, and
- their actual use.

These are obviously interrelated, but it is well-known that they do not simply translate into each other. Innovation actors in other fields, e.g., in environmental technologies or sustainable consumer products, have experienced remarkable "mismatches" between attitudes and actual use. Since CAD has not yet been introduced at a scale where it has measurable influence on everyday mobility behavior, empirical evidence about changes in usage patterns is still missing. But one might reasonably assume that similar differences or "mismatches" will also occur in this field. It is, e.g., currently still open how attitudes towards autonomous vehicles among interested citizens (the subpopulation usually interviewed during field trials) relate to the actual usage of a new AV-based mobility service within a certain area (which would define the actual impacts). This creates some uncertainty for diffusion scenarios and policy decision-making since the input data so far mainly depend on information derived from early attitude studies.

We recommend that these limitations should be communicated more explicitly among stakeholders and to the wider public, and that the scenarios are adapted as soon as new information becomes available. In science-industry-policymaking debates, the term "social acceptance" appears to have a slightly different meaning than in the academic discussion outlined above. We read it as a metaphor for approaches which are trying to capture the societal dynamics (including diffusion, but also, i.e., user resistance or policy conflict) related to CAD. First studies into certain aspects of this subject have been published, but the large number of innovation actors involved in CAD development and deployment, as well as the vast legal and institutional framework which influences the field, create a complex innovation landscape whose elements and interactions are not yet sufficiently well-captured. Further research should be dedicated to this problem.

2.2 Diversity of Expectations

It can be observed that different stakeholders have different expectations about how CAD can contribute to solving the current problems in the transport system. Some of the narratives, expectations and illusions are unrealistic and exaggerated when reflecting them in serious research studies, such as the studies conducted in chapters "Business Analysis and Prognosis Regarding the Shared Autonomous Vehicle Market in Germany", "Social Acceptance of CAD in Japan and Germany: Conceptual Issues and Empirical Insights", "Transportation Effects of Connected and Automated Driving in Germany" and "Transportation Effects of CAD in Japan". Transport researchers agree that AVs won't be available soon for solving today's transport problems.

Research needs to systematically compile and scrutinize the motivations of the different stakeholders for drawing their narratives. During the joint workshops in Kyoto it was discussed that, for example, providers of AVs and automated services want to convince venture capitalists of their company's merits; therefore, positive expectations towards the market potential and profit generation are key. Moreover, it needs to be researched whether and to what extent the—sometimes exaggerated—narratives of the different stakeholders shape the expectations of society towards CAD. It was also argued during the workshops that the risks of these interrelationships leading to unexpected feedback loops and undesired outcomes should be explored. For example, young people's choice of occupation may be influenced by the expectation that automation will lead to an early rationalization of occupational profiles (e.g., truck drivers, bus drivers). Career choices based on optimistically exaggerated expectations may then lead to an unintended workforce shortage of these occupational profiles in the near future.

2.3 Impact Estimation in Combination with Other Factors in the Transport Sector

Existing research on the impact of vehicle automation on travel and transport has mostly looked at the isolated influence of vehicle automation. This means that—as in the research reported in this book—models were utilized to analyze the differences between business-as-usual-scenarios and business-as-usual-plus-vehicle-automation scenarios. Our findings suggest that vehicle automation makes a difference, but does not lead to a fundamentally different transport ecosystem. The impacts found are not disruptive and make a limited contribution to getting closer to climate- or broader sustainability goals.

However, the interaction between vehicle automation and other factors or measures influencing the transport sector have not yet been explored sufficiently. It may well be the case that vehicle automation unfolds a different potential if combined with—for example—fundamentally altered parking or public transport policies. This is because vehicle automation and other factors may synergetically reinforce—or counterbalance—each other.

A starting point for exploring the potential of vehicle automation in combination with other factors is the formulation of desirable mobility futures, i.e., normative scenarios of how societies envision their future. Formulating such desired scenarios as societal objectives is not a task primarily for academia. Instead, each society—be it on the municipal, national or even a wider geographic level—has its own mechanisms to develop such visions, e.g., through democratic or participatory processes. Hence, the research task in this context concerns approaches of how to integrate vehicle automation as a factor among many such processes, and devise methods to identify the contribution of vehicle automation in combination with other factors. Such approaches and methods may include a wide range of qualitative and quantitative techniques, ranging from scenario planning to travel-demand modeling.

One thing, however, seems clear: while the approaches to automation impact estimation so far were mostly expert systems, in the future it will be increasingly important to develop understandable and transparent methods that work well in co-productive processes which also involve non-expert stakeholders.

2.4 Wider Impacts of Vehicle Automation Beyond Transportation

The convergence of findings by different researchers on the impact of vehicle automation on transport in recent years indicates that we are increasingly able to obtain a better understanding of the likely developments induced by automation. Hence, analyses and models as presented in chapters "Business Analysis and Prognosis Regarding the Shared Autonomous Vehicle Market in Germany", "Transportation Effects of Connected and Automated Driving in Germany" and "Transportation

Effects of CAD in Japan" in this book were successful when it comes to the transport impact of automation. However, transport impacts are—in most cases—only a proxy for other benefits or changes. For example, if we take as an example increased trip length caused by decreased values of travel time: They essentially mean more freedom in destination choice, i.e. increased utility for travelers. However, more travel means more emissions and may—in the long term—also impact on land use and settlement structures.

Hence, there are wider consequences of vehicle automation which impact on many dimensions of sustainability, including the environment, safety, equity and the economy. Among these wider influences some stand out as specifically important but methodologically challenging. These include:

(a) land-use patterns and urban form as a consequence of residential and other location choice interacting with urban planning;
(b) equity impacts as caused—for example—by different capabilities to use automation technologies by different user groups;
(c) impacts of automation on logistics supply and value chains.

For these dimensions of the impact of vehicle automation, strong narratives and some conceptual exploration exist. However, quantitative analysis and modeling for these dimensions of vehicle automation impact is still in infancy and hence represents an important field for future research.

Particularly with regard to the equity issues, it is necessary to systematically investigate which political, institutional, infrastructural, planning and organizational frameworks are required for CAD to contribute to mobility justice. Important aspects include the aging of society, which is a key demographic issue for the future in both Japan and Germany.

Reference

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