Taking responsibility: A responsible research and innovation (RRI) perspective on insurance issues of semi-autonomous driving

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ABSTRACT

Semi-autonomous driving is an emerging – though not unprecedented – technology which cannot necessarily be seen as safe and reliably accident-free. Insurance companies thus play an important role as influential stakeholders in the negotiation and implementation processes around this new technology. They can either push the technology (e.g. by offering beneficial, promotional insurance models for semi-autonomous car owners) or constrain it (e.g. by providing restrictive insurance models or no insurance cover at all). Insurers face questions concerning ethical or societal consequences on various levels: not only when it comes to promoting the technology – whose impact is not yet certain and may range from saving to endangering lives – but also with respect to insurance models such as "pay as you drive", which may involve discriminatory elements. The concept of responsible research and innovation (RRI) is well suited to accompanying and guiding insurers, policy makers and other stakeholders in this field through a responsible negotiation process that may prove beneficial for everyone. Part of the RRI approach is to make stakeholders aware of "soft" factors such as the ethical, societal or historical factors which influence innovation and of the need to include these aspects in their activities responsibly.

1. Introduction

Automation in cars has a long history. While the future vision of driverless and accident-free cars was already discussed decades ago (Kröger, 2016), it has regained momentum in recent years due to the development of ever more advanced driver assistance systems (ADAS). Autonomous driving is now one of the principle visions guiding vehicle technology development. Some experts and stakeholders expect fully autonomous driving to become a reality in the mid-term future and are confident that semi-autonomous cars will be seen on our streets very soon (see for example National Highway Traffic Safety Administration, 2018). Whether such enthusiastic technological forecasts prove accurate or not, there are in any case many socio-technological aspects that involve high degrees of uncertainty, e.g. the public's willingness to allow themselves to be driven by a machine, the issue of liability in accidents involving autonomous vehicles and the question of whether semi-autonomous vehicles will actually have a positive effect on traffic safety. As car manufacturers introduce more and more ADAS to the market, progressing along the path towards fully automated cars, the challenge for policy makers and all stakeholders is to find answers to these emerging questions.

Insurers are key stakeholders in the societal negotiation process around autonomous and semi-autonomous driving and will play a major role when it comes to introducing such technology on the streets. Their veto power – of refusing to insure semi-autonomous or

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autonomous vehicles – not only puts them in a strong and influential position in negotiations, but also entails a societal obligation to accept responsibility in the governance process. It is within their power to influence this process substantially through their attitude towards these new technologies and their regulation. It is up to them to either promote or even push the technology by offering beneficial insurance models, or to undermine the whole undertaking by refusing to insure vehicles driven in autonomous mode.

In this paper, we propose a concept of responsible research and innovation (RRI) that will allow insurers to assume responsibility in the societal negotiation process of automated driving. Consequently, and in line with the focus of this special issue, we concentrate on semi-autonomous driving. After introducing the situation and concepts in use, we expatiate on RRI and its potential for insurers and their role in the negotiation process. We then illustrate this, using pay-as-you-drive insurance models as an example of how semi-autonomous vehicles might be insured. Finally, we end by making recommendations for the insurance sector. Many examples and analyses are taken from or refer to Germany – where a lively debate of visions of automated driving is currently underway – though experiences and perspectives from other countries are taken into account where appropriate.

2. Insurance and semi-autonomous driving: The current situation

2.1. What does the notion of semi-autonomous driving actually refer to?

"Semi-autonomous driving" is a somewhat blurred term. Obviously, actions can be autonomous or not – *tertium non datur*. Nevertheless, this expression is quite common and often used when talking about a preliminary stage on the path towards autonomous driving. Although – or perhaps because – the term is frequently used, it is not clear what it actually refers to. Our aim in the following paragraphs is therefore to clarify our use of the term.

When we talk about semi-autonomous driving, we are using the definition set out in the SAE International Standard J3016 (SAE International, 2014) on vehicle automation, which is very widespread not least because it has been adopted by the NHTSA (US National Highway Traffic Safety Administration) and other institutions. The SAE standard recognizes six levels of vehicle automation, from 0, referring to no automation, to 5, meaning full automation. The steps in between are driver assistance (1), partial (2), conditional (3), and high (4) automation. In line with this definition, the levels we are referring to when we use the term "semi-autonomous" in this article are level 3 and level 4 automation. The levels 1 and 2 describe forms of automation that have already been realized in current car models in the form of ADAS. The first level 3 technology is ready to be launched in the form of Audi's new traffic-jam pilot in its 2019 A8 model. So far, however, the necessary legal approval has not been granted (Nguyen, 2017). Levels 4 and 5 represent the technological developments that stakeholders – and the automotive industry in particular – expect to see in the future. As they have yet to be implemented, any reference to level 4 or 5 vehicles is a question of visions and expectations. The technological development itself is still unpredictable and uncertain; it is unclear whether the associated expectations and aims will in fact ever be met. Its socio-technical implications are equally uncertain. Nevertheless, visions of highly automated and autonomous driving influence not only the construction and design process, but also the way stakeholders act: their expectation that such vehicles will become a reality in the future prompts them to take action to regulate the forthcoming technology and ensure its good governance. For stakeholders, this means adopting a particular stance towards the vision and the possible future technology (Grunwald, 2014). A wide range of professional, political, and civil society stakeholders are involved in negotiating the best ways in which to shape the technology's development and influence its outcome.

Level 3 and level 4 automation, which we refer to in this paper as "semi-autonomous", is of particular interest in that it involves delegating a high degree of responsibility to the vehicle. At the same time, this is still a long way from full automation or even "autonomy". While both level 4 and, to a lesser extent, level 3 go beyond present legislation, they still require very different regulation to that needed by fully autonomous driving modes. The challenges they pose with respect to ethical, social, and liability issues in a mixed and complex driving environment also differ in certain respects from those posed by full automation. While some parts of our analysis also apply to fully autonomous driving, we will focus in the present paper on the more pressing issue (in terms of its state of technological development) of semi-autonomous driving.

2.2. The safety argument and the challenge of risk determination

Supporters of vehicle automation often claim that it will reduce accident numbers. In its National Motor Vehicle Crash Causation Survey (NMVCCS), conducted from 2005 to 2007, the NHTSA also found that drivers are at least partly responsible for more than 90% of road accidents (National Highway Traffic Safety Administration, 2008, US Department of Transport, 2017, p. 67). In their conclusion, they expect ADAS to help prevent accidents. In a similar vein, semi-autonomous cars are expected to reduce not only car accident numbers but by extension also car insurance premiums – at least in the long term. Risk calculations for these premiums are challenging, however. The actual impact on safety that semi-autonomous driving might have is unclear. As new automated driving features entail new dangers (e.g. mixed traffic with different levels of automation, situations in which drivers take back control), extrapolating accident statistics may not be appropriate (Kalra and Paddock, 2016, p. 183). Alongside many endorsements of vehicle automation, there are also sceptical voices: "Despite their potential benefits, automated vehicles currently possess a number of limitations that technology has not yet been able to overcome. Most notably, semi-automated vehicles are not able to drive in more complex or challenging road conditions or environments" (Robertson et al., 2016, p. i). The impact of semi-autonomous or autonomous driving is uncertain and may range from saving to endangering lives and from reducing to increasing costs (also keeping in mind a scenario in which accident rates decline but the costs per accident rise). Thus there is no clear indication, based on either financial or ethical perspectives, as to which development should be favoured and supported by insurance companies. Furthermore,

new approaches and knowledge are needed to calculate premiums as there are no historical records for semi-autonomous driving risks and damage costs (Munich Re, 2016). Understanding the reliability of machine decisions will be a key factor, as will the use of machine learning tools to calculate premiums more accurately by taking more data types and variables into account (see Section 4.1). Increasingly generated in-car, the accessibility of this data will play a role in determining whether insurers are able to remain competitive. Access will need to be negotiated with car manufacturers. The European regulation proposed the creation of "an interoperable, standardised, secured, and open-access platform or possible future in-vehicle applications or services" (European Parliament and Council of the European Union, 2015). However, there is no agreement about the structure and design of the technical solution for this aim by the different stakeholders. While OEMs favour transferring in-vehicle data to an OEM-own server, which is then made accessible to third-parties, they would be disadvantaged with regards to limited and delayed access to (time critical) data and would favour direct access to data via an on-board interface (European Commission, 2016, pp. 76 f).

In addition, clear licensing regulations and high standards of testing appear indispensable. This is especially important for insurers, as weak licensing requirements that result in higher accident costs would have to be taken into account when calculating premiums. Defining and designing new testing methods for semi-autonomous vehicles constitute a huge challenge, however (Winkle, 2016, Kalra and Paddock, 2016). No matter how much effort is put into testing and validating, safety testing is very different for automated systems and 100% safety will never be achieved (for a detailed discussion see Wachenfeld and Winner, 2016, p. 447).

2.3. Legal frameworks for semi-autonomous driving and driving insurance

As described above, semi-autonomous driving is still only a vision. As with any future innovation, the impact it may have on such aspects as vehicle safety and the incidence and severity of road traffic accidents – be it negative or positive – is still uncertain. This poses a challenge for regulatory authorities in general, and for regulators of liability and insurance in particular. The legal framework, in turn, is of crucial importance to all stakeholders, and especially to insurers and their attitude towards the emerging technology. When determining stakeholder relations between manufacturers, insurers, and drivers with respect to financial risk distribution in the event of accidents, this is a central issue in the negotiation process. Accordingly, this section explores current legal regulations concerning insurance issues that govern the relations between insurers, car manufacturers, and drivers. As the legal framework for semi-autonomous driving is still being discussed and revised, and to date has not been harmonized within the EU, we will focus on the legal situation in Germany as an example, highlighting differences in other countries merely in passing.

Current regulations (Regulation 79 of the Economic Commission for Europe of the United Nations (UNECE) and the Vienna Convention on Road Traffic (VC)) allow automated vehicles provided that drivers can either manually override the autonomous systems or keep their hands on the steering wheel at all times. Due to the urgent need to clarify regulatory issues, the UNECE World Forum for Harmonization of Vehicle Regulations prioritized the regulation of automated vehicles in the ongoing revision of *Regulation 79*. Nonetheless, it regards comprehensive regulation as a long-term goal because this will depend on future technical development and testing (European Commission, 2015, p. 13). It is likely even after the revision of *Regulation 79* that drivers may not be allowed to benefit from all the capabilities of semi-autonomous cars unless they take full responsibility for liability and safety risks themselves (for a more detailed discussion, see European Commission, 2017; Lutz, 2016).

A regulatory solution designed to clarify liability relations between stakeholders would have to define the rights and duties of drivers of semi-autonomous cars in order to distinguish "normal" human driver errors from careless behaviour in this new situation. A recently adopted amendment to the German Road Traffic Act was sharply criticized, not only by some policy makers (Deutscher Bundestag, 2017b), for leaving important questions unanswered, e.g. how quickly a driver should be able to take over control of the car in the case of an emergency. Other stakeholders also voiced their doubts. In its official statement about the draft amendment, the influential German Automobile Club (ADAC) for example criticized the lack of legal certainty (Deutscher Bundestag, 2017a). The *Sorgfaltspflichten* (due diligence obligations) contained in the German Road Traffic Regulations *(StVO)* clearly need to be reconsidered in much greater detail. These state that drivers should be thoughtful and take care not to cause harm while driving, though they are generally allowed to engage in other tasks, such as talking to other passengers. So far, StVO (article 23) only prohibits drivers explicitly from using their mobile phones, which is probably one of the biggest potential distractions. Overall, the authorities in Germany (and in other countries) seem to continue to refuse to permit drivers to engage in other activities while driving, yet this is one of the key advantages promised by semi-autonomous driving. However, the temptation to do so, not to mention the fatigue that results from constant monitoring, will nevertheless pose new safety risks.

While various driver liability models exist in the different EU Member States (for a comprehensive overview, see Schellekens, 2015), there appears to be a degree of consensus that some form of "no-fault insurance" such as Germany's *Kfz-Haftpflichtversicherung* would be suitable for automated vehicles and might help implement autonomous driving (Eastman, 2016, p.1; for the historical development of the German Haftpflichtversicherung, first introduced in 1909, see Arps, 1976, Gadow, 2002). If insurance is obligatory for car owners and liability is not fault-based, insurance will not be dependent on the technology; it is irrelevant whether the vehicle is driven by a human or a machine (Schellekens, 2015, p.516). Furthermore, it provides compensation for accident victims without having to embark on a complex and costly process to determine who is at fault (Eastman, 2016, p.1). However, this regulation leaves the problem of determining who should ultimately pay for accident damage. The new risks as mentioned above could result in higher costs for insurers, and consequently for their clients in the current legal situation, though these might be reimbursed if manufacturers are taken into regress on the basis of product liability. It is harmonized to a considerable extent in the EU (Schellekens, 2015, p.209) and makes manufacturers liable for hardware or software errors. Since vehicle functions are controlled by ADAS rather than by the driver, liability should be transferred increasingly to the technical system – and by extension to the manufacturer. Some experts in fact predict a general shift from driver liability to product liability in autonomous vehicles (Smith, 2017, Gasser, 2016,

Sheehan et al., 2017). It is questionable whether this shift will already take place when it comes to semi-autonomous driving with respect to the regulatory situation, however. Product liability will probably be less a matter of debate in level 4 automation, as the system in this case – by definition – should be able to operate the vehicle independently in certain, predefined situations (e.g. on highways). By contrast, in level 3 automation the human driver – again by definition – is responsible for the vehicle regardless of whether the car is in assistance mode or not. In any case, the "black boxes" that are included in passenger cars equipped with ADAS might be helpful in ascertaining the cause of the error (driver or machine) in the event of an accident (Gasser, 2016, 545-546; for a more detailed summary of product liability, particularly in Germany, see Winkle, 2016). What makes the situation more difficult for insurers is that product liability is limited in scope and entails notifiable exceptions.[1] Furthermore, car insurers will have the burden to prove the defect, the damage and the causal relationship between the defect and damage (§ 1 (4) ProdHG). A more positive consequence of potential vehicle part errors for the insurance sector is that a shift towards product liability is expected to increase the demand for product liability insurance (Sheehan et al., 2017, p. 125). As semi-autonomous driving is accompanied by an increase in sensor systems, electronics, and program parts, the risk of technical failures increases simultaneously.

Potential conflicts about how accountability is allocated between manufacturers, suppliers, insurers, and car drivers and owners as described above should be addressed at an early stage by adequate regulations and in negotiations concerning the implementation of semi-autonomous driving.

2.4. Expectations of semi-autonomous driving and the understanding of responsibility within the insurance sector

We will now take a brief look at how the insurance industry itself envisions the implications of the technology, and how this is already apparent in its behaviour on the market. Despite technical and regulatory uncertainties, insurance companies take a positive attitude towards automated cars and already provide discounts for cars with assistive technology that have been proved to reduce accidents (Kollewe, 2016). In Germany, France, and Great Britain, for example, the insurance company Allianz offers cheaper insurance (a 25% discount) for cars with automation (Allianz, 2016, Titcomb, 2016). As automated systems are seen as making cars safer and helping to avoid accidents – by up to 38 percent in the case of autonomous emergency braking, a study found (Fildes et al., 2015) – insurers are obviously willing to support this development. However, these initial signs should not be viewed as a reliable indicator of future developments on the market, especially given the very limited number of cars that are equipped with ADAS to date. If semi-autonomous vehicles were to successfully reduce crashes in the future, this could pose a challenge for insurers. First, falling premiums could have a potentially negative impact on revenues and lead to tougher competition (Sheehan et al., 2017, p. 124). Second, car manufacturers, which are already involved in car-sharing and rental activities and are moving towards further diversification, might even decide to offer insurance themselves – depending on how discussions of and legal developments relating to responsibility and liability proceed. This is clearly an alarming scenario for insurers (Murphy and Mullins, 2016; Fortune, 2016), as well as from a societal perspective: carmakers will have a strong interest in claiming the infallibility of their own autonomous cars as compared with manually driven cars. This could be very problematic for manual drivers, as it would jeopardize fair insurance compensations for them.

There are also those who take a very sceptical view of the promise that semi-autonomous driving will reduce accident numbers and believe that the safety argument is overrated. Siegfried Brockmann, head of accident research for German insurers (UDV), argues that drivers are better than generally assumed – causing only one accident with personal injury every three million kilometres. Moreover, he claims that human drivers, if no longer required to steer the vehicle, are not a good emergency backup in the event of an imminent accident, at least when they are engaged in other tasks (GDV, 2015a). A reliable machine-driver handover – be it in predefined standard situations (as expected with "level 4 driving") or in situations in which the driver serves as the fall-back authority (which should be the case more often in "level 3 driving" than in "level 4 driving") – also remains a socio-technical challenge (Walch et al., 2015). Insurers have to rely on robust testing regulations to minimize their financial risk when insuring new cars. Consequently, the German Insurance Federation (GDV) calls for mandatory testing processes for automated cars with a view to minimizing these new risks for insurers (GDV, 2015b). We have already mentioned the difficulties of semi-autonomous vehicle testing, which give rise to uncertainties about the reliability of this type of car as compared to manually driven cars.

The uncertainty surrounding any rapid technological development that could simultaneously entail significant benefits and high potential risks constitutes a complex challenge for insurers and requires them to act within a constellation involving a wide variety of interdependencies between the different stakeholders, as we shall see in the following section. If the insurance industry were able to define its responsibilities in this process, this would be an important step towards adopting a strategy capable of managing the challenge posed by the new technology.

Within the framework of their corporate social responsibility activities, some insurance corporations have formulated an understanding of responsibility with regard to their own business and their particular possible impact on society, as the following examples may illustrate:

- **CIS** feels it has a responsibility to improve road safety and claims that it has "a duty to try and prevent future losses, which in turn

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[1] The scope of the Product Liability Act only covers property damage if this damage was caused to an item of property other than the defective product (§ 1 (1) ProdHG), if the item of property is used for private use, which is a problem for taxis or public transport vehicles (§ 2 (1) ProdHG), and the state of scientific and technical knowledge at the time when the producer put the product into circulation was not such as to enable the defect to be discovered (Winkle, 2016). A transduced text of the German law is available online: https://www.gesetze-im-internet.de/englisch_prodhaftg/englisch_prodhaftg.html#p0013 (last accessed: 31.01.2018).

will make motor insurance more affordable, especially for young inexperienced drivers" (Easier, 2007).

- **HUK Coburg** spoke out in public against manufacturers or any industry or company in general having a monopoly on vehicle data, stating that in the interests of consumer protection people should have a choice about who owns their data and for which purposes (Franz, 2017).
- **Allianz** sells PAYD as a means of educating drivers and as proof that they attribute high value to the privacy of their customers (Allianz, 2017).

In adopting these stances, insurers go beyond what Porter and Kramer (2006) criticize as random charity projects and PR activities. However, none of the activities mentioned above are by any means promoted without self-interest: if car manufacturers had a monopoly on vehicle data, the insurance business would lose access to valuable data. It is also clear that insurances wish to avoid losing young drivers as customers or the trust of customers when it comes to privacy issues. Overall, the cited activities and statements are reactions to market requirements and struggles for competitiveness rather than proactive commitments to society.

As we will argue, the RRI concept is a very apt and indeed indispensable new tool for insurers willing to take a more active role in the innovation process of semi-autonomous cars in a responsible and socially desirable way. The following section will therefore provide a brief overview of the concept of RRI. We will then explore how this concept can be used to highlight the relationships between insurers and different groups of relevant stakeholders, while at the same time raising certain ethical questions and drawing attention to the various responsibilities that arise in innovation processes relating to semi-autonomous driving.

3. Insurers and semi-autonomous driving from an RRI perspective

3.1. What is RRI?

The key words "responsible" and "socially desirable" play an important role in the conceptualization of responsible research and innovation (RRI). In one of its best-known definitions, the concept is described as "a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)" (von Schomberg, 2011, p. 9).

This definition already suggests that RRI can be seen as a concept that goes beyond earlier approaches such as constructive technology assessment (CTA) or the social shaping of technology (SST) (Grunwald, 2011).[2] Owen et al. (2012) expand on this by elaborating three distinct features of RRI. The first feature can be subsumed under the notion of "societal desirability" or "science for society" (Owen et al., 2012, p.754). In this respect, RRI sets itself apart from earlier concepts in that it focuses more on the positive potential of science and innovation rather than dealing with the negative aspects associated with technological or scientific advances – their risks and unintended negative impacts (Owen et al., 2012, p. 754). Grunwald (2011) explores a similar feature of RRI, writing that RRI, while sharing the same motivations as technology assessment (Grunwald, 2011, p. 14), goes further in shaping not only technology but innovation itself, "according to society's needs, expectation and values" (Grunwald, 2011, p. 16).

The second feature of RRI is described by Owen et al. (2012) as "science with society", which consists of three dimensions: reflection, anticipation, and inclusive deliberation. These three dimensions themselves are not new developments found solely in RRI practice. They are "building on concepts of anticipatory governance, technology assessment in its various forms and public engagement." (Owen et al., 2012, p. 756). What sets RRI apart is that it integrates these three dimensions to form a framework (Owen et al., 2012, p. 756) and as such becomes institutionalized in policy- and decision-making processes (Owen et al., 2012, p. 756). This "dimension of responsiveness" (Owen et al., 2012, p. 756) can also be found in von Schomberg's (2011) definition and is a distinctive feature of RRI. The aspect of inclusive deliberation with and the inclusion of various stakeholders in the innovation process is especially important.

The third distinct feature of RRI is the way it "reframes responsibility" from the (individual) scientist to other actors in the innovation process such as "universities, innovators, businesses, policy-makers and research funders" (von Schomberg's, 2011, p.756) and, more broadly, towards a collective approach to responsibility. The latter might be supported by public debate and by what has been described as a "particular moral obligation to engage in the collective debate that shapes the context for collective decision making" by members of the public (von Schomberg, 2007, p. 12).

These and similar conceptual considerations concerning RRI have also found their way into the Horizon 2020 programme of the European Commission (EC), based on early activities supported by the EC (de Saille, 2015). This is particularly true of the "Science with and for Society" funding programme, though it also applies to other areas due to the results of efforts to mainstream the concept. In the European context, RRI is seen as a way of enabling collaboration between different societal actors and stakeholders and thereby enhancing the research and innovation process through a focus on engagement and access to data, as well as by increasing equality, focusing on ethical aspects and furthering information and education (European Commission, n.d.).

In recent years, there have been many more discussions about RRI, and a wide variety of activities on and in line with RRI principles – including many projects funded by the EC and others – have been conducted. These include wide-ranging, multi-

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[2] Another earlier approach in this regard is the aforementioned concept of Corporate Social Responsibility (CSR). RRI considers societal desirability from a non-expert perspective and from the start, while CSR attempts rather to diminish negative impacts of technology and business and does not necessarily involve non-expert opinions. Porter and Kramer (2006) discuss these and other shortcomings of CSR.

stakeholder and public dialogue projects (e.g. Zwart et al., 2017) as well as projects and other activities tailored to the needs of specific stakeholder groups such as civil society organizations (CSOs) and industry (Lubberink et al., 2017, Porcari et al., 2015). At the same time, conceptual and methodological work on and discussions of RRI have become more diverse. This has resulted for example in proposals to use principal-agent theory to better understand and help improve RRI processes (Bolz, 2017), or to include – especially with a view to visions of the future (or to broad "guiding visions") – a hermeneutic perspective (Grunwald, 2014). Furthermore, it has been variously pointed out that the concept of RRI focuses on socio-economic issues – as distinct from ethical and risk issues, for example – to a greater extent than older "science and society" approaches, placing the emphasis on such aspects as competitiveness, employment, and valorisation (Zwart et al., 2014) but still lacking social specificity (Coenen, 2016). As a process innovation (Coenen, 2016), the rise of RRI has also led to debates about the pros and cons of rights-based decision-making processes on the one hand (Ruggiu, 2016) and of new governance models on the other hand, which more strongly emphasise the co-shaping and co-creation of innovation by a wide variety of stakeholders (Groves, 2015). This key element of the concept of RRI implies a further weakening of the traditional expert role as compared to earlier risk and even ethical discourses. At the same time, the shift from safety to responsibility may entail a shift in responsibility from the developers and producers of a technology to its users or other stakeholders, thereby falling short of the ideal of shared responsibility (Van de Poel and Robaey, 2017).

A proactive approach to meeting society's demands and openly communicating the inherent risks of a technology most certainly has good chances of being well received by the public and of standing out from other business approaches. There is growing public awareness of the ethical issues of technology, particularly with regard to privacy, and scandals in the car industry in recent years have shattered trust in some companies. Historically, insurance and technological developments have mutually influenced one another in many cases. The role played by fire insurance in the later phase of the industrial revolution is often overlooked, for example – as is the impact that this new type of insurance had on the structure and system of the insurance business itself (Henning, 1980). Insurance also plays a prominent role in the history of the automobile: mass motorization would have been impossible without third-party insurance (Arps, 1976, Gadow, 2002). Whether insurers took these actions primarily in recognition of their societal responsibility – third-party insurance cover was first offered at the end of the nineteenth century, before legal regulation (Gadow, 2002, p. 47) – remains the subject of historical research and debates. The RRI approach serves not only as orientation for insurance companies concerning the desirability of semi-autonomous driving and the decision of whether to support it or not, but also with regard to innovation in the insurance sector itself: in terms of insurance pricing models. Safety by design is now common practice and RRI is the response to the demand for responsibility by design.

3.2. RRI as applied to insurance issues of semi-autonomous driving

Applying the RRI concept to semi-autonomous driving immediately raises three overarching questions, upon which we will focus in the following:

1. Innovation for society: Is it actually desirable for society to further promote innovations in the area of semi-autonomous vehicle features? To answer this fundamental question, it is necessary to look not only at the statistics and scenario-based forecasts (e.g. do semi-autonomous features prevent severe or even fatal accidents?) but also at their social and ethical implications.
2. Innovation with society: Who are the stakeholders and relevant actors that need to be included in the shaping of the innovation process? How do these actors relate to each other, and how ought they to?
3. Reframing of responsibility: Who should be held responsible for any potentially negative consequences of the implementation of semi-autonomous cars, and why?

When focusing on the insurance sector with the first and most fundamental question in mind – whether the implementation of semi-autonomous driving innovation is in fact desirable for society – it becomes clear that it is not reasonable to expect insurers to answer this question on their own. Instead, this seems to be a question that should be decided collectively on the basis of the available facts and likely scenarios. We will discuss the other two questions below, focusing on ethical considerations and trying to identify any unresolved issues that may arise in attempts to balance the interests of the respective stakeholder groups.

3.3. The relationship between insurers and other stakeholders: Ethical and social aspects

The list of stakeholders who are relevant to the debate about semi-autonomous driving and are thus connected in some way to insurers is longer than might initially appear. Some stakeholders were already mentioned above: car manufacturers, regulatory agencies and policy makers. They have a direct and obvious impact on the decision-making process of insurers. Insurance companies depend on car manufacturers sharing important data so that they can calculate their premiums. In turn, both insurers and manufacturers rely heavily on legal regulations that clarify how semi-autonomous driving should be implemented, how liability laws should be applied and what all this entails with respect to the (legal) responsibilities of each stakeholder group.

On the other hand, decisions taken by insurers in order to conform to legal regulations or the data provided by car manufacturers have an impact on their customers. These can be subdivided into two groups: drivers of semi-autonomous cars and drivers of cars with very little or no ADAS. Apart from more directly related stakeholders, insurers have also to keep in mind other stakeholders such as society at large and its influence on policy makers with regard to regulations (Bolz, 2017), as well as especially vulnerable road users such as cyclists and pedestrians (Directive, 2010/40/EU, article 4(7)). Though not involved in a direct customer relationship with insurers, the latter are nonetheless strongly affected by decisions made by insurers, e.g. concerning the level of pedestrian safety

programmed into the software of a semi-autonomous car they insure.

The stakeholder group that insurers most obviously have to negotiate with are their customers, as they rely on their acceptance. In addition, society at large or "public acceptance" can have a major impact on insurance companies as well, e.g. through media coverage of the question of insuring semi-autonomous driving. Since car insurance is obligatory, liability issues are a central topic in the public debate on semi-autonomous cars and may intensify the already high degree of competition in the insurance industry. Critics warn against premature regulatory measures and the suspected strategy of car manufacturers and insurance companies to burden vehicle owners with the risks. Furthermore, there are concerns about the costs of automated driving (Bazilinskyy et al., 2015, p. 2536, Table 1), perhaps as a result not only of increased car costs but also of increased insurance premiums. This could raise questions of distributive justice. The issue of fair access to semi-autonomous cars needs to be considered, especially in light of the costs of infrastructure that will be borne by everyone, not only by the direct beneficiaries of the new technology. Furthermore, insurance incurs considerable costs for drivers. Thus it should be taken into account that a new car with the newest technology will not be affordable to everyone and that existing inequalities in terms of wealth should also not be exacerbated by raising the costs of insuring older, manually driven cars (Grunwald, 2016, p. 650). Privacy is another central issue in the public debate, and insurance companies need to find a way to comply with data protection regulations and conform to public privacy demands while at the same time using vehicle data to calculate premiums and make claims to manufacturers for regress.

These ethical questions of privacy and data protection as well as problems of distributive justice – concerning both the penalising of people who cannot afford semi-autonomous vehicles by charging higher insurance premiums and the unfair burdening of risks to the disadvantage of drivers – should not only be addressed simply by following customer wishes or public opinion. Genuine ethical challenges arise when seeking to reconcile the interests of different stakeholder groups regarding semi-autonomous driving.

One of these ethical challenges is also faced by insurers when dealing with their different customer groups: both the drivers of semi-autonomous cars and the drivers of conventional cars with little to no ADAS are customers of insurance companies, and it is in the interests of these companies to keep both groups satisfied so as not to lose them to a competitor. It is between these two groups of drivers that an old ethical challenge arises: the debate over whether safety should be valued above freedom (in personal decision making) or freedom above safety. (See, for example, the discussion of the ethics committee on automated and networked driving on behalf of the German Federal Ministry of Transport and Digital Infrastructure: Bundesministerium für Verkehr und digitale Infrastruktur, 2017, p. 10, 20). The joy and freedom associated with manual driving seems to be of value to a substantial number of drivers, as shown by Robertson et al. (2016), who report that a majority of respondents (69%) strongly agreed that they enjoyed driving (Robertson et al., 2016, p. 12). Similarly, Bazilinskyy et al. (2015) point out that the "joy of driving" prompts people to choose manual driving over automated driving. While it is important for insurers to know about the preferences of their customers, these studies show that it can be problematic from an RRI perspective to rely solely on surveys or opinion polls. What people in their role as users of semi-autonomous cars and customers of insurance companies want and what is morally right and societally desirable to do are not always the same. As far as the freedom and joy associated with driving a manual car is concerned – which incidentally might prompt insurers not to offer excessive incentives to buy semi-autonomous or indeed fully autonomous vehicles – the first consideration should be whether the benefits of experiencing freedom and joy while driving outweigh the potential costs, namely an increase in the number of accidents involving more severe injuries or deaths. Providing drivers with incentives to buy semi-autonomous cars for safety reasons to the detriment of drivers who choose manual cars might in fact be the ethically right thing to do, even if this runs contrary to the interests of a substantial group of customers of insurance companies and by extension to the interests of insurers themselves. A societal consensus is needed if insurers are to know which position to take on this matter. It is telling that even the aforementioned German ethics committee does not offer a clear stance on this matter and instead advocates a "democratic process of consideration from a fundamental rights perspective" with respect to the reduction of safety risks and restriction of personal freedom (Bundesministerium für Verkehr und digitale Infrastruktur, 2017, p. 20, own translation).[3]

The topic of "safety" (and especially of "safety distribution") also plays a central role in another ethical challenge, one that concerns the different interests of drivers of (both manually driven and semi-autonomous) vehicles on the one hand, and of more vulnerable road users, like cyclists and pedestrians, on the other. Studies discussing surveys and focus group results indicate highly ambivalent attitudes in regard to this question: respondents tended to adopt somewhat contradictory stances, according general priority to the safety of groups of people or innocent bystanders while at the same time exhibiting a kind of "self-preserving attitude" in advocating autonomous vehicles programmed primarily to protect the vehicle's occupants (Robertson et al., 2016, p. 16; Bonnefon et al., 2016, p. 1573).[4] While these findings might give insurers a reason to favour semi-autonomous vehicles that prioritize vehicle occupant safety, this might not be the ethically right approach. It might equally be argued that (1) drivers of cars (semi-autonomous or not) pose a greater risk to other road users (Hevelke and Nida-Rümelin 2015, p. 626, Statistisches Bundesamt, 2016, p. 30[5]), doubtless on account of their size, speed and mass. And (2), that drivers are actually safer in collisions with these vulnerable road users because of the crumple zones in modern cars (Robertson et al., 2016, p. 16). As such, it might be ethically right to prioritize the safety of cyclists and pedestrians for two different reasons. The first concerns considerations of justice and fairness: if cyclists and pedestrians are not the ones making road use more dangerous, why should they be the ones burdened with significantly more of the

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[3] In the same section, the ethics committee of the German Federal Ministry of Transport and Digital Infrastructure remarks critically on "pay-as-you drive" insurance models as having the potential to undermine the "idea of a responsible citizen" (Bundesministerium für Verkehr und digitale Infrastruktur, 2017, p. 20, own translation). For our own take on pay-as-you-drive insurance models, see Section 4 in the present paper.

[4] The ethics committee of the German Federal Ministry of Transport and Digital Infrastructure mentioned above seems quite clear on this matter: in the case of accidents involving (semi-)autonomous cars, innocent bystanders should not be victimized (Bundesministerium für Verkehr und digitale Infrastruktur, 2017, p. 11).

[5] The majority of fatal accidents involving cyclists and pedestrians are caused by collisions with cars.

risks? Hevelke and Nida-Rümelin (2015, p. 626, 629) provide a similar argument in favour of attributing the responsibility for crashes to the users of fully autonomous vehicles. The second reason relates to safety considerations: while occupants of cars may suffer injuries in collision accidents, those suffered by cyclists and pedestrians are likely to be more severe and also lead to more fatalities.[6] The second line of thinking was used for example by the above-mentioned focus groups as an argument in favour of prioritising the safety of vulnerable road users over that of vehicle occupants (Robertson et al., 2016, p. 16). The first argument can be seen as an implicit reason why the notion of "operational risk", for example of a car, is interpreted very broadly in the German Road Traffic Act (StVG; see Bundesministerium der Justiz und für Verbraucherschutz, 2017b). According to Ernst (2011), the broad liability defined in Section 7 (1) of the StVG can be "regarded as the price" of allowing the use of motor vehicles despite their being a source of danger (Ernst, 2011, p. 241). In this case, insurers may have to make an unpopular decision that runs contrary to the wishes of a large stakeholder group - their own customers: namely that offering incentives to opt for semi-autonomous vehicles that prioritize the lives and safety of vulnerable road users like cyclists and pedestrians may have economic disadvantages but is still the right choice from an ethical perspective.

3.4. Insurers as key stakeholders in the debate about whether semi-autonomous driving is a responsible and ethically acceptable innovation

Since questions of liability and insurance are central to the debate about the potential consequences of extensive use of semi-autonomous driving, insurers are not only a crucial but also a powerful stakeholder group because they have the capacity to influence the use of semi-autonomous cars in one of two extreme directions. Were insurers to refuse to insure damages incurred by semi-autonomous vehicles, it would be very difficult if not impossible to establish them on the market (unless manufacturers assume the role of insurer, though this could also cause problems for them due to negative PR). If insurance premiums for the drivers of semi-autonomous cars were to fall, sales might well increase, as might the scope for manufacturers to invest in further innovation. Thus insurers either drive forward innovation or create obstacles – in both cases via financial incentives.

A democratic and constitutional deliberation process should decide how much value is attributed to reducing safety risks when this involves curtailing individual freedoms, as there is no ethical rule that always favours safety or security over freedom (Bundesministerium für Verkehr und digital Infrastruktur, 2017, p. 20). Furthermore, decisions about ethics programmed into the software of semi-autonomous cars should be based on more than opinion polls of customers, as these after all represent only one of the road-user stakeholder groups.

Such broad public discourse might alleviate the burden of insurers having to decide on their own which car types they should support. A broad societal discourse could ensure that public values are upheld by car manufacturers when designing vehicles and by insurance companies, while at the same time providing both stakeholder groups with a reliable and appropriate framework within which to operate.

The insurance industry would be well advised to promote a broad discussion and deliberation process based on a strong RRI approach (Coenen and Grunwald, 2017) that closely links public discussions and stakeholder deliberations to political decision-making processes. As regards the breadth of the deliberative process, it would make sense to design it in such a way as to take the wide variety of perspectives into account at the earliest possible stage.[7]

The following section will focus on the concept of pay-as-you-drive insurance, this being one specific example of how insurers are already having to deal with the challenges to their business practices posed by technological innovations in the car market.

4. Example of the application of RRI in pay-as-you-drive insurance models

4.1. PAYD – How it works and why it will gain importance

Pay-as-you-drive (PAYD) and similar insurance models use telematics systems or mobile phone apps to calculate premiums according to individual driving behaviour. While telematics and PAYD tariffs are not a new phenomenon, and some national markets (Italy) have already moderate to high market shares, telematics insurance market was projected to expand from $857 million in 2015 to $2.2 billion in 2020 (Institute of international finance, 2016, p.8). With the introduction of semi-autonomous driving, the amount of data produced in cars – which are already equipped with many electronic systems – will increase significantly. Innovation in the insurance sector equals data usage with modern technologies, and one application area is risk and premium calculation based on real-time data from the car (Institute of international finance, 2016, p.6). PAYD insurance models already use vehicle-specific data to calculate premiums, and are likely to do so to an even greater extent in semi-autonomous vehicles. According to insurers, factors currently used are the time of the day, mileage driven, velocity, weather, type of streets, acceleration behaviour and curve behaviour (Allianz, 2017). In-car behaviour like texting, operating the radio, and talking on the phone has been considered by the insurance

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[6] According to data published by the German Federal Statistical Office, this is in fact the case for roads with an increased incidence of accidents involving motorized vehicles and pedestrians or cyclists. On roads in built-up areas and within city limits, 95.5% of all road-traffic accidents involving injuries to pedestrians and 90.8% of all road-traffic accidents involving injuries to cyclists occur in these areas. The situation is similar when it comes to traffic accidents involving fatalities: 70.2% of all pedestrians and 61.6% of all cyclists killed in road traffic accidents occur within city limits (Statistisches Bundesamt, 2016, p. 13).

[7] To give but one example, again with respect to Germany: the Allgemeiner Deutscher Fahrrad-Club e.V. (ADFC), the largest association of cyclists in Germany, has been lobbying for trucks to be equipped with ADAS for a couple of years now and directly supports efforts in this direction (see for example http://human-factors-consult.de/en/projects/automotive/abalid/). A CSO of this kind that represents a large number of vulnerable road users and already engages with the emerging technology field could make crucial contributions to a successful innovation process in semi-autonomous driving.

company State Farm (Kumba Sennaar, 2017), and in the US, even data that have nothing to do with driving (credit scores and governmental statistics on e.g. health and education) may be used by the insurance sector (OECD, 2017, p.26).

A number of different usage-based insurance and premium models have been developed that focus in different ways on the kind of use (e.g. "pay-how-you drive" insurance bases premium calculation mainly on the quality of driving). As they are quite similar – in the sense that they are all essentially usage-based – we will henceforth refer to all the different types as PAYD.

There are several reasons why PAYD is an attractive insurance model for insurance companies. The first is its potential for dual use of the data and technical infrastructure retrieved from a black box or obligatory eCall function in semi-autonomous cars. This latter feature is used to send an automatic emergency call with information about the location and technical circumstances in the event of an accident (EU regulation, 2015/758). Though this function is not intended to be used primarily for calculating insurance premiums, it could obviously be useful, not only with regard to the above-mentioned function to detect cases of product liability (where manufacturers can be held accountable for an accident, thereby giving insurers the right to seek compensation from manufacturers). There is also a general rise in the volume and types of data being generated in cars (VBW Position Paper, 2016, p. 3), and machine learning algorithms are increasingly used by insurances to analyse this data and develop risk prediction models (Sennaar, 2017).

Besides these enabling factors, the market is putting pressure on insurance companies to gain access to the data produced in the car. First, this would allow them to learn more about the risks of semi-autonomous driving in general (Munich Re, 2016). Second, the development of new, consumer-oriented products like PAYD and the more precise calculation of risks with more data (Gerpott and Berg, 2012, p. 8) are a way of responding to the pressure for market differentiation in the highly competitive insurance sector (e.g. Husnjak et al. 2015, p. 816f.). From a driver's perspective, PAYD is attractive because it is supposed to reduce accidents caused by "bad" driving behaviour (e.g. speeding) and offer financial incentives for "good" driving behaviour (Gerpott and Berg, p. 4f., p. 11; Bolderdijk et al., 2011, p. 1182). Most PAYD policies are structured to be cheaper than standard insurance, e.g. incorporating a payback option once an app concludes that a customer is a safe driver[8] and a guarantee that the costs will not be higher than the standard premium. PAYD mobile applications are also a means to attract a growing customer segment that has grown up in the digital age and seeks personalized products and a direct user experience (Institute of international finance, 2016, p. 2). Mobile applications that give direct feedback on driving performance and improvements in driving style over time[9] remind of the self-tracking and gamification trend.

Insurance companies can apply PAYD to driver behaviour in manual mode and use the surplus of data and monitoring functions, such as vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2X) communication, to consider factors influencing driving style in more detail. It is conceivable for instance that such data would reveal how safely a driver handles lane changes or left turns at crossings. PAYD can also be applied to the behaviour of car users in a semi-autonomous setting. In this scenario, some of the driving tasks would be exchanged for monitoring tasks, which can likewise be performed in either a "better" or "worse" manner. Neglecting monitoring tasks could increase the accident risk, so monitoring the vehicle interior and the driver's eye movements could ensure that the driver does not engage in too many secondary activities, especially those prohibited by law – such as using a mobile phone, reading a book or sleeping (Fletcher and Zelinksy, 2009, p. 774).

It should not be forgotten that using black box systems to monitor driver behaviour is neither extraordinary nor new – as the ongoing discussion of these systems testifies. It has long been the case that tachographs perform this very task. The first tachographs for cars were already introduced in the 1920s. In 1970, they became mandatory for buses and trucks in EEC member states (Regulation (EEC) 1463/70). Even back then it would have been possible to analyse these tachograph records and use this data. Indeed this was done quite regularly in the case of accidents, allowing the course and circumstances of accidents to be reconstructed in great detail. Moreover, aspects relating to driver behaviour and driving skills could be detected by recording and evaluating engine speed, for example (Kraft, 1971). The concept of accident proneness – meaning some people are inclined to have accidents more likely than others – has been discussed throughout the twentieth century (Burnham, 2009) and profiling is a longstanding tradition in the car insurance business. Therefore, it remains unclear why tachographs were never fitted to cars, despite calls for this to be done having already been made at the time. Nowadays, thanks to big data technology, analysing all this data is much easier. All the same, PAYD may be the solution to a problem that never actually existed.

4.2. Advantages of PAYD from an RRI perspective: Increased justice and safety and decreased discrimination

There are three main reasons why PAYD can be seen as an insurance model that more fairly shares costs between the individual customers of insurance companies:

1. An individualized form of insurance pricing, PAYD can be seen as a step forward as compared to conventional insurance models in which careful and safe drivers subsidize the cost of accidents caused by risk-taking or inexperienced drivers. Calculating insurance premiums on the basis of actual driving behaviour, e.g. speeding, increases justice and fairness. The same is true of semi-autonomous cars, with alert users subsidizing the costs incurred by more distracted users who are unable to take control in

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[8] A telematics-based insurance model with a pay-back option called "Betterdrive" is offered for example by the German insurance company CosmosDirect (2017).

[9] See e.g. app descriptions like: "Take part in the scoring list of the best and compare your driving style with others" https://play.google.com/store/apps/details?id=de.allianz.bonusdriveapp&hl=de and "Check your Driving Style Scores on the move: keep track of your overall score, view all your journeys and how many miles you've travelled during your policy year" https://play.google.com/store/apps/details?id=com.d3t.betterdriver&hl=de (last accessed: 31.01.2018).

hazardous situations in a timely manner.

2. PAYD also decreases discrimination in that it charges users according to their own driving behaviour rather than the average driving behaviour of an aggregate group to which they have been assigned (Dijksterhuis et al., 2015, p. 93), e.g. "young male drivers". Such profiling is known to be a source of discrimination in credit scoring, in which scores are determined by aggregating, for example, those living in certain areas that are inhabited by people with lower socio-economic power and thus, it is assumed, lower creditworthiness (O'Neil, 2016, p.144). The use of such discriminating factors can be prohibited by law. In 2012, for example, the EU ruled that gender discrimination in the form of higher premiums for men, who are generally assumed to drive less safely, is not allowed (MEMO 11/123, 2011). Using PAYD models to stop discriminating against young drivers in general would be another step forward, and could potentially help alleviate the societal problem of a generation of drivers in the UK who find it difficult to afford rising insurance premiums (Bowker, 2009), due to the fact that the group of young drivers is a high-risk group (Tong et al., 2015).

3. In addition, studies have shown that PAYD insurance models can affect and change driver behaviour (Bolderdijk et al., 2011, p. 1182; Dijksterhuis et al., 2015, p. 102) and can therefore be seen as a kind of "education" programme that encourages people to adopt a safer driving style. These findings are a win–win situation for insurers and drivers, not to mention a societally desirable outcome given that accident numbers can be reduced by safer driving styles and more alert users (in semi-autonomous scenarios).

Overall, PAYD models that rely on an increasingly large amount of data collection and monitoring functions in the car can make a significant contribution to increasing justice and decreasing discrimination in insurance pricing and incentivize people to adopt responsible and safe driving styles.

4.3. Disadvantages of PAYD from an RRI perspective: The problematic use of profiling and a threat to freedom, solidarity and privacy

As so often, however, the devil is in the detail. A closer look at PAYD models of insurance reveals that they could also threaten freedom, privacy and the solidarity principle, and result in non-transparent and discriminatory insurance costs for a minority. There are several reasons for this:

1. PAYD as a just and non-discriminatory insurance model can benefit from machine learning algorithms that may use increased amounts of data produced in the car for insurance premium calculation (VBW Positions Paper, 2016, p. 3, Gerpott and Berg, 2012, p. 8). However, this can also be seen as a serious downside. Even though machine learning algorithms are able to identify the most predictive risk factors within a huge pile of data generated by connected cars, it is difficult to make the basis for this assessment of risk factors transparent and predictable for customers (for a general discussion of ethics in machine learning, see: Mittelstadt et al., 2016). Errors resulting from faulty measurements or predicted correlations of behaviour and risk, leading to unfair penalties for customers, are difficult to scrutinise, even for the insurers themselves. Because machine learning algorithms are by definition not designed by humans but are generated automatically (Mittelstadt et al., 2016, p. 7f.), reconstructing what they have learned and how is a complex and time-consuming task. Profiling customers on the basis of misleading data in combination with inscrutable algorithms can lead to unfair outcomes. Another problem of PAYD models – which is independent of but connected to machine learning – is that working with increasing numbers of variables has the potential to result in discrimination.

Traditionally, auto insurers have calculated premiums based on actuarial studies of aggregated historical data to produce rating factors that include driving record, personal characteristics (age, gender, and marital status), vehicle type, garage location, vehicle use and previous claims (NAIC, 2017). Usage-based insurance (UBI) such as PAYD has the advantage of utilizing individual and current driving behaviour patterns rather than relying on aggregated statistics and driving records, thereby making premium pricing more individualized and precise (NAIC, 2017; Institute of international finance, 2016, p.2). While the first UBI models defined driving behaviour as simply the number of miles or kilometres driven per year (Bordoff and Noel 2008, p. 1, Bolderdijk et al., 2011, p. 1182), newer models also include driving style, e.g. braking or accelerating behaviour and the time of day and kind of streets used (Bolderdijk et al., 2011, p. 1182). The UBI approach may be fairer, as drivers pay a premium according to the degree of risk they take rather than according to the risk of the statistical group to which they belong (Zagorin, 2017). There is a potential downside, however, as premium calculation may also become increasingly complex and entails a danger of errors being made in behaviour-risk correlations, discrimination and injustice. The developments in risk scoring with PAYD may be likened to creditworthiness scoring: this used to be based on the bank manager's assessment after meeting and talking with the loan applicant until this approach was replaced by scoring based on a profiling algorithm. Though the former was inevitably discriminatory at times, for example when a bank manager refused to approve a loan on the basis of the client's race, age or other personal factors, the latter scoring method has been criticized not only for being discriminatory, but also for its lack of transparency (O'Neil, Cathy 2016, p.145). Generally speaking, PAYD models are nothing more than an elaborate form of profiling. Although the use of profiling algorithms will be restricted in the EU by law from May 2018 (Regulation (EU), 2016/679, Recital 71), this will probably not protect drivers effectively from the disadvantages of this method of judgement (Wachter et al., 2016).[10] Giving a practical example, this could mean that people who have a longer commute, have to use certain streets or are not free to decide when to drive their car, for example due to their

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[10] Wachter et al. (2016), for example, criticise that the GDPR lacks precise language as well as explicit and well-defined rights and safeguards against automated decision-making, which includes decisions based on profiling.

working place and hours, may have to pay a higher price for their insurance.

2. Data privacy and security are another major concern with regard to increased monitoring and use of surveillance methods in semi-autonomous vehicles and for PAYD insurance models. The fact that PAYD insurance models encourage consumers to give up their privacy to insurance companies in exchange for financial incentives can be problematic, even when these customers do so willingly (Derikx and Reuver, 2016, p. 73). The risks associated with the collection and processing of large amounts of data are difficult to discern for the average customer. For example, when a car becomes a device that generates huge volumes of different kinds of data, the user's data privacy may be at risk as it may be possible to identify the person in question on the basis of the accumulated data in conjunction with other external snippets of information (Lüdemann, 2015, p.247). In addition to the problem of data de-anonymization in a big data world, data leaks could prove a problem. The PAYD concept was awarded a Big Brother Award in 2007 (Borchers, 2008) because, according to the jury, it is an illusion to believe that data from the black box will remain in the hands of the car owner and the insurance company. The EU position on the obligatory eCall function coming into effect in 2018 (Regulation (EU), 2015/758) has also been criticized as a way of opening the doors to commercial uses of data (Lüdemann, 2015, p. 247).

In order to address these issues, it is necessary to take a look at the data protection laws that are already in place and see how they apply to PAYD. The data privacy law (BDSG) in Germany allows insurers to use data only in the case of explicit consent (Bundesministerium der Justiz und für Verbraucherschutz, 2017a). Pursuant to the BDSG, customers should be given transparent information about the kinds of data that are generated when they drive their car and to whom this data will be transferred (VBW Position paper, 2016, p. 12). They should also be able to determine what happens with the data generated in the car in any case (VBW Position paper, 2016, p. 12).

Privacy-by-design principles are also generally recommended by EU-wide regulation, but so far not widely discussed or explicitly prescribed in a detailed manner. Possibilities would be e.g. to prefer in-car processing to cloud or app solutions, and to use anonymisation techniques (see: Iqbal and Lim, 2006, VBW Position paper, 2016, p. 12). A basic privacy preserving strategy is to keep customer and driving style data separately. Data from the car are transferred to a service provider, which calculates a score, and this score is transferred to the insurer. Thus, the insurance is not informed about personal data such as the time of the day or streets a customer drives. The issue of consent, which is problematic e.g. in car-sharing, can be managed if a mobile app is used that has to be activated by the driver for every journey and every driver of a car. Furthermore, insurance models that constantly measure driving behaviour and adjust the price accordingly can be distinguished from models that measure driving behaviour only within a specified time frame at the beginning of the contract, for example the first six months,[11] in order to minimize unnecessary data collection and storage beyond the intended purpose (Lepper, 2015, p. 38-40).

If manufacturers and insurers do not take adequate technical measures, insurers might obtain data not intended to be used for PAYD, e.g. black box data, and data intended for PAYD calculations might leak to third parties interested in, e.g. mobility profiles. Both scenarios could compromise customer trust. Furthermore, PAYD should remain a non-obligatory option, as is the case now. However, there could be pressure in the future to choose PAYD, not only because of financial incentives and penalties, but also for moral reasons. If it eventually turns out that PAYD actually fosters safer driving behaviour and reduces accident rates, opting in to PAYD models and sharing data with insurance companies may become a perceived moral obligation: refusing to opt in to PAYD models may then be seen as threating the livelihood of other road users – a compelling argument for personal or societal pressure to conform.

3. If PAYD insurance models do become obligatory, one outcome might be a not insignificant behavioural pressure to "acquire credit" by using certain kinds of streets and by driving at certain "cheap" times of the day – a behavioural pressure that not all customers can readily bend to. On the one hand, this could jeopardize the autonomy and freedom of people to decide when and where to drive. On the other, it could threaten the solidarity principle, which is also a basic principle of insurance in general – if for example a customer has to take more dangerous routes than the average driver. Or some drivers blink their eyes frequently due to a medical condition, thus being assumed to drive in a tired state and having to pay more for their car insurance for reasons unrelated to how intentionally safe or risky their driving style is. As is the case with developments in medical insurance that are the subject of critical debate, such as when incentives are provided to adopt a healthier lifestyle, (BfDI, 2015), there is only a small gap between the positive impact this could have on behavioural choices and the potential threat to personal autonomy (Ethik-Kommission, 2017, p. 20). While it is certainly societally desirable to demand that people take responsibility for their risky driving, awareness is needed to prevent the potentially unintentional discrimination of individuals whose personal predispositions and social circumstances cannot be changed. Thus the widespread adoption of PAYD insurance models could also diminish solidarity, which may be seen as a basic tenet of the insurance sector (Fleisch, Müller-Stewens, 2009, p. 86) and is certainly a fundamental political principle in general.

The individualization entailed by the use of big data in the insurance business is often criticized as part of a societal trend towards de-solidarization (Bitter and Uphues, 2017). However, it should be noted that the solidarity principle applies strictly speaking – also historically – to social insurance, but not to car insurance. Nevertheless, it might be appropriate to describe the increasing

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[11] This is offered, for example, by the US insurer "Progressive" in the form of its PAYD-based "Snapshot" insurance (Progressive, 2017).

differentiation by ever more individualized risk categories as a fragmentation of insurance tariffs. While traditionally insurers constructed risk pools using statistical sampling, the vision of the future is to use machine learning algorithms and IoT sensors to price coverage in real time and using data linked to individuals rather than samples of data linked to groups (Zagorin, 2017). This fragmentation can be seen as having been downright forced by the market, as insurance holders tend to switch to more favourable insurance tariffs – eventually leaving individuals with high risks to disadvantageous tariffs with high or even unaffordable insurance premiums (Bitter and Uphues, 2017). No legal framework exists to confine such a development. From an RRI perspective, however, a move away from economic opportunism and towards a self-understanding as societal security generator (Bitter and Uphues, 2017) would be desirable. One excellent example of what RRI could mean in the insurance sector would be to find sector-specific guidelines on how to avoid this kind of de-solidarization, much like the efforts that are already undertaken by the British association of insurers in the area of privacy (ABI, 2013).

4. One very simple but important objection to PAYD is that it does not work as intended in some cases. For some existing app solutions, users report technical failures when it comes to user recognition and data transmission to the mobile app, as well as a general lack of transparency as far as the outcomes in terms of score or calculated premiums are concerned.[12] This may cause customers to become frustrated and reject from the outset an innovation that is potentially societally desirable. To avoid this, more effort could be put into developing error-free applications before they are placed on the market.

5. Conclusion: An RRI perspective on PAYD as an example of insurance for semi-autonomous vehicles and recommendations for the insurance sector

Assuming that the technology behind semi-autonomous vehicles does indeed prevent severe accidents and save lives, this would make it a societally desirable innovation. If insurers incentivize drivers to use semi-autonomous vehicles, e.g. by offering attractive insurance models that favour this mode of driving, they could be deemed – depending on the specific details of their insurance practices – to be acting responsibly and meeting their ethical obligation. If in the future there are substantial reasons to doubt the generally positive societal impacts of semi-autonomous features in vehicles, insurers may very well be morally obliged to change direction and discourage the use of semi-autonomous vehicles, independently of any economic considerations.

PAYD can be an attractive way to address certain ethical and social problems of insurance practices. It has the potential to increase justice in the insurance sector and to eliminate discriminatory practices, such as profiling based on various background factors (gender, place of residence etc.), by using the increasing amounts of data generated in automated cars to base insurance premiums on the actual behaviour of individual drivers on the roads. It might also take the autonomous mode into account as a factor that either reduces or increases risk. At the same time, PAYD insurance models may present new social and ethical issues arising from new kinds of profiling. In addition, the amount of data that may be collected in semi-autonomous cars and used for PAYD poses new ethical challenges concerning data privacy and security. Existing regulations are not sufficient to prevent the potential harm that may result if companies that produce and use data from cars do not take ethical and social issues seriously. An RRI or similar approach is therefore essential so that insurers can define their responsibilities, act accordingly, and not lose the trust of their clients. The following five points may serve as a rough guideline for insurance companies willing to engage actively with the societal and ethical issues arising from their business and to take responsibility:

1. Create fair insurance premiums

Developing insurance models, be it of the PAYD type or other models for autonomous or manual driving, is the insurance sector's primary domain – this is what they do. It is therefore the responsibility of insurers to design insurance models that meet society's standards of fairness, solidarity, and personal freedom. Based on the premise that the innovation of semi-autonomous driving is societally desirable, it should be encouraged through financial incentives without exacerbating socio-economic gaps in society.

2. Self-regulate

To ensure that fair insurance practices are adopted industry-wide, it may be useful for the insurance sector to self-regulate. This could be done for example by pushing for ethical analyses (Porcari et al., 2015, p. 47) that apply RRI concepts to insurance-related questions or by drafting codes of conduct for insurance practices in this area, e.g. data privacy (Association of British insurers, 2013).

3. Become mutually responsive

Mutual responsiveness is another key feature of RRI that insurers could adopt. This would involve making their insurance practices transparent to the public, i.e. to society as a whole as the "principal of innovation" (Bolz, 2017), as well as to all potential customers. There are various interesting questions in this respect: what will insurance premiums be based on, which data will be collected, how will they be used, and how can they be protected from third parties? Mutual responsiveness would also entail

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[12] See user reports online at: https://play.google.com/store/apps/details?id=com.d3t.betterdriver&hl=de, https://play.google.com/store/apps/details?id=com.d3t.betterdriver&hl=de (last accessed 31.01.2018).

"pursuing open and transparent communication" (Porcari et al., 2015, p. 47) about uncertainties regarding the costs or unknown risks of both semi-autonomous driving and its insurance. Participatory formats in which drivers are also asked about their experiences, needs and values may be an appropriate approach to discussing problems with PAYD systems and potential wider societal implications, and societally accepted and desirable solutions.

4. Actively engage with other stakeholders

In view of the knowledge deficit that insurers will undoubtedly have when it comes to critical issues outside their field of competence (for example concerning technical issues relating to software and telematics design), the insurance sector would be well advised to discuss and define responsibilities in an exchange with other stakeholders such as manufacturers, customers, policy makers, and representatives of the public, including representatives of such stakeholder groups as cyclists. Where appropriate, insurers could also exert their power to influence other stakeholders to take their respective responsibilities seriously. For example, insurance practices favouring semi-autonomous vehicles that give high priority to the safety of vulnerable road users or bystanders would incentivize manufacturers to build semi-autonomous vehicles of this kind.

5. Take an active role in societal discourse on semi-autonomous driving

The measures outlined above may be useful for insurers both in their own right and with a view to accomplishing another goal, namely to take an active role in societal discourse on semi-autonomous driving. Such discourse is vital in order to ensure that the innovation of semi-autonomous cars with all its inherent uncertainties and potential risk is implemented in a societally desirable way and is accepted by the public. Insurers can contribute to this inevitable discussion, deliberation, and decision processes, especially by engaging with other stakeholders and society as a whole in open communication and by offering transparent information not only about their insurance practices, but also about how they evaluate the challenges and expectations of the future of semi-autonomous driving from their unique perspective. The insurance industry's strong position as a key stakeholder group, which at the same time – and for its own sake – has to take into account the perspectives of a wide variety of stakeholders, may help forge a broad public consensus on the future of our mobility systems.

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References

Allianz SE, 2016. Teil-AUTOmatisiertes Fahren – sicherer und günstiger unterwegs: https://www.allianz.com/de/presse/news/geschaeftsfelder/versicherung/160812_automatisiertes-fahren-sicherer-und-guenstiger-unterwegs/, last accessed: 01.09.2017.

Allianz SE, 2017. Telematik-Versicherung: Besonders junge Fahrer profitieren: https://www.allianz.de/auto/kfz-versicherung/telematik-versicherung/#daten-sicher, last accessed: 31.01.2018.

Arps, L., 1976. Durch unruhige Zeiten: deutsche Versicherungswirtschaft seit 1914. Von den zwanziger Jahren zum Zweiten Weltkrieg (II. Teil), Verlag Versicherungswirtschaft, Karlsruhe.

Association of British insurers, 2013. Selling telematics motor insurance policies – A Good Practice Guide, published online: https://www.abi.org.uk/globalassets/sitecore/files/documents/publications/public/migrated/telematics/selling-telematics-motor-insurance-policies—abi-good-practice-guide.pdf, last accessed: 30.08.2017.

Bazilinskyy, P., Kyriakidis, M., Winter, J., 2015. An international crowdsourcing study into people's statements on fully automated driving. Procedia Manuf. 3, 2534–2542. http://dx.doi.org/10.1016/j.promfg.2015.07.540.

BfDI (Bundesbeauftragte für den Datenschutz und die Informationsfreiheit), 2015. Andrea Voßhoff warnt vor dem Einsatz von Fitness-Apps durch Krankenkassen, press release, 16 July 2015, Bonn/Berlin: https://www.bfdi.bund.de/DE/Infothek/Pressemitteilungen/2015/18_WarnungVorFitnessapps.html last accessed: 29.08.2017.

Bitter, P., Uphues, S., 2017. Big Data und die Versicherungengemeinschaft – ,Entsolidarisierung" durch Digitalisierung? ABIDA-Dossier. Available online: http://www.abida.de/sites/default/files/13%20Entsolidarisierung.pdf.

Bolderdijk, J.W., Knockaert, J., Steg, E.M., Verhoef, E.T., 2011. Effects of Pay-As-You-Drive vehicle insurance on young drivers' speed choice. Results of a Dutch field experiment. Acc.; Anal. Prevent. 43 (3), 1181–1186. http://dx.doi.org/10.1016/j.aap.2010.12.032.

Bolz, K., 2017. Who should be the principal of innovation? J. Respons. Innovat. 4 (1), 78–81. http://dx.doi.org/10.1080/23299460.2017.1320645.

Bonnefon, J., Shariff, A., Rahwan, I., 2016. The social dilemma of autonomous vehicles. Science 352 (6293), 1573–1576. http://dx.doi.org/10.1126/science.aaf2654.

Borchers, D., 2008. Big Brother kommt an., Heise, media publication from 10.06.2008: https://www.heise.de/newsticker/meldung/Big-Brother-kommt-an-213477.html, last accessed: 31.08.2017.

Bordoff, J.E., Noel, P.J., 2008. The impact of pay-as-you-drive auto insurance in California. The Hamilton Project, The Brookings Institution: https://pdfs.semanticscholar.org/aa88/f12803eb4306ce4fd390f73395ebcf88f81.pdf, last accessed: 31.08.2017.

Bowker, D., 2009. Rise In Young Driver Premiums Could Lead To Uninsurable Generation, Warns The Co-operative Insurance, 02.03.2009: https://www.onlineprnews.com/news/343-1235829766-rise-in-young-driver-premiums-could-lead-to-uninsurable-generation-warns-the-cooperative-insurance.html, last accessed: 31.01.2018.

Bundesministerium der Justiz und für Verbraucherschutz, 2017a. Bundesdatenschutzgesetz (Federal Data Protection Act): https://www.gesetze-im-internet.de/englisch_bdsg/index.html, last accessed: 31.08.2017.

Bundesministerium der Justiz und für Verbraucherschutz, 2017b. Straßenverkehrsgesetz (StVG) (Road Traffic Act): https://www.gesetze-im-internet.de/stvg/index.html, last accessed: 31.08.2017.

Bundesministerium für Verkehr und digitale Infrastruktur, 2017 Ethik-Kommission: Automatisiertes und Vernetztes Fahren, report: http://www.bmvi.de/SharedDocs/DE/Anlage/Presse/084-dobrindt-bericht-der-ethik-kommission.pdf?_blob=publicationFile, last accessed: 31.08.2017.

Burnham, J.C., 2009. Accident prone. A history of technology, psychology, and misfits of the machine age, The University of Chicago Press, Chicago.

Coenen, C., 2016. Broadening discourse on responsible research and innovation (RRI). NanoEthics 10 (1), 1–4. http://dx.doi.org/10.1007/s11569-016-0255-4.

Coenen, C., Grunwald, A., 2017. Responsible research and innovation (RRI) in quantum technology. Ethics Inf. Technol. http://dx.doi.org/10.1007/s10676-017-9432-6.

CosmosDirect, 2017. "Betterdrive" insurance option: https://www.cosmosdirekt.de/betterdrive/telematik-tarif/?mediacode=bi.Kfz_Kfz_T3_Themen.Telematik.pay%20as%20you%20drive&k_vtweg=51288, last accessed: 24.08.2017.

de Saille, S., 2015. Innovating innovation policy: the emergence of 'Responsible Research and Innovation'. J. Respon. Innovat. 2 (2), 152–168. http://dx.doi.org/10.1080/23299460.2015.1045280.

Dijksterhuis, C., Lewis-Evans, B., Jelijs, B., Waard, D., Brookhuis, K., Tucha, O., 2015. The impact of immediate or delayed feedback on driving behaviour in a simulated Pay-As-You-Drive system. Acc. Anal. Prevent. 75, 93–104. http://dx.doi.org/10.1016/j.aap.2014.11.017.

Derikx, S., Reuver, M., 2016. Can privacy concerns for insurance of connected cars be compensated? Electronic Markets 26 (1), 73–81. http://dx.doi.org/10.1007/s12525-015-0211-0.

Deutscher Bundestag (Ausschuss für Verkehr und digitale Infrastruktur), 2017a. Ausschussdrucksache 18(15)486-B: Stellungnahme zur 101. Sitzung, Öffentliche Anhörung am 20.03.2017: ADAC: https://www.bundestag.de/blob/498582/352f2004c78bd422ab033a8aff15980a/101_sitzung_486b-data.pdf, last accessed: 01.09.2017.

Deutscher Bundestag, 2017b. Straßenverkehrsgesetz für automatisiertes Fahren geändert, 30.03.2017: https://www.bundestag.de/dokumente/textarchiv/2017/kw13-de-automatisiertes-fahren/499928, last accessed: 01.09.2017.

Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport Text with EEA relevance: http://data.europa.eu/eli/dir/2010/40/oj, last accessed: 31.08.2017.

Ernst, H.-G., 2011. Der Betrieb des Kraftfahrzeugs. Die Rechtsprechung des Bundesgerichtshofs. SVR Straßenverkehrsrecht, 7, Nomos, 241 – 246: http://www.svr.nomos.de/fileadmin/svr/doc/Aufsatz_SVR_11_07.pdf, last accessed: 31.08.2017.

Ethik-Kommission, 2017. Automatisiertes und vernetztes Fahren. Available online: https://www.bmvi.de/SharedDocs/DE/Anlage/Presse/084-dobrindt-bericht-der-ethik-kommission.pdf?_blob=publicationFile.

Easier (2007): Young driver road deaths could mean next generation is uninsurable, 19.03.2007: https://www.easier.com/15508-young-driver-road-deaths-could-mean-next-generation-is-uninsurable.html, last accessed: 31.01.2018.

Eastman, A.D., 2016. Is no-fault auto insurance the answer to liability concerns of autonomous vehicles? Am. J. Bus. Manage. 5 (3), 85–90. http://dx.doi.org/10.11634/216796061605816.

European Commission, n.d., official webpage on the Horizon 2020 and the programme Science with and for Society: https://ec.europa.eu/programmes/horizon2020/en/h2020-section/science-and-society, last accessed: 31.08.2017.

European Commission, 2015. Progress report on the 2014 activities of the World Forum for Harmonisation of Vehicle Regulations: https://ec.europa.eu/growth/sectors/automotive/technical-harmonisation/international_en, last accessed: 01.09.2017.

European Commission, 2016. C-ITS Platform. Final report. Available online: https://ec.europa.eu/transport/sites/transport/files/themes/its/doc/c-its-platform-final-report-january-2016.pdf.

European Commission, 2017. Study on the assessment and certification of automated vehicles. Final Report: http://ec.europa.eu/growth/tools-databases/newsroom/cf/itemdetail.cfm?item_id=9199, last accessed: 01.09.2017.

European Parliament and Council of the European Union, 2015: Position of the Council at first reading with view to the adoption of a regulation of the european parliament and of the council concerning type-approval requirements for the deployment of the eCall in-vehicle systembased on the 112 service and amending Directive 2007/46/EC: http://data.consilium.europa.eu/doc/document/ST-5130-2015-REV-3/en/pdf last accessed: 26.01.2018.

Fildes, B., Keall, M., Bos, N., Lie, A., Page, Y., Pastor, C., Pennisi, L., Rizzi, M., Thomas, P., Tingvall, C., 2015. Effectiveness of low speed autonomous emergency braking in real-world rear-end crashes. Acc. Anal. Prevent. 81, 24–29. http://dx.doi.org/10.1016/j.aap.2015.03.029.

Fletcher, L., Zelinsky, A., 2009. Driver inattention detection based on eye gaze—Road event correlation. Int. J. Robot. Res. 28 (6), 774–801. http://dx.doi.org/10.1177/0278364908099459.

Fleisch, E., Müller-Stevens, G., 2009. Der Einfluss der RFID-Technologie auf die Unternehmensführung. Ganzheitliche Unternehmensführung in dynamischen Märkten. in: Hünerberg, R., Mann, A., (Eds.), Springer, Wiesbaden.

Fortune, 2016. Future car tech poses significant threat to auto insurers, 20.07.2016, http://fortune.com/2016/07/20/future-car-tech-threatens-insurance/, last accessed: 01.09.2017.

Franz, M., 2017, HUK Coburg: "kein Datenmonopol für die Industrie". Heise Online, 17.08.2017: https://www.heise.de/autos/artikel/HUK-Coburg-Industrie-darf-kein-Datenmonopol-haben-3804840.html, last accessed: 31.01.2018.

Gadow, O.V., 2002. Die Zähmung des Automobils durch die Gefährdungshaftung. Eine Analyse der Entscheidungen des Reichsgerichts zu § 7 des Gesetzes über den Verkehr mit Kraftfahrzeugen vom 03.05.1909, Duncker und Humblot, Berlin.

Gasser, M., 2016. Fundamental and special legal questions for autonomous vehicles. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H. (Eds.) Autonomous Driving. Technical, Legal and Social Aspects. Springer Open, Berlin, Heidelberg, pp. 523–551, http://doi.org/10.1007/978-3-662-48847-8_25.

Gesamtverband der Deutschen Versicherungswirtschaft e.V. (GDV), 2015a. Macht das automatisierte Fahren unsere Straßen sicherer?, GDV press release, 03.03.2015: http://www.gdv.de/2015/03/macht-das-hochautomatisierte-fahren-unsere-strassen-sicherer/, last accessed: 01.09.2017.

Gesamtverband der Deutschen Versicherungswirtschaft e.V. (GDV), 2015b. Wir werden auch hochautomatisierte Autos versichern, GDV press release from June 12th 2015, published online: http://www.gdv.de/2015/06/wir-werden-auch-hochautomatisierte-autos-versichern/, last accessed: 31.08.2017.

Groves, C., 2015. Logic of choice or logic of care? Uncertainty, technological mediation and responsible innovation. NanoEthics 9 (3), 321–333. http://dx.doi.org/10.1007/s11569-015-0238-x.

GDV, 2015a. Macht das automatisierte Fahren unsere Straßen sicherer?, 03.03.2015, http://www.gdv.de/2015/03/macht-das-hochautomatisierte-fahren-unsere-strassen-sicherer/, last accessed: 01.09.2017.

GDV, 2015b. Wir werden auch hochautomatisierte Autos versichern", 12.06.2015, http://www.gdv.de/2015/06/wir-werden-auch-hochautomatisierte-autos-versichern/, last accessed: 01.09.2017.

Gerpott, T.J., Berg, S., 2012. Pay-As-You-Drive-Angebote Von Eerstversicherern Für Privatkunden. Zeitschrift für die gesamte Versicherungswissenschaft (ZVersWiss) 101 (1), 3–29. http://dx.doi.org/10.1007/s12297-011-0154-2.

Grunwald, A., 2011. Responsible innovation: Bringing together technology assessment, applied ethics, and STS research. Enterprise Work Innovat. Stud. 7, 9–31.

Grunwald, A., 2014. The hermeneutic side of responsible research and innovation. J. Respons. Innovat. 1 (3), 274–291. http://dx.doi.org/10.1080/23299460.2014.968437.

Grunwald, A., 2016. Social risk constellations for autonomous driving. Analysis, historical context and assessment. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H. (Eds.), Autonomous Driving. Technical, Legal and Social Aspects. Springer Open, Heidelberg, pp. 641–662. http://doi.org/10.1007/978-3-662-48847-8_30.

Henning, F.-.W. (Ed.), 1980. Entwicklung und Aufgaben von Versicherungen und Banken in der Industrialisierung. Duncker und Humblot, Berlin.

Hevelke, A., Nida-Rumelin, J., 2015. Responsibility for crashes of autonomous vehicles. An ethical analysis. Sci. Eng. Ethics 21 (3), 619–630. http://dx.doi.org/10.1007/s11948-014-9565-5.

Husnjak, S., Peraković, D., Forenbacher, I., Mumdziev, M., 2015. Telematics system in usage based motor insurance. Procedia Eng. 100, 816–825. http://dx.doi.org/10.1016/j.proeng.2015.01.436.

Institute of international finance, 2016. Innovation in insurance: How technology is changing the industry. Available online: https://www.iif.com/publication/research-note/innovation-insurance-how-technology-changing-industry.

Iqbal, M., Lim, S., 2006. Privacy preserving PAYD insurance. International Global Navigation Satellite Systems Society IGNSS Symposium July 17th – 21th 2006, Australia: https://www.researchgate.net/profile/Samsung_Lim/publication/263937545_A_privacy_preserving_GNSS_based_Pay_as_You_Drive_insurance_scheme/links/570dd7db08aed31341cf84ee.pdf, last accessed: 31.08.2017.

Kalra, N., Paddock, S.M., 2016. Driving to safety. How many miles of driving would it take to demonstrate autonomous vehicle reliability? Transport. Res. Part A: Policy Practice 94, 182–193. http://dx.doi.org/10.1016/j.tra.2016.09.010.

Kollewe, J., 2016. Insurer launches UK's 'first driverless car policy'. Adrian Flux designs policy for consumers whose cars already have driverless features, such as auto-parking and ABS. The Guardian, 07.06.2016: https://www.theguardian.com/business/2016/jun/07/uk-driverless-car-insurance-policy-adrian-flux. Last accessed: 01.09.2017.

Kraft, H., 1971. Fahrtenschreiber als Beweismittel im Verkehrsgeschehen. Deutsches Autorecht (DAR) 40 (5), 124–126.

Kröger, F., 2016. Automated driving in its social, historical and cultural contexts. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H. (Eds.), Autonomous Driving. Technical, Legal and Social Aspects. Springer Open, Berlin, Heidelberg, pp. 41–68, http://doi.org/10.1007/978-3-662-48847-8_3.

Lepper, U. (Landesbeauftragter für Datenschutz und Informationsfreiheit Nordrhein-Westfalen), 2015. Zweiundzwanzigster Datenschutz-und Informationsfreiheitsbericht, Düsseldorf: https://www.ldi.nrw.de/mainmenu_Service/submenu_Berichte/Inhalt/22_DIB/DIB_22.pdf, last accessed: 29.08.2017.

Lubberink, R., Blok, V., van Ophem, J., Omta, O., 2017. Lessons for responsible innovation in the business context: a systematic literature review of responsible, social and sustainable innovation practices. Sustainability 9 (5), 721. http://dx.doi.org/10.3390/su9050721.

Lüdemann, V., 2015. Connected Cars – Das vernetzte Auto nimmt Fahrt auf, der Datenschutz bleibt zurück. ZD Zeitschrift für Datenschutz, 247-254: https://beck-online.beck.de/Dokument?vpath=bibdata%2Fzeits%2Fzd%2F2015%2Fcont%2Fzd.2015.247.1.htm&pos=1&hlwords=on, last accessed: 31.08.2017.

Lutz, L.S., 2016. Automated vehicles in the EU: proposals to amend the type approval framework and regulation of driver conduct. Casualty Matters International (GenRe): http://media.genre.com/documents/cmint16-1-en.pdf, last accessed: 07.08.2017.

MEMO/11/123: Sex discrimination in insurance contracts: statement by European Commission Vice-President Viviane Reding, the EU's Justice Commissioner, on the European Court of Justice's ruling in the Test-Achats case. European Commission press release, Brussels, March 1st 2011: http://europa.eu/rapid/press-release_MEMO-11-123_en.htm?locale=en, last accessed: 31.08.2017.

Mittelstadt, B.D., Allo, P., Taddeo, M., Wachter, S., Floridi, L., 2016. The ethics of algorithms: mapping the debate. Big Data Soc. 3 (2), 1–21. http://dx.doi.org/10.1177/2053951716679679.

Munich Re, 2016, Autonomous Vehicles: Considerations for Personal and Commercial Lines Insurers: https://www.munichre.com/site/mram-mobile/get/documents_E706434935/mram/assetpool.mr_america/PDFs/3_Publications/Autonomous_Vehicles.pdf last accessed: 26.01.2018.

Murphy, F., Mullins, M., 2016. Automated cars will be a game changer for the motor insurance sector. Self-driving cars, shared cars, black-box data risk assessment – all to impact on premiums. Irish Times, 29.09.2016, https://www.irishtimes.com/business/automated-cars-will-be-a-game-changer-for-the-motor-insurance-sector-1.2805179, last accessed: 01.09.2017.

NAIC, 2017. Usage-Based Insurance and telematics, 14.09.2017: http://www.naic.org/cipr_topics/topic_usage_based_insurance.htm, last accessed: 31.08.2017.

National Highway Traffic Safety Administration, 2008. National motor vehicle crash causation survey. Report to Congress (DOT HS 811 059), Washington, D.C.: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/811059, last accessed: 01.09.2017.

National Highway Traffic Safety Administration, 2018. Five Eras of Safety: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety, last accessed: 26.01.2018.

Nguyen, V., 2017. Audi A8 Level 3 autonomy first-drive: Chasing the perfect 'jam'. Slashgear, 11.09.2017: https://www.slashgear.com/2019-audi-a8-level-3-autonomy-first-drive-chasing-the-perfect-jam-11499082, last accessed: 26.01.2018.

OECD, 2017. Technology and innovation in the insurance sector. Available online: http://www.oecd.org/pensions/Technology-and-innovation-in-the-insurance-sector.pdf, last accessed: 26.01.2018.

O'Neil, Cathy, 2016. Weapons of Math Destruction. How Big Data Increases Inequality and Threatens Democracy. Crown, New York.

Owen, R., Macnaghten, P., Stilgoe, J., 2012. Responsible research and innovation: From science in society to science for society, with society. Sci. Public Policy 39 (6), 751–760. http://dx.doi.org/10.1093/scipol/scs093.

Porcari, A., Borsella, E., Mantovani, E., 2015. Responsible-Industry executive brief: implementing responsible research and innovation for ICT for an ageing cociety. Italian Association for Industrial Research, Rome.

Porter, M.E., Kramer, M.R., 2006, Strategy and society. The link between competitive advantage and corporate social responsibility, Harvard Business Review, December.

Progressive, 2017. "Snapshot" insurance option: https://www.progressive.com/auto/discounts/snapshot/, last accessed: 01.09.2017.

Regulation (EEC) 1463/70 of the Council of 20 July 1970 on the introduction of recording equipment in road transport. Available online: http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:31970R1463, last accessed: 01.02.2018.

Regulation (EU) 2015/758 of the European Parliament and of the Council of 29 April 2015 concerning type-approval requirements for the deployment of the eCall in-vehicle system based on the 112 service and amending Directive 2007/46/EC. Available online: http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32015R0758, last accessed: 31.08.2017.

Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). Recital 71. Available online: http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32016R0679 last accessed: 31.08.2017.

Robertson, R.D., Meister, S.R., Vanlaar, W.G.M., 2016. Automated Vehicles: Driver Knowledge, Attitudes, & Practices. Traffic Injury Research Foundation (TIRF).

Ruggiu, D., 2016. A reply to Groves. NanoEthics 10 (1), 111–116. http://dx.doi.org/10.1007/s11569-016-0254-5.

SAE International, 2014. Standard J3016: http://www.sae.org/misc/pdfs/automated_driving.pdf, last accessed: 01.09.2017.

Sennaar, K., 2017. How America's Top 4 Insurance Companies are Using Machine Learning. Available online: https://www.techemergence.com/machine-learning-at-insurance-companies, last accessed: 31.08.2017.

Sheehan, B., Murphy, F., Ryan, C., Mullins, M., Liu, H.Y., 2017. Semi-autonomous vehicle motor insurance: a Bayesian network risk transfer approach. Transport. Res. Part C: Emerging Technol. 82, 124–137. http://dx.doi.org/10.1016/j.trc.2017.06.015.

Schellekens, M., 2015. Self-driving cars and the chilling effect of liability law. Comput. Law Sec. Rev. 31 (4), 506–517. http://dx.doi.org/10.1016/j.clsr.2015.05.012.

Smith, B.W., 2017. Automated driving and product liability. Michigan State Law Rev. 1, 1–74.

Statistisches Bundesamt, 2016. Unfallentwicklung auf deutschen Straßen 2015, Wiesbaden: https://www.destatis.de/DE/PresseService/Presse/Pressekonferenzen/2016/Unfallentwicklung_2015/Pressebroschuere_unfallentwicklung.pdf?_blob=publicationFile, last accessed: 31.08.2017.

Titcomb, J., 2016. Motor insurers form alliance to tackle driverless cars. 11 major insurers form group to discuss response to onset of autonomous driving and represent industry. The Telegraph, 18.01.2016: http://www.telegraph.co.uk/technology/news/12106757/Motor-insurers-form-alliance-to-tackle-driverless-cars.html, last accessed: 01.09.2017.

Tong, S., Lloyd, L., Durrell, L., McRae-McKee, K., Husband, P., Delmonte, E., Parry, I., Buttress, S., 2015. Transport Research Laboratory, Published project report 755. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/479202/provision-telematics-research-report.pdf.

US Department of Transportation, 2017. Automated driving systems 2.0: A vision for safety. Public meeting 06.11.2017: https://www.nhtsa.gov/document/automated-driving-systems-20-vision-safety-public-meeting-november-6-2017, last accessed: 26.01.2018.

Van de Poel, I., Robaey, Z., 2017. Safe-by-design: from safety to responsibility. NanoEthics. http://dx.doi.org/10.1007/s11569-017-0301-x.

Vereinigung der Bayerischen Wirtschaft e. V. (vbw), 2016. Automatisiertes Fahren - Datenschutz und Datensicherheit. Position paper: https://www.vbw-bayern.de/Redaktion/Frei-zugaengliche-Medien/Abteilungen-GS/Recht/2016/Downloads/Positionspapiere_3/vbw-Position-Automatisiertes-Fahren-Datenschutz-und-Datensicherheit-August-2016.pdf, last accessed: 31.08.2017.

Von Schomberg, R., 2007. From the ethics of technology towards an ethics of knowledge policy & knowledge assessment. A working document from the European Commission Services, Brussels, http://dx.doi.org/10.2139/ssrn.2436380.

Von Schomberg, R., 2011. Prospects for technology assessment in a framework of responsible research and innovation. In: Dusseldorp, M., Beecroft, R., (Eds.), Technikfolgen abschätzen lehren: Bildungspotenziale transdisziplinärer Methoden. VS Verlag, Wiesbaden, pp 39–61. http://doi.org/10.2139/ssrn.2439112.

Wachenfeld, W., Winner, H., 2016. The release of autonomous vehicles. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H., (Eds.), Autonomous Driving. Technical, Legal and Social Aspects. Springer Open, Berlin, Heidelberg, pp. 589–618. http://doi.org/10.1007/978-3-662-48847-8_21.

Wachter, Sandra, Mittelstadt, Brent, Floridi, Luciano, 2016. Why a Right to Explanation of Automated Decision-Making Does Not Exist in the General Data Protection Regulation. In: SSRN Journal. http://doi.org/10.2139/ssrn.2903469.

Walch, M., Lange, K., Baumann, M., Weber, M., 2015. Autonomous driving: investigating the feasibility of car-driver handover assistance. Proceedings of the 7th International Conference on Automotive User Interfaces and Interactive Vehicular Applications – AutomotiveUI '15, 11–18, http://doi.org/10.1145/2799250.2799268.

Winkle, T., 2016. Development and approval of automated vehicles: considerations of technical, legal, and economic Risks. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H. (Eds.), Autonomous Driving. Technical, Legal and Social Aspects. Springer Open, Berlin, Heidelberg, pp. 589–618, http://doi.org/10.1007/978-3-662-48847-8_28.

Zagorin, E., 2017. Artificial Intelligence in Insurance – Three Trends That Matter: https://www.techemergence.com/artificial-intelligence-in-insurance-trends last accessed: 31.01.2018.

Zwart, H., Landeweerd, L., van Rooij, A., 2014. Adapt or perish? Assessing the recent shift in the European research funding arena from 'ELSA' to 'RRI'. Life Sci., Soc. Policy 10(11). https://doi.org/10.1186/s40504-014-0011-x.

Zwart, H., Brenninkmeijer, J., Eduard, P., Krabbenborg, L., Laursen, S., Revuelta, G., Toonders, W., 2017. Reflection as a deliberative and distributed practice: assessing neuro-enhancement technologies via mutual learning exercises (MLEs). NanoEthics 11 (2), 127–138. http://dx.doi.org/10.1007/s11569-017-0287-4.