The Impact of Telematics on the Insurability of Risks

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Abstract

We analyze the use of telematics in insurance and its consequences for the insurability of risks. For this purpose we first systematically review existing studies and then investigate the consequences of telematics using Berliner's (1982) insurability criteria. Our findings emphasize the effects of new information on information asymmetry and risk pooling, the implications of new technologies on loss frequency and severity, legal restrictions and ethical consequences of the use of the new technologies in the insurance field.

Keywords: insurability, telematics, big data, motor insurance, health insurance

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1 INTRODUCTION

The digitalization – i.e. the integration of the analogue and digital world with manifold new technologies that enhance customer interaction, data availability and business processes – is fundamentally changing the value creation of the insurance industry (see e.g. Eling and Lehmann, 2017). Also recent advances in insurtech have triggered an immense interest among practitioners worldwide. Given this fundamental transformation and immense interest, it is astonishing that the academic discussion on innovative insurance models making use of new technologies is virtually nonexistent so far.[1]

The intention of this paper is to closer discuss one of these innovative models and to analyze its consequences for the insurability of risks. The concrete innovations we are considering is the use of telematics in risk management and insurance. Such models monitor the policyholders or the insured objects, e.g. the how policyholders drive or how many steps they make on a day. To our knowledge the insurability implications of telematics have not been discussed systematically in the academic literature so far. We can, however, draw some conclusions based on industry studies and related academic articles such as the known discussion of genetic testing.

The research approach of this paper is to first establish a database on studies, articles, and working papers on the use of telematics in risk management and insurance. Based on this, we provide insurance practitioners and academics with an overview on the main insurability implications using Berliner's (1982) insurability criteria.

Our main results can be summarized as follows: Although insurance always relied on data (e.g. on claims statistics or mortality tables), telematics systems offer much more data, data which related to individual policyholder behavior and is available in real-time ("big data"). The insurability consequences are reduced information asymmetry and more accurate risk pooling. The effect on loss frequency and severity are not explored well enough to provide an assessment. Moreover, various legal and ethical questions arise that are not fully answered today. Our paper can thus also be interpreted as a starting point and trigger of future research

[1] Recently the Geneva Association addressed the issue to use technology to reduce the protection gap: Schanz, K.-U. and Sommerrock, F. (2016).

on actuarial, business, legal and ethical questions with respect to the use of new technologies in the insurance domain.

After this introduction we first define telematics and give some insight on the market developments for insurance models using this new technology. The data and methodology used of our study are set out afterwards. The results are then presented along the insurability criteria. Finally, we draw some conclusions and discuss potential avenues for future research.

2 DEFINITION AND MARKET DEVELOPMENTS

2.1 DEFINITION

The term "telematics" is a combination of "*tele*communication" and "infor*matics*". In general, it describes in its broad meaning the use of electronic data transmission. Main example is the use of such systems within road vehicles, also called vehicle telematics, surveying location, movements, status and behavior of a vehicle or fleet of vehicles. Although, telematics can be used in many different areas, e. g. medicine ("tele-medicine") or education ("tele-teaching") we focus in our paper on the use of telematics in offering an insurance contract. However, we do not restrict our analysis to motor insurance where the premium is based on telematics (known "pay-how-you-drive" or "usage-based insurance"). We extend the scope to all types of insurance where tracking or monitoring via telematics is used. In addition to motor insurance this includes to date health(-based) insurance in conjunction with so called wearables ("self-tracking") or household insurance based on internet-connected sensors in the building ("smart home"). The potential effects might be most pronounced in these personal lines (motor, health, and homeowner insurance).[2]

The functioning of telematics can be illustrated using motor insurance as an example: By the integration of suitable technology in the vehicle, information of the vehicle can be transferred to the insurer by the mobile communications network, e.g. GPS data. The insurance company typically does not get all the (raw) data directly, but there is a service provider technical responsible for running the system and aggregating the data. Based on this aggregated

[2] Schanz and Sommerrock (2016).

information (typically a score) the insurance company is able to take an exact calculation as well as an adequate pricing of the insurance tariff. The use of data for the purpose of the premium calculation is often accompanied with other services. These additional services could be classified in reactive and proactive services. Reactive services involve facilities, which take effect if a certain event such as an accident occurs. In contrast proactive services target an improvement of the behavior of the policyholder. This improvement should be achieved for example through a warning of better going to garage when parts are expected to get broken. The latter example highlights that telematics is useful not only to improve the risk transfer, but especially also for prevention.

The development of an electronic data transmission offer today is based on three different variations: 1) telematics apps in smartphones, 2) OBD[3] II dongle and 3) permanently installed telematics box ("black box"). Compared to the other variants the telematics app does not need a special hardware in the vehicle and represents the most cost-efficient version; in this case the collected dates are directly transferred from the smartphone to the insurance company. The OBD II dongle, which passes of with the collaboration of an app, can be installed and removed independently by the customer, if the transmission is unwanted. By the OBD II dongle the garage is able raise defects and other relevant dates. The transmission occurs by bluetooth to the smartphone of the car driver (= policyholder). A third technical possibility is the telematics box, which usually is installed in the engine compartment. In comparison with the previous variants there is no smartphone needed, because in the box a SIM card is contained. Other components of the box are usually a GPS system, a motion sensor (or accelerometer), and computer software, which controls how the information is analyzed and transmitted. The quality of data provided by apps, OBD II dongles or telematics boxes might differ significantly, e. g. data of apps might be in general of less quality.[4]

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3 OBD = On-board diagnostics. Such self-diagnostics systems give the vehicle owner or repair technician access to the status of the various vehicle subsystems.

4 In addition, it is not trivial to use telematics data for insurance tariffs. The extent and complexity of telematic data require comprehensive methods of analysis and assessment, see e. g. Weidner and Transchel (2015).

2.2 MARKET DEVELOPMENT

The electronic data transmission still presents a relatively new development in the field of motor, health and household insurance. Telematics auto insurance was invented and patented in 1996.[5] A pioneer in offering telematics tariffs was the U.S. insurance company Progressive Auto Insurance. The first tariff based on telematics was launched in 1998 in the U.S. by Progressive with a pilot product „Snapshot".[6] In 2016 more than two million vehicles were insured via "Snapshot". Progressive earns around 2.5 billion US-$ a year with telematics tariffs and is global market leader in this field. Other U.S.-based insurance companies offering telematics tariffs are amongst others Allstate, Metromile, National General Insurance, and State Farm.

European countries followed in the next years, e. g. in Italy in 2000 first pilots focused on one use case.[7] In the UK and in Italy telematics tariffs are offered and reached at least small market shares. For example, Generali has a leading position in car telematics in Europe.[8] In Italy, a pay-how-you-drive solution with Genertel, the direct insurance company of Generali group, was introduced in 2011.[9] Generali claims to have currently more than 1 million policies in Italy (varying from mileage-based to behavioral tariffs).[10] Recently, Generali announced an R&D agreement with Progressive in 2016 to improve their individual data analytics capabilities and foster product offering.[11] In Italy, there were 4.8 million active telematics policies at the end of 2015 and more than 6.3 million policies or 15–16% of all motor insurance policies at the end of 2016,[12] The Italian market has the highest coverage of telematics-based motor policies globally (ahead of the US (3.3 million) and the UK (0.6 million)).[13] The Italian government is planning to make "black boxes" compulsory to reduce motor insurance premiums which could boost telematics tariffs even more.[14]

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5 Progressive and a Spanish inventor, Salvador Minguijon Perez, invented and patented independently telematics auto insurance (U.S. Patent 5,797,134 and European Patent EP0700009B1).
6 Olson (2014).
7 Swiss Re (2017).
8 Generali (2016c).
9 Generali (2016c).
10 Generali (2016c).
11 Generali (2016c).
12 Swiss Re (2017).
13 Swiss Re (2017).
14 Much (2014).

In the UK, insurethebox is the largest telematics motor insurance provider which uses telematics technology.[15] Insurethebox launched its product in 2010 and has collected over three billion miles of driving data so far.[16] The co-operative insurance is another UK based telematics insurance company.

In many other European countries such as Germany or Switzerland, the implementation of electronic data transmission rates is tracked rather distrustful and skeptical.[17] In spite of the creation of an additional choice and the enlargement of the freedom of choice the calculation of the insurance tariff is considered as dubious at the moment.[18] This uncertainty of the consumers lead to a lack of telematics tariffs compared with other countries that might be explained by the insurability of risks.

Until 2016 only a few smaller insurance companies offered telematics tariffs in Germany.[19] Sometimes the number of contracts was limited so that the offers could be characterized as pilot projects. However, in 2016 the two market leading motor insurers of Germany, Allianz and HUK-COBURG started with telematics tariffs (BonusDrive[20] respectively Smart Driver[21]). Both tariffs target as specific customer group young drivers. If the driving behavior in accordance with certain criteria, policyholder can benefit from a reduction of their premium (up to 40%)[22]. At the moment eleven German insurance companies offer telematics tariffs,[23] but the market importance of these tariffs is still very limited.

15 Insurethebox (2017a).
16 Insurethebox (2017b).
17 See for concerns raised e.g. Morawetz (2016).
18 Buxbaum (2006) describes the key characteristics of the target customers as people comfortable with new technologies, less concerned about privacy issues, tend to be concerned about environmental issues, and often think about ways to control driving costs. Based on this they conclude that PAYD will be rather a niche, but at least estimate that 25 to 30 percent of the population might be interested. Weidner and Transchel (2015) highlight another problem which might be of potential concern that is that data might be interfered with many sources of error and that investment in IT security necessary. Both might deteriorate the trust in telematics systems.
19 For example, in 2014 the German insurance company Sparkassen-Direktversicherung launched German's first telematics tariff. However, the number of users was limited to 1000.
20 Allianz (2016).
21 HUK-COBURG (2017).
22 See for more information https://www.allianz.de/auto/kfz-versicherung/telematik-versicherung/ [17-06-02]
23 For an updated list and a comparison of these insurance covers see http://www.finanztip.de/kfz-versicherung/telematik-tarif/http://www.finanztip.de/kfz-versicherung/telematik-tarif/ [17-06-02]

In health insurance there are only some insurance providers who link their products with telematics. Generali offers Vitality as an innovative wellness program.[24] According to Generali, policyholder do not want insurance just to pay claims; they seek “real values at all times” from their insurer.[25] Policyholder are believed to want to live a healthier lifestyle and be rewarded for it too. As a health management program globally, Vitality motivates, rewards and supports policyholders within its model and offers new possibilities for various stakeholders. Ultimately, Generali thinks that it will change the way that people view and engage with insurance.[26]

Vitality was launched in 1997 by the Discovery Group in South Africa. It is one of the world’s largest wellness program and has expanded its global operations to the UK, the U.S. and across Asia with over 3.5 million members (figures from 2016).[27] In July 2016 the program started in Europe (with Germany first[28], followed by France[29]). Generali Vitality combines actuarial, behavioral and clinical tools in a step-by-step program that helps members improve their health through wellness activities and healthy lifestyle choices. Members receive rewards for getting healthier, which ultimately is assumed to have a positive impact on the prevalence of mortality and morbidity experience in the insurance business and in society.[30] However, empirical evidence for that is still rare. An unsolved problem is to find a group of people to which the group of users of such health programs can be compared, because there is heavy selection bias of people willing to give their health data to be used within insurance contracts (normally they are much healthier than the average population). That’s why a random group of people cannot be used as a reliable control group.

In Germany, Generali Vitality is offered for new customers of term life or occupational disability insurance policies with either Dialog Lebensversicherungs-AG or Generali Lebensversicherung AG, respectively.[31] Sometimes, there’s the misconception that Vitality is (also) linked to health insurance in Germany: So far it is not. The prevailing legal opinion is

24 See for more information https://generalivitality.com/ [17-06-02].
25 Generali (2017).
26 Generali (2017).
27 All information provided by Vitality on its website: https://generalivitality.com/ [17-06-02].
28 Generali (2016a).
29 Generali (2016b).
30 Generali (2017).
31 Generali (2017).

that private insurance companies would violate the German insurance laws if they use personal data of the policyholders for the premium of health insurance contracts. In social health insurance (federal) supervisors do not allow the use of such data.[32]

With respect to smart home the insurance market still depend on the developments in making homes to “smarter” homes. The technology is already there (e.g. fire detectors, flooding sensor and alarm systems), however, market penetration of users of smart home devices is until now very low and, of course, even lower insurance contracts based on smart home.

For all the areas mentioned above prognoses expect high growth of insurance premiums for telematics based insurance contracts within the next years, e. g. Swiss Re expects more than 100 million telematics-based policies to be in force by 2020, generating premiums in excess of EUR 250 billion.[33] Therefore, insurability of these risks should be assessed systematically.

[32] However, insurance companies pay (partly) wearables for their policyholders. This can be interpreted as selection and marketing mechanism. Social health insurers have an interest in young and healthy policyholders. The use of wearables and the willingness to give data is correlated with the health status. Because of inadequate compensation between social health insurers with high risk policyholders and low risk policyholders there are incentives for selection, even though there’s an obligation to enter the contract with (in contrast to private health insurers who can select explicitly their customers).

[33] Swiss Re (2017).

3 DATA AND METHODOLOGY

3.1 DATA

We reviewed studies on telematics that were published between 2000 and 2016 and that specifically mentioned aspects of insurance or insurability. To capture all relevant references and ensure that only studies meeting academic quality standards were included in the survey, we followed a strict search and selection strategy (see Appendix A).[34] This strategy resulted in the identification of 23 academic papers and industry studies (see Appendix B).

Most articles come more from the technical side and are published in journals on safety research (e.g. Ayuso et al. 2014; Farmer et al., 2010), while others come more from the business side (e.g. Azzopardi and Cortis, 2013; Paefgen, 2013; Tindall, 2012). Only very little material exists from the risk and insurance field (Mürmann and Kremslehner, 2016) and the actuarial domain (Weidner et al. 2015 a, b). Notable is also the peer reviewed journal "Telematics and Informatics", an interdisciplinary journal examining the social, economic, political and cultural impacts and challenges of information and communication technologies.

3.2 METHODOLGY

Berliner (1982) introduced a comprehensive approach for differentiating insurable and uninsurable risks.[35] This approach is based on nine insurability criteria and is frequently used to analyze insurance markets and products.[36] The criteria are categorized into three broad categories and classify risks in terms of actuarial, market, and societal conditions (see Table 1).

Table 1 Insurability criteria and related requirements according to Berliner

Insurability Criteria			**Requirements**
Actuarial	(1)	Randomness of loss occurrence	Independence and predictability of loss exposures
	(2)	Maximum possible loss	Manageable
	(3)	Average loss per event	Moderate
	(4)	Loss exposure	Loss exposure must be large
	(5)	Information asymmetry	Moral hazard and adverse selection not excessive
Market	(6)	Insurance premium	Cost recovery and affordable
	(7)	Cover limits	Acceptable
Societal	(8)	Public policy	Consistent with societal value
	(9)	Legal restrictions	Allow the coverage

[34] A detailed description of the search strategy is available from the authors upon request.
[35] See also Berliner (1985), Berliner (1986).
[36] See, e.g., Biener and Eling (2012), Biener et al. (2015), Doherty (1991), Jaffee and Russell (1997), Janssen (2000), Karten (1997), Nierhaus (1986), Schmit (1986), and Vermaat (1995).

In the actuarial category the insurability catalogue requires independence of risks and reliable estimation of loss probabilities (randomness of loss occurrence), manageable maximum possible losses per event in terms of insurer solvency (maximum possible loss), moderate average loss amounts per event (average loss per event), a sufficiently high number of loss events per annum (loss exposure), and no excessive information asymmetry problems (i.e., moral hazard, adverse selection). These criteria thus include the law of large numbers; the larger the number of mutually independent and identically distributed risks in a pool, the lower the variance of losses in the risk pool.

The two market criteria consider the adequacy of insurance premiums to provide a sufficient return on capital for the insurer (but still affordable by the target population) as well as to the acceptability of policy cover limits for the target population. A sufficient premium must cover the expected losses, but also allow safety loadings (to account for fluctuations of expected losses and the uncertainty in the estimation) and a cost loading for the underwriting expenses. Typically also cover limits are needed for an insurer to achieve a certain security level and thus to make a risk insurable.

The two societal criteria are that coverage needs to be in accordance with public policy and societal values and in line with law. To be compliant with public policy means, among others, not issuing insurance policies for trivial risks and making sure that policies provide no incentive for criminal actions. In a broader sense sustainability and ethical questions have to be acknowledged, e.g. reputational risk for the insurance company could be significant. Legal restrictions involve the types of activities an insurance company is permitted to engage in and prohibitions against insuring certain risks.

4 ANALYSIS OF INSURABILITY

4.1 ACTUARIAL CRITERIA

(1) Randomness of Loss Occurrence

The first criterion is related to the independence of risks and the quantification of loss probabilities. Because of telematics insurers can create smaller risk pools, which will lead to a more distinguished separation of good and bad risks. Nevertheless, the loss occurrence in each risk pool is still random. Compared to insurance contracts which are not based on telematics data the independence of the underlying risks in principal remains unchanged.

As regards the predictability of loss exposures there is uncertainty of the effects of changed behavior of policyholders. For example, providing car drives with a score of their driving (from 0 % to 100 % at the top) will allow them to adjust their mode of operations, e.g. driving slower. The result of that uncertainty is that prices have to include higher risk margins.[37]

(2) Maximum Possible Loss

Risks exhibiting maximum losses that exceed the capacity the risk capital of an insurance company are considered uninsurable. While the current volume of telematics activities is too small to raiser serious concerns with respect to this criterion, the potential accumulation risk from new technologies might be considered. In an increasingly connected world technology could increase the maximum possible loss if risks are not independent anymore, thus reducing the insurability of risks. For example, Biener et al. (2015) analyze the insurability of cyber risks and show that one major hurdle is the accumulation risk. Given that all individuals and companies are using the same software and systems. Increasing the diversity of software products and IT systems might thus be beneficial from an insurability perspective. One open question in this context is whether telematics systems give rise to any cyber risk, e.g. when they are hacked (see Biener et al., 2015).

[37] For example, such an effect was observed when EU insurance companies were legally obliged to introduce unisex tariffs. Before 2012 tariffs were calculated for women and men separately. The new tariffs included a margin above as insurance companies had to estimate the ratio of women or men signing the contracts. The historical ratios were not a good prediction because of the significant differences of new premiums compared to the former ones and potential adverse selection.

(3) Average Loss per Event

Telematics devices might increase or decrease the average loss per event. On the one side, working with devices might reduce costs because a lot of information on underwriting and loss events is automatically provided. Also the incentives for fraud might be reduced. On the other side, the average loss might increase because of the devices are costly to implement and might also be destroyed in a loss event. It is questionable if and how much policyholders would take of these costs. When insurance is combined with other additional services the willingness to pay for such services could help to cover the investments to be made by the insurance companies. When looking for example at the health sector, one can see that technological innovations rather increase than decrease costs (see Erixon & van der Marel, 2011). Another important lever to reduce administration and productions costs is incentivizing and controlling prevention measures.

(4) Loss Exposure

The size of the risk pools has to be adequate that the insurer can calculate the loss probability. Several studies note that risk pooling remains limited due to the small size of many telematics schemes and the consequent limited applicability of the law of large numbers. However in most cases the size should be sufficient. This criterion also considers the frequency of losses. A general positive of telematics might be a reduction in loss frequency.

(5) Information Asymmetry

Insurers are allowed to use the information on the individuals, they will be able to form smaller homogenous risk pools.[38] As a consequence good risks are paying a lower and bad risks a higher premium and might not be able to afford the premium payment at all. This fragmentation debate is similar to the ongoing discussion about the usage of genetic information for risk calculation in health insurance. Hoy & Ruse (2005) argue that the reduction of adverse

[38] For example, health and life insurers could not only separate people by age and smoker/non-smoker, but for instance by their activity level. Another example is the motor insurance, where todays data in enriched with driving behavior (acceleration, breaking behavior, speed etc.).

selection and therefore the increasing efficiency comes along with the effect that individual with bad health conditions are punished twice and that some people would not take a genetic test because they are afraid that it influences their insurance premium (instead of seeing the test as a prevention instrument for detecting serious diseases). Furthermore, the authors argue that it could be beneficial for good risks to subsidize bad risks. Doherty & Posey (1998) find that for uninformed individuals a genetic test has a positive private value if prevention is sufficiently effective in lowering the premium, even though they have to share the information with the insurer. Following their argument, we think when individuals have the chance to emerge from bad risk class by prevention or changing behavior, technology can be beneficial for the society and does not contradict the solidarity principle.[39] Of course, ethical questions have to be addressed (see 4.3), because in health insurance behavior is often not (fully) the cause of certain illnesses.

4.2 MARKET CRITERIA

(6) Insurance Premium

With telematics insurers can make their pricing more precise. Good risks will get a premium reduction. Bad risks will have to pay more or are not getting insured at all. Especially in countries with developing insurance markets telematics can reduce the premium or reserve risks. Telematics tariffs allow for a more experienced based calculation. Prior modelling of claims is not so important.

But also in developed markets telematics has its relevance: For example, in Germany the expectation is that there'll be negative technical results in motor liability insurance in 2017 (combined ratio > 100%). In addition, investments results are low due to the low-interest environment. As a result overall costs could be not covered by the premiums. A better risk-based calculation of premiums could reduce losses in that line of business.

[39] Note that in some Italian regions young drivers only get insurance if they take a telematics tariff. This shows that also for bad risks having telematics can be beneficial as a prerequisite for insurability.

A more granular risk adjustment could lead to the situation that some people could not afford the premium. This should be from an ethic perspective not the case where people are not able to modify their (by changed behavior). The questions is if such issues can be solved by private insurance markets. If not, social care and tax regulation might be alternatives.

In contrast, more granular risk adjustments based on telematics could also help to decrease (almost non-affordable) premiums for others. For example, motor insurance is very expensive for young drivers compared to their low income. Sometimes reductions for young drivers apply if insurance contracts are linked with the insurance of the parents (accident-free). Tracking the driving behavior could reduce significantly the risk of accidents of these young drives. That's good for them and it would help to better price the premiums instead using age-based tariffs.

(7) Cover Limits

In general insurance markets are able to cover certain risks. For example in the German car insurance market there was an overcapacity of cover supply resulting in decreased average premiums. In general we would not expect telematics to reduce the ability of insurance markets to cover risks.

4.3 SOCIETAL CRITERIA

(8) Public Policy

The increasing transparency of humans will raise ethical and legal questions, e.g. if it is line with current freedom and equal rights? Can we accept that bad risks individuals might cannot purchase insurance? Is it line with the solidarity principal?

The public perception might be also different from case to case. For example, it might be cultural acceptable to price health insurance different for smokers than for smokers. But, it would be regarded more discriminating if policyholders were priced on their genetic dispositions (high blood pressure or diabetes in the family).[40] In motor insurance there might

[40] The acceptance of discrimination for things people can influence (smoking) is much higher than things people cannot influence. See Schmeiser et al. (2014).

be also good reasons to price driving behavior. The argument for that is not only on an individual level: road safety is a common good to which all drives contribute (or not). Driving bad is risk for others and scoring driving by telematics for insurance is quite similar to enforcing traffic regulations which are commonly accepted.[41]

The questions posed in this area are not easy to answer. Nonetheless, answering them could heavily influence insurability.

Another critical question for the societal acceptance of telematics is the question who profits and who does not profit from the introduction of the new tariffs. One might easily say that the good risks will profit by telematics by the discount they get and that the insurance company then will adjust the price of the bad risks to anticipate their higher loss probability. However, just saying that good risks are the winners and bad risks are the loosers is not enough, because it also might happen that bad risks become insurable if they are willing to use telematics (the example of the young driver who uses telematics for signaling).

(9) Legal Restrictions

The use of telematics for insurance purposes raises legal questions, which relate in particular to (insurance) contract law, to supervisory law (regulation) and to data protection law. Often these are interlinked with each other.

In respect of (insurance) contract law, regulators have to define which data can be collected and which data can be used by insurance companies for risk calculation, e.g. they have to make sure that discriminating characteristics cannot be derived by big data analytics (e.g. gender, ethnicity etc.). Legally it might be useful to separate between an insurance contract and

[41] Maas et al. (2008) illustrate that the willingness to share data and to use data for insurance pricing varies by topic and by country. For example, the willingness is highest for motor insurance, followed by housing and health. The acceptance to use health data is highest in the UK and lowest in Switzerland. See also Schmeiser et al. (2014).

an agreement to provide data via telematics (though both have to be considered economically as a ‘combined’ product).

From the supervisory law perspective, regulation in respect of outsourcing is of a certain relevance, because often insurance companies do not process the data by themselves. Service provider – normally non-financial, non-regulated entities without special supervision on them – act in between the policyholder and the insurance undertaking. Delegating tasks form a regulated insurance undertaking to a non-regulated telematics company may require supervisors’ (prior) consent on the arrangement.[42] Although outsourcing (e.g. within an insurance group) should be feasible, outsourcing requirements for the insurance company might be prohibitive. Supervisors closely monitor developments in the financial sector in relation to big data and think of adequate oversight, supervision, and/or regulation (see e.g. Joint Committee (2017)).

A special issue raised by telematics is privacy of personal data.[43] Telematics normally implies that individual data of a person is collected. Even if aggregated, the data allow for conclusions that are of a very private nature. An often example brought forward is that the insurance company would know about love affairs of its policyholders. Normally, policyholders have to allow for using their personal data. Legally, there’s a (written) consent needed (in addition to signing the contract). However, this consent can be withdrawn. In Europe data protection laws allow for the withdrawal by the policyholder at any time and without negative consequences on the contract (especially not cancellation of the contract).

Data security is a relevant topic as well. Cyber risks are increasingly important in an interconnected world (internet of things). Anonymisation, pseudonymisation, encryption and other measure against cyber-crime will help to increase data protection and insurability of risks based on telematics. This a technical challenge which will influence much development of

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42 E.g. under Solvency II regulatory requirements are in place for ‘critical’ outsourcing.

43 Personal data can be defined as any information relating to an identified or identifiable natural person ('data subject'); an identifiable person is one who can be identified, directly or indirectly, in particular by reference to an identification number or to one or more factors specific to his physical, physiological, mental, economic, cultural or social identity (Joint Committee (2017), p. 14).

markets. More transparency on how and which data are shared with the insurance company would be helpful. There is a certain reputational risk of insurance companies where telematics data is used.

Standardization of data sets and data transmission is an issue, too. Car manufacturer are not interested in common definitions or open interfaces because they try to build up business models and value chains based on these data. Advancements in the area of emergency calls (eCall)[44] based on telematics boxes trigger balancing interests of stakeholders.[45]

In summary, consumer, data, and competition have to be protected.

[44] See the so-called European eCall Regulation (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).

[45] Hering and Kraft (2015).

5 CONCLUSION

The intention of this paper was to analyze the use of telematics in insurance in light of the insurability criteria developed by Berliner (1982). We show that a number of problems with the insurability of telematics impede the market development. Table 2 summarizes these in light of the Berliner insurability framework.

Table 2 Assessment of insurability for risks monitored with telematics

Insurability criteria	Main findings	Assessment
(1) Randomness of loss occurrence	• Smaller risk pools possible (randomness remains) • Uncertainty of the effects of changed behavior of policyholders	*Rather not influenced by telematics*
(2) Maximum possible loss	• Reduction in costs • IT investments (shared with policyholders in the case of additional services?)	*Effects rather unknown; might be problematic*
(3) Average loss per event	• Arguments for an increase or decrease of average loss (reduced claim settlement costs and fraud vs. costly technology) • Empirically more evidence for lower claim size (Tindall, 2012); the benefits of telematics exceed the costs (Pitera et al., 2013)	*Telematics rather improves insurability*
(4) Loss exposure	• Adequate size of risk pools should be given • Empirically more evidence for lower frequency (20% less accidents both in Wouters and Boz, 2002 and Tindall, 2012)	*Telematics rather improves insurability*
(5) Information asymmetry	• Information asymmetry is reduced, but strong selection bias in existing empirical studies • Adverse selection: In some cases ambiguous, but rather advantageous selection (Mürmann and Kremslehner, 2016) • Moral Hazard: Most studies find a positive influence of telematics on behavior (Wouters and Boz, 2002; Tindall, 2012 vs. Heinzmann and Schade, 2002), but the influence seems to diminish over time (Bolderdijk et al., 2011)	*Telematics rather improves insurability*
(6) Insurance premium	• More precise (actuarial) pricing possible • Premium reductions / discounts make insurance more affordable • Also developing insurance markets might profit and overcome lack of data or poor data quality	*Telematics rather improves insurability*
(7) Cover limits	• Not affected	*Rather unaffected by telematics*
(8) Public policy	• Ethical questions caused by the use of telematics • Discrimination, solidarity	*Might be problematic*
(9) Legal restrictions	• (Insurance) contract, supervisory and data privacy law has to be taken into account. • In many countries were a high restrictions to use personal data, in particular health data (privacy) • Data security has to be ensured (anonymisation, pseudonymisation, encryption) • Data standardization	*Might be problematic (depending on jurisdiction)*

Given the relatively early stage of the market development, there are many fold open questions that might be addressed by future research. Overall, it seems that the true impact of telematics on driving behavior is not fully explored or at least some ambiguous results might be observed. Both experimental and empirical research might be needed to better explore the risk implications of telematics. One possible direction might be the design of an experiment with driving simulators. For example, a comparison of the driving behavior without observability and without insurance protection analyzed with the driving behavior 1) without observability and with full insurance, 2) with observation and individual feedback (but without passing on to an insurer) and 3) with observation and transfer to an insurer for the risk-adequate Calculation of premiums. Driving simulators are very common in recent experiential accident research (see, for example, Dixit et al., 2013), but an application in the context of business and economic questions is not known to us.

Another avenue for future research might be to conduct choice based conjoint analysis of different telematics products in order to better understand the customer expectations and their willingness to pay. While such studies exist for the life and health industry (see Braun et al., 2016; Barwitz, 2017), we are not aware of any study in the field of non-life insurance and considering telematics.

In addition, the interaction of actuarial, market and societal criteria has to be further analyzed. Especially legal restrictions on the use of (personal) data should be better understood with their impact on the insurability of risks. Interdisciplinary approaches in research could be a promising way forward.

REFERENCES

Allianz (2016), Geld zurück für sicheres Autofahren (Press Release 16-04-23), https://www.allianzdeutschland.de/wer-gut-auto-faehrt-bekommt-geld-zurueck/id_77469302/index [17-06-02].

Berliner, B. (1982), Limits of Insurability of Risks, Englewood Cliffs, NJ: Prentice-Hall.

Berliner, B. (1985), Large Risks and Limits of Insurability, *Geneva Papers on Risk and Insurance* 10(4): 313-329.

Berliner, B. and Bühlmann, N. (1986), Subjective Determination of Limits of Insurability on the Grounds of Strategic Planning, *Geneva Papers on Risk and Insurance* 11(2): 94–109.

Biener, C. and Eling, M. (2012), Insurability in Microinsurance Markets: An Analysis of Problems and Potential Solutions, *Geneva Papers on Risk and Insurance* 37(1): 77–107.

Biener, C., Eling, M. and Wirfs, J.H. (2015), Insurability of Cyber Risk: An Empirical Analysis, *Geneva Papers on Risk and Insurance* 40(1): 131–158.

Braun, A., Schmeiser, H. and Schreiber, F. (2016), On Consumer Preferences and the Willingness to Pay for Term Life Insurance, *European Journal of Operational Research* 253(3): 761–776, https://doi.org/10.1016/j.ejor.2016.02.023.

Dixit, V., Harrison, G., and Rutström, E. (2013), Estimating the Subjective Risks of Driving Simulator Accidents, *Accident Analysis and Prevention*, 62: 63–78.

Doherty, N. A. (1991), The Design of Insurance Contracts When Liability Rules Are Unstable, *Journal of Risk and Insurance* 58(2): 227–246.

Eling, M. and Lehmann, M. (2017), The Impact of Digitalization on the Insurance Value Chain and the Insurability of Risks, Working Paper.

Generali (2016a), Generali Vitality: better health starts today (Press Release 16-06-23), http://www.generali.com/media/press-releases/all/2016/Generali-Vitality-better-health-starts-today [17-06-02].

Generali (2016b), Le programme Generali Vitality lancé en France (Press Release 16-09-06), http://presse.generali.fr/communique/121740/Le-programme-Generali-Vitality-lance-en-France [17-06-02].

Generali (2016c), Generali and Progressive announce telematics R&D agreement, http://www.generali.com/media/press-releases/all/2016/Generali-and-Progressive-announce-telematics-R-D-agreement [17-06-02].

Generali (2017), Introduction to Vitality, https://generalivitality.com/ [17-06-02].

Hering, J. and Kraft, M. (2015), Was Versicherer jetzt bei der Entwicklung von Telematik-Tarifen berücksichtigen sollten, *Zeitschrift für Versicherungswesen* 66(14): 451–456.

HUK-COBURG (2017), Telematik: Smart Driver startet deutschlandweit, https://www.huk.de/presse/nachrichten/aktuelles/telematik.html [17-06-02].

Insurethebox (2017a), What is telematics?, https://www.insurethebox.com/telematics [17-06-02].

Insurethebox (2017b), Will 28th January be a dark day for drivers? (Press Release 17-01-26) https://www.insurethebox.com/wp-content/uploads/2017/01/ITB17.38-Accident-survey-final.pdf [17-06-02].

Jaffee, D. M. and Russell, T. (1997), Catastrophe Insurance, Capital Markets, and Uninsurable Risks, *Journal of Risk and Insurance* 64(2): 205–230.

Janssen, J. (2000), Implementing the Kyoto Mechanisms: Potential Contributions by Banks and Insurance Companies, *Geneva Papers on Risk and Insurance—Issues and Practice* 25(4): 602–618.

Joint Committee (2017), Discussion Paper on the Use of Big Data by Financial Institutions, https://esas-joint-committee.europa.eu/Publications/Discussion%20Paper/jc-2016-86_discussion_paper_big_data.pdf [17-06-02].

Karten, W. (1997), How to Expand the Limits of Insurance, *Geneva Papers on Risk and Insurance*, 22(85): 515–522.

Maas, P., Graf, A. and Bieck, C. (2008), Trust, transparency and technology, *European Customers' Perspectives on Insurance and Innovation. IBM und I. VW-HSG, St. Gallen*.

Morawetz, M. (2016), Wavy Lines Taken with Telematics in Motor Insurance, http://media.genre.com/documents/kfz1603-en.pdf [17-06-02].

Much, M. (2014), Vorsicht zahlt sich aus, *GDV-Positionen 93*, http://positionen.gdv.de/den-fahrer-im-blick/2/ [17-06-02].

Nierhaus, F. (1986), A Strategic Approach to Insurability of Risks, *Geneva Papers on Risk and Insurance—Issues and Practice* 11(2): 83–90.

Olson, P. (2014), Insurers aim to Track Drivers through Smartphones, 14-08-05, http://www.forbes.com/sites/parmyolson/2014/08/05/for-insurers-apps-become-a-window-to-monitor-drivers/ [17-06-02].

Schanz, K.-U. and Sommerrock, F. (2016), Harnessing Technology to Narrow the Insurance Protection Gap, Zurich.

Schmeiser, H., Störmer, T. and Wagner, J. (2014), Unisex Insurance Pricing: Consumers' Perception and Market Implications, *Geneva Papers on Risk and Insurance—Issues and Practice 39*(2): 322-350.

Schmit, J. T. (1986), A New View of the Requisites of Insurability, *Journal of Risk and Insurance* 53(2): 320–329.

Swiss Re (2017). Unveiling the full potential of telematics: How connected insurance brings value to insurers and consumers: An Italian case study. Zurich.

Vermaat, A. J. (1995), Uninsurability: A Growing Problem, *Geneva Papers on Risk and Insurance—Issues and Practice* 20(4): 446–453.

Weidner, W. and Transchel, F. W. G. (2015), Aktuarielle Besonderheiten bei der Kalkulation von Telematik-Tarifen in der Kfz-Versicherung, *Zeitschrift für die gesamte Versicherungswissenschaft* 104(5): 595–614, https://doi.org/10.1007/s12297-015-0320-z.

APPENDIX A: SEARCH AND IDENTIFICATION STRATEGY

- We searched for the terms 'telematics' and 'insurance' or 'telematics' and 'insurability' in the journal databases EBSCOhost (Business Source Premier and EconLit) and ABI/INFORM Complete. In addition, we searched for the terms in the Social Science Research Network (SSRN) and via Google Scholar.
- We reviewed all issues from January 2000 to December 2016 of the following journals: Journal of Finance, American Economic Review, Journal of Risk and Insurance, Insurance: Mathematics and Economics, Journal of Financial Stability, The Geneva Papers on Risk and Insurance – Issues and Practice, and The Geneva Risk and Insurance Review. Other journals from the field of risk and insurance were also reviewed (Journal of Insurance Regulation, Risk Management & Insurance Review, ASTIN Bulletin, North American Actuarial Journal, European Actuarial Journal).
- We reviewed all working papers from the annual meetings of the American Risk and Insurance Association (ARIA) for 2011, 2012, 2013, 2014, 2016, and the 2010 and 2015 World Risk and Insurance Congress.
- We reviewed all citations in relevant studies to identify additional relevant material.

APPENDIX B: LIST OF STUDIES

Table B1 Academic articles and industry studies on telematics

#	Title	Author	Data & Methodology	Key Results	Year	Journal
1	Asymmetric Information in Automobile Insurance: Evidence from Driving Behavior	Mürmann, A., Kremslehner, D.	• 'Telematic' data set with detailed information about driving behavior (speed, distance driven, road type), pay-as-you-drive contract • Pricing of the contract is based on the aggregate distance driven and road typ; contract is more likely to be chosen by younger, females and in urban areas (with valuable cars and higher engine power); results hold only for this group • They also have access to the corresponding insurance data; 2,340 cars over 3 months (Feb-April) • Also uses income /purchasing power to find evidence for influencing coverage and behavior, but they cannot find one	• Number of car rides and relative distance driven on weekends are significant risk factors • Average speeding and number of car rides are negatively related to high third-party insurance -->opposite to prediction of adverse selection • Number of car rides and relative distance driven at night are positively related to first party coverage --> in line with adverse selection • Risk-averse or less overconfident people buy more liability coverage and use their car more considerate by taking fewer short rides) • Telematic policy holders drive less than the average	2016	Working Paper WU Wien
2	Classification of scale-sensitive telematic observables for riskindividual pricing	Weidner, W., Transchel, F., Weidner, R.	• Pricing of telematics • Propose scale-sensitive approach that treats observations on semantically different levels	• Show how maneuvers, trips and trip sections as well as the total insurance period can be analyzed to gain insights into individual driving behavior	2016	European Actuarial Journal
3	Aktuarielle Besonderheiten bei der Kalkulation von Telematik-Tarifen in der Kfz-Versicherung	Weidner, W., Transchel, F.	• Pricing of telematics • Pricing applied on the level of individual driving styles, whereby the actual scoring is achieved through the use of convex linear combinations on a simplex	• In the calculation of premiums, the considerable costs caused by the high data volume must also be taken into account • Data are interfered with by many sources of error • Investment in IT security necessary	2015	Zeitschrift für die gesamte Versicherungswissenschaft
4	Telematics System in Usage Based Motor Insurance	Husnjak, S., Perakovic, D., Forenbacher, I., Mumdziev, M.	• Study with 22 participants only • 70% reported improved driving score because of technical solution	• Overview of telematics implementations and technical description • Results motivate to start larger study (200 participants) in Eastern Europe	2015	Procedia Engineering
5	Time and distance to first accident and driving patterns of young drivers with pay-as-you-drive insurance	Ayuso, M., Guillén, M., Pérez-Marin, A. M.	• Study of 16'000 young drivers (<30) with a PAYD insurance in Spain • Analyzed their risk of accident as a function of driving patterns	• Compares novice drivers with experienced young drivers • Night and speeding are risk factors for both groups, also gender differences are observed	2014	Accident Analysis & Prevention
6	Telematics strategy for automobile insurers	Paefgen, J.	• Technical description of systems • Business case for new entrant • Structure of international markets for insurance telematics services • Interview with 13 insurance companies in the German speaking countries	• Business case depends primarily on technology costs and the reduction of the average claims rate in a PAYD tariff • PAYD offering constitutes a risky endeavor that is subject to several uncertainties, but comes with the prospect of substantial	2013	Working Paper i-lab.ch (ETH and HSG)

				profits in an otherwise saturated market		
7	Implementing Automotive Telematics for Fleet Insurance	Azzopardi, M., Cortis, D.	• SWOT analysis telematics vs. conventional • Interviews of 25 key stakeholders in Malta	• local insurers have interests in such insurance schemes as enhanced fleet management and monitoring translate into an improved insurance risk.	2013	Journal of Technology Management & Innovation
8	Economic Analysis of Onboard Monitoring Systems in Commercial Vehicles	Pitera, K., Boyle, L., Goodchild, A.	• Cost-benefits-analysis to better a better understand the economic implications of OBMSs • In addition to the benefits of reduced crashes, the benefits associated with reduced mileage, reduced fuel costs, and the electronic recording of hours of service (HOS) are considered	• Sensitivity analysis demonstrates that OBMSs are economically viable under a wide range of conditions • For some types of fleets, a reduction in crashes and an improvement in HOS recording provides a net benefit of close to $300,000 over the 5-year expected life span of the system	2013	Transportation Research Record Journal of the Transportation Research Board
9	Developing Insurance Telematics	Tindall, J.	• Study of 10,000 policyholders aged 18-25 who had telematics based insurance products • Also describes state of telematics insurance market	• On average they had a 20% lower claim frequency and 30% lower average claim size	2012	Journal of the Australian & New Zealand Institute of Insurance & Finance
10	Driving behavior analysis with smartphones: insights from a controlled field study	Paefgen, J. , Kehr, F., Zhai, Y., Michahelles, F.	• Used fixed route and mobile app for their assessments (students from HSG)	• Evaluate a mobile application for assessment of driving behavior, smartphones have some improvements (study is from 2012)	2012	Conference paper
11	Effects of pay-as-you-drive vehicle insurance on young drivers' speed choice: Results of a Dutch field experiment	Bolderdijk, j., Knockaert, J., Steg, E. M. and Verhof, E.	• Field experiment with 141 people younger than 30, from Nov 2007 - June 2008 • Monitoring with GPS devices (where, speed, time, how many) • 4 phases: pre, intervention 1, intervention 2, post (each 2 months) • no financial discount during pre and post, but in intervention 1 and 2 for good driving (up to 50EUR per months, in total 200 EUR) + feedback • they also framed loss and gain of 50 EUR, could not find any differences	• PAYD reduces speeding • Awareness of being monitored fades over time	2011	Accident Analysis & Prevention
12	Telematics data in motor insurance: creating value by understanding the impact of accidents on vehicle use	Ippisch, T.	• Telematics-based data from 1598 Italian motorists (from Octo Telematics) • Authors uses post crash analysis to illustrate importance of telematics	• Studies the accident impact on travel and driving behavior • Accident involvement significantly impacts motorists travel and driving behavior • points out research gaps	2010	Dissertation HSG
13	Effects of in-vehicle monitoring on the driving behavior of teenagers	Farmer, C., Kirley, B., McCartt, A.	• Analyzes if teenage driving behavior improves when a monitoring and feedback device is installed • Vehicles of 85 teenage drivers	• Seat belt use improved when violations were reported to parents • Consistent reductions in speeding were achieved only when teenagers received alerts about their speeding behavior.	2010	Journal of Safety Research

				• Electronic monitoring of teenage drivers can reduce the incidence of risky behavior, especially seat belt nonuse. More complicated behavior is more difficult to change, however. • Parent participation is key to successful behavioral modification		
14	In-vehicle data recorders for monitoring and feedback on drivers' behavior	Toledo, T., Musicant, O., Lotan, T.	• IVDR in 1991 vehicles of a single company (compact pick-ups, used during work) • measures behavior, drivers were informed, but no feedback for drivers or managers • Feedback stage: Post feedback online, comparison with other drivers • Also past crashes were collected • Based on blind stage they calculated the riskiness	• Reductions in crash rates and the risk indices are observed in the short-term. • Driving risk indices can be used as indicators to the risk of involvement in car crashes	2008	Transportation Research Part C: Emerging Technologies
15	Safety correlation and implications of an in-vehicle data recorder on driver behavior	Musicant, O., Lotan, T., Toledo, T.	• 103 drivers with an in-vehicle data recorder (IVDR) • Gave feedback to drivers	• Effect of IVDR diminishes over time • Exposure to the feedback generated from the system has a potentially high impact on collision reduction with over 40% reduction in crash rates using before and after data. • Behavioral change has been maintained for 9 months	2007	Preprints of the 86th Transportation Research Board Annual Meeting
16	The 100-car naturalistic driving study phase II – results of the 100-car field experiment	Dingus et al.	• 100 vehicles with IVDR continuously measuring the vehicle position, speed, and acceleration using GPS, acceleormeters and video cameras • Expensive study over 13 months	• Event database was created, similar in classification structure to an epidemiological crash database, but with video and electronic driver and vehicle performance data	2006	Department of Transportation, Washington D.C.
17	Speed management, European Conference of Ministers of Transport, OECD Publishing.	ECMT	• Number of participants and feedback not reported	• Weekly summary of reports sent to people in Iceland reduced accidents by 43% over 6 months (	2006	OECD Publishing
18	Mileage-Based User Fee Demonstration Project: Potential Public Policy Implications of Pay-As-You-Drive Leasing and Insurance Products	Buxbaum, J.	• Market survey and field experiment • Telephone survey of 400 households + 100 add. Households, + mail • 130 driver, at certain points drivers were offered cash rewards for reducing mileage • only mileage data was collected	• PAYD concepts, if implemented, would likely be targeted to niche markets. 25 to 30 percent of the marketplace might be interested • among vehicle leasers, 50 to 75 percent might be interested • Provides key characteristics of the target market: People Comfortable with new technologies, less concerned about privacy issues, tend to be concerned about environmental issues,	2006	Cambridge Systematics

				and often think about ways to control driving costs		
19	Reducing Asymmetric Information in insurance markets: cars with black boxes	Filipova, L., Welzel, P.	• Theoretical paper how black boxes reduce moral hazard and asymmetric information • Assumes that insurers can offer a contract with access to recorded information ex post, i.e., after an accident, in addition to the usual second-best contracts.	• Find that this leads to a Pareto-improvement of social welfare except when high risks initially received an information rent. • Regulation can be used to establish Pareto-improvement also in these cases. • Explicit consideration of privacy concerns of insurees does not alter our positive welfare results.	2010	Telematics and Informatics
20	Quantitative assessment of driver speeding behavior using instrumented vehicles	Ogle, J.	• Presents a framework and methods for quantifying and analyzing individual driver behavior using instrumented vehicles • 172 instrumented vehicles from the Commute Atlanta program were utilized to collect individual driver speeding behavior	• On average, nearly 40% of all driving activity by the sample population was above the posted speed limit. • The amount and extent of speeding was highest for young drivers. • Trends indicate that speeding behavior decreases in amount and extent as age increases	2005	PhD dissertation
21	When technology tells you how you drive—truck drivers' attitudes towards feedback by technology	Roetting, M., Huang, Y.-H., McDevitt, J., Melton, D.	• 66 participants and 9 focus groups which discussed the topic • Evaluates whether feedback can improve safety of trucking operation	• Behavior based safets (BBS) methods to improve safety by engaging workers by teaching them to identify critical safety behavior (industry workers, lumbermen etc.) • Technology in trucks could be used to observe critical behavior of truck drivers	2003	Transportation Research Part F: Traffic Psychology and Behaviour
22	Moderne Verkehrs-sicherheits Technologie Fahrdatenspeicher und Junge Fahrer	Heinzmann, H.J., Schade, K.	• Voluntary subjects	• Driving with an accident data store in the private car does not have a significantly positive effect on the driving behavior of male drivers aged between 19 and 25 years. • Neither the frequency of accidents significantly decreases nor the amount of damage (also no reduction in the frequency of registered traffic violations)	2002	Berichte der Bundesanstalt für Straßenwesen, Mensch und Sicherheit
23	Traffic accident reduction by monitoring driver behaviour with in-car data recorders	Wouters, P., Bos, J.	• 840 vehicles of which 270 equipped with a recorder • Vehicles were part of a business fleet	• Driver know that their driving behavior is recorded. • Only the presence led to an accident reduction of 20%	2000	Accident Analysis & Prevention