Acceptance Factors of Car Insurance Innovations: The Case of Usage-Based Insurance

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***Abstract*—Usage-Based Insurance (UBI) is an application of Intelligent Transportation Systems (ITS) in the context of car insurance. UBI refers to insurance models in which insurers collect driving data using a telematics device. Based on the collected information, insurers can offer individual discounts depending on driving behaviour and provide feedback about each trip. Although there are plenty of advertising materials about the benefits of UBI, its user acceptance and usability have not received much research attention so far. To cover this gap, we conducted two user studies: semi-structured interviews with UBI users and a qualitative analysis of 186 customer inquiries concerning a UBI program from a web forum of a German insurer. We found that UBI can benefit drivers, insurers and society. Moreover, the country driving conditions, the policy conditions, the users' perceived driving style, the perception of UBI, and the premium reduction influence UBI acceptance. Regarding traffic safety, some of our participants were concerned that UBI may provoke dangerous driving behaviour under certain circumstances. Finally, we make recommendations for insurers derived from users' views, such as to provide to drivers more control over the user interface and over the way driving feedback is given to them. Concerning the driving scores, the ways in which they are calculated should be more transparent.**

***Index Terms*—intelligent transportation system, Pay-As-You-Drive, usage-based insurance, usability, user acceptance**

I. Introduction

A variety of technologies related to topics such as Vehicular Ad Hoc Networks (VANETs), traffic signal control, intelligent vehicles, among others, are covered in Intelligent Transportation Systems (ITS) [1]. A further innovation in ITS is Usage-Based Insurance (UBI), which is a new trend in the car insurance business. Whereas the traditional car insurance models calculate the insurance fee based on static data (e.g., age, gender, address, car color) and the driving history, UBI calculates premiums based on individual driving style using actual driving data [2]. The traditional car insurance models implement a subsidised system, where better drivers subsidise drivers who have a higher accident risk. In contrast, UBI allows fair and personalised policies. The main benefit of UBI for insurers is reduced losses due to more accurate risk calculation [2], [3]. Drivers are also expected to benefit, because such insurances incentivise them to improve their driving style through feedback [2]. Thus, UBI has the potential to benefit society due to reduction in traffic congestion, facility costs, and the amount of accidents [4].

The main disadvantages of UBI are the investment costs [5] and the impact on user privacy [2], [3], [5]. For example, users would not want to disclose some information (i.e., where, when, and how they drive) to insurers, government agencies, or other companies [2]. Usability is an important aspect of UBI solutions, where user interaction with cars and with additional devices is often required. Therefore, people may reject a UBI solution with a low usability. Solutions with high user acceptance and usability have the potential to benefit society. However, the usability and the user acceptance of current real-world UBI systems are not known. As the first step towards identifying them, we conducted two user studies: a series of semi-structured interviews with UBI users and a qualitative analysis of customer posts about a UBI system called BonusDrive. BonusDrive is a UBI program implemented by Allianz (Germany) for young people (18-28 years old) or a family with a young member. In BonusDrive, driving data (i.e., braking, cornering, acceleration, speeding, time of day, and type of road driven) are collected using a telematics device to calculate the driving score. A Bluetooth connection between the telematics device and the car is used for vehicle identification.

A. Contribution

We conducted interviews with UBI users to identify possible concerns about usage of such services (i.e.,

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dangerous driving, drivers' habit restriction, drivers' privacy decrease). Our findings are corroborated through analysis of real-world UBI inquiries from an insurer forum. We find that providing drivers more control over the user interface and the way driving feedback is given, and making UBI programs more transparent, might help to mitigate these concerns. Furthermore, we identify user acceptance factors related to external conditions (i.e., country driving conditions, policy conditions, and premium reduction) and drivers' internal characteristics (i.e., perceived driving style and perception of UBI). Finally, we provide some recommendations for insurers based on the analysis of our user studies.

B. Outline

This paper is organised as follows. Section II presents UBI and related work. Section III describes the methodology used to conduct the semi-structured interviews with UBI users and the forum analysis of UBI customer inquiries. Section IV and section V present the findings of the interviews and the forum analysis, respectively. They are further discussed in Section VI, including recommendations for insurers. Section VII presents the limitations of our user studies. Finally, Section VIII concludes and outlines future research directions. Research materials used in the user studies are given in Appendix A.

II. Background and Related Work

A. Usage-Based Insurance

Fig. 1 depicts a Usage-Based Insurance model, where a driver provides her collected driving data to a service provider via a telematics device, such as a Bluetooth dongle (a plug-and-play device), a black box (a professionally installed device), a smartphone or a built-in embedded system that is already present in the recently made cars. Pay-As-You-Drive (PAYD) is often used as a synonym for UBI.

The service provider calculates the driving score and statistics of the driver and sends them to the insurer to calculate the premium discount. The service provider may be the same entity as the insurer, but in practice it is often a different company that has the corresponding know-how. In this case, user data is usually pseudonymized, and the insurers argue that as they do not have access to the raw behavioral data, and the service providers only process the pseudonymized data, users' privacy is well protected, and possible privacy concerns are mitigated [6], [7].

B. Benefits, Acceptance, and Academic UBI Systems

Litman [4] compares several distance-based insurance solutions and evaluates potential concerns and benefits for drivers, insurers, and society. Soleymanian et al. [2] find that the drivers improve their driving behaviour after using UBI for six months, decreasing the daily average braking. Mayer [8] studies the acceptance factors for UBI. He finds that the saving potential and the expected effect on driving pleasure are important acceptance factors, while privacy concerns do not play an important role. Similarly, Derikx et al. [3] find that customers are willing to share their driving data when small financial rewards are offered.

Some academic solutions for UBI have been proposed, but not implemented in practice. Händel et al. [9], Iqbal et al. [10], and Troncoso et al. [11] propose solutions that process driving data locally in the car and send to the insurer only aggregated data to calculate the premium. Boquete et al. [12] propose a similar system with a repository where the insurer can access driving data. Additionally, aggregated data for supporting road vehicle traffic monitoring can be provided [9]. Kung [13] proposes a privacy enhancing architecture for ITS, which highlights the relevance of architecture in designing a privacy-by-design solution.

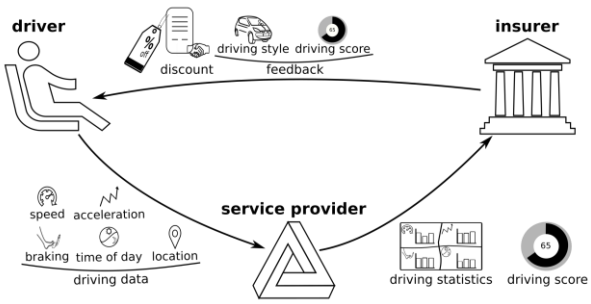

Figure 1. General usage-based Insurance model.

III. Methodology

We conducted two studies to understand users' attitudes and usage of UBI. A series of semi-structured interviews with UBI users and forum inquiries of a UBI program were analysed using thematic analysis [14] and qualitative content analysis [15], respectively.

A. Interviews

This study was designed and conducted at an Austrian university during a research internship that originated from a university in Germany. For this reason, we took as reference the UBI programs in Austria and Germany. Originally, we planned to conduct semi-structured interviews with 10 current, 10 former, and 10 potential UBI users. *Current users* are people covered by a UBI program. *Former users* are people who had been covered by a UBI program and for some reason are no longer covered by it. *Potential users* are people who potentially could be UBI users, but have never been covered by UBI so far. The users in the latter category should be over 18 years old with a driving license, have less than five years of driving experience or be under 30 years old. These conditions are defined by German and Austrian insurance companies for users to be eligible for a UBI insurance. However, due to recruiting difficulties this plan was later revised (see below). Interviewees were asked about their experiences, opinions, and comments regarding UBI. For potential users we prepared a short video to explain to them how UBI works, without mentioning any advantages or disadvantages of this insurance model.

To prepare and to conduct the interviews, we first developed the interview questions based on academic

papers, news, and brainstorming sessions. Second, we submitted the interview questions and the ethical and data protection considerations to the ethics committee at the Austrian university, and received the ethical approval. Third, we recruited the participants and conducted the interviews. Finally, we transcribed the interviews and analysed them using thematic analysis [14]. The research resources used in the user studies: the recruitment questionnaire, interview questions, and the UBI explanation video, are provided in Appendix A.

1) Participant recruitment

Participants were recruited via an e-mail list for user studies at the Austrian university. We set the inclusion criteria according to the definition of current, former, and potential UBI users.

After running the recruitment questionnaire for five weeks, we received 190 full responses from 3 current, 2 former, and 185 potential users. Therefore, the initial interview plan had to be adjusted. Three current, two former, and twenty (10 female, 10 male) potential users were invited via e-mail to be interviewed, but only one former user and 17 potential users responded to our invitation (9 female, 9 male). Interviewees were compensated with EUR 20 in cash.

2) Data collection

We conducted the interviews in person or via Skype video calls. All interviews were conducted in English. The participants provided an informed consent about data usage and processing. Interviews lasted between 15 and 54 minutes (M=40.18, SD=10.98). For each interview we made audio recordings and notes. After conducting interviews, all recordings were transcribed and the collected information (recordings and notes) was stored with restricted access.

TABLE I. DEMOGRAPHIC DATA OF INTERVIEW PARTICIPANTS

	Category	N
Age (years)	18-21	5
	22-25	8
	26-29	5
Education	secondary school	6
	bachelor degree	11
	master degree	1
Gender	Female	9
	Male	9

Table I presents demographic data of participants. The most represented age category was between 22 and 25 years old, and most participants had bachelor degree. Our sample is balanced across gender (9 female, 9 male). Most of the participants are from Austria (five), followed by Serbia (two), and one participant from each of the following countries: Brazil, Bulgaria, Croatia, Germany, Greece, Italy, Korea, Macedonia, Russia, Spain, and Turkey.

3) Data analysis

We conducted an inductive thematic analysis [14] going from codes to themes. Firstly, one researcher read the transcriptions of interviews and wrote down initial ideas. Secondly, he proposed initial codes for relevant characteristics of the data. Then, he grouped the codes into categories (subthemes) based on the context and the way in which the participants mentioned the codes during the interviews. The themes emerged by grouping similar subthemes together. Finally, the authors discussed the themes and the subthemes, checking the connection between them and the codes.

B. Forum Analysis

Allianz forum [16] is an online public space, where the customers can submit inquiries about Allianz products, specific concerns, or general questions about insurance. According to the Terms of Use, the users cannot include personal or external data in the posts (e.g., name, address, license plates, etc.) and they agree that Allianz or other users can use their texts for posting information or other purposes. We analysed users' inquiries concerning an Allianz product called BonusDrive, a UBI program for drivers between 18 and 28 years of age. In BonusDrive the driving behaviour is determined based on data such as speed, acceleration, braking, GPS location, time of day and type of road driven.

1) Data extraction

We selected words related to UBI based on BonusDrive documentation, news, and academic papers. Those words were used as filter keywords to retrieve 186 posts related to BonusDrive, using a process described in Appendix A.

2) Data analysis

We conducted a qualitative content analysis [15] of the extracted posts. Initially, two researchers independently worked through the first 56 posts to identify relevant categories and to code the posts into identified categories. Then, they discussed their identified categories, designing a unified code book. Using it, the researchers coded all posts, reaching a Cohen's Kappa coefficient of greater than 0.80 (an almost perfect agreement according to Landis *et al*. [17]).

IV. INTERVIEW FINDINGS

In the interviews with one former and 17 potential UBI users, 3 themes, 15 subthemes and 37 codes were identified, which are presented in Table II. Below we present the identified themes, subthemes, and codes (in *italics*). For interviewees' quotes we use the acronym FU (Former User) and PU (Potential User).

TABLE II. THEMATIC ANALYSIS FROM INTERVIEWS WITH USERS

Theme	Subtheme	Code
Advantages	Benefits for drivers	Drivers profiling is performed Driving data are connected with each other Drivers get additional services Drivers identify driving mistakes Drivers are encouraged to improve their driving style UBI is a fair system
	Benefit for insurers	Insurers' losses are prevented
	Benefits for society	Car accidents decrease Security in traffic increases
Disadvantages	Dangerous driving	UBI may provoke dangerous driving

	Drivers' habit restriction	Driving habits are restricted Driving enjoyment decreases
	Drivers' privacy decreases	UBI decreases drivers' privacy People have nothing to hide from insurers Drivers feel uncomfortable being tracked Other technologies do not provide privacy
	Feedback not customisable	Feedback should be customisable by drivers Feedback during trips distracts drivers
	Scoring system	Driving data do not determine driving skills Driving data may be wrong
	Telematics device	Drivers have to configure the telematics device before each trip Telematics device may be outdated
	Use of driving data for other purposes	Someone may use driving data for other purposes
Acceptance Factors	Country driving conditions	Driving traditions influence drivers' habits Relaxed regulation prevents from improving driving skills
	Perceived driving style	Own driving style perception Monitored drivers drive better
	Perception of UBI	UBI opinion of a relative, friend, or expert Insurer's reputation Service provider's reputation Negative experience of UBI users People do not trust insurers
	Policy conditions	Insurance conditions Insurance costs UBI transparency
	Premium reduction	Insurance discount Premium discount motivates to change driving style

A. Advantages

Users mentioned positive consequences or benefits of using UBI for different stakeholders (i.e., drivers, insurers, and society). Table I. Demographic data of interview participants.

Benefits for drivers were supported by three arguments. First, *drivers profiling is performed* (i.e., good and bad/reckless), giving an advantage to good drivers. PU-13 mentioned: "they (insurers) can adjust the price better for risky and reckless drivers". Second, *driving data are connected with each other*, providing a more accurate estimation of driving style based on more data points. For example, GPS location could be used to validate speed limits and type of road, among others. So, FU-01: "Speed I think, this could be monitored and then by combining with the GPS location, you could assess that for example: the car is driving this way and you have a speed limit of 50 and the driver is going 80". Finally, UBI users find that by using UBI, *drivers get additional services* such as emergency call and car location. PU-17 noted: "in a car is a good thing actually because if you have an accident or anything and you cannot call someone, the company (insurer) knows where you are from the GPS location".

Another mentioned benefit was that *drivers identify driving mistakes* through feedback. PU-13: "just like saying about speed, acceleration, and braking those things are helpful to fix their (drivers) habits [...] the driver himself cannot recognize that he is too fast". Thus, *drivers are encouraged to improve their driving style* and get a premium discount. Therefore, some users think that *UBI is a fair system*.

Benefit for insurers mean that *insurers' losses are prevented*. PU-14 stated: "to reduce losses for the insurance company, I think they have to consider […] real driving skill at the firsthand". Thus, insurers may reduce loss if their customers decide to move to UBI, because in UBI insurers could make a more accurate estimation of drivers' risks based on real driving data.

Benefits for society were also mentioned, such as a decline of the number of car accidents (*car accidents decrease*). They have a positive effect on road safety, such as improved security in traffic (*security in traffic increases*). PU-12 noted: "if you drive in a safe way, you decrease the risk for the insurer and you decrease the overall risk in traffic [...] the overall rate of traffic accidents would decrease".

TABLE III. CATEGORIES FROM ALLIANZ FORUM (186 POSTS), TOPICS LABELED WITH * WERE ALSO DISCUSSED IN THE INTERVIEWS. THE NUMBER OF POSTS OF EACH CATEGORY IS INDICATED IN BRACKETS ( ). SOME POSTS INCLUDED MORE THAN ONE CATEGORY

Category	Explanation
*Wrong score (39)	Score obtained for a trip is different from the driver's expectation
Trip recorded, but not saved (31)	App showed ongoing recording, but trip was not shown in the logbook afterwards
App stopped working (25)	After updating the smartphone or changing app properties the app stops working
Starting problems (25)	Due to logistical or technical problems the user cannot begin to use BonusDrive
Trip not recorded (21)	Trip recording process did not start or trip was only partially recorded
*Problems with Bluetooth (16)	Bluetooth pairing process does not work, or connection breaks down
Distrust in the insurer (15)	User suspects Allianz provides wrong, unrealistic or contradictory information on purpose
*BonusDrive may provoke dangerous driving (11)	Trying to improve driving score, users generate dangerous situations
*Trips are recorded although users do not drive their cars (10)	Recording trips in passenger mode or when the user travels by foot, train, bike or in another car
*Trip recording starts too late (9)	Trip recording process starts later than the actual trip, leading to wrong scores
Information is lost (6)	Users cannot see previously saved information in the app
App takes too long to save the trip (3)	Users have to wait in the car several minutes after the trip end till the trip is saved

B. Disadvantages

Users also reported some disadvantages of UBI usage, which are described below.

Dangerous driving could be provoked by UBI drivers trying to get a high score or to change their own driving style, causing dangerous situations or accidents (*UBI may provoke dangerous driving*). For example, PU-13 noted: "[...] if they (some drivers) receive a score less than 100, they would try another style every next trip. So, they will change their driving style every day and I don't think that it would be very helpful [...] you won't be as attentive and it causes accidents".

Drivers' habit restriction worries some users, who believe that UBI imposes limitations on their driving (*driving habits are restricted*). PU-10 claimed: "I don't like to have some limitation when I'm driving, I just like to drive". Such limitations, whether perceived or actual, may decrease driving enjoyment (*driving enjoyment decreases*).

Drivers' privacy decreases when using UBI (*UBI decreases drivers' privacy*). Although some users stated that *people have nothing to hide from insurers*, others feel uncomfortable knowing that they are being tracked (*drivers feel uncomfortable being tracked*). FU-01 mentioned: "I would not like to be monitored this much. It would be a feeling that somebody's constantly annoying me, wherever I am".

However, other users argued that nowadays other popular technologies are not privacy-respecting (*other technologies do not provide privacy*) and UBI could be one of those. For example, PU-10 stated: "we already don't have privacy in a lot of other things because they collect our data […]".

Feedback not customisable was among the issues reported. Users suggested that *feedback should be customisable by drivers*. They mentioned that getting feedback or advice during a trip could be distracting and annoying for the drivers (*feedback during trips distracts drivers*). In this situation, the drivers could pay more attention to the feedback instead of the road, such as: PU-13 "especially during driving it would just be distracting because I know it's very distracting [...] if a person tells you about your driving style while you drive" and PU-10: "it depends on the person, some don't like to get recommendations about what to do better because they think they are doing their best".

Scoring system of UBI is based on the collected driving data, which are used to compute the driving score.

Users criticised the way in which calculations are made, stating that the "time of the day" and "GPS location" cannot be adjusted without changing the driver's lifestyle. PU-09 mentioned: "if I'm price-sensitive I will move toward the better part of day to drive. Then, my lifestyle is impacted, influencing me to move in a more expensive time of day for driving".

Furthermore, some users argued that the driving data are not enough to determine driving style (*driving data do not determine driving skills*). Therefore, UBI should consider other external factors (e.g., pedestrians, traffic conditions, weather, and driving history) to get an accurate driving score and driving behaviour. For example, PU-14 noted: "I don't think those five data have a direct connection to the drivers' driving skill [...] it is not really directly related to the possibility of accidents. So, I think they should put more variables in those data. I think five is too simple to know the person's driving ability".

Others users argued that the telematics device may gather wrong or inaccurate driving data due to GPS signal loss or some technical problems (*driving data may be wrong*), which affect their driving score. For example: FU-01 "GPS data on my location on my phone depends on the Internet signal which in Ireland is very bad sometimes [...] it (insurer) is measuring your speed and acceleration on data that are not right [...] that obviously affected the score that you got".

Telematics device has to be configured by drivers before each trip (*drivers have to configure the telematics device before each trip*) to collect the driving data. That is a hassle for some users, especially FU-01 claimed: "you get in the car, [...] I forgot to put it ON again. Then, you have to stop, to put it ON and you can leave". Additionally, some users were concerned that the *telematics device may be outdated*.

Use of driving data for other purposes was reported as the main disadvantage of using UBI. Users mentioned that someone (i.e., insurer, service provider, or others) could use their driving data without authorization for other purposes (*someone may use driving data for other purposes*) such as customer profiling. PU-09: "what if I go to the hospital very often? You might be inclined to partner with the health insurance and offer me health insurance because you think there is something wrong with me or maybe I'm hiding something from my health provider". FU-01 mentioned: "they know where you move, where you are going every day, where you work, they can infer where you were working, you were going shopping [...] if they sold that information, you know, it will bother me"). Other uses may be solving accident investigations or identifying traffic violations, such as driving over speed, breaking signals, street racing, among others.

C. Acceptance Factors

We identified important factors for users to make a decision about being covered by UBI or not. These factors are described below.

Country driving conditions is referred as rules (e.g., speed limit, parking), regulations (e.g., laws, data protection), and drivers' driving behaviours in a specific country where UBI is offered. Some users consider it too complicated to have a good driving style due to the influence of country driving conditions on drivers' habits (*driving traditions influence drivers' habits*). Also, they stated that *relaxed regulation prevents from improving driving skills*, such as PU-10 claimed: "you go to Greece and then you see people from England, Germany, and other strict countries how they behave. Why are they not acting like they act in England or Germany? Because their police are stricter than in Greece".

Perceived driving style is defined as how the users perceive their own driving style. According to that, they could decide to join (good driving style) or not (bad driving style) a UBI program. For example, PU-17 said "if I was a bad driver then, I wouldn't want to change to this one because I wouldn't get too many discounts".

Users described "good driving style" as following the rules, being careful and respectful with other drivers (*own driving style perception*). Users mentioned that usually drivers adapt their driving behaviour when they know that someone is monitoring them (*monitored drivers drive better*). FU-01 stated: "people who are monitored they

tend to behave [...] if you are monitored you're going to be a good boy".

Perception of UBI means *UBI opinion of a relative, friend, or expert* which is important to the users in their decision making about UBI. This opinion is based on information about *insurer's reputation*, *service provider's reputation*, and users' reviews. For example, PU-03 mentioned: "I'd ask some people, who are more experienced. For example, my dad who drives for already, I don't know, 30 years. Probably I will ask some of my friends, who already have experience with insurances. Also, I will ask people who already used this kind of insurance".

Some users highlighted negative experiences as the most relevant in perception of UBI. Thus, *negative experience of UBI users* (related to the insurer, the service provider, the UBI program, or the telematics device) provides users with insight about potential issues. PU-05 stated: "I think that it would demotivate me if I have read a negative experience. It would not motivate me if I have heard two people saying that it was good because that's I was expected. I expect companies to do what they are supposed to do".

Usually users need more information about UBI because *people do not trust insurers*: PU-10 "I would just ask as many possible details about the contract because […] I don't trust insurance".

Policy conditions such as *insurance conditions* and *insurance costs* were mentioned. Users remarked on program conditions (e.g., coverage, kilometers driven, discount) and contract conditions (e.g., terms of use, cancellation conditions) as important information for making a decision about UBI. FU-01 asked: "what is the pricing? How did they get the price? How are they using the data of the driving on a day-to-day basis for everyone?" and PU-09 inquired: "I want to know in which countries that's covered, cause if I travel a lot across borders it's quite important that one has that kind of coverage".

In addition, some users want to know more details about *UBI transparency*, such as: who can access their driving data, where their data are stored, when their data will be deleted, among others. For example, PU-15 stated: "where they (insurers) store the data and when they delete the data would be important for me, because I don't see the point to keep the data after they calculate my premium or my discount for next year. I think, they should just delete it that will be important for me".

Premium reduction was reported as the main users' goal in UBI. Users want to save money reducing their premiums, finding in UBI a way to do it (*insurance discount*). FU-01 mentioned: "the main (motivation) would be money because insuring your car is never cheap and if you can get it to go down by a little, you know, I'll be happy with that". Thus, users found that a *premium discount motivates to change driving style*, such as: PU-06 "the discount, I guess you have a motivation to drive safely and correctly" and PU-09 "if I wanna decrease that money I pay per year, I would improve my driving".

V. Forum Findings

In the qualitative content analysis of Allianz forum, 12 categories were identified. These categories are presented in Table III, where the topics that corroborate our findings from interviews with one former and 17 potential UBI users are labeled with *. We grouped the categories into four general classes, which are described below. Categories are presented in *italics* and the acronym CU (Current User) is used for presenting forum quotes.

A. Scoring System

In UBI, a good driving score means a premium discount for the driver. Many users indicated that they got a *wrong score*. They criticised the criteria to evaluate the driving behaviour, such as CU-36: "Speed limits are totally wrong, based on them the speed rate was put to 20 on today's trip!" and CU-34: "Cornering is negatively evaluated in traffic jams [...] of course, it is not possible to avoid braking in the curve here". Some users reported logistical or technical *starting problems* that prevent them from getting a score, especially often they did not receive in time the Bluetooth dongle needed for trip recording.

In addition, sometimes *trips are recorded although users do not drive their cars*, such that data from train, bike, or another car were collected. For example, CU-88 said: "Yesterday I was a co-driver in a completely different car (which has nothing to do with me or my insurance), on my phone Bluetooth was completely switched off. When the trip began, my cell phone indicated that the trip recording was started".

B. Driving Data Loss

The process to calculate the driving score is based on driving data. Some users reported losing their collected driving data (*trip recorded, but not saved*), such as CU-171 described: "The app records the trips, but does not save them". Others claimed that the trips are not recorded at all or only partially (*trip not recorded*).

In some cases, previously recorded *information is lost*, for example, CU-110: "The trips between 01.09.2016 and 04.09.2016 were recorded, but are not seen in the rating until some days later", meaning that saved driving data cannot be seen in the app. Thus, the users cannot get an accurate driving score.

C. Negative Consequences of Using UBI

After using the UBI solution for at least a year, some users made negative valuation of the system. They expressed *distrust in the insurer*, assuming the insurer might affect their driving score on purpose, as CU-68 argued: "I have 96 km on 11 trips, although I drive every day for over a month to work and back, and the trip is supposed to be scored. Since the bonus program depends on the kilometers, I feel kind of ripped-off [...]".

Furthermore, they argued that trying to improve their driving score, they could generate dangerous situations or cause an accident (*BonusDrive may provoke dangerous driving*). CU-107 claimed: "I have myself already provoked the anger of other drivers because I drove 20

km/h on a federal highway with curves, just to get a good rating".

D. Telematics Device Issues

In BonusDrive the smartphone app plays an important role as a telematics device collecting the drivers' driving data, sending them to the service provider, showing the driving style feedback, and reporting the incidents to the insurer. The users referred that sometimes *app stopped working*, usually after installing an update. For example, CU-83 stated: "Since installing the update yesterday, nothing works anymore, neither on my iPhone nor on the iPad".

Some users referred to *app takes too long to save the trip* as another problem with UBI. CU-74 claimed: "I do not want to always sit in the car for five minutes and wait for the app to complete the trip". In those cases, if the user does not wait for a few minutes after the trip end, the app shows an error and no data of this journey are saved. Furthermore, *trip recording starts too late* was also reported due to *problems with Bluetooth* or GPS connection problems, such as CU-23: "The app does not find my Bluetooth connection in the car. Other connections are detected".

Most of the identified categories described above are related to usability issues. Users were concerned about getting a good driving score. During this process, they identified different situations which represent a barrier to achieve their goals. Moreover, some of these situations were anticipated in the interviews by potential users, and also mentioned by the former user. These situations are labeled with * in Table III.

VI. Discussion

In this section, we discuss UBI transparency and the consequences of using such programs. Furthermore, we make recommendations for insurers, which were derived from users' views. Finally, we raise several concerns that are specific to smartphone-based UBI.

A. Transparency in UBI

Users mentioned the importance of transparency in terms of insurance conditions and costs, as well as data sharing patterns, score calculations, telematics device calibration and data protection.

In Allianz forum, when customers asked about those topics, the company representatives avoided answering, arguing that the information constitutes a "trade secret". However, it can be argued that one does not need to make the algorithm public in order to make its resulting score transparent. The field of Explainable Artificial Intelligence (XAI) [18] is dealing with a similar problem, and it is possible that solutions other than publishing the algorithm are available.

We see several weaknesses in the "trade secret" argument. One can expect that some users will try to game the system if they know how it works. However, we can refer to Kerckhoffs' principle from information security, which states that for a cryptographic system to be secure, one has to assume that the enemy knows everything about it, except the key [19]. By analogy, we conclude that transparency will not be a threat to a well-designed scoring algorithm. Moreover, the experience with open source software indicates that source code availability and the number of exploitable vulnerabilities are not correlated [20].

Another side of the "trade secret" argument is that it is economically better for the company. However, there is a well-developed ecosystem of IT businesses that are built on top of open source software. This demonstrates that sharing the code does not imply that a business will be economically non-viable.

While we do not argue that all UBI enterprises should be open source, such a model is plausible. Moreover, results of XAI research could be applicable to UBI too. This indicates that there is room for improvement when it comes to UBI transparency.

At the moment, the lack of transparency may motivate drivers to change their style on each trip, trying to understand how the system works, to get higher scores. Such changes might provoke dangerous situations on the road. And having a closed system does not mean that some users will not try to game it.

B. Consequences of UBI Usage

During the driving learning process, drivers get feedback from the instructor during each trip. Thus, they develop and improve their driving style. After getting their license, drivers usually do not take further lessons for various reasons, such as economical, timing, or because they consider themselves good drivers. Using UBI they may have a personal driving instructor, who can help them identify their driving mistakes through feedback. This way, drivers may improve their driving style, increasing traffic security and safety. Users can also get additional services, such as emergency calls, identifying available parking facilities, and stolen vehicle recovery, among others.

Although some users mentioned as a benefit for insurers that UBI provides more accurate risk estimation, allowing insurers to profile drivers, this may have negative consequences. Drivers may be discriminated, because insurers may prefer a certain type of customers. Thus, drivers with a high potential driving risk will be forced to stay as traditional car insurance customers, where premiums will increase due to the declining number of customers. In this way, UBI might turn into a car insurance program only for drivers with low driving risk [5].

Other concerns identified by some participants were related to privacy. For example, users realised that patterns of behaviour could be inferred from GPS location data, which may be used for purposes other than calculating the premium or providing feedback.

Some participants believe that when an accident occurs, the insurer is alerted automatically, and the insurer can help because it knows the GPS location of the car. However, we did not find information about such a feature in the materials of any of the ten German insurance companies that we examined. It should be noted, that as of 2018, all new cars sold in the EU must

implement the eCall technology, which automatically dials 112 if a serious incident occurred [21]. The GPS location of the car is included in the meta-data transmitted during the call. It is possible that some people may think that eCall is a feature offered by insurance companies, rather than by car manufacturers. This can impact the perceived level of privacy, as well as the acceptance level of UBI. Therefore it is better if this aspect is clarified by insurers.

C. Recommendations for Insurers

Table IV summarizes the recommendations for insurers. They were grouped into categories according to the topic which insurers should take into account.

Data flow is about how data are physically transmitted. For example, if a mobile data plan is used, these communications can incur additional expenses. Users have to be aware of whether it is their responsibility to pay for the plan, what happens when they reach the data limit, or how scores will be calculated when there was no Internet coverage during the trip.

Insurers can mitigate these concerns in different ways, for example, by designing systems that work independently of Internet access (R_1).

Feedback is a category that relates to the way drivers receive comments about their driving style. For example, it should not be shown too frequently as to not cause alert fatigue, it should be concise and be provided via channels that do not distract users from driving. One approach to customising frequency and verbosity could be the use of Likert scales (R_2, R_3). For example, users could optionally answer questions like "I find the frequency of alerts (too low - low - just right - high - too high)" at the end of a trip or at a time of their choosing.

Feedback has an educational potential which can be leveraged by suggesting ways to improve the driving skills, rather than just pointing out deficiencies. Drivers need to know exactly what to do to improve their driving skills, instead of resorting to trial and error for getting a higher score (R_4). For example, a driving instructor could explain in a video the steps one needs to follow in order to improve their driving (R_5).

It is also important to show feedback at the right time, while the details about the trip are still fresh in the driver's mind. Research shows that quick feedback loops (R_6) between an action and a comment about that action provide a better learning experience [22]. Immediate feedback can be appropriate, as long as it is provided through a channel that does not distract the driver (e.g., a steering wheel) (R_7). Otherwise, a balance is required, the optimal delay parameters can be established experimentally (R_8).

Personalization means adapting UBI to the users' specific context. For example, shift workers can rest during the day, and drive at night. A system should take this into account and not reduce the score just because one drives at a late time. Insurers could develop job-specific UBI models to avoid penalizing drivers who, for example, have to drive during the night for work-related reasons (R_9). In addition, the criteria for determining the driving style should be adapted to take into account the country in which UBI will be implemented (R_{10}).

TABLE IV. RECOMMENDATIONS FOR INSURERS (R) DERIVED FROM USERS' VIEW

Category	R	Explanation
Data flow	R_1	Remove the data flow concern, e.g., design systems that work independently of Internet access
Feedback	R_2	Customize feedback frequency
	R_3	Customize feedback verbosity
	R_4	Provide specific tips about how to improve the driving score
	R_5	Turn criticism into guided training
	R_6	Shorten the feedback loop
	R_7	Apply non-invasive/non-distracting feedback channels
	R_8	Experimentally determine the optimal feedback loop duration (loops that are too short may be detrimental)
Personalization	R_9	Develop job-specific models
	R_{10}	Design country-specific models
	R_{11}	Generate a route plan in advance
	R_{12}	Recommend routes for different styles or preferences
Quality assurance	R_{13}	Thoroughly test the telematics device and software, especially in edge-cases
	R_{14}	Develop measurement standards for UBI devices
Scoring	R_{15}	Create "Trip retrospective" feature
	R_{16}	Provide a score dispute mechanism
	R_{17}	Avoid producing scores from inaccurate, incomplete or outdated information
Transparency	R_{18}	Conduct observation studies in order to find out in what ways UBI may provoke dangerous driving
	R_{19}	Make score calculation methodology transparent
	R_{20}	Make the data sharing patterns transparent
	R_{21}	Conduct DPIA as the GDPR requires and share results with users, in an easy to understand format
User interface	R_{22}	Automate or remove the initialization step from the procedure of using UBI
Others	R_{23}	Provide a "cost explainer" tool of UBI
	R_{24}	Provide an "estimation calculator" of UBI scoring process
	R_{25}	Provide a "do not record" or "delete trip" option

Figure 2. A mock-up of a route selection screen, that offers choices.

Moreover, insurers could provide drivers more information to prepare their trips. UBI could present a route plan in advance, highlighting the areas with traffic restrictions, speed limits, and other constraints (R_{11}).

Routes for different driving styles could be recommended (R_{12}). For example, to enjoy the landscape, UBI could suggest taking a rural road. Alternatively, taking a highway with higher speed limits is preferred if the user wants to drive faster (Fig. 2).

Quality assurance is a category of issues we have found, which is related to the quality and reliability of UBI systems.

Companies should not use software or telematics devices that are not calibrated or otherwise not functioning correctly (R_{13}). For example, a participant explained that in one case the trip data reported acceleration from 0 to 100 km/h in 2 seconds, which did not happen in reality. Such cases can undermine the credibility of UBI. This problem can also be mitigated on a policy level, through the development and enforcement of standards that telematics systems must comply with (R_{14}).

Another class of issues that can occur due to insufficient testing is related to updates. Some participants reported that the software stopped working after installing an update. Thus, it is important to test updates prior to roll-out, as well as provide a rollback feature, so users could revert to an earlier version (R_{13}).

Scoring is about the ways in which scores are computed. When users understand how this happens, it can potentially increase their trust in the system and lead to higher levels of satisfaction. For example, at the end of the trip, users could see an annotated map, with tips about what they could have done better (Fig. 3) (R_{15}).

Further, insurers could provide a dispute mechanism that drivers can use to explain why their actions were justified in a circumstance where UBI gave them a bad score. That feedback could be analyzed by the insurer and taken into account in the scoring process (R_{16}).

Furthermore, insurers should avoid using inaccurate data (e.g., faulty sensor readings, outdated maps or incorrect speed limits, etc.) in the scoring process (R_{17}).

Transparency comprises suggestions about increasing a user's awareness of the data collection and sharing practices, as well as the ways in which the data are used to calculate driving scores. This can alleviate the concerns that some may have, as a result of incomplete or inaccurate mental models of how a system works.

In addition, some participants mentioned that UBI can provoke dangerous driving, when users change their style, attempting to guess how the scoring works. Insurers could improve attitudes towards UBI by conducting observation studies, to find out in what ways UBI may provoke dangerous driving, and take mitigating steps (R_{18}).

Making the method of score calculation transparent and easy to find would be helpful to users who seek this information (R_{19}). Several participants stated that whenever they requested a detailed answer to the question "how is my score calculated?" they never found one, and eventually gave up.

During the interviews, several participants mentioned that they wanted to know who the data are shared with and for what purpose. Making the data sharing patterns transparent is not just a General Data Protection Regulation (GDPR) [23] requirement, but it can also increase trust in UBI (R_{20}).

Another GDPR requirement is to conduct a DPIA (Data Protection Impact Assessment), as per article 35, for minimizing privacy risks (R_{21}). If the results of the DPIA were made public and were conveyed in a form that non-experts can understand, it could increase the acceptance of UBI.

User interfaces (UI) have a major influence on how a system is perceived. It is therefore important to ensure that the user experience is smooth and that all the points of friction were removed.

Some participants said that activating the smartphone app required manual steps, which they sometimes forgot to perform. As a result, the trips were not recorded. The user experience of such apps should be reviewed, to automate certain procedures and reduce the need for manual interventions (R_{22}).

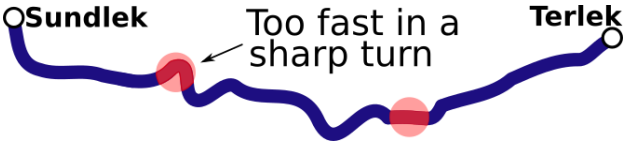

Figure 3. A mock-up of a trip retrospective feature. The red dots mark behaviour that reduced the driving score. Users can press a marker to get tips about what they could have done better.

Others category groups additional tools and features that we proposed based on our interviews

Some current users were disappointed with the cost savings UBI brought them, because they were below their expectations. Insurers could provide a "cost explainer" tool that clarifies how the premium was calculated (R_{23}).

Other participants stated that they would choose an insurance company by comparing cost estimates. Insurers could provide an "estimation calculator" which allows users to see how much money they will save by choosing UBI (R_{24}).

Based on our participants' feedback, we can recommend the addition of a feature to prevent a trip from being recorded, or delete it after the fact. This will protect the users' privacy, if they do not want to disclose some of the locations they visited. In these cases some users applied workarounds, such as not taking their phone with them, or disabling Bluetooth to disconnect the telematics device. However, additional measures need to be applied to prevent abuse (e.g., some users can delete trips where they know they broke traffic rules) (R_{25}).

D. Additional Considerations for Smartphone-Based UBI

Even though smartphone-based UBI programs offer advantages (e.g., noninvasive measurements of the car's performance, potentially large user base due to wide availability of smartphones, among others), disadvantages related to data quality and reliability of measurements are reported in such programs [24]. Another issue that could affect UBI smartphone programs is the lack of sufficiently granular permission management. Currently, when an app prompts the user for GPS permissions, and

the user presses "Allow", the option effectively means "Allow the current program and all the others that were granted the GPS permission in the past". A vocabulary and level of granularity that can express "I want only program X to use GPS right now" would be an improvement. Without this flexibility, the privacy level offered by UBI smartphone apps is likely to be lower than the level provided by black boxes or embedded systems. To the best of our knowledge, at the time of this writing, only the latest versions of iOS and Android (13 and 10.0 respectively) offer such granularity. Although it is possible that only a small number of users will be aware of this difference, the ethical approach is not to expect users to deal with it themselves, but rather place this burden on the stakeholders who are best qualified to address the root cause. Moreover, update availability is another issue. At the time of this writing, less than 10% of Android-based devices are running the latest version, and circa 70% are running a version that is at least 2 years old [25]. Thus only a small number of users can take advantage of improved permission granularity. This may further reduce UBI acceptance levels.

VII. Limitations

Although we got valuable insights from our interviews with UBI users, the number of interviewees was limited, and we only managed to interview one former user, maybe due to the few UBI programs offered in Europe, and their novelty. The age range only included people under 30 years old, because most of the UBI programs in the German and Austrian market focus on this population. We also considered an online forum of a single UBI solution in Germany, which does not allow us to generalise our findings.

VIII. Conclusion and Future Work

We identified advantages and disadvantages of using UBI, by interviewing potential users and one former user, then we cross-checked these with feedback from current and former users of UBI.

We conclude that such systems may help drivers identify their mistakes, based on feedback provided to them. Insurers may decrease their losses through more accurate risk estimation, rooted in objective telemetry data. Moreover, UBI may decrease the frequency of car accidents and increase traffic safety, by motivating drivers to be more cautious.

A potential downside of UBI can occur when there is no transparency about the way scores are calculated. In such cases, some drivers could decrease road traffic safety, by changing their driving style often, in an attempt to guess how the system works and improve their score.

According to our findings, UBI acceptance is influenced by users' perception of their driving style, as well as the driving traditions and regulations of the country where UBI is offered.

In addition, this research leads us to several recommendations that can potentially mitigate the negative consequences of UBI, and improve the usability and acceptance levels of such programs. Acceptance can be further improved, by interviewing more former UBI users to understand the reasons they quit their UBI program.

Although tutoring is outside the scope of a UBI system, some participants find the learning potential appealing. Perhaps this can be leveraged, thus giving potential users more reasons to join such programs.

Our interviews also show that transparency plays a crucial role in the entire user experience. We believe transparency can be achieved through explainable UBI scores, without having to divulge any trade secrets. An alternative solution could be based on open source software. It will make the system technically transparent, but this is not sufficient, unless there is a usable UI that drivers can understand.

Our next step for this project is to build a user acceptance model for UBI using the findings of this study. This model will be validated via an online survey.

Appendix A User Study Resources

For the purposes of reproducibility, we share our user study resources at the following link: https://github.com/juan-quintero/ubi-interviews-forum-analysis. These resources include the questionnaire for recruiting of the interviewees, interview guide, and the UBI video, as well as the scraping process for the UBI queries from the insurer's forum.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Juan Quintero and Zinaida Benenson designed and conducted the user studies (semi-structured interviews and forum analysis), as well as analysed the data. Alexandr Railean and Juan Quintero proposed recommendations for insurers based on users' views. All authors wrote the paper and had approved the final version of this paper.

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