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Buying-off privacy concerns for mobility services in the Internet-of-things era

A discrete choice experiment on the case of mobile insurance

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Abstract
Internet-of-things technologies will enable collecting vast amounts of mobility data from car owners. Such connected car services can be value-adding but also create new privacy hazards. This paper studies whether and how privacy concerns of car owners can be compensated by offering monetary benefits. We study the case of usage based car insurance services for which the insurance fee is adapted to measured mileage and driving behaviour. A conjoint experiment shows that consumers prefer their current insurance products to usage based car insurance. However, when offered a minor financial compensation, they are willing to give up their privacy to car insurers. Consumers find privacy of behaviour and action more valuable than privacy of location and space. The study is a first to compare different forms of privacy in the acceptance of connected car services. Hereby, we contribute to more fine-grained understanding of privacy concerns in the acceptance of digital services, which will become more important than ever in the upcoming Internet-of-things era.

Keywords: Internet-of-things, Privacy, Mobile value services, Conjoint analysis

1 Introduction

Internet-of-things is transforming the mobility industries as cars are increasingly becoming connected through dedicated SIM cards or smartphones. Connected cars will generate large amounts of data about mileage and driving behaviour that can be used for

a large variety of value-added services in many areas, like traffic safety, vehicle diagnostics and preventive maintenance and advanced real time navigation. However, there are also many opportunities for customer relationship management, (proximity) marketing and after-sales service. Services can be offered by the car industry (e.g., large and small car dealers, equipment producers), financial industry (e.g., insurers) or other service providers (e.g., leasers, rental providers).

However, vast amounts of data collected in connected cars can create privacy and ethical hazards. In general, privacy concerns negatively affect the intention to use digital services (Malhotra et al 2004; Miyazaki & Fernandez 2001). Service providers can compensate privacy concerns by offering convenience or monetary rewards as has been shown for e-commerce services (Hann et al 2007; Li et al 2010; Laudon 1996). However, sensitivity of disclosed personal data will be substantially higher for connected car services than traditional electronic services as highly detailed habits and mobility patterns can be inferred. Since sensitivity of disclosed personal data has a significant positive effect on related privacy concerns (Bansal, Zahedi & Gefen 2010), the question arises whether and how such elevated privacy concerns can still be compensated by service providers.

This paper studies if and how privacy concerns for connected car services can be compensated financially. We study this issue through a discrete choice experiment in which the buy-off value of different types of privacy risks is evaluated. We define privacy as "an interest that individuals have in sustaining a 'personal space' free from interference by other people and organizations" (Clarke 1999). As a case to study this issue, we focus on usage based insurance services (cf., Handel et al 2013). Insurance services are especially relevant as privacy concerns regarding the insurance industry and its online platforms are already high. Specifically, we consider usage based insurance services for which the insurance fee is based on actual car-use. Differentiating insurance fees based on car use is relevant since damage risks are correlated to the amount of driven kilometres (Vonk, Janse, van Essen, & Dings, 2003) as well as driving behavior (Lajunen, Karola, & Summala, 1997). Usage based insurance services are starting to emerge on the market that utilize not only GPS-data but also motion sensors to measure car acceleration/deceleration and driving behavior.

Section 2 provides a theoretical background on privacy. Section 3 provides the method, followed by results in Section 4. Section 5 discusses the findings and concludes the paper.

2 Background

2.1 Defining privacy in the Internet-of-things paradigm

Many definitions of privacy exist in literature. Traditionally, privacy has been conceptualized as a right to control over information about oneself. Westin (1967) defines privacy as the ability of individuals to determine for ourselves when, how, and to what extent information about us is communicated to others. Altman (1976) regards privacy as a dialectic and dynamic boundary regulation process which allows a selective control of access to the self or to one's group. Alternatively, privacy is defined as a condition of not having undocumented personal information known or possessed by others (Parent 1983).

More recently, utilitarianists have conceptualized privacy as an interest rather than an absolute right. Clarke (1999) considers privacy as a thing that people like to have. Clarke (1999) defined privacy as "an interest that individuals have in sustaining a 'personal space' free from interference by other people and organizations".

This study will follow the utilitarian view of privacy as an interest, since this implies that privacy can be redeemed and traded long as the benefits of the service overrun related sacrifices, users will be persuaded to participate. In line with this conceptualization, several studies on e-commerce consider privacy as a tradeoff between the disclosure of personal information and service related benefits (Chorppath & Alpcan, 2013; Dinev & Hart, 2006; Hann et al., 2007; Laudon, 1996; Li et al., 2010).

Assuming that privacy is an interest, Clarke (1999) suggests various types of privacy that may be relevant. Clarke defined four categories of privacy, including privacy of the person, privacy of personal data, privacy of personal behavior and privacy of personal communication.

Privacy interests can be affected by various activities, i.e. (1) information collection, (2) information processing, (3), information dissemination, and (4) invasion (Solove 2006). Finn et al (2013) argue that these four types of privacy do not cover potential privacy issues of recent technological advances. Technologies such as whole body image scanners, RFID-enabled travel documents, unmanned aerial vehicles, advanced DNA enhancements, second-generation biometrics and connect mobile services raise additional privacy issues. Therefore, Finn et al (2013) expanded Clarke's categorization to seven types of privacy: privacy of the person, privacy of behaviour and action, privacy of personal communication, privacy of data and image, privacy of thoughts and feelings, privacy of location and space, and privacy of association.

Mobile insurance services especially affect privacy of behaviour and action, data and image, and location and space. Privacy of behaviour and action can be affected as data from mobile devices allow identifying travel activities. Especially when combining positioning data from mobile devices, GPS chips and social media, extensive information on one's behaviour and action can be generated. Privacy of data and image is affected as mobile insurance will typically require personal data to be shared. Privacy of location and space is especially impacted by tracking technologies in mobile phones and cars. Usage based insurance products typically require sharing location information with insurers. Almost all connected devices, even without GPS-sensors, provide detailed information on their location IP addresses, WiFi hotspots and router information.

2.2 Privacy and monetary compensation

Privacy is generally seen as a value that stimulates individual freedom and social development (Solove, 2006). Based on a review of existing studies, Paine et al. (2007) show that the general public is increasingly concerned about their online privacy and willing to take countermeasures. At the same time, studies show that most consumers consider disclosing personal information as an integral part of modern life, necessary to obtain products and services (Preibusch, 2013; TNS Opinion and Social, 2008). As such, individuals do consider a utilitarian trade-off between perceived benefits of online services and sacrifices of disclosing personal information.

Disclosure of personal information generally results in elevated privacy concerns (Bansal et al 2010). Various empirical studies show that elevated privacy concerns negatively affect the intention to use online and mobile services (Malhotra et al., 2004; Miyazaki & Fernandez, 2001).
Laufer and Wolfe (1977) suggest that individuals perform a "calculus of behavior" to assess the consequences of providing personal information. On the basis of this theoretical construct, individuals consider a trade-off between perceived benefits and sacrifices of disclosing personal information. This implies that unavoidable privacy concerns, associated with the use of mobile insurance, have to be compensated in order to persuade consumers to adopt. Hann, Hui, Lee & Png (2007) state that providers can mitigate the negative effect of privacy concerns on intention to use in two ways: (1) by offering privacy policies regarding the handling and use of personal information and (2) by offering benefits such as monetary rewards or convenience. The latter type of compensating benefits have been further operationalized by Li, Sarathy, & Xu (2010) into expected monetary benefits and perceived usefulness.
Laudon (1996) argues that personal information is a commodity that can be priced and exchanged for monetary benefits. Further research by Jen, Ingying, Wei-Ting & Chang showed that the expected monetary benefits have a positive influence on intention to use electronic services. Hereby monetary benefits could be achieved through a discount on existing services or direct pay-outs (Jen et al., 2013).

3 Method

We conduct a discrete choice experiment to evaluate the interplay of privacy concerns, monetary compensation and the intention to use usage based insurance services. Conjoint analysis is a statistical approach, often used in market research to determine customer preferences (Green et al 2001; Henscher et al 2005; Louviere et al 2000). Based on implicit trade-offs, perceived utilities by the respondents can be estimated per profile characteristic. By involving financial dimensions in the composition of these profiles, the willingness to pay might also be an output of the conjoint analysis (Henscher et al 2005). We use stated-choice model (Louviere et al., 2000) rather than rating-based conjoint analysis since in reality consumers also make a discrete choice between multiple car insurance packages.

3.1 Sample

The population of interest comprises all Dutch private car owners. The survey was carried out at a car ferry service in the Netherlands (Schoonhoven) in October 2014. To maximize the chance of finding private car owners, the survey was carried out on a Friday. After approval of the ferry service, car owners were approached to complete the questionnaire. Hardcopy questionnaire results were imputed into a spreadsheet.
Sixty respondents completed the questionnaire, of which five were omitted due to missing data. The resulting sample is representative in terms of gender (48% male compared to 49% in the target population) and car use (55 kilometers per day on average compared to 37 kilometers in the target population). The sample is biased towards highly educated (51% higher education compared to 34% in the target population) and younger people (34% between 18 and 25 compared to 13% in the target population).

3.2 Measurement instrument

In order to value individuals' privacy in monetary units, the three relevant forms of privacy identified in Section 2 are operationalized into attributes, see Table 1. Hereby, the attribute levels are composed in such a way that one level involves privacy harm and the other level involves no privacy harm.

Privacy type (construct)	**Attribute**	**Level 1 (no privacy harm)**	**Level 2 (privacy harm)**
Privacy of location and space	Kilometer registration	Manual (web platform)	Automatic (in-car GPS)
Privacy of behavior and action	Registration road behavior	No	Yes (in-car motion sensor)
Privacy of data and image	Additional insurance offerings	No	Yes
	Third party advertisement	No	Yes

Table 1: Conjoint attributes and levels

Operationalization of the privacy types is done by building upon examples of mobile insurance products that are emerging on the market currently. As such, operationalization is as close to reality of respondents as possible, which contributes to the external validity of the study.

Privacy of location and space is operationalized into the attribute *Kilometer registration*, which is an important input for usage based car insurance. The insurer can measure the number of kilometers driven automatically through GPS tracking, which harms privacy of location and space. Alternatively, the consumer could register the number of kilometers driven manually through a website, which does not harm privacy of location and space.

Privacy of behavior and action is operationalized into the attribute *Registration road behavior.* Driving behavior could be measured automatically through an in-car motion (G-force) sensor that registers acceleration, deceleration and abrupt steering movements. By doing so, insurers gain in-depth insights in the actual user behavior which harms privacy of behavior and action.

Privacy of data and image is operationalized into the reuse of data generated by a usage based insurance service for secondary purposes. The attribute *Additional insurance offerings* refers to the insurer sending personalized offerings and promotions based on the data collected about the user. The sending of promotions by parties other than the insurer is referred to as *Third party advertisement.* As both options reuse data provided by the user for secondary purposes, they both negatively affect privacy of data and image.

The results of the conjoint analysis will provide the utility that participants derive from every attribute level. By adding a fifth attribute, these utilities can be converted into monetary compensation level, thereby eliciting the buy-off value of privacy. This fifth attribute *Relative consumer saving* is defined as the discount consumers will receive when adopting the usage based insurance policy. To analyze potential non-linear effects, three attribute levels are included: 0, 10 or 20 euros discount. The level of discount is considered appropriate considering the average monthly fee of all-risk Dutch car insurance policies equals €34.

Based on the defined attributes, choice-sets are composed in which respondents compare two alternative usage based insurance options. In addition, respondents were asked whether they prefer the proposed insurance policy or their current policy. A balanced composition of twelve choice-sets and related attribute levels was generated using Ngene software. Based on the choice-sets and defined attributes, a questionnaire was designed and subsequently pretested with three participants.
The consistency of the model results was verified randomly dividing all respondents' choice-preferences in two equal parts and running the analysis individually for both parts. All estimated coefficients in the sub-groups have the same direction as in the full model, and deviations are generally acceptable.
Finally, the uniqueness of each attribute was assessed by computing the correlations between coefficients. All correlations were lower than 0.80, which indicates that the model was able to unique identity the influences of the included attributes. (Hensher et al., 2005).

4 Results

Biogeme software is used to analyze the choice behavior of the respondents (Bierlaire 2003). The dataset includes all predefined choice-sets and all respondents' choices from the questionnaire. The model-file includes a syntax program language to provide instructions to the Biogeme engine.
Table 2 provides the part worth utilities of the attributes. All attributes are statistically significant. *Relative consumer saving* has the highest importance: 65% of a choice for usage based insurance depends on the discount offered. The residual importance is almost equally distributed over the other attributes which implies a balance willingness to pay for all attributes.

Attribute	Attribute Level	Part worth utility	Range	Importance	Rank
Kilometer registration	Manual	0	.288	7.34%	5
	Automatic	-.288†			
Registration road behavior	No	0	.378	9.64%	2
	Yes	-.378*			
Additional insurance offerings	No	0	.369	9.41%	3
	Yes	.369*			
Third party advertisement	No	0	.351	8.95%	4
	Yes	-.351*			
Relative consumer saving	€ 0	-1.42*	2.536	64.66%	1
	€ 10	.304			
	€ 20	1.116			
Constant			-1.21		

Table 2: Part worth utilities

† p < .10; * p < .05

Table 2 also shows a significant disutility of 1.21 compared to the current car insurance policy. In other words, respondents derive a structural disutility from usage based insurance services of 1.21.

Next, we transform utility levels to buy-off values using the *Relative consumer saving* attribute. As 20€ savings corresponds to 2.536 utility points (see Table 4), 1 utility point equals 7.89€. Based on this valuation, the structural disutility of usage based insurance equals €9.54, i.e. a buy-off value of €9.54 per month should be offered for consumers to switch to usage based insurance services.

Table 3 presents the buy-off values for each form of privacy harm. In the table, the utility is calculated in a buy-off value using the attribute *Monetary compensation*.

Type of privacy	Attribute	Involved attribute level	Utility	Buy-off value per month
Privacy of location and space	Kilometer registration	Automatic (in-car GPS)	-0,288†	€2,27
Privacy of behavior and action	Registration road behavior	Yes (in-car motion sensor)	-0,378*	€2,98
Privacy of data and image (internal)	Additional insurance offerings	Yes	0,369*	-€2,91
Privacy of data and image (external)	Third party advertisement	Yes	-0,351*	€2,77

† p < .10; * p < .05

Table 3: Conjoint utilities and buy-off value privacy

Table 3 shows that all buy-off values are in a similar range. Privacy of behavior and actions has a slightly higher buy-off value, equaling €2.98 per month.

Regarding the privacy of data and image two buy-off values are determined, relative to the internal and external reuse of personal data. Respondents are willing to sell their personal data for third party advertisements if they receive a financial compensation of €2.77 per month. Strikingly, to receive relevant personalized promotions from the insurance company itself, respondents are willing to *pay* a monthly fee equaling €2.91.

Next, we explore moderating effects of demographics on the utilities, which is especially relevant considering the sampling bias towards younger and higher educated people. Table 4 shows that demographics have considerable effect on the utilities in the conjoint model. For instance, highly educated respondents only require €4.42 to adopt usage based insurance, while lower educated respondents demand €21.33. Moreover, respondents driving more than 30,000 kilometers per year require more compensation than those that drive less.

	Full model	Age group		Education level		Average number of kilometres per year	
		<41.5 (N=27)	>41.5 (N=26)	Low (N=22)	High (N=31)	<30,000 (N=38)	>30,000 (N=17)
Constant	9.46*	7.12*	11.29*	21.33*	4.42*	7.48*	15.67*

Kilometer registration	2.27	1.51	3.16	2.37	2.35	3.14*	-1.27
Registration road behavior	2.98*	3.55*	1.65	.54	3.03*	2.48	1.32
Additional insurance offerings	-2.91*	-1.49	-4.21*	-6.71	-1.66	-2.39	-2.19
Third party advertisement	2.77*	2.34	3.81	3.77	2.30	2.93*	-.10

* $p < .05$

Table 4: Buy-off values for different demographic groups (in euros per month)

Regarding the privacy attributes, demographic groups differ only slightly. For instance, younger respondents derive more disutility from registration of road behavior than older people (€3.55 and €1.65 respectively). Higher educated people appear to derive more disutility with the registration of road behavior. However, we should point out here that sample size for the sub-groups is low and thus results can only be used in a speculative manner.

5 Discussion and conclusions

Our study shows that specific privacy concerns about usage based insurance services can be compensated by offering a marginal monthly fee. Consumers perceive privacy of behavior and action as more valuable than privacy of location and space. Regarding privacy of data and image, the buy-off value depends on who exploits privacy-sensitive data. While usage of personal data for personalized offerings from the insurer is positively evaluated, third party advertisements have a negative utility.

Our findings do indicate that consumers prefer conventional car insurance policies considerably compared to usage based insurance, regardless of privacy concerns. As such, other considerations than privacy will likely play a role in the adoption decision of consumers. For instance, unwillingness to switch in general or normative considerations of fairness in insurance policies may play a role. We also found that people driving more kilometres are less likely to accept usage based insurance, which can be explained because this group would pay a higher fee due to the nature of the product.

The main downside of this survey is its representativeness. Highly educated people and people in the age-interval of 18-35 are overrepresented, and the conjoint analysis suggests that younger and highly educated people are less concerned about privacy risks. Another limitation is that interaction effects between the different dimensions of privacy were not included, which could be added in future studies.

In terms of operationalization, different dimensions of privacy could have been measured differently. For instance, privacy of data and image could also relate to the degree to which users have control over who uses their data for non-commercial purposes. Moreover, if the operationalization of privacy of data and image would have included calculation of risk profiles and raising of rates based on driving behaviour, higher disutility may have been found.

This paper takes a utilitarian view on privacy and assumes privacy concerns can be compensated financially. While this view fits the increasingly dominant utilitarian privacy literature, we are aware that there are other privacy schools that have differing conceptualizations and consider privacy as a right that cannot be bargained for (e.g., Westin, 1967).

The study contributes to theories on privacy by distinguishing multiple dimensions of privacy rather than the typically one-dimensional operationalization in literature. The study shows that the buy-off value for privacy varies depending on the dimension of privacy concerned. This is especially relevant as Internet-of-things and connected cars concepts will involve ever more complex data to be released which may affect different dimensions of privacy in different ways.

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