Reducing asymmetric information with usage-based automobile insurance

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Abstract: Automobile insurers currently use available information about the vehicle, the owner and residential area when determining the probability of a claim (insurance risk). A drawback is that several risk classification variables are based on the policyholder's self-reported risk. This study highlights the fact that the information asymmetry associated with classifying risk may cause unfair premiums, since it is possible for high risk drivers to mimic low risk drivers. The aim of this paper is to explore the possibility of reducing information asymmetries by introducing a Usage Based Insurance (UBI) option where the driving behavior is monitored. While most models focus on identifying the high risk type, this approach provides an opportunity for the *low risk* individuals to reveal their type. The results suggest that voluntary UBI is an efficient instrument to separate risks and that the low risk drivers do not suffer the utility loss generally associated with asymmetric information. Introducing UBI as an additional contract enables full coverage at an actuarially fair premium for *both* types of policyholders. Besides, by reducing information asymmetries UBI can, in a wider perspective, provide incentives for the high risk driver to become a low risk driver by reducing risk-taking behavior.

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1. Introduction

With perfect information an automobile insurer can identify the insurance risk by observing driving behavior and where, when and how the vehicle is used. In reality this information is unknown and instead the insurer tries to identify the risk by observable characteristics that correlate with the probability of reporting a claim. In the presence of asymmetric information the insurers are not able to distinguish between high and low risk customers who belong to the same risk class on the basis of their observable characteristics. In the Swedish automobile insurance market at least two difficulties can be observed; first, that several risk classification variables, such as main user of the car and previous claims, are based on self-reports of the policyholder. This provides incentives for high risk individuals to mimic low risk individuals by providing untruthful reports about risk type. Second, it is difficult to reduce *both* the accident risk and the probability of a claim (insurance risk). The insurer can put a price on reporting a claim (deductible), which reduces the insurance risk since it becomes more expensive to report an accident. But, whether or not this actually decreases the accident risk is ambiguous, especially for smaller accidents where the economic cost is low (Chiappori and Salanié; 2000). Since traffic accidents impose a large strain on the public budget, it is policy relevant that the insurer is able to provide incentives for accident-preventing actions, not only incentives to report fewer claims.

This present paper applies the Rotschild and Stiglitz (1976) (RS) classical results to the Swedish automobile insurance market, and suggests that high and low risk drivers may currently be pooled in risk groups that are considered homogenous by the traditional risk classification. We argue that an insufficient risk classification results in unfair premiums where type L subsidizes type H if the insurer cannot distinguish risk on the basis of observable characteristics. The existing information asymmetry is a result of the

insurer's restricted access to available information due to laws and regulations.

The purpose of the paper is to show that the insurance industry can reduce asymmetric information by making use of emerging techniques for collecting information about driving behavior. This type of contracting is called Usage Based Insurance (UBI) and the interest in its usefulness has increased rapidly among vehicle insurers during the last decade. Insurance companies like Norwich Union (UK), Aioi and Toyota (Japan), Hollard Insurance (South Africa) etc. are involved in pilots or already offer UBI-solutions. A related study by Filipova-Neumann and Welzel (2010) analyzes the outcome when UBI is introduced as an additional contract. In contrast to their study, where risk types pay the same premium in the no loss state and where only the low risk type receives full coverage if an accident occurs, we demonstrate that the premiums differ and that both types receive full coverage. In our setting no one receives partial coverage at the same time as there are economic incentives to become a low risk driver, since the low risk type always pays a lower premium.

We initially assume that the insurer offers a regular insurance contract and that the high risk driver can mimic the low risk driver, whereafter the insurer introduces UBI as an additional contract. The UBI contract combines a low premium with an in-vehicle device that registers driving, while the regular contract offers the same coverage but at a higher insurance premium and no monitoring. Compared to the traditional RS-outcome under asymmetric information, where only the high risk individual receives full coverage at actuarially fair premiums, *both* risk types receive full coverage at their respective actuarially fair premiums. The reason is that low risk drivers can signal their type, which also reduces the opportunity for high risk drivers to mimic low risk drivers. The self selection of low risk drivers

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will constitute a propitious (favorable) selection of risks. The regular contract, on the other hand, will include a larger share of more risk taking drivers which creates an adverse selection of risks.

Besides increasing the actuarial fairness in the automobile insurance market, our conclusion is that UBI may, in the long run, reduce the number of accidents and their associated costs. One reason is that it is possible to provide incentives for driving safely, which will likely result in both lower accident and claim probabilities. Still, one common argument against UBI is that it infringes on privacy, which highlights the importance of data management and the design of these systems. Another potential caveat is that introducing UBI in the market implies an unknown investment cost, which makes the insurance industry hesitate to introduce UBI in the market. This points to the policy relevance of the issue, since much of the accident cost is covered by other than the insurance industry.

The remainder of this paper is organized as follows: Section two describes the asymmetric information problem, within the context of the Swedish automobile insurance market. The section also addresses accident cost from a social perspective by illustrating how the accident costs are distributed between the society and the private insurance industry in Sweden. Section three provides a brief summary of the RS result. Thereafter we apply the results to the Swedish automobile insurance market and argue that the likelihood of opportunistic behavior possibly leads to unfairness. Finally we introduce UBI and argue that it is possible to separate risks according to driving behavior. We also argue that if there exists a disutility of being monitored the surplus of the premium reduction must be at least as large as the cost of the privacy loss; otherwise a separating equilibrium may not exist. The final section provides concluding remarks.

2. Background

Asymmetric information is a latent problem in most insurance markets. The general idea is that individuals are heterogeneous in risks, such as driving behavior, and that this is private (hidden) information that is important for the contract but unknown to the insurer. According to the standard interpretation this information advantage results in a situation where the highest risks buy insurance. Hence, risky drivers are expected to be more likely to purchase extensive insurance coverage. This implies that those with insurance constitute an adverse (bad) selection of risks. In addition the individuals may undertake private (hidden) actions that affect the risk and thereby the contract. An insured individual is then less cautious when having insurance since s/he does not fully carry the financial risk of an accident. This is known as moral hazard, and examples include insufficient car maintenance and exercising less care when driving while insured.

In many applications information asymmetries become synonymous with either adverse selection or moral hazard. There may be reason to reevaluate the concept of private information, as several studies have suggested that private information can also lead to propitious (favorable) selection (Hemenway; 1990, DeMeza & Webb; 2001, Finkelstein & McGarry; 2006, Karagyozova & Siegelman; 2006, Fang et al; 2006, DeDonder & Hindriks; 2009). Along the same line of reasoning some agents may perform preventive actions that reduce the risk if they have bought an insurance policy. Examples are having a vehicle with safety equipment, always wearing a safety belt and being cautious on the road and with the vehicle. According to the propitious selection theory, these individuals show a high demand for insurance and are good risks ex post.

To handle the information asymmetry in practice, automobile insurers typically price their policies by observable characteristics based on the

owner, the vehicle itself and national registration address of the vehicle owner, which statistically correlate with the risk of an accident. Availability of data limits the variables the insurer can use in the pricing scheme. All contracts that share the same observable risk classification variables are considered to be homogenous in risk and are divided into the same premium cell, or equivalently, the same risk group. The intention is to create groups where the differences in risks are larger between groups than within each group. The pricing scheme is then based on the assumption of homogeneity, implying that the insurer does not consider any further heterogeneity other than the observable characteristics described above.[1]

In Sweden each insurer collects data and creates an own risk classification and, as in all countries, availability of information is decisive for the accuracy of identifying risk. The insurers are not allowed to share information about their policyholders and several of the risk classification variables are based on self-reports of the individual. The insurers have limited opportunities to observe whether or not a policyholder is honest about risk type, which implies that a high risk type can mimic a low risk type. We identify at least four difficulties associated with this. A first case is previous claims with other insurance companies. It is obviously a disadvantage if the insurers do not share past claims since previous claims provide a strong signal of driving behavior. Empirical analyses have found that drivers tend to underreport their past claims if this variable is based on self-reports (see for instance Cohen; 2005). Furthermore, if insurers do not share information of

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[1] The Swedish Financial Supervisory Authority functions as a controller of the insurers to ensure that competition is maintained in the industry. The pricing scheme was previously regulated according to a principle of fairness. The price should match the expected cost of the policy. Nowadays the authorities only monitor the degree of competition.

claims high risk drivers have incentives to switch insurer if an accident occurs (Cohen; 2005, Arvidsson; 2010). The reason is that an individual can underreport claim history when joining a new insurer and thus receive a lower premium, compared to staying with the current insurer. This problem is largest among new policyholders for whom the insurer has no previous observations.

A second example of dishonesty is home district, which is based on the national registration information. The policyholder may live in a large city with a high risk exposure but be registered in a small town with a considerably low risk. In this case the insurers price the policy as if the vehicle is used in a less risky environment when actually the vehicle, and driver, are exposed to higher risk.

A third example is the possibility that middle aged people, who generally have good premium ratings, are the fictitious owners of the cars, and hence also the owners of the insurance policy, while their children are the true users. This is a common way to lower the insurance premium for young individuals. With most Swedish policy schemes, the owner is assumed to be the main user and, if not the owner, has to state whether someone else is going to use the car regularly, especially if the driver is below the age of 25. The vehicle owner is obliged to have minimum coverage and the policy covers the vehicle, the driver (who is assumed to be the owner) and the passengers. Untruthful reports generally result in reduced indemnity if the fraud is detected. But, the possibilities for the insurer to prove the fraud are generally very limited. It is difficult for the insurers to estimate how large these potential deviation problems are and how large the associated losses may be.

A fourth drawback of the current risk classification is that low risk drivers have little opportunity to affect the premium size by behaving in a safe way, at least in the short run. Cohen (2008) shows that low risk individuals who switch insurer are pooled with high risk individuals, which implies that they have to pay a higher premium than the actuarially fair. In a similar way low risk policyholders tend to stay with their current insurer, since they cannot reveal their type when switching. Cohen further shows that the insurance company in her study earned more profit from long-term policyholders, because these were often low risk and paid a slightly higher premium than the actuarially fair.

Our conclusion is that there is currently no evident connection between safe driving behavior and the premium; generally it takes several years for a good driver to signal his or her type in order to receive a more accurate premium.
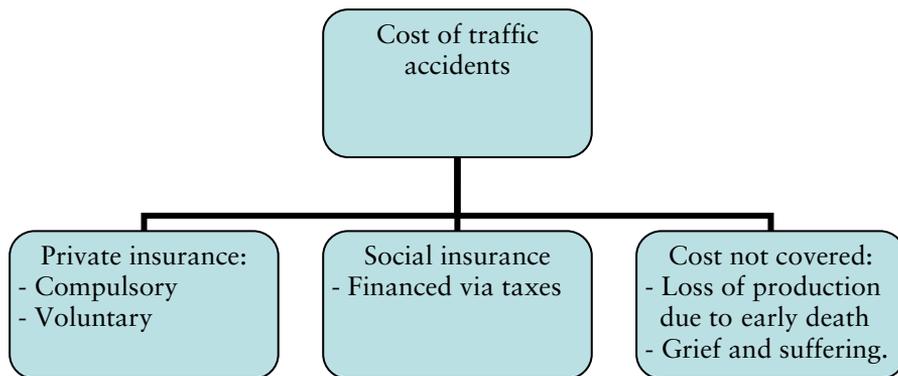
2.1 The social accident costs

Identifying risk and providing incentives to reduce the accident risk are also important from a social perspective. Traffic injuries are known to be a serious public health problem in many countries; e.g. in 2005 the associated direct and indirect costs corresponded to 2 percent of the EU's GNP (SCADplus; 2007). [2] In many countries private automobile insurance is required by law to cover these costs. In Sweden, however, the compulsory automobile insurance mainly works as a complement to the social insurance system (Arvidsson 2010). Many of the accident costs are covered by

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[2] Moreover the individual's non-financial costs for grief and suffering due to accidents are thought to be much higher than the out-of-pocket costs.

the social insurance system; examples include medical care, rehabilitation and early retirement due to a traffic accident. The social security system does not regress costs associated with traffic accidents against the insurer. In many other countries reimbursement comes from the compulsory auto insurances, and regress is a basic principle, which generally generate higher compulsory insurance premiums (Strömbäck; 2003).

Figure 1. Distribution of the Swedish accident costs.

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                    ┌─────────────────┐
                    │ Cost of traffic │
                    │    accidents    │
                    └─────────────────┘
                             │
        ┌────────────────────┼────────────────────┐
┌───────────────┐   ┌────────────────┐   ┌──────────────────┐
│Private insurance:│ │Social insurance│   │ Cost not covered:│
│- Compulsory   │   │- Financed via  │   │- Loss of production│
│- Voluntary    │   │  taxes         │   │  due to early death│
└───────────────┘   └────────────────┘   │- Grief and suffering.│
                                          └──────────────────┘
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Hence, a common interest for the society and the insurance industry is to provide incentives to increase driver's preventive efforts such that the risk is reduced. As stated in the introduction, a reduced risk for the insurer (claims) does not necessarily imply a reduced risk for the society (accidents). The insurer can affect the probability of a claim by the terms in the contract, one example being deductibles. If the number of claims decreases due to preventive efforts following an increased deductible, the accident risk is reduced. If a higher deductible only reduces the incentive to report a claim, the accident risk is not affected. How the policy is designed and how the risk classification is performed are therefore relevant also from a social perspective.

2.2 Usage-based-insurance

The difficulties reviewed in section 2 are a result of limitations of the present risk classification to target driving behavior. Up until now it has not been possible for the insurance industry to efficiently collect information on individual driving behavior. In some countries traffic offences are used as proxies for risky behavior in the insurance rating, while in others, such as Sweden, it is classified information. Using traffic violations in the risk classification would target high risk drivers, but it is not a comprehensive measure of driving behavior.

In-vehicle devices, however, are becoming more and more common and are already being used for different purposes by, for instance, insurance companies. Monitoring driving behavior reduces the degree of risk approximation. Usage Based Insurance (UBI) can be seen as part of what is referred to as Intelligent Transport Systems (ITS). The basis is that the insuree has an in-vehicle computer with a digital map containing current speed limits (similar to existing GPS navigation systems available in the market). The computer registers the driving patterns such as where, how and what time of the day the vehicle is driven. Thereafter a mobile communication unit transfers the data, or summary statistics of this, to the insurer. There currently exist various techniques for collecting information about driving habits, such as mileage and/or driving behavior, ranging from annual vehicle inspections to advanced GPS techniques with continuous reporting of driving records.

The majority of existing UBI-contracts are focused on driven distance and that the premium should vary with mileage. This is referred to as Pay-As-You-Drive (PAYD). Compared to a fixed annual charge, PAYD gives the driver an (economic) incentive to reduce the mileage, which in turn affects

accident risk exposure. With PAYD it is also possible to differentiate by road sections depending on their riskiness and the hours of the day. Another version of UBI is referred to Pay-As-You-Speed (PAYS), the purpose being to create incentives to reduce speeding (Schmidt-Nielsen and Lahrman; 2004 and Hultkrantz and Lindberg; 2012). This implies that a more frequent speeder will pay a higher Traffic Insurance premium compared to a driver who obeys the speed restrictions. Hultkrantz et al. (2010) provide a theoretical analysis of PAYS-insurance and show that it can be helpful in receiving the first best solution.

3. Reducing information asymmetry

We focus on a pure Nash equilibrium where all drivers of the same type choose the same contract. The analysis is based on the insurance model introduced by Rotschild and Stiglitz (1976) where insurers sell a menu of contracts. The results constitute a basis for most work done in the context of insurance markets and we start with a brief reproduction of these results in section 3.1. Thereafter we apply the results to the Swedish automobile insurance market and examine why premiums can be unfair and why a separating equilibrium may not exist when individuals self-report their risk type and information about previous claims is not shared among the insurers (3.3).

3.1 The model

There are $M \geq 2$ risk neutral insurance companies and N risk averse individuals with identical von Neumann-Morgenstern utility functions $u(W)$ with $u'(W) > 0$ and $u''(W) < 0$, where W is wealth. The assumptions imply that more wealth is always preferred to less and that the individual always prefers the expected value of a risk to owning the risk itself.

There are two types in the driver population. The low risk type, L, is the safe road user who primarily drives within speed limits, keeps a safe distance from the car in front and takes other road users into consideration etc. The high risk type, H, tends to be less careful towards other road users and drives more aggressively; a higher frequency of abrupt breakings, rapid acceleration and higher speed levels. Individuals are identical, except for their accident probability p_i ($i=H,L$), where $p_H > p_L$.

When driver type is private information, the insurer at best knows the fraction of each type in the population. The share of high risk drivers is λ and the share of low risk drivers is $(1-\lambda)$, which implies that the average risk in society is $\lambda p_H + (1-\lambda)p_L$.

There are two states of nature; either there is no accident (NA) or there is an accident (A) that results in a loss, L, where L < W. The size of the accident cost is assumed to be independent of type, but the expected cost is higher for type H since $p_H > p_L$. The insurance premium is denoted, Z_i. For simplicity we assume that individuals, due to the indemnity, have the same financial utility whether a loss is incurred or not, implying that the indemnity corresponds to the loss, d=L. [3] Hence, with full insurance the utility is the same irrespective if a loss is incurred or not. This assumption is not realistic since the utility is likely to be much lower in the accident state. Nonetheless the motive here is not to analyze the outcomes where the utility differs between states, but rather to analyze if it is possible to separate types by offering different contracts that provide incentives to reveal the driver type. For this reason we assume that the economic utility is the same in both states with full insurance.

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[3] Since the insurance makes the utility of wealth independent of state, this is equivalent to formulating the expression as the utility of having insurance, i.e. avoiding the accident cost $U_i(dp_i - Z_i)$..

$U_i(W)= p_iu(W-Z_i-L+d)+(1-p_i)u(W-Z_i)\geq 0$ $(i = H, L)$

The single crossing property implies that the slope of EU_L in a two-states-of-the-world diagram is always steeper than EU_H and that the curves only cross once (Rees and Wambach; 2008). Note that if we allow for both adverse and propitious selection in the market this condition may not hold. Still, we do not consider risk aversion, or any other characteristics that lead to high utility of insurance and low risk, and we only assume that drivers differ in risk.

3.2 The RS-results

Based on Rees and Wambach (2008) the RS results can be graphically summarized with figure 2 and figure 3. The vertical axis in figure 2 represents the accident state while the horizontal axis represents the no accident state. The 45 degree line represents the certainty line where wealth is the same in both states $W_A=W_{NA}$. By assuming that an equilibrium exists, five steps are required to derive the equilibrium contracts.

First, if the insurers offer the same contract to both types in equilibrium a feasible outcome has to lie below or on the dotted pooling zero-profit line; otherwise the insurer makes a loss. The pooling zero profit line is given by $W_A=W_{NA}-L + d$, where $W_{NA}= W-Z$ and $Z= [\lambda p_H+(1-\lambda)p_L]d$. If an insurer offers a contract at P' another insurer can offer a contract with a slightly lower premium at point a. This attracts all customers, which implies that P' cannot be an equilibrium. If instead the insurer offers a contract on the pooling zero profit line, at P, some other insurer could offer a contract at a point such as X. A contract at point X only attracts low risk types since it

lies under EU_H and above EU_L, hence only the low risk type get higher utility from this contract. Since a contract at point X would give approximately zero profit if taken by both risk types it will make a profit if only low risk types take it. This point is called a cream skimming deviation since it is profitable for the insurer. Hence, it is possible for the insurer to offer a contract such that either the high risk type or the low risk type deviates and therefore a pooling equilibrium does not exist. Suppose instead that the insurer offers two contracts in equilibrium, where C_L is chosen by type L and C_H is chosen by type H (fig. 3).

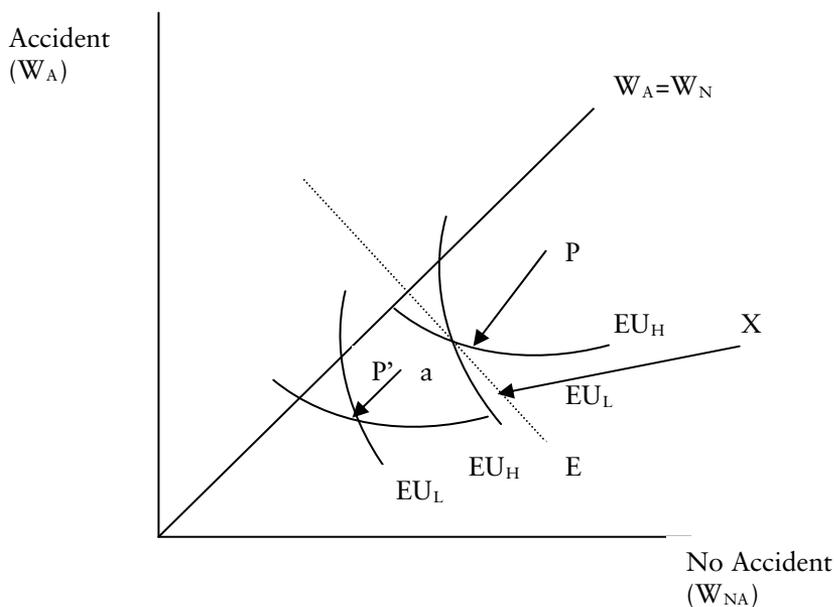Figure 2. **Non-existence of a pooling equilibrium.**

Figure 3 represents a separating equilibrium and the 45 degree line represents the certainty line where wealth is the same in the both states $W_A = W_{NA}$. The point E $=(W, W-L)$ describes the initial endowment without

insurance. The two solid lines are the insurers' zero profit lines for each risk type, where the slope is $-(1-p_i)/p_i$ for $i=H,L$.

In the second and third step it can be shown that no contract can make a profit, or loss, in equilibrium. The intuition is that if one of the two contracts makes a loss, then it is strictly better for the insurer not to offer this contract. Similarly, if it is possible for the insurer to make a deviation and make a positive profit, then an equilibrium is not possible.

Figure 3. A separating equilibrium.
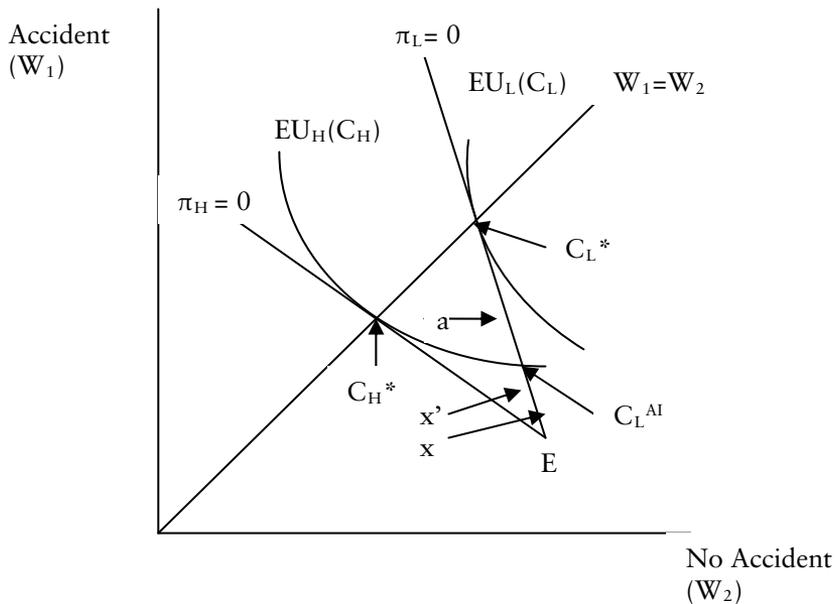
The fourth and fifth step illustrates the separating equilibrium. Figure 3 shows that with full information both types receive full insurance at their respective actuarially fair premiums. The reason is that the insurer perfectly observes the risk and can set an actuarially fair premium, more precisely

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the high risk type gets contract $C_H^* = \{d_H, Z_H\}$ and the low risk type gets contract $C_L^* = \{d_L, Z_L\}$.

When there is asymmetric information the first best outcomes are not achieved. If the insurer were to offer the first best contracts C_L^* and C_H^*, the high risk type would prefer the contract offered to the low risk type rather than her own first best allocation. The reason is that the premium is lower, while the coverage is the same as in the high risk contract. Hence the high risk type has incentives to deviate and earn a positive surplus of $(Z_H - Z_L)$ by pretending to be low risk. As a consequence, both risk types prefer the contract intended for the low risk driver. Therefore a separating equilibrium does not exist with the first best contracts. Instead, the classical RS separating equilibrium contract under asymmetric information is $C_H^* = \{d_H, Z_H\}$ and $C_L^{AI} = \{d_L, Z_L\}$, where $d_H = L$ and $d_L < L$. This means that the high risks obtain full insurance while the low risks obtain partial insurance at their respective fair premium. Hence, the low risks suffer a loss of utility from asymmetric information.

To see this, assume that the insurer offers another contract with more coverage, at a point *a* above C_L^{AI} on the zero profit line in Figure 3. This contract is preferred by type L since it offers more coverage compared to C_L^{AI} at their actuarially fair premium. Unfortunately this contract is also preferred by the high risk drivers for whom the insurer would make a loss since $Z_L < Z_H = d_L p_H$. Similarly, if type L is initially at some point x on the zero profit line in figure 3, and the insurer offers a contract at x', all type L drivers deviate since it offers more coverage at their actuarially fair premium. Type H does not deviate since the point is below $EU_H(C_H)$ and thus implies lower utility. Since it is possible to offer a better contract to type L, point X is not an equilibrium. As a result contract C_L^{AI} is the best the insurer can do for type L, where neither type H nor type L have incentives to

deviate. The equilibrium contract under asymmetric information is therefore C_H^* and C_L^{AI}.

3.3 The Swedish automobile insurance market – an application

In this section we apply the RS result to the Swedish automobile insurance market. As described in section 2, the Swedish automobile insurance market struggles with information asymmetry, and as a result a high risk driver can mimic a low risk driver. This implies that type L and H can be pooled together in the same contract if the risk classification fails to separate risk types. If this is the case the premium will not be actuarially fair and the low risk will subsidize the high risk.

One particular example of a pooling contract is the compulsory automobile insurance coverage. All vehicle owners in Sweden are required to purchase this coverage. With the information asymmetry described in the Swedish insurance market, insurers may not be able to separate risks according to the observable characteristics currently used in the risk classification. Since all vehicle owners are obliged to purchase this coverage, it is not possible to drop out of the market, as it would be with a voluntary insurance policy. The possibility for type H to mimic type L is largest in the beginning of a policyholder-insurer relation, especially when the insurers do not share claim history. The reason is that the insurer does not have any previous observations of new customers. If, in addition, the problem of under-reporting previous claims and other variables is large there is a chance that the risk classification will fail to provide homogenous groups since type H mimics type L.

There may be two outcomes; first there may not exist a separating equilibrium with the current risk classification. Even though the insurer can readjust the risk categorization ex post by observing the outcome (claim or not), it is still possible for type H to deviate and mimic type L after a claim by switching insurer and under-reporting previous claims. The reason is that insurers do not share claim history. Second, if type H and L are pooled in the same contract, low risk drivers subsidize high risk drivers; type L pays a higher premium than the actuarially fair while type H pays a lower premium than the actuarially fair. Either way, the low risk drivers lose utility from the asymmetric information and are likely to reveal their type if they get a chance to do so.

3.4 The solution with UBI

In order to separate the driver types we assume that the insurers can offer, as an additional contract, an UBI-contract with an in-vehicle device that monitors driving behavior. The UBI-contract corresponds to C_L^* in Figure 3. The UBI-policy offers full coverage at Z_L and the premium will stay low if the driver acts safely and drives within the speed limits; if not, the premium will increase to Z_H. The other contract is a regular insurance policy with no monitoring; it offers full coverage at the higher premium Z_H. Hence, both contracts offer the same amount of (full) coverage but at different prices, $d_L=d_H=L$, $Z_L<Z_H$.

The low risk type has incentives to sign the UBI-contract, since with this type L can reveal his or her low risk to the insurer and receive a low premium. The high risk driver is indifferent between the contracts, the reason

being that the UBI-premium is conditioned on driving behavior and if type H does not act safely, the premium will be Z_H.

When introducing UBI as an additional contract, the optimal pair of contracts is the same as in the first best. The low risk individual strictly prefers the UBI-contract, $C_L^* = (d_L, Z_L)$ since $Z_L < Z_H$. There is no reason why type L would prefer to pay a higher premium compared to their own lower premium for the same coverage.

The high risk type might prefer to deviate and choose the UBI-contract as long as s/he benefits from doing so, i.e. as long as $Z_H - Z_L \geq 0$. Still, a potential deviation is not associated with an efficiency loss since the insurer has full observability in contract C_L^*. If the high risk type deviates s/he becomes type L in order to receive the lower premium, Z_L. Otherwise the insurer readjusts the premium such that the type H gets the higher premium, Z_H. This means that there is no opportunity to benefit from mimicing the other type when the insurance market introduces UBI-insurance. This result differs from the RS-result in that the insurer can optimize over the same problem as in first best, and that both types can receive full coverage at their actuarially fair premiums.

According to the RS results only high risks get full coverage at their actuarially fair premium when there is asymmetric information. In the Filipova-Neumann and Welzel (2010) model the low risk driver receives full coverage if an accident occurs, and type H and L pay the same premium in the no loss state. To reduce privacy invasion, the insurer only receives driving data when an accident occurs. Thereafter the insurer decides if the individual is a high or low risk; that is, if the individual receives full coverage or not. This implies that the low risk type is rewarded only if an accident occurs.

Our results differ from the RS and FNW results in that both risk types receive full coverage at their actuarially premium. The insurer receives information about the drivers continuously, not only in the accident state, which makes it possible to reward type L with a lower premium. A reward in terms of a lower premium may also offset the possible disutility, α, of being monitored.

This implies that the surplus of the lower premium in the UBI contract must be at least as large as the disutility of being monitored, $Z_H - Z_L - \alpha \geq 0$. With α type L will be at some point on the zero profit line between C_L^{AI} and C_L^*. Type H may deviate and choose the UBI-contract, but as stated earlier the insurer can observe type since the UBI-contract is associated with monitoring.

3.5 Market implementation

Since introducing UBI in the market comes with an unknown investment cost insurers may hesitate to implement it. In this section we briefly look at what could happen if an entrant offers UBI, while all other insurers stick to the regular contract.

To illustrate a market implementation of UBI we assume that type H can mimic type L under the standard contract; that is, the risk classification fails to separate risks and the regular contract is a pooling contract. As before, the probability that the driver is of type H is λ and the probability that the driver is type L is $(1-\lambda)$. The pooling zero profit (dotted line) in Figure 3 is given by $W_1 = W_2 - L + d$, where $W_2 = W - Z$ and $Z = [\lambda p_H + (1-\lambda) p_L]d$. In section 3.2 we showed that a pooling equilibrium cannot exist since it is possible for an insurer to offer a contract at some point, above EU_L, which

only attracts the low risk individual. Since this contract would give zero profit if chosen by both risk types, the insurer makes a profit if only type L buys it.

Assume that an entrant offers a UBI contract (point UBI in Figure 4). If all other insurers continue to offer regular contracts, without monitoring, the UBI contract will attract all low risk types since the contract lies above the indifference curve of type L. This is clearly a cherry picking or a cream skimming deviation by the insurer. Since the regular contract will produce a zero profit if both type L and H purchase it, the insurer will make a negative profit if the low risk individuals drop out. The reason is that a higher share of high risk individuals will imply a higher expected cost of providing insurance and the pooling premium will be too low.

Figure 4. Market skimming of low risk drivers by offering UBI.

Accident
(W_1)

No Accident
(W_2)
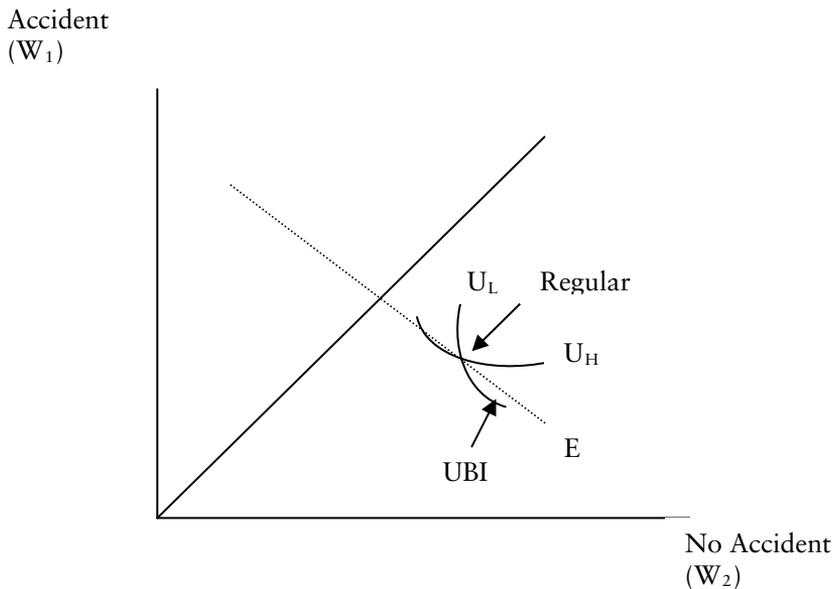
This is not an equilibrium in the long run since the other insurers will start to offer UBI-insurance in order to receive a zero profit and even out the distribution of risks among the insurance companies. In the long run all insurers will offer UBI and there will be a zero profit. However, with all companies offering UBI a separating equilibrium, as described in section 3.4, will exist.

4. Concluding remarks

This paper shows that it is possible to reduce asymmetric information in the automobile insurance market by introducing voluntary UBI as an additional contract. We have argued that the current risk classification may be inefficient since high risk drivers can mimic low risk drivers. This implies that it is possible for type H to deviate and choose a contract intended for type L, and that there are no strong incentive compatibility constraints such that a separating equilibrium exists. The weak constraints also violate the homogeneity assumption; that is, the belief that insurers efficiently divide risk into homogenous groups. This does not imply that the insurers perform a poor classification, but rather that restrictions of available information, at least partially imposed by society, tend to cause unfair premiums. The insurance industry can reduce its costs by using deductibles and adjusting the premiums. This implies that the interest in UBI may be larger for the society than for the insurer, at least in Sweden. The primary reason is that the social costs may be larger than the insurance costs, since the compulsory automobile insurance policy mainly works as a complement to the social insurance system.

Solutions that require monitoring are associated with privacy concerns, and minimizing the utility loss associated with monitoring the UBI design is therefore important. This could, for instance, be dealt with if the insurers receive information as summary statistics, rather than individual data, in order to develop risk classification variables. One objection, however, is that if people were that averse to privacy invasions, there would be no markets for cell phones and credit cards; nor would there be markets where usage is monitored and charged. Nevertheless, the level and security of tracking behavior are important issues.

It is also important to see the distinction between a UBI-contract and, for instance, a uniform tax (or similar) like the one imposed on the compulsory insurance premium in Sweden in 2007. The purpose of this tax was to alleviate the accident costs imposed on society. Unlike a uniform premium increase, a UBI-option provides the possibility for the insuree to affect the premium size by acting as a safe driver.

Providing an analysis where type H makes a positive deviation and becomes a type L is beyond the scope of this paper. The aim is rather to illustrate that it is possible to separate types by reducing the information asymmetries in the Swedish automobile insurance market. Despite the potential gains of UBI, the insurance industry is hesitating to implement these systems. The introduction of voluntary UBI might work as a business concept for a start-up insurance company, since it provides a cherry picking opportunity. The pros and cons of UBI need further investigation, and a recommendation for future research is to evaluate and analyze empirical data from UBI pilots.

References

Arvidsson, S.: 2010, "Does private information affect the insurance risk? – Evidence from the automobile insurance market". Scandinavian working papers in economics (S-WoPEc) 2010:1.

Chiappori, P-A. and B. Salanié: 2000, "Testing for asymmetric information in insurance markets". *Journal of Political Economy* 108(1), 56-77.

Cohen, A.: 2005, "Asymmetric information and learning: evidence from the automobile insurance market". *The Review of Economics and Statistics* 87(2), 197-207.

Cohen, A.: 2008, "Asymmetric learning in repeated contracting: an empirical study". NBER Working Paper No. 13752.

DeDonder, P. and J. Hindriks: 2009, "Adverse selection, moral hazard and propitious selection". *Journal of Risk and Uncertainty* 38(1), 73-86.

DeMeza, D. and D. Webb: 2001, "Advantageous selection in insurance markets". *RAND Journal of Economics* 32(2), 249-262.

Fang, H., M. Keane, and D. Silverman: 2006, "Sources of advantageous selection: evidence from the medigap insurance market" Working Paper no 12289, Department of Economics, Yale University.

Filipova-Neumann, L. and P. Welzel: 2010, "Reducing asymmetric information in insurance markets: Cars with black boxes". *Telematics and Informatics,*(article in press).

Finkelstein, A. and K. McGarry: 2006, "Multiple dimensions of private information: evidence from the long-term care insurance market". *American Economic Review* 96(4), 938-958.

Hemenway, D.: 1990, "Propitious selection". *Quarterly Journal of Economics*, 105(4), 1063-1070.

Hultkrantz L. and G. Lindberg: 2012, "Pay-As-You-Speed: An economic field experiment". Scandinavian working papers in economics (S-WoPEc) No. 2009:10. (forthcoming in *Journal of Transport Economics and Policy*, 2012).

Hultkrantz L., J-E. Nilsson, and S. Arvidsson: 2010, "Internalization of speeding externalities". Working Paper, Örebro University, Dept of Economics.

Karagyozova P. and P. Siegelman: 2006, "Is there propitious selection in insurance markets?". Working Paper no 2006-20. Department of Economics University of Connecticut.

Rees R., and A. Wambach: 2008. "The Microeconomics of insurance". Foundation and trends in microeconomics. Now Publishers Inc. Hanover.

Rotschild M. and J-E. Stiglitz:1976, "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information". The Quarterly Journal of Economics 90(4).

Scadplus : SCADPlus, 2007. "Road safety action programme 2003-2010". [Online] Available at: http://europa.eu/scadplus/ [Accessed 1 May 2009]

Schmidt-Nielsen, B. and H. Lahrman: 2004, "Traffic Safe Young Drivers, Experiments with Intelligent Speed Adaption". Working paper, TRG, University of Aalborg.

Strömbäck, E.: 2003, "Trafikskadelagen – ersättning vid trafikskada", [Traffic injury law-reimbursement at traffic injury]. Stockholm: Norstedts juridik AB.