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Transparency Aversion and Insurance Market Equilibria

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Abstract

Telemonitoring devices can be used to screen consumers' characteristics and mitigate information asymmetries that lead to adverse selection in insurance markets. However, some consumers value their privacy and dislike sharing private information with insurers. In the second-best efficient Wilson-Miyazaki-Spence framework, we allow for consumers to reveal their risk type for an individual subjective cost and show analytically how this affects insurance market equilibria as well as utilitarian social welfare. Our analysis shows that the choice of information disclosure with respect to revelation of their risk type can substitute deductibles for consumers whose transparency aversion is sufficiently low. This can lead to a Pareto improvement of social welfare and a Pareto efficient market allocation. However, if all consumers are offered cross-subsidizing contracts, the introduction of a transparency contract decreases or even eliminates cross-subsidies. Given the prior existence of a WMS equilibrium, utility is shifted from individuals who do not reveal their private information to those who choose to reveal. Our analysis provides a theoretical foundation for the discussion on consumer protection in the context of digitalization. It shows that new technologies bring new ways to challenge cross-subsidization in insurance markets and stresses the negative externalities that digitalization has on consumers who are not willing to take part in this development.

Keywords: Adverse Selection, Digitalization, Privacy, Screening, Transparency Aversion
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1 Introduction

Screening consumers' characteristics can mitigate problems arising from information asymmetries that lead to adverse selection in insurance markets. With the ongoing process of digitalization, new technologies are used to acquire, store and manage more information about consumers, aiming to price insurance policies more accurately according to the respective risk. One way to do so is using telemonitoring devices, such as wearables in health insurance or a telematics system in motor insurance. The U.S. health insurer *Aetna* announced in September 2016 that it will subsidize a significant amount of Apple watches for its policyholders of employer insurance contracts if they are used for collecting health data in Aetna's analytics-based wellness and care management programs.[1] The life and health insurer *John Hancock* offers discounts on premiums, various rewards and a free wearable with its *Vitality* program. On its website, individuals can calculate their vitality age[2] by answering questions, among others, about eating habits, weekly hours of exercising, smoking habits, alcohol intake, height, weight, waist circumference, blood pressure, cholesterol and mental wellbeing.[3]

However, as the public discussion about consumer protection shows, many consumers value their privacy and don't feel comfortable sharing too much information with public institutions or companies, such as insurers.[4] They exhibit a disutility from transparency or - in other words - a transparency aversion. The degree of this transparency aversion might differ among consumers but does not necessarily depend on whether consumers are "low risks" or "high risks". It is rather correlated with their valuation of privacy, their view on digitalization, cyber security, trust in companies and public institutions with respect to data abuse and related experience, and even their political orientation, e.g. their views on consumer rights.[5] The disutility a consumer experiences depends

[1] See http://investor.aetna.com/phoenix.zhtml?c=110617&p=irol-newsArticle&ID=2206242.

[2] A person's *Vitality Age* should serve as an indicator of overall health and wellness and inform the insurer about a person's mortality in a more comprehensive way than age does.

[3] See https://www.johnhancockinsurance.com/life/John-Hancock-Vitality-Program.aspx.

[4] See for instance http://actuaries.asn.au/Library/Opinion/2016/BIGDATAGPWEB.pdf. The debate on privacy even reaches the non-academic fiction literature. In the dystopian novel *The Method* (Zeh (2012)), the German author Juli Zeh, describes a future health dictatorship, where laws are written in order to optimize population health.

[5] Kremslehner and Muermann (2016) use a telematics data set of driving behavior and the corresponding drivers' insurance data set to analyze the relevance of private information of driving behavior for policyholders' choice of car insurance contract and the conditional loss distribution. They find that the choice of a telematics based insurance

on his preference for privacy and might be big enough to outweigh the utility increase from risk adequate insurance and prevent him from purchasing insurance. In that case, offering an insurance policy that requires policyholders to reveal private information in a market with imperfect information does not attract all individuals with a low probability of loss and does therefore not work as an ideal screening mechanism. Insurers might not be able to distinguish whether consumers do not wish to reveal private information because they exhibit a high loss potential or a high transparency aversion. Given that consumers exhibit heterogeneous transparency aversion the question arises whether and in which way digitalization affects the standard results for insurance market equilibria, market performance and social welfare.

In this paper, we address this question by introducing an insurance policy that offers full coverage at a fair premium, but requires the revelation of private information. We aim to show analytically how this affects the standard results regarding the second-best efficient insurance market equilibria within the Wilson-Miyazaki-Spence framework and analyze the resulting implications on social welfare. Our analysis shows that the choice of information disclosure with respect to revelation of their risk type can substitute deductibles for consumers whose transparency aversion is sufficiently low. We show that the availability of a transparency contract can lead to a Pareto improvement of social welfare and a Pareto efficient market allocation if the fraction of high risks in the market without a transparency contract is sufficiently high for the market equilibrium to be described by self-selection contracts in the Rothschild-Stiglitz sense. If a cross-subsidizing WMS equilibrium exists, the introduction of a transparency contract decreases or even eliminates cross-subsidies. The equilibrium resulting therefrom depends on the fraction of transparency averse low risks. The price for an insurance policy that does not require policyholders to reveal private information then depends on the availability of an insurance contract that does require this information as well as on the number of consumers choosing such a contract. Given the prior existence of a cross-subsidizing WMS equilibrium, the availability of a transparency contract results in a lower deductible for transparency averse low risks and high risks pay a higher premium for full coverage. Utility is shifted from individuals who do not reveal their private information to those who choose to reveal. In this case, the impact a transparency contract has on the insurance market's performance as well as

contract is correlated with policyholder characteristics. Such a pay-as-you-go policy is more likely to be chosen by young women living in urban areas.

on social welfare is ambiguous and depends on the composition of individuals in the market, with respect to their risk type and transparency aversion.

In the context of consumer protection, our analysis provides a theoretical foundation for the negative externalities that digitalization has on consumers who are not willing to take part in this development. It shows that new technologies bring new ways to challenge cross-subsidization in insurance markets and the policies offered to each consumer depend on other consumers' valuation of private information.

The following Section 2 provides a literature review. In Section 3, we introduce the theoretical framework of our model. Section 4 presents the equilibria that emerge when introducing the fairly priced full coverage insurance policy that requires the revelation of private information. Resulting implications on utilitarian social welfare are analyzed in Section 5. Section 6 concludes and provides a short outlook on potential future research.

2 Related Literature

We build our model on the standard literature on adverse selection. The widely referenced study by Rothschild and Stiglitz (1976) analyzes insurance market equilibria in the context of perfectly competitive insurers and two types of consumers: Individuals with a high probability of loss and individuals with a low loss probability. Insurers cannot observe consumers' risk types. The market equilibrium outcomes in this model depend on the fraction of high-risk individuals. If this fraction exceeds a critical value, a pooling contract priced at the average risk does not attract low-risk consumers and therefore the market equilibrium is described by two self-selecting separating contracts. If the fraction of high risks deceeds the pivotal fraction, there is no market equilibrium because competitors could always attract low risks with a more attractive contract. Wilson (1977) modifies the assumptions in a way that an insurer can anticipate which policies offered by competitors will become unprofitable as a result of changes in its own policies. He assumes that unprofitable policies will be withdrawn. The insurer adjusts its supply accordingly or withdraws own policies if they in turn become unprofitable. This property ensures the existence of an equilibrium. If a separating equilibrium in the sense of Rothschild and Stiglitz (1976) (RS) exists, the Wilsonian equilibrium equals the RS separating equilibrium. Otherwise, the market is described by a Wilsonian pooling equilibrium. In either case, the market equilibrium is not efficient in terms of risk allocation, since low-risk individuals receive only partial coverage. Miyazaki (1977) and Spence (1978) extend the Wilsonian anticipatory equilibrium analysis to contract menus that result in separating, cross-subsidizing, jointly zero-profit making Wilson-Miyazaki-Spence (WMS) contracts that are second-best efficient.

Several studies focus on how screening policyholders' characteristics can mitigate inefficient information asymmetries (e.g. Crocker and Snow (1986), Crocker and Snow (2011), and Dionne and Rothschild (2014)). Some authors (e.g. Hoy (1982), Hoy (2006)) also look at the implications of screening on social welfare

Browne and Kamiya (2012) analyze a framework in which consumers can purchase an insurance policy that requires taking an underwriting test and sharing the results with the insurer. In a Wilsonian market with nonmyopic insurers, they show that offering such policies leads to the existence of underwriting equilibria in which low- risk individuals obtain greater insurance coverage than they would in a setting without underwriting test. The authors consider a positive fee for the underwriting test but do not take into account consumers' valuation of privacy.

Filipova-Neumann and Welzel (2010) name two potential reasons for disliking the revelation of private information: (1) The premium risk that individuals face if they are not informed about their own risk type (2) The inherent disutility from giving up privacy. While several studies have analyzed the first case, often in the context of medical checkups or genetic testing (e.g. Doherty and Thistle (1996), Doherty and Posey (1998), Hoy and Polborn (2000)), the number of academic articles focusing on the second case has recently been increasing as well in various fields. Acquisti et al. (2016) point out that "exploiting the commercial value of data can often entail a reduction in private utility, and sometimes even in social welfare overall". Among other personal costs, they list quantity discrimination in insurance markets, the risk of identity theft and simply "the disutility inherent in just not knowing who knows what or how they will use it in the future." Filipova-Neumann and Welzel (2010) examine the effects of monitoring technologies in automobile insurance markets with adverse selection, such as cars with 'black boxes'. In addition to the usual second best contract, they introduce a contract that gives access to recorded information to the insurer after an accident. The authors show that offering this kind of monitoring technologies can lead to a Pareto improvement of social welfare in an automobile insurance market with asymmetric information. In one scenario of their analysis, Filipova-Neumann and Welzel (2010) account for privacy concerns[6] that are represented by a loss of utility for a fraction of low risks that is defined as having an inherent preference for privacy. In their model, the preference for privacy does not change their main result. However, in their setting, data is retrieved and analyzed only when the driver reports an accident.[7] Therefore, an ex-ante classification of risks is not possible. The adjustment to the respective risk type that is revealed by the 'black box' is displayed in an ex-post adjustment of the indemnity payment rather than an ex-ante premium adjustment. We follow Browne and Kamiya (2012) in analyzing how the existence of insurance contracts that include screening possibilities with respect to consumers' risk types affects the standard results in insurance markets with nonmyopic insurers. To the best of our knowledge, we are the first ones to analyze the role of privacy preferences in this setting and its effect on market equilibria and social welfare.

3 The Theoretical Framework

3.1 Basic Framework

We consider an imperfect insurance market with asymmetric information. Individuals are endowed with initial wealth w_0 and face a loss of $D \in [0, w_0]$ with probability π_i, where $i \in \{L, H\}$ and $0 < \pi_L < \pi_H < 1$. The loss probability is an individual's private information. The fraction of high-risk individuals in the market is denoted by λ, whereas $(1 - \lambda)$ is the fraction of low risks. Individuals are risk averse with a twice differentiable concave von Neumann-Morgenstern utility function over final wealth $u(\cdot)$, i.e. $u'(\cdot) > 0$ and $u''(\cdot) < 0$. Risk neutral, nonmyopic insurers operate in a competitive market environment and offer jointly zero-profit making insurance policies that are characterized by an indemnity payment q offered in return for a premium p paid by the policyholder. As a result, individuals monetary wealth is given by $w_1 = w_0 - p$ if no loss occurs, whereas the realization of a loss yields a wealth state $w_2 = w_0 - p - D + q$.

Consumers' private information can be retrieved, for instance through the implementation of tech-

[6] They analyze privacy concerns in a more extensive way in a previous version of this article (Filipova et al. (2005)), where they also consider individuals that are uninformed about their own risk type.

[7] This setting can impact the correlation between transparency aversion and a low probability of accident. Transparency averse drivers who are also low risks could exhibit lower private costs from having such a black box installed than implied by their transparency aversion, since they know that the likelihood of having to report their data is small, if data is not reported at any time but only in the case of an accident.

nological monitoring devices. Whether or not this information is shared with the insurer, e.g. by implementing a telemonitoring device, is agreed upon before contract inception. For the sake of simplicity, we neglect insurer's acquisition and administrative expenses. Each individual decides whether to reveal private information before contract offers, i.e. coverage q and premium p are determined by anticipating the resulting effect of the coverage on the premium. Consumers then choose whether to purchase the insurance product according to their individual expected utility.

3.2 Standard Policies

The Wilson-Miyazaki-Spence (WMS) equilibrium contracts (M_H, M_L) are characterized by $M_i = (p_i^M, q_i^M)$ for $i \in \{H, L\}$.

An individual's expected utility of a WMS contract M_i is given by:

$$V_i(M_i) = (1 - \pi_i) \cdot u(w_0 - p_i^M) + \pi_i \cdot u(w_0 - p_i^M + q_i^M - D) \tag{1}$$

The WMS equilibrium contract parameters $(q_L^M, q_H^M, p_L^M, p_H^M)$ result from the following maximization problem:[8]

$$\max_{q_L^M, q_H^M, p_L^M, p_H^M} \quad V_L(\mathrm{M}_L) \tag{2}$$

$$\text{s.t.} \quad V_H(M_H) \geq V_H(M_L) \tag{3}$$

$$\lambda(p_H^M - \pi_H q_H^M) + (1 - \lambda) \cdot (p_L^M - \pi_L q_L^M) \geq 0 \tag{4}$$

$$V_H(M_H) \geq V_H(H) \tag{5}$$

The expected utility of low-risk individuals is maximized under the incentive compatibility constraint (3). The aggregate break-even constraint (4) displays the crucial difference to the RS framework, in which insurers break even individually on each contract. Constraint (5) ensures that there is no cross-subsidization from high risks to low risks. If this constraint is binding, the WMS

[8] There may be more than one solution to the maximization problem. In order to resolve the non-uniqueness problem and ensures that the equilibrium is second best efficient, we follow Crocker and Snow (2008) and assume that when individuals are indifferent between two contracts they choose the one offering more coverage.

contracts correspond to the RS contracts. If constraint (5) does not bind, high risks receive full coverage and are cross-subsidized by low risks.[9] Netzer and Scheuer (2010) show that under the assumption of standard preferences, such cross-subsidization takes place if the fraction of high-risk individuals in the market λ deceeds a critical fraction λ^{RS}. [10] The assumption that the market is described by cross-subsidizing WMS contracts if $\lambda < \lambda^{RS}$ and by a RS separating equilibrium otherwise ensures a second-best efficient market allocation given the adverse selection externalities as shown by Crocker and Snow (1985).[11] For the case $\lambda \geq \lambda^{RS}$, i.e. when the WMS equilibrium correspond to the RS equilibrium, contracts break-even individually and the insurance premium is given by $p_i = \pi_i q_i$, where $i = H, L$. In the separating equilibrium (H, L) with $H = (p_H, D)$ and $L = (p_L, q_L)$ low risks forgo a part of their utility because they do not receive full insurance coverage[12]. A high-risk individual's expected utility of a RS separating contract H is given by:

$$
\begin{aligned}
V_H(H) &= (1 - \pi_H) \cdot u(w_0 - p_H) + \pi_H \cdot u(w_0 - p_H + D - D) \\
&= u(w_0 - \pi_H D)
\end{aligned} \tag{6}
$$

A low-risk individual's expected utility of a RS separating contract L is given by

$$
\begin{aligned}
V_L(L) &= (1 - \pi_L) \cdot u(w_0 - p_L) + \pi_L \cdot u(w_0 - p_L + q_L - D) \\
&= (1 - \pi_L) \cdot u(w_0 - \pi_L q_L) + \pi_L \cdot u(w_0 - \pi_L q_L - D + q_L)
\end{aligned} \tag{7}
$$

If the market fraction of high risks deceeds the critical value, i.e. $\lambda < \lambda^{RS}$, the WMS equilibrium contracts (M_H, M_L) include a cross-subsidy from low-risk individuals to high-risk individuals and high risks receive full coverage, i.e. $M_H = (p_H^M, D)$ and $M_L = (p_L^M, q_L^M)$.

The high-risk individuals' utility of a WMS contract M_H is then given by:

[9] See e.g. Netzer and Scheuer (2010) or Mimra and Wambach (2014).

[10] Netzer and Scheuer (2010) show that there is a unique critical value λ^{RS} at which the transition from zero to positive cross subsidization occurs, given that condition (5) is satisfied. Fudenberg and Tirole (1990) show that condition (5) is satisfied if individuals' risk aversion is not decreasing too quickly in income, e.g. for CRRA preferences with a coefficient of at least one. We follow Crocker and Snow (1985) and Browne and Kamiya (2012) in the use of th notation λ^{RS} as the pivotal fraction of high risks in the market. However, those authors use it in the context of the transition from a RS separating equilibrium to a Wilson pooling equilibrium.

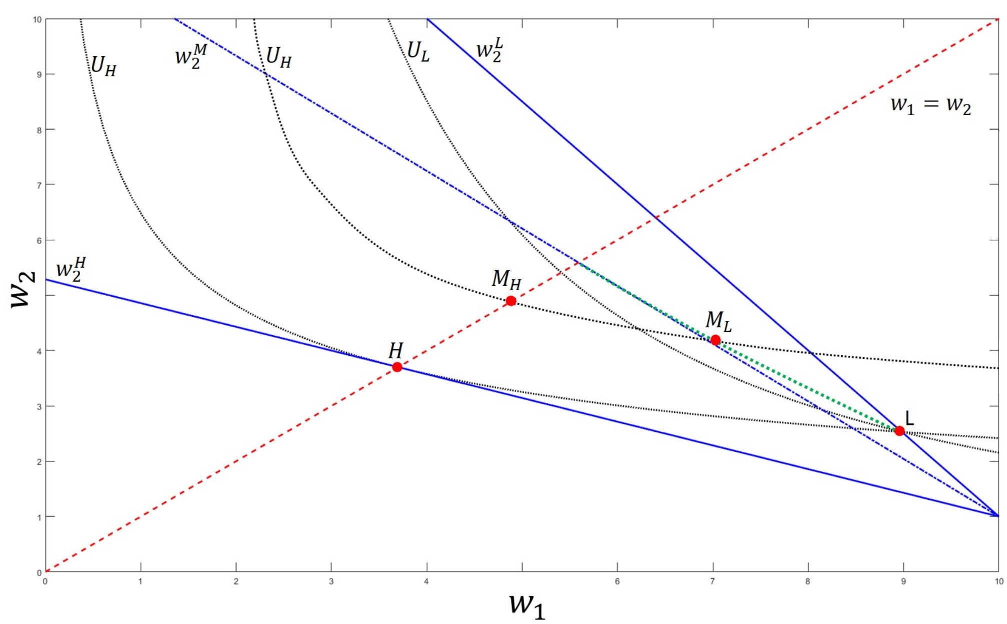
[11] Compare Crocker and Snow (2008).

[12] In the separating equilibrium, it has to be $q_L < D$ for high-risk individuals not to be attracted by the insurance contract designed for low risks.

$$V_H(M_H) = u(w_0 - p_H^M) \quad (8)$$

Figure 1 illustrates the WMS equilibrium. The individuals' wealth state in case of no loss w_1 is represented by the x-axis, whereas the wealth state in case of a loss w_2 is displayed on the y-axis. The green dotted curve that runs from the RS low risk contract L to the certainty line represents all feasible low risk contracts that satisfy the WMS constraints. Along this curve low risks' expected utility is maximized at the cross-subsidizing contract M_L. The corresponding high risk WMS contract M_H is located where the certainty line crosses the high risks' indifference curve U_H that yields the same expected utility for high risks as the low risk WMS contract M_L. If the fraction of high risks λ in the market increases enough for the green dotted WMS-curve to run entirely below the low risks' indifference curve U_L at the low risk RS contract L, any cross-subsidizing contract offers less expected utility to the low risks than their RS contract and the market is described by a RS equilibrium.

Figure 1: WMS Equilibrium



In the WMS equilibrium, high risks always receive full coverage. In comparison to the RS contract H, they move to the north east of the certainty line and get full coverage for a lower premium. The price subsidy thereby is financed by the low risks, who pay an actuarially unfair price in order to receive higher coverage.

3.3 Policies with Screening Option

Similar to Browne and Kamiya (2012), we introduce a conditional contract that offers full coverage in exchange for the fair premium if individuals are willing to share a sufficient amount of information to reveal their true risk type. That information can for instance be retrieved using telemonitoring technologies. The conditional contract is described by $T_i = (p_i^T, D)$ for $i = H, L$. Since most policies do not ask for a specific payment for the telemonitoring device but rather pay for the data management as well as installation and maintenance of the devices out of their revenue, we assume that consumers who decide for a conditional contract T_i with telemonitoring do not have to bear direct costs for the devices. Therefore, these costs are not a decision criterion. The premium for a contract T_i offered to individuals that have revealed their risk type i by sharing private information is given by:

$$p_i^T = \pi_i D \tag{9}$$

The contract with transparency option offers full coverage at a fair price and therefore increases low risks' monetary utility in comparison to either one of the contracts with partial coverage discussed in the previous subsection. However, we assume that policyholders' utility from insurance is not only determined by their monetary wealth, but takes into account the individuals' valuation of privacy and the resulting disutility from the level of transparency agreed upon at contract inception.

Definition 1: *The disutility resulting from sharing private information for individual j is described by $\psi_j \in [0, \infty)$.*

The overall utility a consumer j gets from purchasing an insurance product that requires the revelation of private information is described by

$$V_{i,\psi_j}(w_i) = U(w_i) - \psi_j. \tag{10}$$

Individuals decide whether or not to purchase insurance by trading off the maximization of expected utility of monetary wealth $U(w_i)$ against the minimization of disutility from sharing private information. The latter is modeled additively as a second attribute to the utility function.[13] Hence, an individual's utility of a contract $T_i, i \in \{H, L\}$ is given by:

$$\begin{aligned} V_{i,\psi_j}(T_i) &= [(1-\pi_i)\cdot u(w_0 - p_i^T) + \pi_i \cdot u(w_0 - p_i^T + D - D)] - \psi_j \\ &= u(w_0 - p_i^T) - \psi_j \\ &= u(w_0 - \pi_i D) - \psi_j \end{aligned} \tag{11}$$

4 Equilibrium Analyses

4.1 Consumers' Participation Constraints

In order to specify the demand for conditional policies T_i with $i = H, L$, we investigate on the cases in which individuals' utility from the transparency contract is higher than their expected utility from an alternative contract offered to them.

Lemma 1: *High-risk individuals will never have an incentive to choose the conditional contract T_H and will therefore never reveal their private information, regardless of their transparency aversion.*

Proof: *See Appendix A.1.1.*

For low-risk individuals, we have to differentiate between the underlying market equilibria, i.e. whether the contract offered to them alternatively to the transparency contract is a RS contract L or a WMS contract M_L.

Let $\lambda \geq \lambda^{RS}$, i.e. without the transparency contract, the market yields a RS separating equi-

[13]The multiattribute value function is given by the sum of two utility functions with different arguments. For a comparison, see Eisenführ et al. (2010) or Keeney and Raiffa (1993). Numerous articles on insurance market equilibria have taken into account different types of consumers' characteristics and have modeled them as a second attribute to the consumers' utility function. This strand of literature considers characteristics, such as patience (e.g. Sonnenholzner and Wambach (2009)), overconfidence (e.g. Huang et al. (2010)), ambiguity aversion (e.g. Koufopoulos and Kozhan (2016)), and regret (e.g. Huang et al. (2016)). In the context of the valuation of privacy, this approach is taken by e.g. Filipova-Neumann and Welzel (2010).

librium. Then low risks will decide for a contract with transparency if and only if:

$$
\begin{aligned}
V_{L,\psi_j}(T_L) &> V_L(L) && (12)\\
\Leftrightarrow u(w_0 - \pi_L D) - \psi_j &> (1-\pi_L)\cdot u(w_0 - \pi_L q_L) + \pi_L \cdot u(w_0 - \pi_L q_L + q_L - D)\\
\Leftrightarrow u(w_0 - \pi_L D) - \psi_j &> u(w_0 - \pi_L D - \mu_L^L)\\
\Leftrightarrow \psi_j &< u(w_0 - \pi_L D) - u(w_0 - \pi_L D - \mu_L^L)
\end{aligned}
$$

where μ_L^L is the low risk's risk premium[14] associated with the RS separating contract L.

The interpretation of Inequality (12) is straight forward: For an individual to choose the insurance contract with transparency, the extra utility gained from full insurance must exceed the disutility from giving up private information.

Let $\lambda < \lambda^{RS}$, i.e. without the transparency contract the market is described by WMS contracts. Then, the low risks' participation constraint for the transparency contract is given by:

$$
\begin{aligned}
V_{L,\psi_j}(T_L) &> V_L(M_L) && (13)\\
\Leftrightarrow u(w_0 - \pi_L D) - \psi_j &> (1-\pi_L)\cdot u(w_0 - p_L^M) + \pi_L \cdot u(w_0 - p_L^M + q_L^M - D)\\
\Leftrightarrow u(w_0 - \pi_L D) - \psi_j &> u(w_0 - p_L^M - \pi_L D + \pi_L q_L^M - \mu_L^M)\\
\Leftrightarrow \psi_j &< u(w_0 - \pi_L D) - u(w_0 - p_L^M - \pi_L D + \pi_L q_L^M - \mu_L^M)
\end{aligned}
$$

where μ_L^M is the low risks' risk premium associated with the WMS contract for low risks M_L.

The extra utility gained from full insurance and not having to subsidize the high risks must exceed the disutility from giving up private information.

If conditions (12) or (13) are fulfilled in the respective underlying market situation, low-risk individuals reveal their risk type in order to purchase the insurance product T_L. This leads to symmetric information between those consumers and insurers. In other words, those low risks drop out of the pool of unidentified risks and receive full coverage at a fair price.

[14] I.e. the amount of money a low-risk policyholder would be willing to pay additionally to the fair insurance premium to obtain full insurance coverage in the absence of transparency aversion.

4.2 Transparency Aversion Among Consumers

Since our results would not be comparable to the results of the standard asymmetric information literature, if we considered a continuous range of transparency aversion among possible insurance buyers, we look at the two polar cases.[15] Therefore, we assume now that individuals either do not exhibit any transparency aversion or they are sufficiently transparency averse to violate Inequality (12) or Inequality (13), respectively, i.e. $\psi_j \in \{0, \bar{\psi}_\tau\}$ with $\tau = L, M$; $V_{L,\bar{\psi}_M}(T_L) < V_L(M_L)$ and $V_{L,\bar{\psi}_L}(T_L) < V_L(L)$.[16]

Hence, transparency averse individuals choose to not reveal their private information, since the disutility resulting therefrom outweighs the utility gain from full insurance coverage, while individuals who do not exhibit transparency aversion choose to reveal their private information and will not suffer any loss of utility therefrom.

Definition 2: *Let $k_\tau \in (0, 1)$ with $\tau = L, M$ be the fraction of low risks with $\psi_j = \bar{\psi}_\tau$, respectively.*[17] *For those consumers the disutility from transparency exceeds the utility gain from a fairly priced contract with full insurance in comparison to the RS separating contract L and the WMS contract for low risks M_L, respectively.*

Lemma 2: *The resulting fraction of low risks in the new pool of risks unknown to the insurer is given by:*

$$(1 - \lambda_\tau) := \frac{(1 - \lambda)k_\tau}{(1 - \lambda)k_\tau + \lambda} \tag{14}$$

[15] Allowing for a continuous range of transparency aversion results in value functions that do not only differ among the two risk types but among all individuals. Our approach in this context is similar to the approach taken by Filipova et al. (2005).

[16] We assume that consumers do not know the transparency aversion among fellow consumers and therefore can only make their buying decision by comparing their expected utility of the transparency contract with their expected utility of the RS-contract or the WMS-contract based on the initial pool of risks. If consumers could anticipate the transparency aversion of other consumers or if we considered a multi-period framework, in which consumers can compare their expected utility of a transparency contract with the expected utility of a new RS-contract or WMS-contract based on a new pool of risks, this assumption should be adjusted to $\bar{\psi}_\tau$ being sufficiently high for $V_{L,\bar{\psi}_\tau}(T_L)$ to be dominated by the expected utility of any resulting RS- or WMS-contract for the respective risk type, e.g. $\bar{\psi}_\tau = \infty$.

[17] We neglect the polar cases $k_\tau \in \{0, 1\}$ in our analysis. For $k_\tau = 1$, no individual is willing to reveal private information and the introduction of a transparency contract to the market has no effect on market equilibria as it does not attract any individuals. If $k_\tau = 0$, all low risk individuals are willing to share their private information in order to get full insurance at a fair price. This case leads to a market with perfect information and hence to a separating equilibrium (H, T_L).

Consequently, the fraction of high risks in the new pool is given by:

$$\lambda_\tau := \frac{\lambda}{(1-\lambda)k_\tau + \lambda} \tag{15}$$

Proof: *See Appendix A.1.2.*

In order to investigate how the option to reveal private information before contract inception affects market equilibria, we again have to differentiate the two possible cases of the underlying market composition and the resulting market equilibria without the transparency contract. In other words, we distinguish market equilibria with the transparency option for a market that would result in a RS or a WMS equilibrium, respectively, had there not been the option to reveal consumers' risk types. The availability of a transparency contract can alter the nature of the market equilibrium or the equilibrium configuration by increasing the fraction λ of high risks in the market with asymmetric information. As a result, we have to distinguish three mutually exclusive and collectively exhaustive cases.[18]

4.3 Persistence of a RS Separating Equilibrium

Proposition 1: *Suppose it is $\lambda^{RS} < \lambda$, i.e. without the transparency option there is a self-selecting separating equilibrium (H, L). Then it is $\lambda^{RS} < \lambda \leq \lambda_L$. The separating equilibrium persists. But the non-transparency averse low risks (the ones whose utility from full insurance outweighs the disutility from transparency) choose the conditional contract with full insurance over the contract with partial coverage. Three contracts persist in equilibrium: (H, L, T_L).*

Proof: *The proof follows immediately from Lemma 1 that implies $\lambda \leq \lambda_L$ and from the definition of λ^{RS}.* □

[18] A similar distinction in a different context is made by Crocker and Snow (2008) who analyze the effect of background risk on the performance of insurance markets. However, in their framework, the existence of background risks increases the pivotal fraction λ^{RS} of high risks that alters the nature of the equilibrium rather than the fraction λ of high risks in the market.

Figure 2: Persistence of a RS Separating Equilibrium

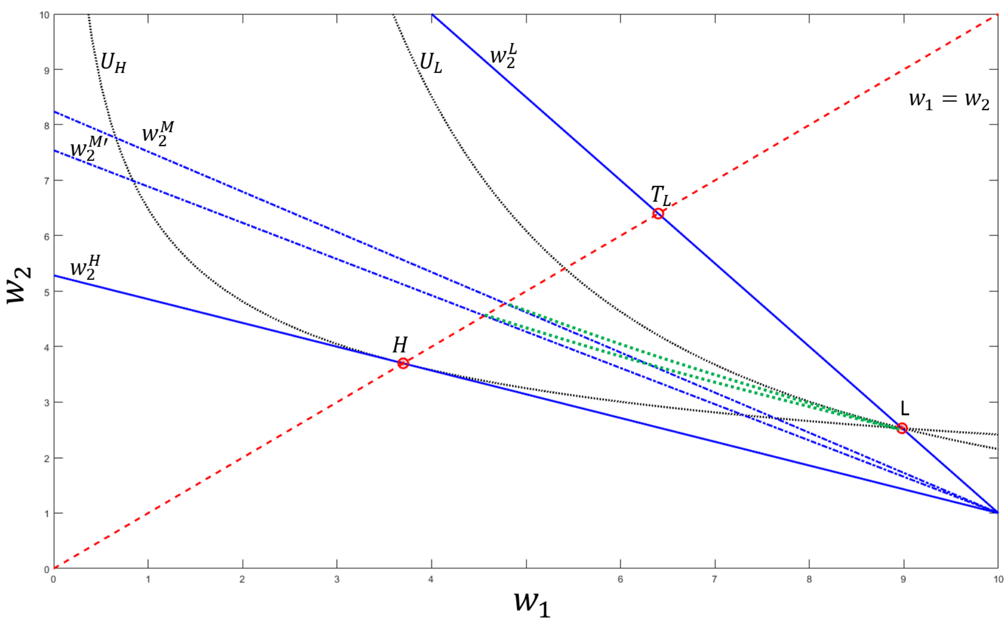


Figure 2 illustrates the case in which a separating equilibrium exists, i.e. $\lambda^{RS} < \lambda$. Any cross-subsidizing WMS contract $M_L = (q_L^M, p_L^M)$ offers less expected utility to low risks than contract L since the green dotted curve illustrating the set of potential low-risk WMS contracts runs entirely below the low risks' indifference curve U_L. The fraction of high risks in the market is already sufficiently high for a separating equilibrium (H, L) to exist and the availability of the transparency contract can only increase the fraction of high risks in the pool of unidentified risks, i.e. it can only shift the green dotted curve of feasible cross-subsidizing contracts farther below the low risks' indifference curve U_L. The new market equilibrium is described by three contracts, namely the transparency contract T_L and the two contracts H and L that persist in equilibrium and separate the high risks from low risks with high transparency aversion. In this case, the availability of a transparency contract improves market performance by lowering non-transparency averse low risks' deductibles without changing the other equilibrium contracts.

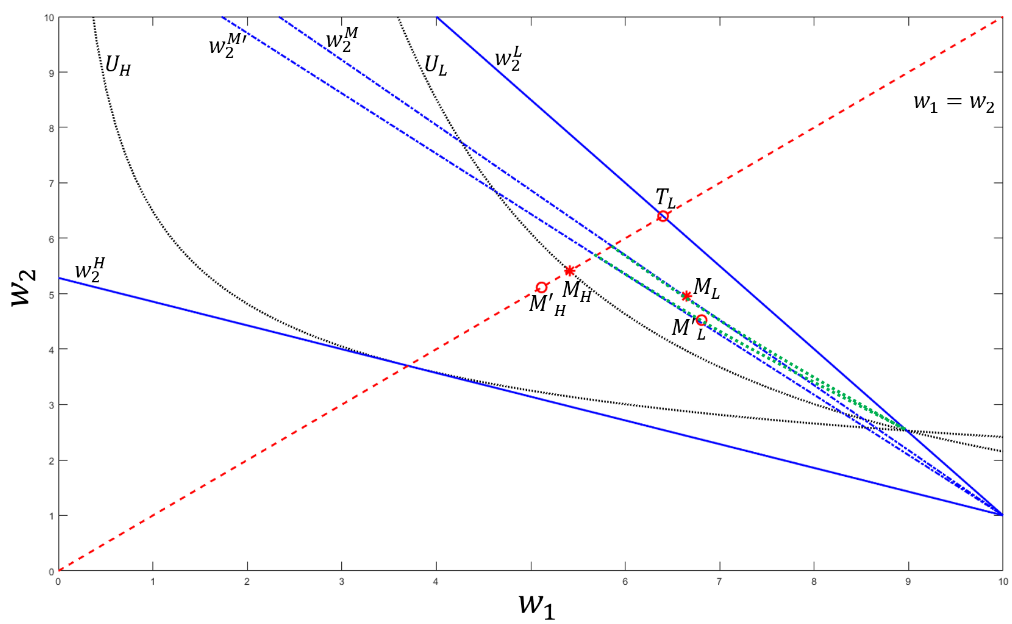
4.4 Evolution of a WMS Equilibrium

Suppose now, it is $\lambda < \lambda^{RS}$, i.e. without telemonitoring there is a WMS equilibrium (M_H, M_L). Then the availability of the transparency contract can result in two possible scenarios depending on the fraction of transparency averse individuals in the market:

Proposition 2: *If the number of individuals that do not wish to share their private information is sufficiently high, so that it is* $\lambda \leq \lambda_M < \lambda^{RS}$*, the market equilibrium* (M'_H, M'_L, T_L) *is described by two WMS contracts and a contract offering the transparency option.*

Proof: *The proof follows immediately from Lemma* 1 *that implies* $\lambda \leq \lambda_M$ *and from the definition of* λ^{RS}. □

Figure 3: Persistence of a WMS Equilibrium



The persistence of the WMS Equilibrium is illustrated in Figure 3. It shows that the insurer's pooled zero profit line shifts downwards (from w_2^M to $w_2^{M'}$) due to a higher fraction of high risks in the market. With a downward shifting joint zero profit line, all feasible combinations of WMS contract menus shift downwards as well. Since there is still a sufficient fraction of low risks in the market so that not all feasible cross-subsidizing contracts for low risks (illustrated by the green dotted curve) shift entirely below the low risks' indifference curve U_L, a WMS contract M'_L can still attract the transparency averse low-risk individuals. A new equilibrium (M'_L, M'_H, T_L) establishes. However, in the pool of unidentified risks, a higher premium is associated with any given level of coverage, and lower coverage is granted for any given premium. Therefore, in the new equilibrium, high risks pay a higher premium for full coverage, transparency averse low risks pay a higher deductible and cross-subsidization decreases in comparison to the WMS equilibrium without the transparency contract. The overall effect on market performance is ambiguous as deductibles for transparency averse low risks increase while non-transparency averse low risks receive full insurance coverage.

Proposition 3: *If the number of individuals that are willing to share their private information is sufficiently high, so that it is* $\lambda < \lambda^{RS} < \lambda_M$, *the market equilibrium is described by a three-contract separating equilibrium* (H, L, T_L).

Proof: *The proof follows immediately from Lemma 1 that implies* $\lambda \leq \lambda_M$ *and from the definition of* λ^{RS}. □

Figure 4: From Cross-Subsidizing WMS to RS Separating Equilibrium

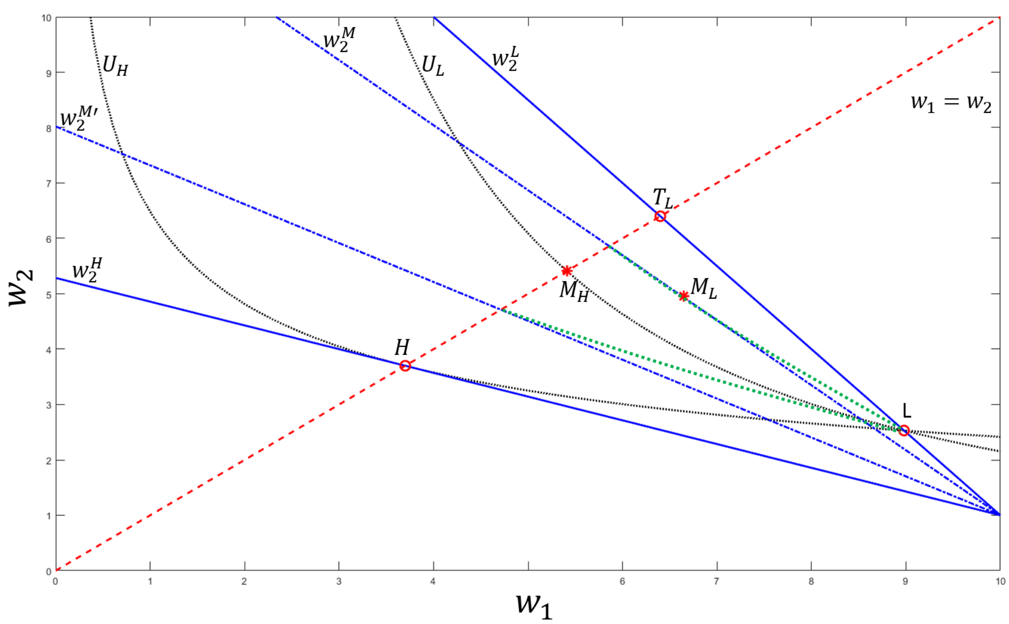


Figure 4 shows a market composition that results in a WMS equilibrium (M_L, M_H) if no transparency contract is offered, and establishes a RS separating equilibrium (H, L, T_L) if consumers can choose to purchase fairly priced insurance conditional on the revelation of private information. The insurer's zero profit line that pools all unidentified risks shifts far below the low risks' indifference curve when the transparency contract is introduced into the market. As a consequence, there is no cross-subsidizing WMS contract on the green dotted curve that can attract low-risk individuals anymore and the market equilibrium is described by self-selecting separating contracts in the RS sense. High risks have to pay a higher premium for full coverage and transparency averse low risks pay a higher deductible. As in the previous case, the overall effect on market performance is ambiguous because non-transparency averse low risks receive full coverage. The availability of a transparency contract in this case eliminates any cross-subsidies.

4.5 Efficiency Analysis

This subsection summarizes the changes in market performance that result from the availability of a transparency contract. To this end, Table 1 shows the changes in the equilibrium contract parameters for the respective consumer groups and the respective underlying market composition.

Cases	High Risks	Transparency Averse Low Risks	Non-Transparency Averse Low Risks
$\lambda^{RS} < \lambda \leq \lambda_L$ $(H, L) \rightarrow (H, L, T_L)$	$q \rightarrow$ $p \rightarrow$	$q \rightarrow$ $p \rightarrow$	$q \uparrow$ $p \uparrow$
$\lambda \leq \lambda_M < \lambda^{RS}$ $(M_H, M_L) \rightarrow (M_H, M_L, T_L)$	$q \rightarrow$ $p \uparrow$	$q \downarrow$ $p \downarrow$	$q \uparrow$ $p \uparrow$
$\lambda < \lambda^{RS} \leq \lambda_M$ $(M_H, M_L) \rightarrow (H, L, T_L)$	$q \rightarrow$ $p \uparrow$	$q \downarrow$ $p \downarrow$	$q \uparrow$ $p \uparrow$

Table 1: Change in Contract Parameters due to the Availability of a Transparency Contract

In the case of a persistent RS equilibrium, non-transparency averse low risks receive full coverage while nothing changes for the two other consumer groups. Hence, if $\lambda^{RS} < \lambda \leq \lambda_L$, the availability of a transparency contract improves market efficiency.

If the market equilibrium in the absence of a transparency contract is described by cross-subsidizing WMS contracts[19], i.e. $\lambda < \lambda^{RS}$, the equilibrium coverage for transparency averse low risks decreases while non-transparency averse low risks receive full coverage and the full coverage for high risks

[19] This corresponds to the second and the third row in Table 1.

in unaffected. The effect on market performance is ambiguous. In this case, the equilibrium price for high risks increases while transparency averse low risks pay less premium and therefore reduce cross-subsidies. Hence, if at least one consumer exhibits a transparency aversion thats's sufficiently high to prevent him from choosing the transparency contract, the existence of such a contract decreases the probability of cross-subsidization.

5 Welfare Analyses

5.1 Changes in Consumers' Expected Utility for the Respective Market Equilibria

For each of the respective scenarios analyzed in Section 4, we look at how the availability of a transparency contract changes consumers' expected utility for the respective consumer groups (high risks, transparency averse low risks, and non-transparency averse low risks) as well as utilitarian welfare. In the subsequent welfare analysis, the second-best efficiency characteristic of the WMS contracts ensures that there is no possibility of improving the market's performance.[20]

Proposition 4: *Suppose $\lambda^{RS} < \lambda \leq \lambda_L$, i.e. a RS separating equilibrium with (H, L) exists without telemonitoring and a RS separating equilibrium (H, L, T_L) exists with telemonitoring, adding a third contract to the market that allows low risks with low transparency aversion to be priced fairly. Further assume that Inequality (12) holds for a fraction $(1 - \lambda)(1 - k_L)$. Then telemonitoring leads to a Pareto improvement of welfare with a welfare increase of*

$$\begin{aligned} \Delta V &= V(H, L, T_L) - V(H, L) \qquad (16) \\ &= (1 - \lambda)(1 - k_L)(V_{L,0}(T_L) - V_L(L)) \\ &= (1 - \lambda)(1 - k_L)[u(w_0 - \pi_L D) - ((1 - \pi_L) \cdot u(w_0 - \pi_L q_L) + \pi_L \cdot u(w_0 - \pi_L q_L + q_L - D))] > 0 \end{aligned}$$

Proof: See Appendix A.2.1.

Since the high-risk individuals and the low-risk individuals with high transparency aversion

[20] Compare Crocker and Snow (2008).

choose the same RS separating contract as in a situation without the transparency option, their expected utility does not change with the introduction of a contract that requires transparency and offers full insurance at a fair price. The welfare gain equals the aggregate expected utility gain of non-transparency averse low risks who receive full insurance at a fair price rather than partial coverage. Since in this setting, individuals who choose the insurance contract with transparency do not exhibit any costs therefrom, this result is in line with Crocker and Snow (1986) who find that market equilibria with costless categorization are potentially Pareto superior to market equilibria without.

Example 1: To illustrate the effects that the introduction of the transparency contract has on market equilibria and social welfare, we choose exemplary values for the individuals' utility function, their loss probability, their initial wealth and the loss they face: $u(w) = ln(w)$, $\pi_H = 0.7$, $\pi_L = 0.4$[21], $w_0 = 10$, $D = 9$. For those values, the pivotal fraction of high risks is given by $\lambda^{RS} \approx 0.58$.[22] We choose $\lambda = 0.6 (> 0.58 = \lambda^{RS})$ and $k = 0.7$, hence $\lambda_L \approx 0.68 (> 0.58 = \lambda^{RS})$, to illustrate the persistence of the RS separating equilibrium.[23] As there is no change in high risks' utility and transparency averse low risks' expected utility, when they are offered the self selecting RS contracts, the welfare gain in this example equals the aggregate non-transparency averse low risks' utility change: $\Delta V = (1 - \lambda)(1 - k_L)(V_{L,0}(T_L) - V_L(L)) \approx 0.0202$.[24]

Proposition 5: *Suppose $\lambda \leq \lambda_M < \lambda_{RS}$, i.e. a WMS equilibrium (M_L, M_H) exists without the transparency policy and a WMS equilibrium (M'_L, M'_H, T_L) exists when adding a contract to the market that allows low risks with low transparency aversion to receive full coverage at a fair premium. Further assume that Inequality (13) holds for a fraction $(1 - \lambda)(1 - k_M)$, then the availability of the transparency contract leads to a utility shift from high risks and transparency*

[21] We chose the loss probabilities in accordance with our graphical illustrations. Qualitatively similar results are obtained using lower values.

[22] The pivotal fraction of high risk λ^{RS} is implicitly determined by $V_L(L) = V_L(M_L) \Leftrightarrow (1 - \pi_L) \cdot u(w_0 - p_L^M) + \pi_L \cdot u(w_0 - p_L^M + q_L^M - D)$, whereas p_L^M and q_L^M depend on λ.

[23] This example corresponds to Figure 2.

[24] For the calculation of the optimal coverage for the RS low risk contract L, see Appendix A.3.1.

averse low risks to low risks without transparency aversion. It is

$$\Delta V_H = V_H(M'_H) - V_H(M_H) < 0, \tag{17}$$

$$\Delta V_{L,\overline{\psi}_M} = V_L(M'_L) - V_L(M_L) < 0 \tag{18}$$

and

$$\Delta V_{L,0} = V_{L,0}(T_L) - V_L(M_L) > 0. \tag{19}$$

The overall change in welfare is ambiguous as it is

$$\begin{aligned} \Delta V &= V(M'_L, M'_H, T_L) - V(M_L, M_H) \\ &= \lambda \Delta V_H + (1-\lambda) k_M \Delta V_{L,\overline{\psi}_M} + (1-\lambda)(1-k_M)\Delta V_{L,0}. \end{aligned} \tag{20}$$

The option to reveal private information in this context leads to a welfare gain if the aggregate increase in non-transparency averse low risks' expected utility outweighs the aggregate expected utility loss for high risks and transparency averse low risks, i.e. if it is

$$\lambda \left[V_H(M_H) - V_H(M'_H)\right] + (1-\lambda)k_M \left[V_L(M_L) - V_L(M'_L)\right] < (1-\lambda)(1-k_M)\left[V_{L,0}(T_L) - V_L(M_L)\right]. \tag{21}$$

Proof: See Appendix A.2.2.

Example 2: To illustrate the persistence of a WMS equilibrium when the conditional insurance contract is introduced to the market, we choose $\lambda = 0.2(< 0.58 = \lambda^{RS})$ and $k = 0.7$, hence $\lambda_M \approx 0.26(< 0.58 = \lambda^{RS})$.[25] The introduction of a transparency contract in a market with this exemplary composition leads to a change in utility for a high-risk individual of

$$\Delta V_H = V_H(M'_H) - V_H(M_H) \approx -0.0170. \tag{22}$$

[25] This example corresponds to Figure 3.

Transparency averse low risks' expected utility changes by

$$\Delta V_{L,\overline{\psi}_M} = V_L(M_L') - V_L(M_L) \approx -0.0222 \tag{23}$$

and non-transparency averse low risks' experience an utility gain of

$$\Delta V_{L,0} = V_{L,0}(T_L) - V_L(M_L) \approx 0.0794. \tag{24}$$

The overall change in expected utility is given by

$$\begin{aligned} \Delta V &= \lambda \Delta V_H + (1-\lambda) k_M \Delta V_{L,\overline{\psi}_M} + (1-\lambda)(1-k_M)\Delta V_{L,0} \\ &\approx 0.0032. \end{aligned} \tag{25}$$

Proposition 6: *Suppose $\lambda < \lambda_{RS} < \lambda_M$, i.e. a WMS equilibrium (M_H, M_L) exists without transparency and a separating equilibrium (H, L, T_L) exists, when adding a contract to the market that allows low risks with low transparency aversion to be priced fairly and receive full coverage. Further assume that Inequality (13) holds for a fraction $(1-\lambda)(1-k_M)$. Then the change in consumers' expected utility for the respective group is given by*

$$\Delta V_H = V_H(H) - V_H(M_H) < 0, \tag{26}$$

$$\Delta V_{L,\overline{\psi}_M} = V_L(L) - V_L(M_L) < 0 \tag{27}$$

and

$$\Delta V_{L,0} = V_{L,0}(T_L) - V_L(M_L) > 0. \tag{28}$$

The overall change in welfare is ambiguous and depends among other factors on the fraction of high risks, low risks with transparency aversion, and low risks without transparency aversion in the market, as it is

$$\begin{aligned} \Delta V &= V(H, L, T_L) - V(M_H, M_L) \\ &= \lambda \Delta V_H + (1-\lambda) k_M \Delta V_{L,\overline{\psi}_M} + (1-\lambda)(1-k_M)\Delta V_{L,0}. \end{aligned} \tag{29}$$

The option to reveal private information in this context leads to a welfare gain if the aggregate increase in non-transparency averse low risks' utility outweighs the aggregate expected utility loss for high risks and transparency averse low risks, i.e. if it is

$$\lambda\left[V_H(M_H) - V_H(H)\right] + (1-\lambda)k_M\left[V_L(M_L) - V_L(L)\right] < (1-\lambda)(1-k_M)\left[V_{L,0}(T_L) - V_L(M_L)\right]. \quad (30)$$

Proof: See Appendix A.2.3.

Example 3: To illustrate the case that the market equilibrium is described by WMS contracts if no transparency policy is available and a RS separating equilibrium establishes with the introduction of the transparency contract in the market, we choose $\lambda = 0.2 (< 0.58 = \lambda^{RS})$ and $k = 0.15$, hence $\lambda_M \approx 0.625 (> 0.58 = \lambda^{RS})$.[26]

The introduction of a transparency contract in a market with this exemplary composition leads to a change in utility for a high-risk individual of

$$\Delta V_H = V_H(H) - V_H(M_H) \approx -0.1141. \quad (31)$$

Transparency averse low risks' expected utility changes by

$$\Delta V_{L,\overline{\psi}_M} = V_L(L) - V_L(M_L) \approx -0.0886 \quad (32)$$

and non-transparency averse low risks' experience an utility gain of

$$\Delta V_{L,0} = V_{L,0}(T) - V_L(M) \approx 0.0794. \quad (33)$$

The overall change in expected utility is given by

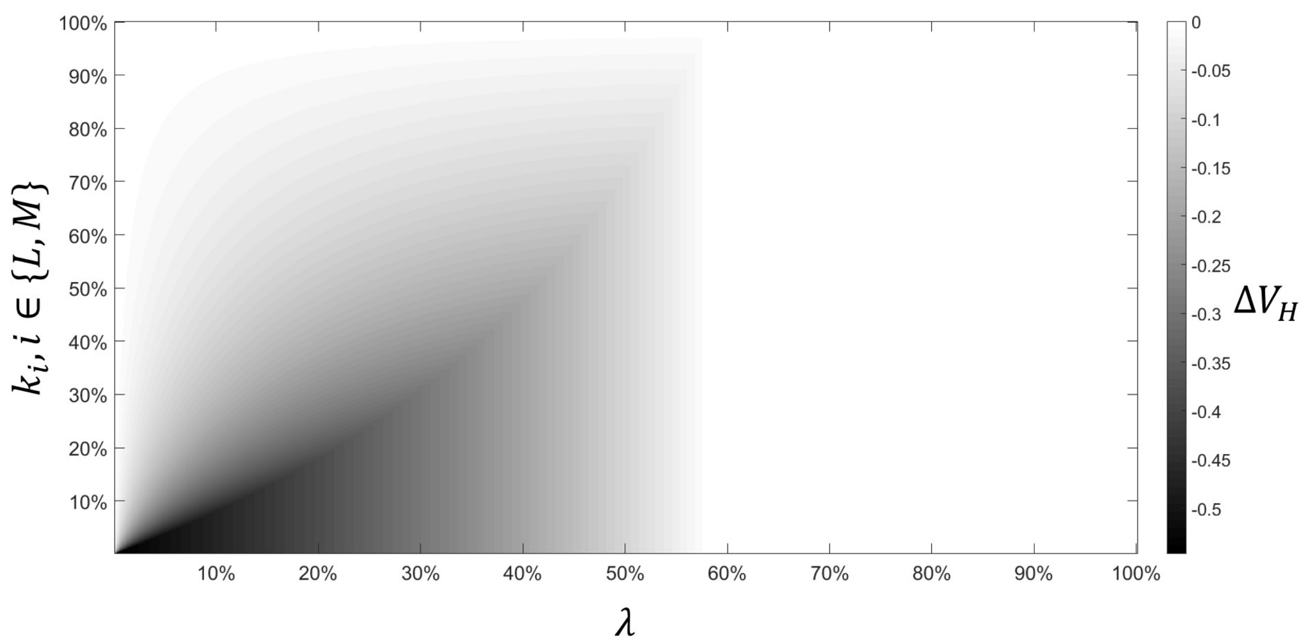
$$\begin{aligned} \Delta V &= \lambda \Delta V_H + (1-\lambda)k_M \Delta V_{L,\overline{\psi}_M} + (1-\lambda)(1-k_M)\Delta V_{L,0} \quad (34) \\ &\approx 0.0205. \end{aligned}$$

[26] This example corresponds to Figure 4.

5.2 Illustration of Changes in Consumers' Expected Utility

In the following, we illustrate how the underlying market composition affects the expected utility of different consumer types when offering a transparency contract. The heat diagrams show the fraction of high-risk individuals in the market on the x-axis and the fraction of transparency averse individuals among low risks on the y-axis. The expected utility change for the respective consumer group is displayed by different shades of gray with the respective values measured by the bar to the right of each diagram. We again choose exemplary values for the individuals' utility function, their loss probability, their initial wealth and the loss they face: $u(w) = ln(w)$, $\pi_H = 0.7$, $\pi_L = 0.4$, $w_0 = 10$, $D = 9$ as in the examples before.

Figure 5: High Risks' Change in Utility due to the Introduction of a Transparency Contract



For any values $\lambda < \lambda^{RS} \approx 0.58$, the insurance market equilibrium is described by WMS contracts if there is no transparency contract offered. Figure 5 shows that the utility change for high risks in this case heavily depends on how the market composition changes with the introduction of such a contract. If the fraction of transparency averse low risks is sufficiently high for the new market equilibrium to still be described by WMS contracts (as shown in the white and light gray shaded area on the left of the diagram), the loss in utility for high risks is lower than if a separating equilibrium establishes with the introduction of the transparency contract (as shown in the darker gray and black shaded area). High risks face the highest loss of utility, when their share in the market is very low but the introduction of the transparency contract still leads to a RS separating equilibrium due to a very low fraction of transparency averse low risks. This is due to the fact that with very few high risks in the market, low risks are willing to subsidize high risks to a large extent in order to gain a high level of coverage. Therefore, the premium for high risks in this case is very low and the reference level of utility in the absence of a transparency contract is high.

Figure 6: Transparency Averse Low Risks' Change in Expected Utility due to the Introduction of a Transparency Contract

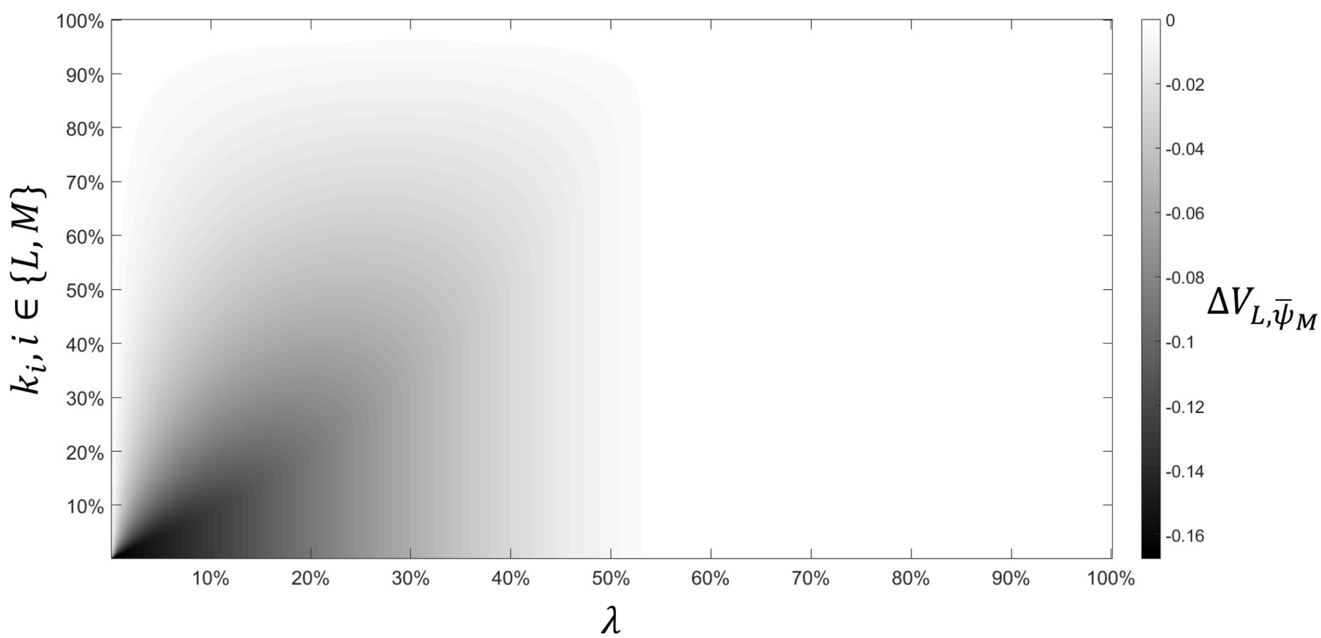
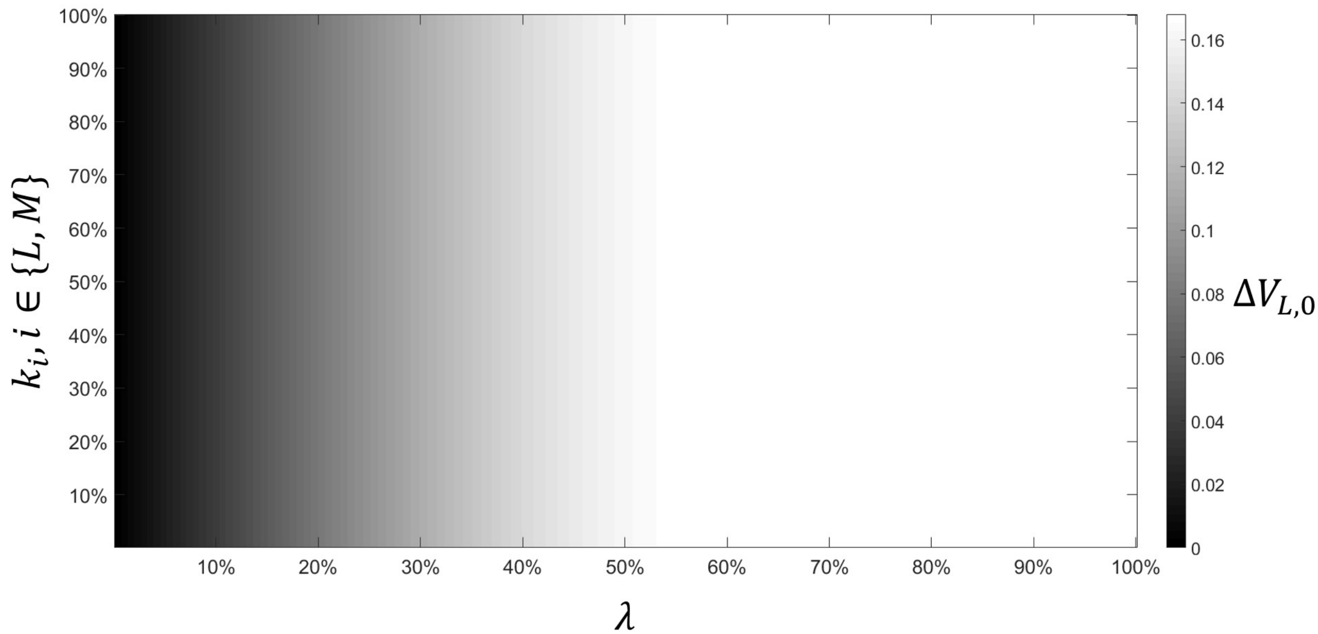


Figure 6 shows the change in transparency averse low risks' expected utility due to the introduction of a transparency contract. Given that the market equilibrium is described by cross-subsidizing WMS contracts in the absence of the transparency policy, the change in transparency averse low risks' expected utility follows roughly the same pattern than the change in high risks' utility. However, in comparison with the high risks' change in utility, the expected utility loss that transparency averse low risks face, if the introduction of the transparency contract leads to a RS separating equilibrium, is lower relative to the expected utility loss they face if a WMS equilibrium is established. Although nothing changes in their probability of loss, low-risk individuals who value their privacy sufficiently high to not be willing to share private information, face a loss of expected utility by the introduction of the transparency contract to the market. This loss is highest when both, the initial fraction of high risks in the market, as well as the fraction of transparency averse low risks, are relatively low. This case corresponds to a change from a WMS equilibrium with a low level of cross-subsidization to a RS separating equilibrium and is illustrated by the black area in the left corner at the bottom of the heat diagram. Since the availability of a transparency contract in this case implies a change from the situation in which many low risks have to subsidize only a few high risks to the situation in which a few low risks have to subsidize many high risks, transparency averse low risks now choose to forgo coverage instead of paying expensive cross-subsidies.

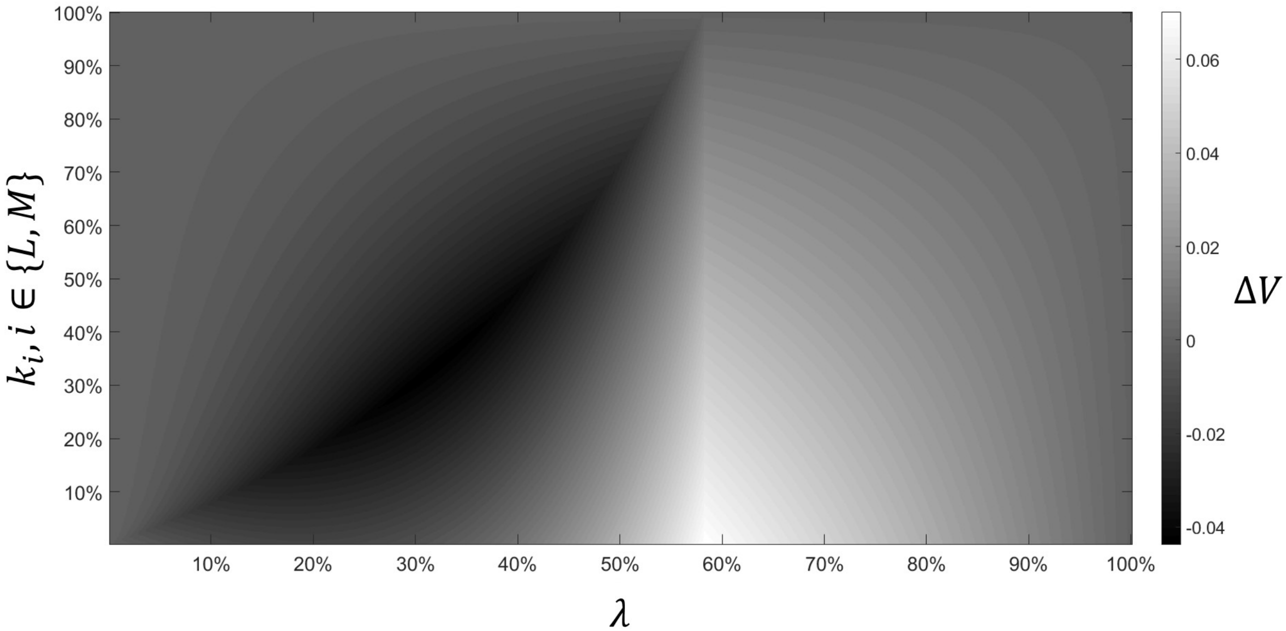
The rectangle on the right side of each, Figure 5 and Figure 6, shows that neither high-risk individuals nor transparency averse low-risk individuals face any change in expected utility if the market composition leads to a RS separating equilibrium in the absence of a transparency contract, i.e. for $\lambda \geq \lambda^{RS} \approx 0.58$.

Figure 7: Non-Transparency Averse Low Risks' Change in Utility due to the Introduction of a Transparency Contract



The obvious winners from the availability of the transparency contract are those consumers who have a low probability of loss and do not face any disutility from revealing their private information. Their expected utility gain increases with the fraction of high risks in the market, as the reference level of expected utility in case of the non-existence of the transparency contract decreases with the fraction of high-risk individuals. Their utility gain is highest when the market equilibrium is described by two self-selecting RS separating contracts in the absence of the transparency policy. The transparency contract enables them to get full insurance coverage whereas the RS contract for low risks features a high deductible.

Figure 8: Change in Utilitarian Social Welfare



The impact the availability of a transparency contract has on utilitarian social welfare is ambiguous and depends on the composition of individuals in the market, with respect to their risk type and transparency aversion. Figure 8 illustrates the Pareto improvement of utilitarian social welfare resulting from the persistence of a RS separating equilibrium with the white and light gray shaded area on the right of the heat diagram. The highest welfare gain resulting from the introduction of a transparency contract is reached when there are just enough high-risk individuals in the market for a RS separating equilibrium to exist in the absence of the transparency contract, and few low-risk individuals exhibit a transparency aversion, i.e. the number of individuals who benefit from the introduction of a transparency contract is very high. This case is represented by the white area. If a WMS equilibrium exists in the absence of a transparency contract, the aggregate expected utility loss of high risks and of transparency averse low-risk individuals can outweigh the aggregate utility gain of non-transparency averse low risks. The welfare loss is highest where the introduction of the transparency contract causes a change from a WMS equilibrium to a RS separating equilibrium, as it is illustrated by the black area in the heat diagram.

6 Conclusion and Outlook

Among the risks that digitalization poses on the insurance industry, there are also a lot of chances that stem from this development. Telemonitoring devices, such as wearables in health insurance or telematics systems in motor insurance, can serve to screen consumers' characteristics. Therefore, they can be used to price the insurance policyholders' risk more accurately and mitigate inefficient information asymmetries that lead to adverse selection in insurance markets. However, some individuals value their privacy and don't feel comfortable sharing information with insurers. They exhibit a disutility from being transparent consumers. The degree of this transparency aversion might differ among consumers but does not necessarily depend on whether consumers are "low risks" or "high risks". The disutility a consumer might face when revealing private information might outweigh the utility increase from a potential premium reduction or higher coverage.

In our analysis, we consider an insurance market with asymmetric information consisting of risk neutral, nonmyopic insurers that operate in a competitive market environment and risk averse consumers who differ in their risk type and transparency aversion. We build on the framework developed by Wilson (1977), Miyazaki (1977) and Spence (1978) that yields the second best efficient separating, cross-subsidizing, jointly zero-profit making Wilson-Miyazaki-Spence (WMS) contracts and introduce the possibility for consumers to reveal their risk type for a certain subjective cost in exchange for a premium adjustment. We show analytically how this possibility affects the standard results regarding insurance market equilibria in the WMS framework and the respective effects on consumers' individual expected utility and social welfare, given that a certain fraction of consumers exhibits transparency aversion.

The WMS insurance market equilibrium outcomes depend on the fraction of high-risk individuals. If this fraction exceeds a critical value, a cross-subsidizing contract does not attract low-risk consumers and therefore the market equilibrium is described by two self-selecting separating contracts. Since the transparency contract only attracts low-risk individuals, the fraction of high-risk individuals in the pool of unidentified consumers can only increase due to the availability of such a policy. As a result, the availability of a transparency contract does not break up an existing RS separating equilibrium. Our analysis shows that the choice of information disclosure with respect to revelation of their risk type can substitute deductibles for consumers whose transparency aversion is sufficiently low. We show that the availability of a transparency contract can lead to a Pareto improvement of social welfare and a Pareto efficient market allocation if the fraction of high risks in the market without a transparency contract is sufficiently high for the market equilibrium to be described by self-selection contracts in the Rothschild-Stiglitz sense. However, if a cross-subsidizing WMS equilibrium exists in the absence of a transparency contract, the introduction of such a policy decreases or even eliminates cross-subsidies. The equilibrium resulting therefrom depends on the fraction of transparency averse low risks. The price for an insurance policy that does not require policyholders to reveal private information then depends on the number of consumers choosing a transparency contract. Given the prior existence of a cross-subsidizing WMS equilibrium, the availability of a transparency contract results in a lower deductible for transparency averse low risks and high risks pay a higher premium for full coverage. Utility is shifted from individuals who do not reveal their private information to those who choose to reveal. In this case, the impact a transparency contract has on the insurance market's performance as well as on social welfare is ambiguous and depends on the composition of individuals in the market, with respect to their risk type and transparency aversion. The welfare loss is highest where the introduction of the transparency contract causes a change in the nature of the equilibrium, from a WMS equilibrium to a RS separating equilibrium. If at least one consumer exhibits a transparency aversion that is sufficiently high to prevent him from choosing the transparency contract, the existence of such a contract decreases the probability of cross-subsidization.

Our analysis provides a theoretical foundation for the discussion on consumer protection in the context of digitalization. It shows that new technologies bring new ways to challenge cross-subsidization in insurance markets and stresses the negative externalities that digitalization has on consumers who are not willing to take part in this development.

An interesting modification of our model could analyze in how far our results may alter when telemonitoring is costly, whereas the costs could either be borne by the policyholders using it, or the costs could be distributed among all policyholders as a premium loading.

Further research could abstract from the discrete standard models in the area of asymmetric information and look at the effects a continuous level of transparency, as well as a continuous distribution of transparency aversion have on the insurance market. Alternative frameworks might also help to understand how the effects alter in different regulatory environments: One can for instance think of a case where transparency becomes a conditional requirement for the insurance contract to come into effect, for instance if automobile producers pre-install monitoring devices in all vehicles. When full transparency is enforced, information is symmetric and the insurer can price individuals according to their respective accident probabilities. This setting raises the question whether high-risk individuals are still insurable when they have to reveal their risk type. Further, in this case, there can be two possible scenarios: (1) If it is possible to not purchase insurance at all, e.g. by not buying a car, individuals with high transparency aversion will choose to do so, and the market composition of risks depends on the correlation between the accident probability and transparency aversion. (2) If the individual has to be insured, the enforced transparency leads to a substantial welfare loss resulting from the disutility policyholders obtain by sharing private information. In order to draw implications for the insurance industry, empirical research is needed on how transparency aversion is distributed in the population.

References

Acquisti, A., Taylor, C. R., and Wagman, L. (2016). The economics of privacy. *Journal of Economic Literature*, 52(2):442–492.

Browne, M. J. and Kamiya, S. (2012). A theory of the demand for underwriting. *Journal of Risk and Insurance*, 79(2):335–349.

Crocker, K. J. and Snow, A. (1985). The efficiency of competitive equilibria in insurance markets with asymmetric information. *Journal of Public Eimconomics*, 26(2):207–219.

Crocker, K. J. and Snow, A. (1986). The efficiency effects of categorical discrimination in the insurance industry. *Journal of Political Economy*, 94(2):321–44.

Crocker, K. J. and Snow, A. (2008). Background risk and the performance of insurance markets under adverse selection. *The Geneva Risk and Insurance Review*, 33(2):137–160.

Crocker, K. J. and Snow, A. (2011). Multidimensional screening in insurance markets with adverse selection. *Journal of Risk and Insurance*, 78(2):287–307.

Dionne, G. and Rothschild, C. (2014). Economic effects of risk classification bans. *The Geneva Risk and Insurance Review*, 39(2):184–221.

Doherty, N. A. and Posey, L. L. (1998). On the value of a checkup: adverse selection, moral hazard and the value of information. *Journal of Risk and Insurance*, pages 189–211.

Doherty, N. A. and Thistle, P. D. (1996). Adverse selection with endogenous information in insurance markets. *Journal of Public Economics*, 63(1):83–102.

Eisenführ, F., Langer, T., Weber, M., Langer, T., and Weber, M. (2010). *Rational decision making*. Springer.

Filipova, L., Welzel, P., et al. (2005). Reducing asymmetric information in insurance markets: Cars with black boxes. *Discussion Paper Series Nr. 270, University of Augsburg.*

Filipova-Neumann, L. and Welzel, P. (2010). Reducing asymmetric information in insurance markets: Cars with black boxes. *Telematics and Informatics*, 27(4):394–403.

Fudenberg, D. and Tirole, J. (1990). Moral hazard and renegotiation in agency contracts. *Econometrica: Journal of the Econometric Society*, pages 1279–1319.

Hollis, A. and Strauss, J. (2007). Privacy, driving data and automobile insurance: An economic analysis. *MPRA Paper*.

Hoy, M. (1982). Categorizing risks in the insurance industry. *The Quarterly Journal of Economics*, pages 321–336.

Hoy, M. (2006). Risk classification and social welfare. *The Geneva Papers on Risk and Insurance. Issues and Practice*, 31(2):245–269.

Hoy, M. and Polborn, M. (2000). The value of genetic information in the life insurance market. *Journal of Public Economics*, 78(3):235–252.

Huang, R. J., Liu, Y.-J., and Tzeng, L. Y. (2010). Hidden overconfidence and advantageous selection. *The Geneva Risk and Insurance Review*, 35(2):93–107.

Huang, R. J., Muermann, A., and Tzeng, L. Y. (2016). Hidden regret in insurance markets. *Journal of Risk and Insurance*, 83(1):181–216.

Keeney, R. L. and Raiffa, H. (1993). *Decisions with multiple objectives: preferences and value trade-offs*. Cambridge University Press.

Koufopoulos, K. and Kozhan, R. (2016). Optimal insurance under adverse selection and ambiguity aversion. *Economic Theory*, 62(4):659–687.

Kremslehner, D. and Muermann, A. (2016). Asymmetric information in automobile insurance: evidence from driving behavior.

Mimra, W. and Wambach, A. (2014). New developments in the theory of adverse selection in competitive insurance. *Geneva Risk and Insurance Review*, 39(2):136.

Miyazaki, H. (1977). The rat race and internal labor markets. *The Bell Journal of Economics*, pages 394–418.

Netzer, N. and Scheuer, F. (2010). Competitive markets without commitment. *Journal of political economy*, 118(6):1079–1109.

Rothschild, M. and Stiglitz, J. (1976). Equilibrium in competitive insurance markets: An essay on the economics of imperfect information. *The Quarterly Journal of Economics*, 90(4):629–649.

Sonnenholzner, M. and Wambach, A. (2009). On the role of patience in an insurance market with asymmetric information. *Journal of Risk and Insurance*, 76(2):323–341.

Spence, M. (1978). Product differentiation and performance in insurance markets. *Journal of Public Economics*, 10(3):427–447.

Wilson, C. (1977). A model of insurance markets with incomplete information. *Journal of Economic theory*, 16(2):167–207.

Zeh, J. (2012). *The Method*. Random House.

A Appendix

A.1 Proofs Equilibrium Analysis

A.1.1 Proof of Lemma 1:

(i) : If $\lambda \geq \lambda^{RS}$:

For high-risk individuals in order to prefer the transparency contract over a RS-separating contract H, it has to hold:

$$\begin{aligned} V_{H,\psi_j}(T_H) &> V_H(H) \\ u(w_0 - \pi_H D) - \psi_j &> u(w_0 - \pi_H D) \\ \psi_j &< 0 \end{aligned} \tag{35}$$

This is violated by assumption.

(ii) : If $\lambda < \lambda^{RS}$:

For high-risk individuals in order to prefer the transparency contract over a WMS contract M_H, it has to hold:

$$\begin{aligned} V_{H,\psi_j}(T_H) &> V_H(M_H) \\ u(w_0 - \pi_H D) - \psi_j &> u(w_0 - p_H^M) \end{aligned} \tag{36}$$

This inequality can never hold due to the assumption $\psi_j > 0$ and the relationship $\pi_H D > p_H^M$ that follows from Constraint (5). □

A.1.2 Proof of Lemma 2:

Given Definition 2, the fraction of individuals with $\psi_j = 0$, that reveal their information by choosing the telemonitoring contract and hence leave the pool of risks the insurer cannot identify is given by $(1-\lambda)(1-k_\tau)$. Therefore, the fraction of consumers who do not wish to reveal their informa-

tion and therefore build a new pool of risks unknown to the insurer is described by $(1-\lambda)k_\tau+\lambda$. □

A.2 Proofs Welfare Analysis

A.2.1 Proof of Proposition 4:

Low risks' expected utility of a separating contract without transparency:

$$\begin{aligned} V_L(L) &= (1-\pi_L)\cdot u(w_0-p_L)+\pi_L\cdot u(w_0-p_L+q_L-D) \\ &= (1-\pi_L)\cdot u(w_0-\pi_L q_L)+\pi_L\cdot u(w_0-\pi_L q_L+q_L-D) \end{aligned} \tag{37}$$

High risks' utility of a separating contract without transparency:

$$\begin{aligned} V_H(H) &= u(w_0-p_H) \\ &= u(w_0-\pi_H D) \end{aligned} \tag{38}$$

Low risks' expected utility of a transparency contract:

$$V_{L,0}(T_L)=u(w_0-\pi_L D) \tag{39}$$

Utility changes resulting from introduction of the transparency contract:

Change in utility for high risk individuals:

$$\Delta V_H = V_H(H)-V_H(H)=0 \tag{40}$$

Change in expected utility for transparency averse low risk individuals:

$$\Delta V_{L,\bar{\psi}_L} = V_L(L)-V_L(L)=0 \tag{41}$$

Change in expected utility for non-transparency averse low risk individuals:

$$\begin{aligned}\Delta V_{L,0} &= V_{L,0}(T_L) - V_L(L) \\ &= u(w_0 - \pi_L D) - [(1-\pi_L)u(w_0 - \pi_L q_L) + \pi_L u(w_0 - \pi_L q_L + q_L - D)] \\ &> 0\end{aligned} \tag{42}$$

Overall consumers' expected utility without a transparency contract in a separating equilibrium:

$$V(H,L) = \lambda V_H(H) + (1-\lambda)V_L(L) \tag{43}$$

Overall consumers' expected utility with a transparency contract in a separating equilibrium:

$$V(H,L,T_L) = \lambda V_H(H) + (1-\lambda)k_L V_L(L) + (1-\lambda)(1-k_L)V_{L,0}(T_L) \tag{44}$$

$$\begin{aligned}\Delta V &= V(H,L,T_L) - V(H,L) \\ &= \lambda \Delta V_H + (1-\lambda)k_L \Delta V_{L,\bar{\psi}_L} + (1-\lambda)(1-k_L)\Delta V_{L,0} \\ &= (1-\lambda)(1-k_L)\cdot[u(w_0 - \pi_L D) - [(1-\pi_L)u(w_0 - \pi_L q_L) + \pi_L u(w_0 - \pi_L q_L + q_L - D)]] \\ &> 0\end{aligned} \tag{45}$$

□

A.2.2 Proof of Proposition 5:

To show:

$$(i) \qquad \Delta V_H = V_H(M'_H) - V_H(M_H) < 0, \tag{46}$$

$$(ii) \qquad \Delta V_{L,\overline{\psi}_M} = V_L(M'_L) - V_L(M_L) < 0 \tag{47}$$

$$(iii) \qquad \Delta V_{L,0} = V_{L,0}(T_L) - V_L(M_L) > 0 \tag{48}$$

$$(iv) \qquad V(M_L', M_H', T_L) - V(M_L, M_H) \quad > \quad 0 \tag{49}$$

$$\Leftrightarrow \lambda\left[V_H(M_H) - V_H(M_H')\right] + (1-\lambda)k_M\left[V_L(M_L) - V_L(M_L')\right] \quad < \quad (1-\lambda)(1-k_M)\left[V_{L,0}(T_L) - V_L(M_L)\right]$$

(i):

$$\begin{aligned} V_H(M_H') - V_H(M_H) &< 0 \\ \Leftrightarrow u(w_0 - p_H^{M'}) - u(w_0 - p_H^M) &< 0 \\ \Leftrightarrow u(w_0 - p_H^{M'}) &< u(w_0 - p_H^M) \end{aligned} \tag{50}$$

Since the utility function is increasing in wealth, this holds due to $p_H^{M'} > p_H^M$.

(ii): For any given level of coverage, transparency-averse low risks have to pay a higher premium for a cross-subsidizing contract if the fraction of high risks in the market is higher. Hence, the maximum expected utility a low-risk individual can get from a cross-subsidizing contract based on a higher fraction of high risks is lower. WMS contracts are determined by maximizing low risks' expected utility within the set of feasible cross-subsidizing contracts that satisfy conditions (3), (4), and (5). Since the contract M' is determined to maximize low risks' expected utility based on a higher fraction of high risks than the contract M (see Lemma 1), it is

$$V_L(M_L') - V_L(M_L) < 0. \tag{51}$$

(iii): Since low-risk individuals chose the transparency contract if and only if their transparency aversion is sufficiently low for the participation constraint (13) to hold, (iii) holds by construction.

(iv):

$$
\begin{aligned}
V(M_L', M_H', T_L) - V(M_L, M_H) &> 0 \qquad (52)\\
\Leftrightarrow \lambda \Delta V_H + (1-\lambda) k_M \Delta V_{L,\overline{\psi}_M} + (1-\lambda)(1-k_M)\Delta V_{L,0} &> 0\\
\Leftrightarrow \lambda \left[V_H(M_H') - V_H(M_H)\right] + (1-\lambda)k_M \left[V_L(M_L') - V_L(M_L)\right] &> -(1-\lambda)(1-k_M)\left[V_{L,0}(T_L) - V_L(M_L)\right]\\
\Leftrightarrow \lambda \left[V_H(M_H) - V_H(M_H')\right] + (1-\lambda)k_M \left[V_L(M_L) - V_L(M_L')\right] &< (1-\lambda)(1-k_M)\left[V_{L,0}(T_L) - V_L(M_L)\right]
\end{aligned}
$$

□

A.2.3 Proof of Proposition 6:

To show:

$$(i) \qquad \Delta V_H = V_H(H) - V_H(M_H) < 0, \qquad (53)$$

$$(ii) \qquad \Delta V_{L,\overline{\psi}_M} = V_L(L) - V_L(M_L) < 0, \qquad (54)$$

$$(iii) \qquad \Delta V_{L,0} = V_{L,0}(T_L) - V_L(M_L) > 0, \qquad (55)$$

$$
\begin{aligned}
(iv) \qquad V(H, L, T_L) - V(M_H, M_L) &> 0 \qquad (56)\\
\Leftrightarrow \lambda \left[V_H(M_H) - V_H(H)\right] + (1-\lambda)k_M \left[V_L(M_L) - V_L(L)\right] &< (1-\lambda)(1-k_M)\left[V_{L,0}(T_L) - V_L(M_L)\right]
\end{aligned}
$$

(i):

$$\begin{aligned} V_H(H) - V_H(M_H) < 0 \\ \Leftrightarrow u(w_0 - \pi_H D) - u(w_0 - p_H^M) &< 0 \\ \Leftrightarrow u(w_0 - \pi_H D) &< u(w_0 - p_H^M) \end{aligned} \tag{57}$$

Since the utility function is increasing in wealth, this holds due to $\pi_H D > p_H^M$.

(ii): If Constraint (5) is binding, the WMS contracts correspond to the RS contracts. Therefore, the low risk RS contract L lays within the set of feasible cross-subsidizing contracts that low-risk individuals maximize their expected utility over. Hence, low risks expected utility $V_{L,\overline{\psi}_M}$ stemming from a contract L can never exceed their expected utility $V_L(M_L)$ from a WMS contract M_L and it is $V_{L,\overline{\psi}_M} = V_L(M_L) \Leftrightarrow L = M_L$, i.e. if and only if low-risk individuals' expected utility of the two contracts is the same, the contracts are identical.

(iii): Since low-risk individuals chose the transparency contract if and only if their transparency aversion is sufficiently low for the participation constraint (13) to hold, (iii) holds by construction.

(iv):

$$\begin{aligned} V(H, L, T_L) - V(M_H, M_L) &> 0 \\ \Leftrightarrow V(H, L, T_L) - V(M_H, M_L) &> 0 \\ \lambda\lambda\Delta V_H + (1-\lambda)k_M \Delta V_{L,\overline{\psi}_M} + (1-\lambda)(1-k_M)\Delta V_{L,0} &> 0 \\ \Leftrightarrow \lambda\left[V_H(H) - V_H(M_H)\right] + (1-\lambda)k_M\left[V_L(L) - V_L(M_L)\right] &> -(1-\lambda)(1-k_M)\left[V_{L,0}(T_L) - V_L(M_L)\right] \\ \Leftrightarrow \lambda\left[V_H(M_H) - V_H(H)\right] + (1-\lambda)k_M\left[V_L(M_L) - V_L(L)\right] &< (1-\lambda)(1-k_M)\left[V_{L,0}(T_L) - V_L(M_L)\right] \end{aligned} \tag{58}$$

□

A.3 Exemplary Calculations Welfare Analysis

A.3.1 Example 1

For the calculation of low-risk individuals' expected utility from a separating contract L, we need to derive the optimal coverage for a contract that does not attract high risks. The optimal coverage can be determined by the following maximization problem:

$$\max_{q_L} \quad (1-\pi_L)\cdot u(w_0-p_L)+\pi_L\cdot u(w_0-p_L+q_L-D) \tag{59}$$

$$\begin{aligned}
\text{s.t.} \qquad & (1-\pi_H)\cdot u(w_0-p_L)\le u(w_0-p_H)+\pi_H\cdot u(w_0-p_L+qL-D)\\
& p_H=\pi_H D\\
& p_L=\pi_L q_L\\
& q_L\le D\le w_0\\
& 0<\pi_L<\pi_H<1\\
& 0<\lambda<1
\end{aligned}$$

We use an alternative approach oriented at the graphical illustration: From Rothschild and Stiglitz (1976), we know that the fair odd lines are of the following form

$$Ei=-\frac{1-\pi_i}{\pi_i}w_1+n \tag{60}$$

with $i\in\{H,L\}$.

The position of the fair odd lines are derived as follows

$$\begin{aligned} w_0 - D &= -\frac{1-\pi_i}{\pi_i} w_0 + n \\ n &= \frac{1-\pi_i}{\pi_i} w_0 + w_0 - D \\ n &= (\frac{1-\pi_i}{\pi_i} + \frac{\pi_i}{\pi_i}) w_0 - D \\ n &= \frac{1}{\pi_i} w_0 - D \end{aligned} \tag{61}$$

Therefore, the low risks' fair odd line is given by:

$$EL = -\frac{1-\pi_L}{\pi_L} w_1 + \frac{1}{\pi_L} w_0 - D \tag{62}$$

Analogously, the high risks' fair odd line is given by:

$$EH = -\frac{1-\pi_H}{\pi_H} w_1 + \frac{1}{\pi_H} w_0 - D \tag{63}$$

In order to derive the high risks' indifferent curve, we first solve their expected utility by the wealth state in case of an accident w_2.

$$\begin{aligned} V_H &= (1-\pi_H)u(w_1) + \pi_H u(w_2) \\ u(w_2) &= \frac{V_H - (1-\pi_H)u(w_1)}{\pi_H} \\ w_2(w_1) &= u^{-1}\left(\frac{V_H - (1-\pi_H)u(w_1)}{\pi_H}\right) \end{aligned} \tag{64}$$

The level of high risks' utility at full insurance for a fair premium is given at:

$$V_H(D) = u(w_0 - \pi_H D) \tag{65}$$

In order to derive the indifference curve for high risks at the expected level of the full insurance contract, we plug this expected utility level into $w_2(w_1)$:

$$w_2(w_1, V_H(D)) = u^{-1}\left(\frac{u(w_0 - \pi_H D) - (1-\pi_H)u(w_1)}{\pi_H}\right)$$

Since the optimal contract for low risks has to make high risks indifferent to their fair contract with full insurance while still letting the insurer break even, the optimal q_L is found at the intersection of the high risks' indifference curve $w_2(w_1, V_H(D))$ and the low risks' fair odd line EL.[27] Therefore, the optimal contract for low risks is implicitly defined by the following condition:

$$\begin{aligned} w_2(w_1, V_H(D)) &= EL \\ u^{-1}\left(\frac{u(w_0 - \pi_H D) - (1-\pi_H)u(w_1)}{\pi_H}\right) &= -\frac{1-\pi_L}{\pi_L}w_1 + \frac{1}{\pi_L}w_0 - D \end{aligned} \tag{66}$$

For $u(\cdot) = ln(\cdot)$, we get

$$w_2(w_1, V_H(D)) = exp\left(\frac{ln(w_0 - \pi_H D) - (1-\pi_H)ln(w_1)}{\pi_H}\right) \tag{67}$$

and therefore the optimal level of wealth in the no accident state for the low risk contract in a separating equilibrium is implicitly given by

$$\begin{aligned} w_2(w_1, V_H(D)) &= EL \\ exp\left(\frac{ln(w_0 - \pi_H D) - (1-\pi_H)ln(w_1))}{\pi_H}\right) &= -\frac{1-\pi_L}{\pi_L}w_1 + \frac{1}{\pi_L}w_0 - D \end{aligned} \tag{68}$$

With $\pi_H = 0.7$, $\pi_L = 0.4$, $w_0 = 10$, and $D = 9$, we get $w_1 \approx 8.9798$ and therefore $q_L = 2.5505$.

[27] Compare Rothschild and Stiglitz (1976).