E C O N O M I C S   B U L L E T I N

Insurance, Pooling, and Resistance to Reform: The Case of Individual Uncertainty

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Abstract

This paper shows that individual risk-type uncertainty can prevent reforms of the insurance system that would benefit the majority of individuals. We consider the case where a subset of the population is uncertain of their risk type and contrast two insurance regimes; the status quo of mandated pooling of all risk types and the reform proposal being insurance with risk-type separation over time, using Bayesian updating. Most individuals would benefit from the reform since their risk type is better than the average but the reform does not occur due to individual uncertainty.

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1. Introduction

It is common to observe some pooling of risk types in insurance whenever there is some state involvement and most OECD countries rely heavily on the public sector to provide insurance (Hindriks and De Donder 2003). Oftentimes, it is puzzling to observe that political demand does not effect a system change since a majority of the insured subsidizes a minority thereof.

This analysis shows that individual uncertainty can prevent a reform of the insurance system which would result in the majority of the insured being better off. We consider three risk types of which only one is certain of its type. The intermediate risk type cannot distinguish its own position from that of the worst risk type and vice versa. We reveal that this intermingling is a stand-alone argument against the reform taking place. In the reform setting, (i) insurance contracts start with a premium equal to the average loss probability, (ii) contract renewals are undertaken after each period and mirror the individual's loss history up to that point in time in a rational manner, and (iii) the individual's loss history is public knowledge.

This contribution is motivated by reality. An exemplary setting, whose facts may be better understood by the analysis put forth, can be sketched as follows: Consider the regulation of sick leave payment in Germany. In conceptualizing sick leave payment as insurance by the employer, individualized policies ought to appear in wages reflecting the risk types of employees. However, employers have a limited ability to determine wages according to the risk type.[1] Thus, if all employees obtain 100 percent of their wages in the event of sick leave, it is presumably mirrored by a pooled premium which employers subtract from wages across the board. In 1996, the German government reduced the mandated level of sick leave pay from 100 to 80 percent. This would have introduced income variability which could have been overcome by private insurance contracts. These private contracts could have entailed individualized premiums, since the employee and the insurer could have taken advantage of common experience. However, labor unions in many industries prevented this from happening. Unions traded in many employee benefits at the level of the Tarifvertrag to prevent the reform from becoming effective, i.e. employers promised to maintain the sick leave pay level in exchange for being able to scrap several employee amenities. Supposing that the unions indeed represent the interests of employees, this implies that the group of employees preferred the pooled premium to the at least partially individualized premium. This is surprising since the available data suggests that the insurance that is implied by the sick leave payment regulation is advantageous for a relatively slim minority of the employed.[2] The consequence of the obliged pooling is a considerable cross subsidization.

Let us briefly elaborate on the related literature. Hindriks (2001) considers a similar question, that is, under what conditions is a uniform public insurance preferable for a majority of the insured cohort when compared to private insurance. However, the interest of our paper is markedly different. For instance, whereas in his setting, individuals might opt out of private insurance, which has an adverse impact on those who continue to demand insurance, all individuals are insured in both regimes in our setting. Also, whereas in his setting, type-specific private insurance follows from varying coverage rates and premiums, all individuals are insured with the same coverage in both regimes in our framework.[3] Moreover, our study is related to Watt and Vazquez (1997), who compare the relative desirability of insurance that makes use of Bayesian updating when compared to the one-period contracts that result in the separating equilibrium of Rothschild and Stiglitz (1976). They model two risk types and can show that there exist conditions under which all insured strictly prefer the full insurance making usage of the updating process. Finally, Fernandez and Rodrik (1991) originated the idea that individual uncertainty concerning a personal characteristic can act as an obstacle to reforms. Their application concerns the trade context, while our paper presents an application to the insurance context.

In the next section, we present the general setting. Subsequently, the respective systems are described and evaluated from the individual's stance.

2. The General Setting

Individual preferences are described by a vNM utility function U, with $U'>0$, $U''<0$. Exogenous income is W. Income available in a specific state is conditional upon the insurance coverage α, which is uniform across all individuals, and the occurrence of a monetary loss K. All individuals are insured as there is an obligation to enter into a contract. Individuals suffer at most one loss per period. The risk type i is identified by the loss probability p_i, $i=a,b,c$, with $p_a > p_b > p_c$. We assume that individuals of type c are certain of their type, whereas individuals of type a and b can only tell that they are not type c. Individuals have influence on neither the loss probability nor the extent of the loss. The share of group i is λ_i. The cohort is mainly composed of risk types b and c, $\lambda_b + \lambda_c > \frac{1}{2} > \lambda_c$. The insurer initially only knows the respective shares and loss probabilities of the risk types. The occurrence of losses is observed by both insurers and insured. This enables the insurer to update type probabilities over time. Since losses are publicly observable, there are no informational differences among insurers or between the insurer and the insured with regards to the loss experience.[4]

Insurance policies are actuarially fair in both systems. In the status quo, the government mandates that the premium must be the same across all individuals, whereas the reform enables insurers to incorporate all the relevant information.[5]

3. The Status Quo and the Reform

3.1 Status Quo

The premium is given by $\alpha\, p\, K$, where p is the average loss probability.

$$p = \lambda_a p_a + \lambda_b p_b + \lambda_c p_c \qquad (1)$$

Note that the mandate of equal premiums across all individuals rules out that insurers vary coverage. The expected utility with z renewals of the same one-period contract and γ as discount factor is equal to

$$EU_c^{SQ} = \sum_{n=0}^{z} \gamma^n \big((1-p_c)U(W-\alpha pK) + p_c U(W-\alpha pK-(1-\alpha)K)\big) \qquad (2)$$

for individuals of type c and equal to

$$EU_{a,b}^{SQ} = \sum_{n=0}^{z} \gamma^n \left(\frac{\lambda_a}{\lambda_a + \lambda_b} \big((1-p_a)U(W - \alpha pK) + p_a U(W - \alpha pK - (1-\alpha)K) \big) + \frac{\lambda_b}{\lambda_a + \lambda_b} \big((1-p_b)U(W - \alpha pK) + p_b U(W - \alpha pK - (1-\alpha)K) \big) \right) \tag{3}$$

for individuals of types a and b.

We assume that $p_a > p > p_b > p_c$ holds. Consequently, the status quo features a cross-subsidization from types b and c to type a.[6] The status quo does not incentivize individuals to learn about their type so that, for positive learning costs, type-uncertain individuals choose to remain ignorant.

3.2 The Reform

Let us now detail the approximation of the risk type. Every period is an opportunity for the insurer to learn about the risk type of an insured. At the beginning of the first period, the insurance companies know the shares and the loss probabilities of risk types. After the first period, the probability of an individual to be of a specific type can be updated. Each further period allows another observation about the risk type. The information is used in the renewal of the policy at the end of each period. The Bayesian rule for the case of a loss history with *s* losses in *n* periods is

$$\lambda_i(s,n) = \frac{\lambda_i p_i^s (1-p_i)^{n-s}}{\sum_{j=a}^{c} \lambda_j p_j^s (1-p_j)^{n-s}} . \tag{4}$$

giving the probability that the individual at hand who has a loss history *(s,n)* is of risk type *i*. The probability $\lambda_i(s,n)$ converges to 1 as *n* goes to infinity when the individual is in fact of type *i* (Watt and Vazquez 1997) and determines the premium payable for the following period. In general, after *n* periods have elapsed, $s \in [0,n]$, so that these *n+1* possible states of the world need to be considered in the formation of expected utility. An insured with experience *(s, n)* will be charged *p(s,n) α K* for the next period with *p(s,n)*, being the updated loss probability, calculated as follows

$$p(s,n) = \lambda_a(s,n)p_a + \lambda_b(s,n)p_b + \lambda_c(s,n)p_c = \frac{\lambda_a p_a^{s+1}(1-p_a)^{n-s} + \lambda_b p_b^{s+1}(1-p_b)^{n-s} + \lambda_c p_c^{s+1}(1-p_c)^{n-s}}{\sum_{j=a}^{c} \lambda_j p_j^s (1-p_j)^{n-s}} . \tag{5}$$

The insurance becomes more expensive with more losses, whereas a longer duration with given losses lowers the premium.

Individuals of type c have perfect knowledge of their loss probability. Individuals consider a time horizon of *z+1* periods. Since there is a renewal of the contract after the passing of each period, *z* accords with the number of contract renewals. The number *z* is to be distinguished from the number *n,* where the latter denotes the number of periods that have passed when a renewal is undertaken. This leads to expected utility of

$$EU_c^R = \sum_{n=0}^{z} \gamma^n \sum_{s=0}^{n} \frac{n!}{s!(n-s)!} p_c^s (1-p_c)^{n-s} * \\ \left((1-p_c)U(W-\alpha\, p(s,n)K) + p_c U(W-\alpha\, p(s,n)K-(1-\alpha)K)\right) \quad (6)$$

The other risk types only know that they are not of type c and therefore form expectations over the expected utilities of risk types a and b, respectively.

$$EU_{a,b}^R = \frac{\lambda_a}{\lambda_a+\lambda_b}\left[\sum_{n=0}^{z} \gamma^n \sum_{s=0}^{n} \frac{n!}{s!(n-s)!} p_a^s (1-p_a)^{n-s} * \\ \left((1-p_a)U(W-\alpha\, p(s,n)K) + p_a U(W-\alpha\, p(s,n)K-(1-\alpha)K)\right)\right] \\ + \frac{\lambda_b}{\lambda_a+\lambda_b}\left[\sum_{n=0}^{z} \gamma^n \sum_{s=0}^{n} \frac{n!}{s!(n-s)!} p_b^s (1-p_b)^{n-s} * \\ \left((1-p_b)U(W-\alpha\, p(s,n)K) + p_b U(W-\alpha\, p(s,n)K-(1-\alpha)K)\right)\right] \quad (7)$$

There are two major differences of the reform regime to the status quo. Firstly, there is added uncertainty. After *n* periods, there are *n+1* possible states of the world with significantly diverse income levels. Secondly, there is redistribution. The passing of time allows accumulating information, which is used to fine-tune type probability $\lambda_i(s,n)$. The updated loss probability $p(s,n)$ uses $\lambda_i(s,n)$ to approximate the risk-type loss probability over time, as a consequence of which the reception or the payment of a subsidy by the individual phases out.

4. The Comparison

Individuals are in favor of the reform if it increases their expected utility. Hence, given individual uncertainty, individuals support the reform if A_c and $A_{a,b}$ is positive, where

$$A_i = EU_i^R - EU_i^{SQ} \quad (8)$$

$$A_{a,b} = EU_{a,b}^R - EU_{a,b}^{SQ} \quad (9)$$

The reform is accepted if a majority of insured is in favor.

Proposition: *There are reasonable circumstances as to, inter alia, the discount factor, risk aversion and loss probabilities, in which a majority of individuals would benefit from the reform ex post, but oppose it due to individual risk type uncertainty ex ante.*

To validate this proposition, it is necessary to relate $A_{a,b}$ to A_b. Given circumstances in which A_c is positive and A_a negative, the reform hinges on the vote of individuals of type b. If A_b is positive but $A_{a,b}$ is negative, individual uncertainty alone prevents the reform. We will first show that A_a and $A_{a,b}$ are always negative and then discuss effects on A_b and A_c.

Individuals of type a lose from the uncertainty and the redistribution implied by the reform. We briefly illustrate the second aspect. For the insurance company to make zero profits, the average expected premium has to be the same independent of the system. After the first period, this means that

$$
\begin{aligned}
& p\alpha K \\
&= \lambda_a(p_a(p(1,1)\alpha K) + (1-p_a)(p(0,1)\alpha K)) + \lambda_b(p_b(p(1,1)\alpha K + (1-p_b)(p(0,1)\alpha K)) \\
&\quad + \lambda_c(p_c(p(1,1)\alpha K) + (1-p_c)(p(0,1)\alpha K)
\end{aligned} \tag{10}
$$

Rearranging (10) leads to

$$
\begin{aligned}
& \lambda_a(p_a(p-p(1,1)) + (1-p_a)(p-p(0,1))) + \lambda_b(p_b(p-p(1,1)) + (1-p_b)(p-p(0,1))) \\
&\qquad + \lambda_c(p_c(p-p(1,1)) + (1-p_c)(p-p(0,1))) = 0
\end{aligned} \tag{11}
$$

This shows that the change in expected premiums for the different types sum up to zero. The term (11) gives with (1) the following information

$$
\frac{p-p(0,1)}{p-p(1,1)} = \frac{-p}{1-p} \tag{12}
$$

Using (12) after division of (11) by *(p-p(1,1))<0*, we obtain

$$
\lambda_a \frac{p-p_a}{1-p} + \lambda_b \frac{p-p_b}{1-p} + \lambda_c \frac{p-p_c}{1-p} = 0 \tag{13}
$$

The term $(p-p_a)/(1-p) < 0$ depicts the difference in expected premium in the status quo versus that in the reform system for type a. Individuals of type a, in addition to higher expected premium payments, have to put up with added uncertainty. Thus, A_a is always negative.

We can also use (13) to clarify that $A_{a,b}$ has to be negative. Rewrite (13) so that

$$
(\lambda_a + \lambda_b)\left(\frac{\lambda_a}{\lambda_a+\lambda_b}\frac{p-p_a}{1-p} + \frac{\lambda_b}{\lambda_a+\lambda_b}\frac{p-p_b}{1-p}\right) = -\lambda_c \frac{p-p_c}{1-p} \tag{14}
$$

shows that, given individual uncertainty, the expected premium of types a and b is higher in the reform regime. Since type c individuals gain from lower expected premiums, the right-hand side of (14) is negative, the hypothetical type a, b pays higher expected premiums. Again, the uncertainty provides a further reason for $A_{a,b}$ being negative.

It can be shown that individuals of type c will obtain a larger expected utility in the reform regime than in the status quo if the number of renewals *z* and the discount factor is sufficiently high (proof available upon request).

In sum, it is certain for individuals of type a to lose in the reform regime, whereas the benefit of type c individuals is secured within specific parameter ranges. Individuals who do not know their type but mix expected utilities of type a and b individuals will oppose the reform since $A_{a,b}$ is negative. What we do not yet know is whether risk type b would be in favour of the reform if they knew their type, i.e., the sign of A_b. The reasoning for this group is more difficult. Individuals of type b can be overrated as well as underestimated in relation to their true loss probability. To test our proposition and present tangible factors of influence on such an outcome, we present a small simulation.

***Decreasing Absolute Risk Aversion and Constant Relative Risk Aversion*[7]**

Suppose $U(x) = x^y$, $y \in (0,1)$, and p_a=.8, p_b=.4, p_c=.1, λ_a=.4= λ_c, and λ_b=.2, so that p=.44.[8] We consider $z \leq$ 30. For instance, to refer back to the case of sick leave pay, it is reasonable to assume that the average employee has at least 30 work periods, available for approximating the type.

Case	*W*	*K*	α	γ	Result concerning the proposition for	
					y=.5	y=.1
(1a)	5	1	1	.9	A_b >0 for z=1+	A_b >0 for z=1+
(1b)	5	1	.5	.9	A_b >0 for z=1+	A_b >0 for z=1+
(1c)	5	1	.5	.85	A_b >0 for z=1+	A_b >0 for z=1+
(1d)	Increases by .1 starting at 5	Increases by .1 starting at 1	.5	.9	A_b >0 for z=1+	A_b >0 for z=1+

Table 1. DARA/CRRA

Since A_b is always positive, the proposition finds support in the cases given in Table 1. If we were to reduce the gap between p_b and p, this would make the reform proposal less appealing. However, with a sufficient planning horizon, i.e. z being large, the reform proposal still gains support from individuals whom are known to be of type b.

Constant Absolute Risk Aversion and Increasing Relative Risk Aversion

Suppose $U(x) = 1 - e^{-\rho x}$ and p_a=.8, p_b=.4, p_c=.1, λ_a=.4, λ_b=.2, and λ_c=.4, so that p=.44.

Case	*W*	*K*	α	γ	Result concerning the proposition for	
					ρ=1.5	ρ=2
(2a)	5	1	1	.9	A_b >0 for z=13+	A_b >0 for z=27+
(2b)	5	1	.5	.9	A_b >0 for z=1+	A_b >0 for z=6+
(2c)	5	1	.5	.85	A_b >0 for z=1+	A_b >0 for z=6+
(2d)	Increases by .1 starting at 5	Increases by .1 starting at 1	.5	.9	A_b >0 for z=5+	A_b >0 for z=13+

Table 2. CARA/IRRA

The increase in the risk aversion shows a marked negative effect on the attractiveness of the reform since the uncertainty obtains more importance in the trade-off between redistribution benefits against added uncertainty in the reform regime.

5. Conclusion

We considered the prospects of a reform proposal that makes the majority of insured better off ex post. The framework used is one of an insured cohort made up of three different risk types who were given the freedom to switch from the status quo to a reform regime. The status quo is insurance with mandated pooling of risk types, whereas insurance with risk separation, via a learning process, is the prospect. It is proven that individual uncertainty is a stand-alone factor, which can prevent the implementation of the reform.

This analysis was undertaken in light of empirical evidence indicating that the situation depicted reflects reality in that there is pooling in many areas of public intervention and there is learning of the risk type based on loss experience in private insurance markets. This study pointed to the importance of individual type uncertainty when individuals compare the merits of alternative regimes. A next step on the research agenda might be to identify possibilities to ameliorate the effects of individual uncertainty. One avenue seems to be the accumulation of individual loss information prior to any vote, allowing individuals to better deduce individual consequences of the system change. Such mechanisms will be of importance specifically if the reforms prevented by individual type uncertainty have a bearing on efficiency.

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Notes

[1] For instance, many employers in Germany face a minimum level of pay mandated by the respective Tarifvertrag, which practically inhibits the allowance of premium deductions from the wage in the case of high risk employees.

[2] See for reference on statistics of sick employees, e.g. Betriebskrankenkassen (2003).

[3] The fundamental information asymmetry concerning the loss probabilities underlying pooling in insurance markets can be tackled, for instance, by offering a menu of contracts with differing indemnity levels designed to induce the insured to reveal her true risk type by choice (Rothschild and Stiglitz 1976). Alternatively, one may utilize self-selection by means of

long-term commitment. For example, Dionne and Lasserre (1985) show how, with full commitment, multi-period contracts can eliminate the inefficiency due to adverse selection.

[4] Consequently, there is no advantage for the current insurer to share experience with an insured as in Kunreuther and Pauly (1985) or for the insured to hide losses in order to influence the updating process as in Hosios and Peters (1989).

[5] In Germany, for instance, private health insurance providers are mandated by law to charge the premium irrespective of the personal loss experience.

[6] This description depicts the statistics of the labor market motivation described above.

[7] In all our observations of this and the following subsection, we obtain what we show formally above, that is, A_c being positive from the start, whereas A_a and $A_{a,b}$ are always negative.

[8] The loss probabilities could also be lowered without changing the effects as long as the relative differences are reflected as above, e.g. with p_a=.4, p_b=.1, p_c=.05, λ_a=.4, λ_b=.2, and λ_c=.4, so that p=.2, results as those in Table 1 emerge.