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Working Paper

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Würzburg economic papers, No. 37

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Würzburg Economic Papers

No. 37

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Risk Classification and Cream Skimming on the Deregulated German Insurance Market

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Abstract

In a two-stage model insurance companies first decide upon risk classification and then compete in prices. I show that the observed heterogeneous behavior of similar firms is compatible with rational behavior. On the deregulated German insurance market individual application of classification schemes induces welfare losses due to cream skimming. Classification costs and pricing above marginal cost can be prevented by common industry-wide loss statistics which already exist to a rudimentary extent. They allow competition to approach Bertrand type. The computation of a mixed-strategy equilibrium for Bertrand competition allows to explain the decrease of industry profit after deregulation.

JEL Classification:

D82, L51, K23, G22

Keywords:

Insurance Regulation, Cream Skimming, Bertrand Competition

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1 Introduction

The realization of the Single European insurance Market approaches completion by the implementation of the third Life Directive[1] and the third non-Life Directive[2] into national legislation. In Germany, this took place in 1994 with basically two important changes. The first is the home state regulation. Insurance companies need only a single authorization of one member-state to operate in Europe. The second is the extensive deregulation which gives the autonomy of policy conditions and premium calculation to the insurance company. Before 1994 any change had to be filed and approved by the regulatory agency before it could be applied. In fact, most policy conditions were elaborated by the German Insurance Association[3] and they came into force for all insurance companies simultaneously and uniformly. Now, after 1994, insurance companies are free to calculate premiums and to apply them immediately. For this calculation the firms are allowed to ask the applicants for many more information than before and actually some firms classify risks according to a high number of criteria while others apply the same criteria like before the 1994 deregulation. Although all firms start simultaneously product and price competition, they do not behave identically. It is the purpose of this paper to explore the incentives of the firms either to classify risks or not and to explain how the observed heterogeneous market outcome results from individually rational behavior.

Mostly, business consists of selling goods or services to customers. Although a good may be homogeneous in the perception of both, consumers and producers, its properties may vary according to some specifics of the customer who purchases a particular good. Customers may differ in the cost of serving them. The present paper concentrates on the insurance market. In this context, insurance coverage is purely homogeneous when it is a mandatory insurance with standard policy conditions. A customer carries out his duty when he can make proof of an insurance policy. When all insurance companies offer the policy conditions as required by law, the customers are indifferent between all suppliers unless they differ in premiums. The quality is homogeneous in the perception of the consumers. For the insurance companies, every single policy is a contingent payment. Although customers may incur similar kinds of losses, e.g. accidents, they will differ in accident

[1] Council Directive (EEC) 92/96 of 18 June 1992 OJ L360/1.

[2] Council Directive (EEC) 92/49 of 10 November 1992 OJ L228/1.

[3] Gesamtverband der Deutschen Versicherungswirtschaft e.V.

proneness. The latter property is specific to the purchaser and does not depend on the insurance company's promise to pay an indemnity in case of a loss.

Cream skimming consists of assessing the cost of serving a customer and it aims at attracting those customers from a competitor which can be served at lower cost. On an insurance market, one firm may assess an applicant with a detailed questionnaire to estimate the expected loss of the applicant. If it realizes that an actual good risk is accorded an average premium by a competitor, it can offer a lower premium which still covers the expected loss and it will be able to pick raisins from the competitor's customer base due to a more sophisticated screening method. An inactive firm which offers a uniform premium to a wide range of customers is vulnerable when it faces a competitor which is applying a highly sophisticated classification scheme. On average, worse risks remain to the inactive firm and this decreases profit or even leads to losses. Cream skimming is costly. Firms have to spend resources in collecting information from applicants. It is not evident that all firms implement screening mechanisms to the same extent.

Cream Skimming is not specific to the insurance market. The situation of homogeneous goods served to customers which cause different costs can also be found on other markets than insurance although to a lesser extent. In the banking sector, there are customer who are reliant to individual assistance when withdrawing money or for transfers. Others do their business via the internet and no labor force is needed to proceed their payments or transfers. If a bank charges a uniform price for both groups of customers, a competitor may offer banking services without manpower and, consequently, serve only those customers which generate less costs to the bank. These customers can be charged a lower fee and the customers who do not rely on individual assistance will switch to the cheaper bank. The remaining customers will choose the bank which is charging a uniform fee for all customers.

In retail sales, there are customers who pay cash and others who proceed their payments with credit cards. The latter cause higher costs to the shop although both groups buy the same product. Yet, it is unusual to charge an additional fee to customers who pay with credit cards.

For cream skimming it is necessary that consumers differ in some properties which are private information to them but which can be disclosed to firms in a credible way. Here, I will concentrate on expected loss which is an important property of an applicant for insurance coverage when firms have to quote a rate. A further condition for cream skimming is that firms must profit from cream skimming net of screening costs. When firms classify risks by applying identical classifying schemes, information is symmetric and competition is reduced to price competition for each distinct risk class. Improving the screening mechanism allows for further distinctions within risk classes and, hence, allows, for cream skimming. While one firm profits from cream skimming it simultaneously harms its competitor. On a market for mandatory insurance the provision of coverage is guaranteed because demand is inelastic. Only resources spent for screening activities are foregone and, thus, relevant for welfare considerations. Introducing elastic demand would allow for further welfare losses when prices differ from marginal cost. Additional effects would emerge if the application of risk classification schemes affected probabilities or magnitude of losses but moral hazard is out of the scope of the present analysis.

In this paper I will infer that the observed risk classification activities on the deregulated market are compatible with the rational behavior assumption. Furthermore, the resulting mixed strategy equilibrium can explain that similar firms behave differently in the same market. This can better be explained by mutual uncertainty about payoff functions than the classical view that firms randomize their actions. Firms applied risk classification schemes immediately after they were allowed to do so because firms prefer being the sole classifying firm and, once a firm classifies, no further firm will engage in classifying. Welfare considerations suggest to allow firms to run common loss statistics open to all firms. This reduces over all classification cost and competition will align premiums to marginal cost. The recent development of European directives facilitating uniform but rudimentary risk classification as public information is consistent with this implication. Finally, the results of this model are in line with the established results of Rothschild and Stiglitz (1976) who inter alia identify a negative externality of bad risks on good risks due to the mere presence of the former while firms make zero expected profit.

The next section will present the model. Two firms can develop costly risk classification schemes. Each firm knows the distribution of its competitor's cost and the precise amount of its own cost. After the firms know how much it would cost to them, they decide whether to classify applicants for insurance coverage or not in the next stage. After the outcome of the classification decision becomes common knowledge, price competition determines the payoffs. The last stage will be presented before the classification decision because the game will be solved by backwards induction. After a discussion of the model, the concluding section summarizes the main results and gives statements on insurance competition policy.

2 The Model

Let there be a continuum of consumers which are uniformly distributed on the interval $[0;1]$. Each consumer buys exactly one good from one of the two firms $i = 1, 2$. The goods are homogeneous and every consumer seeks for the offer with the lowest price. If both firms offer identical prices, I assume that the firms equally share the market. Before selling insurance policies, the firms $i = 1, 2$ decide whether to apply a risk classification scheme or not. From classifying, the firms learn to distinguish the a good from the $1-a$ bad risks. For simplicity, assume that good risks have zero expected loss. Customers from the high-risk class have expected loss $c > 0$. Figure 1 illustrates the structure of the consumers. The broken horizontal line indicates the expected loss of a random customer. For every single customer a loss is a random event. However, from the perspective of an insurance company, it is appropriate to focus on the expected loss. The law of large numbers ensures that the actual average claim approaches the expected loss arbitrarily close when the number of policies is sufficiently large.

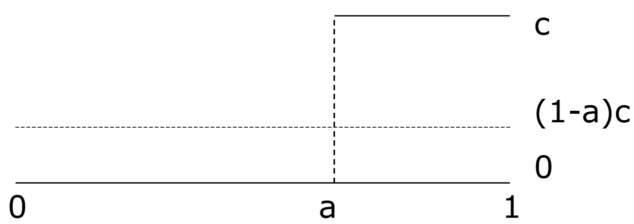

Figure 1: *Risk Classes*

Firms have to develop a classification scheme before applying it. I will call this the first stage of the model. The development will cost a precise amount K_i to firm i which is drawn from a uniform distribution on the interval $[0;T]$. I will assume that firms can only develop identical schemes but it will cost them a random amount. Each firm will be informed about the distribution of its competitor's cost but not the exact value of the realization and it knows its own development cost. All this is common knowledge to both firms.

After nature assigns K_i to firm i, the firms decide about developing and applying a classification scheme in the second stage. Then the outcome of the classification decision becomes common knowledge. In the third stage, premiums are set and payoffs are realized.

Before deciding about classifying activities in the first stage, the consequences in the second stage have to be considered. Hence, according to backwards induction I present the pricing of insurance policies for each outcome of the first stage before exploring the classifying decision. Basically, two scenarios may occur: both firms take the same decision in the first stage (section 2.1) or only one of the two firms classifies (section 2.2). If both firms take the same decision, in the first stage, there is conceptually no difference whether both or no firm classifies. Both situations will be presented in the next subsection before I derive the equilibrium in the asymmetric situation where only one firm classifies.

2.1 Symmetric Classification Decision

If both firms classify, there are two distinct markets. From each of them, the firms know exactly the expected cost of serving a customer and they can set a price for each of them independently. If no firm classifies, none of them can distinguish good and bad risks and the only information available is the average expected loss of an arbitrary customer. In this situation, the firms face an analogous setting to the above and this allows to analyze both symmetric classifying decisions simultaneously.

Insurance coverage with standard uniform policies is a homogeneous good. The customers choose their insurance company only according to the premium level. This behavior is the same for all consumers and, hence, the firm which offers the lowest premium will collect all customers of the relevant market. This setting corresponds to Bertrand price competition.

Originally, Bertrand (1883, p. 503) criticized Cournot's conjecture of quantity setting firms. Cournot had argued that a cartel would not be stable because firms would undercut each other in prices to attract the complete market. With the same argument Bertrand expressed his doubt on the quantity setting firms which could still undercut their prices. For this crucial argument to be valid, it is necessary that all firms have sufficiently large capacities to serve the entire market, if they undercut their competitor's price. One century later, Kreps and Scheinkman (1983) work out the market scenarios which correspond to the two duopoly outcomes. While Cournot envisages the typical manufacturing firm where goods are produced and sold at a later stage, firms in the Bertrand setting simultaneously decide on production and prices. The first setting yields Cournot outcomes and the latter yields marginal cost pricing. In the present context, firms are not restraint by capacities. Price and quantity decisions can be revised at any time. On the insurance market the assumption that every firm could serve the entire market fits the actual situation.

The well-established outcome of Bertrand competition is marginal cost pricing. Actually, this is a Nash equilibrium because none of the firms has an incentive to change its price. Raising the price would deter all customers and lowering it would result in losses. However, besides this unique equilibrium in pure strategies, mixed-strategy equilibria exist too. Dasgupta and Maskin (1986, p. 29) state in a theorem that the solution is symmetric and prices are set according to an atomless density function where the support is an open interval. The existence of an equilibrium in Dasgupta and Maskin holds for cases where the firms have limited capacities, may be smaller than demand would be at marginal cost pricing. Their theorem also covers the case where any firm could serve the entire demand on its own.

The solution to a mixed-strategy equilibrium is a density function. The expected payoff has to be equal for every price which is played with a positive probability.[4] The intuition of the equilibrium is that a higher price promises higher profit with a lower probability and vice versa. For the firm to be indifferent between two distinct prices, the payoffs resulting from the prices conditional upon undercutting the competitor are weighted with the probability of being the firm with the lower price as to obtain constant expected payoff. For the computational method to obtain the mixed-strategy equilibrium Dasgupta and Maskin refer to Beckmann (1967). His analysis is restricted to situations where the firms may have less capacity than necessary to serve the entire market. In this case, it should be obvious that a firm never sets a price equal to marginal cost because it could raise the price without losing customers when the competitor has exhausted its capacity. However, the shape of the density function which corresponds to the equilibrium in Beckmann (1967) fits the above intuition.

The present setting differs slightly from Beckmann's. The firms face an inelastic demand. Third party liability insurance is mandatory to every

[4]See Owen 1995, p. 75.

vehicle owner. Every insurer could easily serve the entire market. So, the capacity of a single firm is always larger than the maximum demand.

Assume that both firms $i = 1, 2$ compete for customers with expected cost γ. Let γ be zero or c if both firms can distinguish both risk classes, or γ can be $(1-a)c$ if both firms do not classify. Let $F_i(x) = Pr(p_i \leq x)$ be the putative equilibrium probability distributions of the Bertrand game. Furthermore assume that the open interval $S = (u; v)$ is the common support of the equilibrium density function indicated by Dasgupta and Maskin. Let $u > \gamma$ and $v \in (u; \infty)$. Profit for firm 1 is $(p_1 - \gamma)[1 - F_2(p_1)]$ and the first order condition is

$$1 - F_2(p_1) - (p_1 - \gamma)F_2'(p_1) = 0. \tag{1}$$

One solution of this differential equation is $F_2(x) = 1 - \frac{D_2}{x-\gamma}$ where D_2 is constant and $x \in S$. For $F_i(x)$ to be a distribution function $F_i(x) \geq 0$ for $x \in S$, $F_i(x) = 0$ for $x \leq \inf S$ and $F_i(x) = 1$ for $x \geq \sup S$ and $F_i'(x) \geq 0$ for $x \in S$.

$$F_1(x) = 1 - \frac{D_1}{x - \gamma} \tag{2}$$

$$F_2(x) = 1 - \frac{D_2}{x - \gamma} \tag{3}$$

are the solutions for $x \in S$ with $D_1 = D_2 = u - \gamma$ and $\sup S = \infty$.

The expected profit of firm i is constant for all prices $p_i \in S$. For $i \neq j$ $E\pi_i(p_i) = (p_i - \gamma)[1 - F_j(p_i)] = (p_i - \gamma)\frac{u-\gamma}{p_i-\gamma} = u - \gamma$. In addition, $E\pi_i(p_i') < E\pi_i(p_i)$ verifies that no firm has an incentive to undercut its competitor's price for $p_i' < u$ and $p_i \in S$ because the expected profits would be $p_i' - \gamma < u - \gamma$ which is always true.

This particular setting yields positive expected profit $u - \gamma$ to the participating firms but the assumption of an inelastic demand over the entire range of possible prices is restrictive. Although insurance coverage may be mandatory, the customers may refrain from owning an automobile when insurance premiums are prohibitively high. The maximum possible loss can be considered as an upper bound for insurance premium. If insurance is not mandatory, not even an extremely risk averse customer is willing to pay more than the loss in case of an accident.[5]

Kaplan and Wettstein (2000, pp. 69 f.) show that the supremum of the support must be infinite for an equilibrium in mixed strategies to exist. So,

[5]See McKenna (1986), p. 87.

the equilibrium presented above cannot be realized if all customers have a finite choke-price. Harrington (1989) has shown that the Bertrand paradox (zero profit) outcome is the only equilibrium outcome when firms produce at constant marginal cost and market demand is bounded, continuous, downward sloping, and has a finite choke-price.[6] Baye and Morgan relax the assumption of a finite choke-price. When firms are uncertain about the customers' choke-price because they only know their distribution, still a mixed strategy equilibrium can exist. As an example, they compute the equilibrium distribution when the maximum willingness to pay is drawn from a Pareto distribution. The variations of the above computation show that positive expected profit is compatible with elastic demand and with customers having bounded choke-prices.

The crucial condition for the mixed-strategy equilibrium (F_1, F_2) to emerge is that the supports of the two distributions must be the same.[7] If they were not, the distribution functions are not an equilibrium and only the pure strategy-equilibrium with marginal cost pricing can emerge. To ensure a positive expected profit, the firms have to coordinate on the lower bound of the support of their equilibrium distribution function. This will also determine their expected profits. Under regulation before 1994 all premiums had to be filed to the regulatory agency and could be applied only after approval. The agency verified that the insurance companies do not set too low premiums to prevent insolvencies. The calculations are based on industry statistics which are identical for all firms. This process of prior approval can credibly establish a lower bound for the price choice of the firms. Under regulation it is legitimate to assume that an actual lower bound exists which cannot be undercut by any firm. Now, after 1994, there is no coordinating institution which is necessary to establish a mixed-strategy equilibrium. As agreements on price setting practices are illegal on competitive markets, the only Nash equilibrium is marginal cost pricing with zero profit.

Finally, the payoffs for the case of the symmetric classification decision can be specified. Failure to coordinate a common lower bound of the support ends up in the Bertrand paradox outcome with prices equal to marginal cost γ. The revenue from selling insurance policies is equal to expected claims. In addition to the claims, the firms have to bear the classification costs K_i if they decide to classify. Hence, profit is zero when no firm classifies and it is $-K_i$ when both firms classify. The detailed presentation of mixed-strategy

[6]Baye and Morgan (1999), p. 60.

[7]See Kaplan and Wettstein (2000, p. 67) for a proof of this argument.

equilibria will help to discuss the motivation of regulation from the firm's point of view in the discussion of the model.

2.2 Asymmetric Classification Decision

One possible outcome of the second stage is that only one firm i classifies risks while the other j does not. Then firm i can distinguish customers with zero expected loss from those with expected cost c. This gives firm i the opportunity to set two different premiums, one for each risk class. The other firm j cannot distinguish risk classes and it can only set a uniform premium for all applicants. The only information available to firm j when making an offer to an arbitrary applicant is that the expected cost will be the average loss $(1-a)c$.

In contrast to the symmetric case, no pure-strategy Nash-equilibrium exists. A mixed-strategy equilibrium, however, does exist. The solution will be in line with the model of Rothschild and Stiglitz (1976) although the settings differ widely. This equilibrium will allow to compute the payoffs which are relevant for the decision in the second stage.

In the first step, I will show that no equilibrium exists where both firms play a pure strategy. Then I will give some properties and conditions for a mixed strategy and, finally, compute it.

Non-existence of Pure-strategy Equilibrium

Assume that firm 1 applies a costly risk classification scheme. Consequently, firm 1 can assign an applicant to the high-risk class with expected loss c or to the low-risk class with zero expected loss. Firm 2 does not classify the applicants and it can only offer a uniform premium. Let p_0 and p_c denote the premiums offered by firm 1 for the good and for the bad risks respectively and let p_2 denote the premium offered by firm 2. The low-risk class faces a pair of premiums (p_0, p_2) and the high-risk class faces a pair of premiums (p_c, p_2). Each customer always purchases from the firm offering the lower premium. If one risk class faces two identical premiums, I assume that each firm serves half of the customers of that risk class. It may happen that the two risk classes are served by different firms or that one firm serves both risk classes.

In an equilibrium, firm 2 will never set a premium p_2 as a pure strategy.

It is obvious that it will never set a premium $p_2 < (1-a)c$ as a pure strategy. Serving the entire market would result in losses. The only possibility for such a strategy to be profitable is that firm 1 undercuts in the high risk class. This situation will not be realized because it would imply losses to firm 1 for sure. There is no chance for firm 2 to make positive expected profit from setting a premium $p_2 < (1-a)c$.

A premium in the interval $[(1-a)c; c]$ cannot be an equilibrium strategy either. If firm 1 anticipates this premium p_2, it will offer $p_0 = p_2 - \varepsilon$ to slightly undercut p_2 and will profitably serve the good risks only. The bad risks with expected cost c would remain with firm 2 and the latter would serve them with $p_2 = (1-a)c < c$ and incur losses. $p_2 = (1-a)c$ cannot be the solution to a pure strategy equilibrium because of cream skimming by firm 1. Whichever premium firm 2 may set in the interval $[(1-a)c; c]$, it can profitably be undercut by firm 1 on the market for good risks. When firm 1 attracts the good risks the bad risks remain with firm 2 which incurs losses.

If firm 2 sets $p_2 = c$ it cannot incur losses whatever the reaction of firm 1 is. Even serving the bad risks only yields a nonnegative profit. The best response of firm 1 would be a pair of premiums (p_0, p_c) with $p_0 = p_2 - \varepsilon = c - \varepsilon$ and $p_c \geq p_2 = c$. This pair of premiums maximizes profit from the good risks. As the bad risks are served with a fair premium, firm 1 cannot profitably attract them. It can only set a premium at or above c. For these premiums of firm 1 to be a Nash equilibrium p_2 must be the best-response to (p_0, p_c). Obviously, it is not because firm 2 would prefer to set a uniform premium $p_2 > (1-a)c$ which undercuts $p_0 = c - \varepsilon$ and serves both risk classes. Hence, a premium $p_2 = c$ cannot be an equilibrium either. Furthermore, a premium $p_2 > c$ cannot be optimal for firm 2 because it could be profitably undercut by firm 1. Firms have an incentive to undercut each other as long as p_2 and p_c exceed c.

This has shown that no premium p_2 exists which can be a pure-strategy of firm 2. Conversely, I will argue that there is no pair of premiums (p_0, p_c) which can be played as pure strategy in a Nash equilibrium.

Firm 1 will never set a premium $p_c < c$. If such a premium sells, it would make losses from the bad risks and raising p_c would increase expected profit. The low-risk premium p_0 may be set above or below $(1-a)c$. In the first case it can be undercut profitably by firm 2 with a pure strategy $p_2 = p_0 - \varepsilon$. In the second case, firm 2 would never sell to good risks and sets $p_2 \geq c$. Then p_0 would not be a best-response to p_2.

Mixed-strategy Equilibrium

As a pure-strategy equilibrium does not exist, a Nash equilibrium can still exist in mixed strategies. I will start by presenting the minimum profit condition for firm 1 which allows to generate restrictions for the support of a mixed strategy. Then I will compute an equilibrium and derive the payoffs to both firms.

As argued above, firm 2 will never set prices below $(1-a)c$ to prevent sure losses. If firm 1 anticipates this, setting a premium $p_0 = (1-a)c - \varepsilon$ guarantees a profit $ap_0 = a(1-a)c$. So, whatever strategy is played in equilibrium, it must generate at least this profit because firm 1 could always recur on the strategy $p_0 = (1-a)c$

Assume that the Nash-equilibrium is characterized by two distribution functions $F_i(\cdot)$, $i = 1, 2$ and that the support of the corresponding density functions is the interval $[(1-a)c; c]$. Once the equilibrium strategies are computed, I will argue that no firm i has an incentive to deviate from $F_i(\cdot)$.

Firm 1 can obtain a minimum profit from playing the pure strategy $p_0 = (1-a)c$ which will never be undercut. Any mixed-strategy must promise equal or higher expected profit than $a(a-1)c$. A price $p_0' < (1-a)c$ would result in a lower profit than $a(1-a)c$ and this is not compatible with the minimum profit condition. Similarly, no price $p_0' > c$ is possible if firm 2's support is contained in the interval $[(1-a)c; c]$ and p_0' would sell with probability zero. This would contradict the minimum profit condition too. Imagine that the mixed-strategy played by firm 2 is defined by the distribution function $F_2(p_0)$ which denotes the probability that p_2 is smaller or equal to p_0 and $p_c = c$. Then firm 1's expected profit is $E\pi_1 = ap_0[1-F_2(p_0)]$. The first order condition is $a[1 - F_2(p_0) - F_2'(p_0)p_0] = 0$ and the solution to this differential equation is $F_2(p_0) = 1 - \frac{C_2}{p_0}$ where C_2 is an arbitrary constant. From the minimum profit of firm 1 follows that $E\pi_1 = ap_1[1 - F_2(p_0)] = aC_2 \geq a(1-a)c$. From $p_2 \in [(1-a)c; c]$ follows that $p_0 \geq (1-a)c$ because firm 1 will not set premiums below $(1-a)c$ as noted above. As $F_2(p_0) = 1 - \frac{C_2}{p_0}$ must be zero for $p_0 = (1-a)c$ this determines $C_2 = (1-a)c$ and the value of the game for firm 1 is

$$E\pi_1 = a(1-a)c. \tag{4}$$

At the highest price possible c, the upper bound of the support, $F_2(x) = 1$

must hold. The distribution function indicates that $F_2(c) = 1 - \frac{(1-a)c}{c} = a < 1$. Note that the distribution function of firm 2 is not atomless. The indifference condition for firm 1 allows that $Pr(p_2 = c) = 1 - F_2(c) = 1 - a$. If the support of firm 1 is an open interval $(\underline{x}_1; c)$ the upper bound c is never played with a positive probability and a price p_1 approaching c arbitrarily close from below undercuts p_2 with the probability $1 - a$ and the expected profit is $(1 - a)c$. So the distribution function for firm 2 is

$$F_2(x) = \begin{cases} 0 & \text{for} \quad x \leq (1-a)c \\ 1 - \frac{(1-a)c}{x} & \text{for} \quad (1-a) < x < c \\ 1 & \text{for} \quad c \leq x. \end{cases} \tag{5}$$

Now, firm 1 can arrange the probability mass of its own density function so as to make firm 2 indifferent between all prices $p_2 \in [(1 - a)c; c]$.

Firm 2 has to consider two aspects when setting its premium, given the mixed strategy $F_1(x)$ from firm 1. First, it knows that it makes losses from the bad risks $(p_2-c)(1-a)$ when $p_2 < c$. Secondly, a premium $p_2 = (1-a)c$ would earn revenue equal to the losses from the bad risks which have to be covered. Raising the premium would raise the revenue but, given $F_1(x)$, the probability of earning any revenue from the good risks decreases. From the indifference condition, profit has to be constant for all prices in the support. Hence, the revenue from the good risks has to be weighted with the probability which makes the expected revenue equal to $(p_2-c)(1-a)$, the loss from serving the bad risks. Aggregating the probabilities for all $p_2 \in [(1 - a)c; c]$ yields the distribution function $F_1(x)$ which actually makes firm 2 indifferent between all possible prices p_2. Since $p_2 = c$ is contained in the support for firm 2 and the profit when setting this price is zero, expected profit must be zero for all other prices $p_2 \in [(1 - a)c; c]$ which are played with positive probability too.

Expected profit for firm 2 is $E\pi_2(p_2) = ap_2[1 - F_1(p_2)] + (1 - a)(p_2 - c)$. The first term is the expected profit from the good risks and the second is the loss from serving the bad risks with premium p_2. The first order condition is $a[1 - F_2(p_2) - p_2F'(p_2)] + (1 - a) = 0$ and the solution is $F_1(p_2) = \frac{1}{a} - \frac{C_1}{p_2}$. C_1 must be determined as to allow zero profit to firm 2. $E\pi_2 = ap_2[1 - \frac{1}{a} + \frac{C_1}{p_2}] + (1-a)(p_2-c) = 0$ holds for $C_1 = \frac{(1-a)c}{a}$. For $F_1(x)$ to be a distribution function it has to adopt the value one at the upper bound $\overline{x}_1$ of the support and the value zero at the lower bound $\underline{x}_1$. Setting $F_1(\underline{x}_1) = 0$ and $F_1(\overline{x}_1) = 1$ yields $\underline{x}_1 = (1 - a)c$ and $\overline{x}_1 = c$ which is in line with the relevant interval. The equilibrium distribution function of firm 1 is

$$F_1(x) = \begin{cases} 0 & \text{for} \quad x \leq (1-a)c \\ \frac{1}{a} - \frac{1}{a}\frac{(1-a)c}{x} & \text{for} \quad (1-a)c < x < c \\ 1 & \text{for} \quad c \leq x \end{cases}$$

and

$$Pr(p_c = c) = 1. \tag{6}$$

Unlike $F_2(x)$ this distribution is atomless. For every price p_2 in the support of firm 1, firm 2 makes zero expected profit. As I noted above, $F_2(\cdot)$ has an atom at $Pr(p_2 = c) = 1 - a$. This means that there is a probability of firm 2 setting a price which has zero probability of earning revenue form the good risks. The price c is the only one which generates no loss from the bad risks which has to be covered from the low-risk class. Expected profit for firm 2 is zero for all $p_2 \in [(1-a)c, c]$.

In contrast to the separating equilibrium of Rothschild and Stiglitz (1976), this equilibrium always exists when bad risks are few. Firm 2 plays $p_2 = c$ with probability $1 - a$. This means that firm 1 could earn positive expected profit $(1-a)\frac{ac}{2}$ from playing $p_0 = c$ with probability one, given the strategy $F_2(\cdot)$ of firm 2. The expected profit is the profit from the good risks which is shared equally between both firms weighted with the probability that firm 2 plays $p_2 = c$. It is easy to verify that firm 1 has no incentive to give probability weight to $p_1 = c$ because the expected profit from this strategy is $(1-a)\frac{ac}{2}$ which is always smaller than the expected profit $a(1-a)c$ from playing $F_1(\cdot)$.

2.3 Classification Decision

When taking the decision in the second stage whether to apply a costly risk classification scheme or not, the firms need the information about the payoffs of the third stage. The payoffs from the price competition have been derived in the previous subsections. The basic outcome is that an insurance company profits only from being the sole classifying firm. In addition to the net profit from selling insurance coverage the firms have to consider the classification costs. When taking the classification decision, the firms know only their own cost K_i but not the exact cost of their opponent. The only information available is that the competitor's cost is a random draw from a uniform distribution on the interval $[T^-; T^+]$.

As the firm i can only rely on beliefs about its opponent's type $K_j' \in [T^-; T^+]$ the solution of the game is a Bayesian Nash equilibrium. This implies that firm i has to specify its strategy for each type K_i he could be assigned to. Although nature has drawn a particular type K_i and revealed it to player i, it is necessary for player i to consider his strategy for all other types $K_i' \neq K_i$, $K_i' \in [T^-; T^+]$, because what j will do depends on j's beliefs about the type of i and each of i's types' strategies. Table 1 shows the expected profits for the firms when nature has privately revealed the type K_i to the firm i which has chosen one strategy from $\{RC; U\}$ where RC and U is the firm's decision for and against risk classification respectively.

(Firm 1, Firm 2)	RC	U
RC	$-K_1, -K_2$	$a(1-a)c - K_1, 0$
U	$0, a(1-a)c - K_2$	$0, 0$

Table 1: Payoffs from the Pricing Stage

Firm i will develop a classifying scheme if it is costless. It will still do so if classification cost does not exceed an upper bound, say $t_i \in [T^-; T^+]$. Then firm i's strategy is RC for $K_i \leq t_i$ and U for $K_i > t_i$. This holds for firm j too. Firm i can compute expected profits from each strategy from the set $\{RC, U\}$. Playing RC yields $-K_i Pr\{K_j \leq t_j\} + (\pi - K_i) Pr\{K_j > t_j\}$ where $\pi = a(1-a)c$. Playing U yields zero expected profit. Let $\Delta T = T^+ - T^-$, then $Pr\{K_j \leq t_j\} = F(t_j) = \frac{t_j - T^-}{\Delta T}$ is the probability that a randomly drawn K_j is smaller than or equal to t_j. So firm 1 plays RC if

$$-K_i \frac{t_j - T^-}{\Delta T} + (\pi - K_i)\left[1 - \frac{t_j - T^-}{\Delta T}\right] \geq 0 \tag{7}$$

or

$$K_i \leq \pi \left[1 - \frac{t_j - T^-}{\Delta T}\right] = t_i. \tag{8}$$

Analogously,

$$K_j \leq \pi \left[1 - \frac{t_i - T^-}{\Delta T}\right] = t_j. \tag{9}$$

(8) and (9) simultaneously yield

$$t_i = t_j = \pi \frac{\Delta T - T^-}{\Delta T + \pi} = \pi \frac{T^+}{T^+ - T^- + \pi}. \tag{10}$$

It is easy to verify that $T^- < t_i < T^+$. The second inequality is $\frac{\pi}{\Delta T+\pi}T^+ < T^+$ and it is always fulfilled for $\pi > 0$. The first transforms to $T^-\Delta T < \pi T^+ - \pi T^- = \pi\Delta T$ or $T^- < \pi$. For the reasonable assumption that classification cost will never exceed net expected profit (before classifying cost) $T^+ < \pi$ the last inequality becomes $T^- < T^+ < \pi$ which is always true.

These computations state that there exist critical values t_i for the classifying costs for $i = 1, 2$. Then the firms play pure strategies in the Bayesian Nash equilibrium as follows: When firms realize that they can develop a classifying scheme at costs which do not exceed that limit they will do so and apply the scheme. If the development costs are higher they will refrain from classification activities.

In the first stage, nature assigns a type K_i to each firm. Any firm will only engage in classification activities if it expects nonnegative profit. A firm $K_i > t_i$ will not classify and has zero expected profit. $K_i \leq t_i$ is the more interesting case. Combining the left side of (7) with (10) yields the expected profit conditional on i playing RC.

$$K_i + \pi\frac{T^+}{\Delta T + \pi}. \tag{11}$$

Inserting $K_i \leq t_i$ in (11) shows that firm i makes zero expected profit when $K_i = t_i$. Then $t_i - K_i$ is the expected profit for firm i at the beginning of the second stage.

As the firms can decide to classify risks after they have knowledge about the cost K_i and the expected profit, they will only choose RC if this promises nonnegative profit. For $K_i < t_i$ the expected profit in strictly positive and over all, before the first stage, the firms have a positive expected profit too. The ex ante expected profit $E\Pi_i$ is $t_i - K_i$ weighted with the probability for all $K_i < t_i$, namely the density function $f(K_i) = \frac{1}{\Delta T}$

$$\begin{aligned} E\Pi_i &= \int_{T^-}^{t_i}(t_i - K_i)\frac{1}{\Delta T}dK_i \\ &= \frac{1}{\Delta T}\left[t_iK_i - \frac{1}{2}K_i^2\right]\Bigg|_{T^-}^{t_i} \\ &= \frac{1}{2\Delta T}(t_i - T^-)^2 > 0. \end{aligned} \tag{12}$$

2.4 Discussion

It is a technical issue that expected profit in this Bayesian Nash equilibrium is positive. The probability for a firm to play the strategies RC and U are determined by the mutual beliefs about the competitor's cost. These are the commonly known distribution functions. If a firm has development costs equal to the critical value $K_i = t_i$, this firm is indifferent between both strategies. The expected payoff from playing RC is equal to $K_i = t_i$. If $K_i < t_i$, firm j does not alter its strategy because no information is revealed to j. Firm i still obtains the expected profit from playing RC. The difference $t_i - K_i$ is then the positive expected profit for firm i when it can play the strategy RC at low cost.

If table 1 were the payoff matrix of a static game with complete information, the outcome would be a mixed-strategy equilibrium and the expected profit would be zero. In the present setting, the probabilities are determined by the cost parameter K_i and these vary as the cost level changes. Firms profit from their cost being unknown to their competitors. There is no incentive to disclose this information.

The classification decision is a pure strategy for both firms. A firm which develops a classification scheme is ex ante not certain about the cost and the probability of achievement but once the scheme is set up the uncertainty about K_i vanishes. The present game is equivalent to the 'Battle of the Sexes'. In this class of games, firms would deliberately unveil their strategy if they could do so in a credible way. This incentive is compatible with the observation of the actual insurance market immediately after deregulation. Firms started their classification program as soon as they were allowed to do. Actually, screening applicants according to many criteria can be observed by competitors and this is a credible commitment. The payoff matrix implies that a firm has an advantage if it manages to commit to RC before its competitor chooses a strategy. This allows to interpret the development cost as a firm's estimation of the time it will take to set up a classification scheme or as an estimation of the effectiveness of a newly elaborated scheme.

Welfare Implications

Welfare considerations can focus on two aspects in this setting. First, the only resources which are forgone are the classification costs. As the firms' expected profit is positive, on average, these costs are borne by the consumers. The ex ante distribution of the classification costs determine the overall classification costs in the insurance industry. Firms classify iff $K_i \leq t_i = \frac{\pi}{\Delta T+\pi}T^+$ and the expected costs are

$$EK = 2\int_{T^-}^{t_i} K_i \frac{1}{\Delta T} dK_i = \frac{t_i^2 - T^{-2}}{\Delta T} = \frac{\left(\frac{\pi}{\Delta T+\pi}T^+\right)^2 - T^{-2}}{\Delta T}. \tag{13}$$

Only in the situation where one firm classifies, the good risks pay premiums which exceed their expected loss. In this situation, the firms earn premium income which cover the classification costs. The probability of this situation is $1/2$ when $t_i = (T^+ + T^-)/2$ is in the middle of the interval $[T^-; T^+]$. Then each firm classifies with probability $1/2$. The probability of an asymmetric classification decision is lower when t_i shifts off the middle of the interval.[8]

Expanding the last term of (13) yields

$$\frac{\left(\frac{\pi}{\Delta T+\pi}T^+ - T^-\right)\left(\frac{\pi}{\Delta T+\pi}T^+ + T^-\right)}{T^+ - T^-}. \tag{14}$$

Similarly to a Laffer-curve, the effect of an increase in individual classification costs on EK is ambiguous. Imagine that the increase is done by a shift of the limits of the interval $[T^-; T^+]$ by the same amount. If t_i is closer to T^+ the probability of exactly one classifying firm decreases. This probability effect outweighs the cost raise. Being on the good (left) side of the Laffer curve, an increase of classification costs raises overall costs in the market. Then the model suggests cost reduction as a policy implication.

As T^- approaches T^+ the uncertainty about the competitor's cost vanishes and from (14) follows $\lim_{T^- \to T^+} = 2T^+$. These are the total classification costs. As expected profit is zero in the mixed-strategy equilibrium in the game with complete information, the costs are still fully borne by the consumers.

When the firms make identical classification decision, I predict Bertrand competition. Classification costs are borne by the firms, if they occur. Typically, R&D costs are sunk. Setting up a classification system can be considered as sunk costs but classifying still generates variable costs when applicants file in detailed questionnaires which have to be analyzed. I have presented a Bayesian game where firms can infer their competitor's type

[8] $\arg\max_q[q(1-q)] = 1/2$.

from its behavior. The present model ends after payoffs are realized. Actually, contracts can be renewed after expiration. This allows for adjustments of the classification system and the premiums which will prevent permanent losses.

The second welfare aspect considers the provision of consumers with insurance coverage. Like in Rothschild and Stiglitz, good risks suffer a negative externality from the presence of bad risks when the applicants cannot credibly reveal their risk class. Their model predicts that good risks are deprived from full insurance and, although the customers are offered a fair premium, a welfare loss from underinsurance occurs. In the present model the good risks always pay a higher premium than their expected cost if one or both firms are not fully informed about the applicants' risk type because they refrain from classifying. In contrast to Rothschild and Stiglitz, the firms offer exclusively full insurance policies. This is adequate for mandatory insurance coverage with standard policy conditions like automobile liability insurance.

The expenditure for insurance is small relative to the purchase of an automobile. However, some consumers will renounce to operate a car if the total expenditure become too high. Introducing elastic demand would imply that provision is no more efficient when prices exceed marginal cost because some customers refrain from purchasing.

If, like in the Rothschild and Stiglitz model, the low-risk customers were free to choose the level of coverage after the firms have set prices above the fair premium, they would purchase less than full coverage. This is a loss of rent for the low-risk customers. On the other hand, the high-risk customers will not obtain overinsurance because an insurance company does not compensate for more than the actual loss. Only when zero or (accidently) both firms incur the classification costs, there is no loss of consumer rent.

Policy Implications

In the context of insurance regulation, the model allows for some implications for insurance regulation policy. As noted in section 2.1, under the German insurance regulation before 1994, firm behavior was highly coordinated by the regulatory agency. The extent of risk classification and premium calculation were under the agency control. All firms applied the same classification scheme and had to keep the price setting conditions which mainly consisted of a minimum premium level. In consequence, firm behavior was symmetric and profit abundant. In the payoff matrix the payoffs from symmetric behavior turn to be the Nash equilibria and in contrast to the competitive market there is no lack of coordination and no mixed strategy equilibrium. It is the regulatory agency which prescribes the same intensity of risk classification to all firms and, thus, the same strategy.

In the present model, there are two sources of welfare losses, classification costs and the difference between marginal cost and prices. Both can be reduced by insurance regulation policy. I have argued that total classification cost can be lowered by decreasing them on the firm level when they are low or increasing them when they are high. The welfare loss from prices exceeding marginal cost can only be reduced by reducing this markup. The model suggests to improve the knowledge of the whole insurance industry about risk classes. The direct effect would be to save on resources on classification activities. Additionally, a drastic reduction of classification cost on the firm level is desirable to ensure that the level of classification cost is on the good side of the Laffer-curve. The first-best situation is attained when both firms assign each applicant to a particular risk class. Then, Bertrand competition eliminates profit margins and welfare losses from limited provision. The information necessary to establish a uniform risk classification system is the same for all firms. It is sufficient to collect them only once in the industry. Either the firms may be allowed to cooperate or the regulatory agency shall provide the information. Considering the literature on R&D cooperation, this is a common policy implication.

The Insurance Block Exemption Regulation[9] is limited to a ten-year period and allows the insurance industry to run common statistics. In general, horizontal agreements by firms are prohibited by Article 81(3) of the EC Treaty. The regulation in force includes a limited number of characteristics in the exemption which may be collected jointly. When interpreting the strategies RC as applying more risk classifying criteria than in strategy U, then the model suggests to extend the number of characteristics to include in the common statistics. Unfortunately, the draft for the succeeding Commission Regulation adopts the previous as it stands.

Of course some restrictions to the implications of the present model exist. I neglect the classical problems of insurance markets like adverse selection and moral hazard. I assume that every applicant can be clearly assigned to one risk class and that the mode of risk classification does not affect the

[9]Commission Regulation (EEC) 3932/92 of 21 December 1992 OJ L397/7.

behavior of applicants for insurance coverage. May be an applicant buys a 4-door car instead of 2-door car to pay less insurance premium although this does not alter his driving habits. Such problems arise when risk classes become highly subdivided.

3 Conclusion

One consequence of the deregulation of the German insurance market is the extensive application of risk classification schemes by insurance companies. This paper has shown that the observed heterogeneous behavior of similar firms on a homogeneous goods market is compatible with the assumption of rational behavior. Thereby, it is in line with the well-established findings of Rothschild and Stiglitz, that bad risks exert a negative externality on the good risks due to asymmetric information about risk types. This gives scope to further welfare improvements. Improving the effectiveness of classification schemes may raise the allocative efficiency of insurance pricing by improving and assimilating the insurers' information on risk classes. Then competition tends to be of Bertrand type.

After deregulation, no regulative agency monitors minimum profit levels. The insurance companies earn zero expected profit when firms have average classification costs and introducing common statistics for all firms on risk classes does not alter the profit level. So, the Insurance Block Exemption Regulation gives rise to welfare enhancement. Upon renewal of the block exemption it would be desirable to extend the number of characteristics which may be collected jointly.

References

Baye, R. Michael and John Morgan (2000), A Folk Theorem for One-shot Bertrand Games, in: Economics Letters 65, 59-65.

Beckmann, Martin J. (1967), Edgeworth-Bertrand Duopoly Revistied, in: Rudolf Henn (ed.), Operations Research-Verfahren III, Anton Hain, Meisenheim am Glan, 55-68.

Bertrand, J. (1883), Theorie des Richesses, in: Journal des Savants, 499-508.

Dasgupta, Partha and Eric Maskin (1986), The Existence of Equilibrium in Discontinuous Economic Games, II: Applications, in: Review of Economics Studies 53, 27-41.

Harrington, Joseph E., Jr (1989), A Re-evaluation of Perfect Competition as the Solution to the Bertrand Price Game, in: Mathematical Social Sciences 17, 315-328.

Kaplan, Todd R. and David Wettstein (2000), The possibility of mixed-strategy equilibria with constant-returns-to-scale technology under Bertrand competition, in: Spanish Economic Review 2, 65-71.

Kreps, David M. and Jose A. Scheinkman (1983), Quantity Precommitment and Bertrand Competition Yield Cournot Outcomes, in: Bell Journal of Economics 14 (2), 326-337.

McKenna, Chris .J. (1986), The Economics of Uncertainty, Oxford Univ. Press, New York.

Owen, Guillermo (1995), Game Theory, 3rd ed., Academic Press, San Diego.

Rothschild, Michael and Joseph Stiglitz (1976), Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information, in: Quarterly Journal of Economics 90, 629-649.

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