Adverse selection and categorical discrimination in the health insurance markets: the effects of genetic tests

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Abstract

In this paper, the effects of new methods for risk classification, e.g., genetic tests, on health insurance markets are studied using an insurance model with state contingent utility functions. The analysis focuses on the case of treatment costs higher than the patient’s willingness to pay where standard models of asymmetric information are not applicable. In this case, the benefit from signing a fair insurance contract will be positive only if illness probability is low. In contrast to the common perception, additional risk classification under symmetric information can be efficiency enhancing. Under asymmetric information about illness risks, however, there can be complete market failure. © 2000 Elsevier Science B.V. All rights reserved.

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1 For an overview see Dionne and Doherty (1992).
1. Introduction

Insurance market equilibria under asymmetric information and welfare effects of imperfect categorical discrimination have been extensively studied in rather generally designed models. In these models, utility functions are assumed to be state-independent and financial loss does not exceed wealth. Hence, a risk averse person would always choose to sign an insurance contract at a fair premium. If the population consists of two different risk types and there is asymmetric distribution of information about the insureds risk types (insureds are informed about their illness risks, while insurance companies are not informed), the market equilibrium is found to be a Nash-equilibrium providing high risk types with full insurance and low risk types with partial insurance (known as Rothschild–Stiglitz–equilibrium). In case of symmetric information about risk types, insureds would prefer not to receive additional information about their illness risks because of the additional income risk caused by more risk adequate insurance premiums.

For health insurance markets, however, these standard models are not generally applicable, mainly for the following reason: loss in health insurance implies non-financial loss of well-being by getting ill. If there exists a method of treatment, this loss of utility can be transformed into a financial loss by visiting a physician and undertaking the costs of the treatment. Without health insurance, a rational patient would compare expected benefits from being treated to the price he would have to pay for the treatment. He would choose to bear his sufferings and not to be treated if treatment costs were higher than his willingness to pay.

The structure of possible losses of well-being (and consequently of wealth) in the health sector is quite heterogeneous. Roughly we can distinguish between acute (curable) diseases and chronic (incurable) diseases. In the latter case, treatment prevents worsening and alleviates complaints, but effectuates no cure and often there is no significant change in life expectancy. Still, costs of long-term treatment can be quite high and, hence, exceed an uninsured patient’s willingness to pay (or even his wealth). Examples for this phenomenon are numerous: bypass surgery in cardiovascular diseases, disc surgery or visits to the health resorts as a treatment of a slipped disc as well as treatment of many internal diseases like rheumatism or subsequent diseases in diabetes can be named here. Since many infectious and other acute diseases are becoming less of a threat (because of new
drugs, operation methods and intensive care medicine), life expectancy keeps on rising and people tend to accumulate chronic diseases while aging. Consequently, in the last decades, there has been a trend towards spending an increasing proportion of the total health care expenditures for treatment of chronic diseases.6

In order to construct a model suitable for the description of the health insurance market, this specific fact has to be taken into account. In Section 2 of this paper, a simple health insurance market model will be presented. State contingent utility functions are used,7 and patients in case of illness are assumed to have the choice between undergoing a treatment or suffering from their diseases. The analysis thereby focuses on the case in which treatment costs are higher than an uninsured person’s willingness to pay and lie within a certain range so that low risk types benefit from a fair insurance contract while high risk types do not.

The effects of genetic testing have become of increasing political importance.8 In recent years there has been a rapid development of new biochemical and microbiological screening methods (e.g., genetic tests) rendering possible not only the diagnosis of diseases that have already occurred, but also enabling the prediction of a higher risk of the onset of specific diseases years later.9 From the insurance point of view, these diagnostic methods have to be considered as new possibilities for more exact risk classification of insured persons, and also as a possible source of new asymmetry in the distribution of information between insurer and insureds. Within the next decade, we especially expect gene technology to strongly push this development by offering (at least to some people) a quite detailed forecast about what kind of illness one is likely to suffer from in the future. Among these potentially predictable diseases are such common chronic diseases as Alzheimer disease,10 diabetes (types 1 and 2),11 malignant neoplasias,12 alcoholism,13 and many more internal,14 orthopedic (osteoarthritis)15

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6 For an overview see Zweifel and Ferrari (1992).
7 In the context of the health insurance market De Meza (1983) introduced state dependent utility functions. He is, however, not concerned about adverse selection problems.
8 In 1996, for example, the Royal Society of London together with the Institute and Faculty of Actuaries have set up a Symposium where medicines and actuaries discussed the impact of genetic testing on the insurance industry (Anderson, 1997).
9 An overview is given in Motulsky (1994), for detailed information see Strachan and Read (1996).
11 See Buhler et al. (1997), Ji et al. (1997), Merriman et al. (1997), Reed et al. (1997), Verge et al. (1996), and Waterworth et al. (1997).
13 See Parsian et al. (1997).
14 See Jouanolle et al. (1997), Norman et al. (1997), Pokorny et al. (1997), and Roussomoustakaki et al. (1997).
15 See Keen et al. (1997).
and psychiatric diseases. In light of these developments, a controversial debate on whether private insurance companies should be allowed to gather genetic information from applicants and to calculate insurance premiums according to the insured person’s genetic risk has started.

In the framework of our model, we contribute to this debate by considering the market outcome under two scenarios: in the first scenario, all information is publicly available. This is discussed in Section 2. From a regulatory point of view, this corresponds to a ‘laissez-faire’ regulation: insurer are allowed to ask for and demand genetic tests from their customers. In Section 3 the case of private information is analysed, where insurer are not allowed to use information resulting from genetic tests. This scenario seems to become more and more relevant. As discussed by Chuffart (1996), there is a tendency by policy makers in many countries to forbid insurer to use genetic information.

We derive the following results.

If information is symmetrically distributed, then, in contrast to standard models, the screening of insurance applicants for illness risks can enhance efficiency. The welfare effect depends on the precision of separating high and low risk types, reaching an optimum at a certain degree of imperfection of the test. More precisely, the highest efficiency gain is achieved if the probability of a false positive test result (indicating high illness probability though the individual has a low risk) is minimized and the probability of a false negative test result is significant. Some genetic tests seem to have quite similar properties.

On the other hand, if the information is private, it will be demonstrated that in case of treatment costs higher than willingness-to-pay, asymmetry in information about the insureds risk types not only could cause signaling costs (i.e., partial insurance for low risk types) as in a Rothschild–Stiglitz- or a Wilson–Miyazaki–Spence-type market equilibrium, but could cause the whole market to break down.

In Section 4 of the paper conclusions for a legal framework to regulate the health insurance market are drawn. We have to be aware that the validity of the results is restricted to only a part of the health insurance sector, i.e., to treatment methods for which some people would not be willing to pay for without insurance. In this area of health insurance, the implementation of a private, voluntary insurance market, where risk classification using any kind of costless information is allowed, would be efficient. For all remaining treatment methods, a basic

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16 See Edenberg et al. (1997), Maziade et al. (1997), and Meissen et al. (1988).
18 For example, a positive test for BRCA1 raises breast cancer risk up to 50% until the age of 50, but BRCA1 is responsible for less than 10% of all breast cancer cases, see Strachan and Read (1996). Another example would be osteoarthritis, see Keen et al. (1997).
(perhaps national) insurance without risk classification is more appropriate from an efficiency point of view.

2. Benefits from signing a health insurance contract

2.1. Basic assumptions

The model is based on the following assumptions.

There are two states of the world, health \((s = 1)\) and illness \((s = 2)\). All individuals have the same state independent initial wealth endowment \(W_0\). There is only one kind of disease which affects people accidentally and independently. The disease does not cause death but some kind of restriction in the quality of life \(^{19}\) so that it reduces utility from \(U_i(W_o)\) to \(U_i(W)\), where \(U_i(W) > U_i(W_o)\) for all \(W\). Individuals are assumed to be risk-averse and have a strictly concave utility function in both states of the world (where \(U'_i(W) > 0, U''_i(W) < 0, U_i(W) \to 0\) for \(W \to 0\), \(s = 1, 2\)). Moreover we assume that there exists only one kind of treatment, leading to full recovery at financial costs of \(T\), which might well be larger than \(W\). \(^{20}\)

Throughout the paper the expected utility of an insured person will be abbreviated as \(EU(p, a, r)\), where \(p_i\) is the personal illness probability (where \(0 < p_i < 1\)), \(a\) is the share in treatment cost that is refunded and \(r\) is the price of one unit of refund, so that

\[
EU(p, a, r) = (1 - p_i)U_i(W_0 - arT) + p_iU_i(W_0 - T + a(1 - r)T). \tag{1}
\]

Expected utility in case of no insurance will be written as \(EU(p; 0)\):

\[
EU(p, 0) = (1 - p_i)U_i(W_0) + p_i \max[U_i(W_0) ; U_i(W_0 - T)] \tag{2}
\]

In case of illness an uninsured person would be willing to pay at most \(R(W)\) for full recovery. \(^{21}\) This implies

\[
U_i(W) = U_i(W - R(W)). \tag{3}
\]

As \(U_i(W) \to 0\) for \(W \to 0\) willingness-to-pay is smaller than wealth.

Initially, we assume that all individuals have the same illness risk \(p\). There exists a fully competitive insurance market where firms compete in contracts. If information is distributed symmetrically, then everybody is offered a health

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\(^{19}\) For example, in case of illness, the patient suffers from chronic pain.

\(^{20}\) The model is static and therefore limited. However, we know from the theory of adverse selection that for infinitely many periods, the first best can be obtained (Dionne, 1983). For finitely many periods, efficiency losses through adverse selection are reduced, but very similar to those in single period models.

\(^{21}\) A similar analysis has been carried out by Cook and Graham (1977).
insurance contract that refunds all treatment costs \((a = 1)\) at a fair premium of \(pT\). If we define \(B\) as the benefit from signing the insurance contract, we get:

\[
B = EU(p,1,p) - EU(p,0) = U_t(W_0 - pT) - (1 - p)U_t(W_0) - pU_t(W_0 - \min[T; R(W_0)])
\] (4)

If \(T < R(W_0)\), \(B\) is nonnegative for all \(0 < p < 1\). In this case every risk-averse utility maximizing individual would sign a health insurance contract at the fair premium, and standard insurance market models can be applied.

2.2. Benefits from health insurance in case of treatment costs higher than willingness-to-pay

In the introduction it has been asserted that in a considerable part of the health care sector treatment costs are higher than an uninsured person’s willingness to pay. In cases where \(T\) exceeds \(W\) this statement is trivial, and examples in health care are not hard to find (e.g., in the areas of transplantation medicine or dialysis). Examples for situations with \(W > T > R(W)\) might be a visit to the health resort, treatment by the chief of staff, etc. In further analysis it will be shown that utility maximizing individuals may benefit from fair insurance against treatment costs higher than willingness-to-pay.

If \(T > R(W_0)\), Eq. (4) simplifies to

\[
B = U_t(W_0 - pT) - (1 - p)U_t(W_0) - pU_t(W_0 - R(W_0)).
\] (5)

\(B\) can be considered as a function of \(p\), and now can adopt positive or negative values. With respect to \(p\), \(B\) reaches a maximum \(^{23}\) where

\[
U_t(W_0 - pT) = \left[U_t(W_0) - U_t(W_0 - R(W_0))\right]/T.
\] (6)

An interior solution only exists if the derivative of \(B\) at \(p = 0\) is positive:

\[
U_t'(W_0) < \left[U_t(W_0) - U_t(W_0 - R(W_0))\right]/T.
\] (7)

This is the necessary condition for \(B\) to have a positive value. For a graphic analysis, see Fig. 1. An individual with illness probability \(p\) can reach point \(C\) on curve \(U_\tau\) at net wealth \(W_0 - pT\) by signing an insurance contract with premium \(pT\). His expected utility in case of no insurance corresponds to the \(y\)-value of

\(^{22}\) This assumption corresponds to the observation that real health insurance companies in case of illness refund treatment costs and do not pay out money without treatment. The two main reasons are that treatment in may cases not only aims at cure but also prevention, and that results from treatment attempts often are part of the diagnosis.

\(^{23}\) Since \(d^2B/dp^2 = U_t'(W_0 - pT)T^2 < 0\), the second-order condition corresponds to a maximum.
point D, lying on line $A_1A_2$ at the same net wealth $W_0 - pT$. 24 The vertical distance between C and D thus measures the benefit from signing the health insurance contract. If condition (7) holds, apart from $A_1$ there is one more intersection (point E) between utility curve $U_1$ and line $A_1A_2$. Accordingly, if $p$ is lower (higher) than some critical value $p_{\text{crit}}$, $B$ is positive (negative) and the individual will sign the health insurance contract (stay without insurance), respectively.

As an important result of these considerations we note that in case of treatment costs higher than willingness-to-pay, signing a fair insurance contract is advantageous if and only if condition (7) holds and $p$ is smaller than $p_{\text{crit}}$. Only low risks insure under a fair premium. This becomes clear if one considers that a fair premium from point of view of the insurer is unfair for the insured, as his willingness to pay is lower than treatment costs. On the other hand, insurance still eliminates any risk. For the high risks, the first effect dominates, so they do not buy insurance cover. While for low risks, if condition (7) holds, the second effect is more relevant. 25

24 This can be seen by noting that the dotted line connects the points $A_1 \{W_0; U_1(W_0)\}$ and $A_2 \{W_0 - T; U_2(W_0)\}$, and that it is cut by D in a ratio of $p(1 - p)$. Expected utility without insurance is calculated from $EU(p, 0) = (1 - p)U_1(W_0) + pU_2(W_0)$, which is the y-value of point D.

25 We thank one referee for pointing this out to us.
2.3. Efficiency effects of categorical discrimination in case of symmetric distribution of information

Having derived the demand for insurance under a fair premium, we now consider the effects of genetic testing on health insurance markets if the test results are available to the insurer. Hoy (1989) showed that there might be positive efficiency effects, if insurers could observe risk avoidance behavior and adjust premium rates accordingly. These effects will be left aside here.

Assume that initially insureds are not informed about their risk types and believe their illness probability to be as high as the average risk \( p \) (where \( 0 < p < 1 \)). Furthermore we assume that there exists a test to find out, if one’s risk type is either \( p_L \) or \( p_H \). The test causes per capita costs of \( c \) utility units, and insurers are allowed to gather the test results from the insureds and use them for premium calculation. The ex ante per capita benefit \( G \) from taking the test can be calculated from

\[
G = q_H \max [EU(p_H, 0); EU(p_H, 1, p_H)] + (1 - q_H) \max [EU(p_L, 0); EU(p_L, 1, p_L)] - \max [EU(p, 0); EU(p, 1, p)] - c.
\]

(8)

where \( q_H \) is the probability of having a positive test result, such that

\[
q_H p_H + (1 - q_H) p_L = p.
\]

At first we assume \( p \leq p_{crit} \), (and consequently \( p_L < p_{crit} \)), so that uninformed individuals would choose to fully insure. This implies

\[
G = q_H \max [EU(p_H, 0); EU(p_H, 1, p_H)] + (1 - q_H)EU(p_L, 1, p_L) - EU(p, 1, p) - c.
\]

(9)

If \( p_H \leq p_{crit} \), the value of \( G \) is always negative, since \( EU(p_H, 1, p_H) > q_H \max [EU(p_H, 1, p_H)] + (1 - q_H)EU(p_L, 1, p_H) \). Then genetic tests only lead to premium risk, an effect well known from the standard models.

In case of \( p_H > p_{crit} \), high risk types would not sign an insurance contract, while low risk types would. As \( EU(p_H, 0) > EU(p_H, 1, p_H) \), the benefit \( G \) then is calculated from

\[
G = q_H EU(p_H, 0) + (1 - q_H)EU(p_L, 1, p_L) - EU(p, 1, p) - c,
\]

(10)

which can be positive if costs of testing are low. An example is given in Fig. 2, where testing costs are assumed to be zero. Uninformed individuals will fully insure and reach an expected utility of \( EU(p, 1, p) = U(W, pT) \) in point C. After taking the test and learning their risk types, high-risk individuals will not sign an insurance contract and have an expected utility of \( EU(p_H, 0) = (1 - p_H)U(W_0) + p_H U(W_0 - RW_H) \), which corresponds to the \( y \)-value of point H. Low risk individuals will become insured and reach point L. Ex ante expected utility of an uninformed person, if he learns his risk type, can be seen from the
Fig. 2. Tests can be welfare improving.

y-value of point C*, the point on line HL at net wealth $W_0 - pT$. Thus, the benefit $G$ from taking the test in this example is the vertical distance between the points C and C*.

We can conclude that, in case of $p_H > P_{crit}$ and zero information costs, $G$ is strictly positive if $p_{crit} \geq p > p'$, i.e., if an uninformed insured would reach a point within the segment EJ of the $U_1$ utility curve, where $J[W_0 - p'T; U_i(W_0 - p'T)]$ is the intersection point between line HL and the $U_i$ utility curve.\(^5\)

If $p > P_{crit}$ (and consequently $p_H > P_{crit}$), uninformed individuals would choose not to insure, and $G$ can be calculated from

$$G = q_H \text{EU}(p_H,0) + (1 - q_H)\max\{\text{EU}(p_L,0)\};$$

$$\text{EU}(p_L,1,p_L) - \text{EU}(p,0) - c. \quad (11)$$

For zero information costs, $G$ then is always nonnegative and strictly positive if $p_L < P_{crit}$. In the example shown in Fig. 2, $G$ in case of $p > P_{crit}$ corresponds to the vertical distance of lines HL and HE at the respective net wealth $W_0 - pT$.

\(^5\) Accordingly, $p'$ is defined as the minimum value for average illness probability, at which $G$ is nonnegative if $c = 0$, and depending on the given values for $p_L$ and $p_H$. This implies, that the number of high risks has to be sufficiently large for $p$ to be larger than $p'$. 


With positive information costs no general statement is possible. If $p_H > p_{\text{crit}}$ and $p_L < p_{\text{crit}}$, the ex ante benefits from taking the test can be positive or negative, but are always negative if $p \leq p'$ or $p_L = 0$.

To complete the analysis, we summarize the results of the relationship between the value of a test and the precision of the test in case of informational symmetry. In contrast to standard models, where premium risk always reduces welfare, the value of a predictive (genetic) test can be positive if (1) members of the carrier group choose not to be insured, and (2) a negative test result does not imply that non-carriers are immune against the illness. This implies that the highest efficiency is obtained if members of the carrier group have a very large illness risk, while members of the non carrier group still have a non negligible illness risk.

3. Health insurance market equilibria under asymmetric information

In the following, we discuss the potential candidates for an equilibrium of the competitive insurance market, if the information about the risk type is not available to the insurer. First, a full insurance pooling contract which can only result out of governmental regulation is considered. Then, the Wilson E2 equilibrium, which under some conditions is also a pooling contract, but not with full insurance, is analysed. Separating contracts in form of the standard Rothschild–Stiglitz equilibrium and the Wilson–Miyazaki–Spence equilibrium, which in the standard models is second best efficient, are discussed. We will show that in this model there are parameter constellations where in all of the abovementioned equilibrium concepts the market breaks down. In Section 3.3, the consequences of genetic tests in a market where insurers are not allowed to use this information are discussed.

3.1. Existence of a pooling contract market equilibrium

As before, assume that the population consists of a proportion $q_H$ of individuals with high illness probability $p_H$ and a proportion $(1 - q_H)$ of people with low illness probability $p_L$ (where $0 < q_H < 1$, $0 < p_L < p_H < 1$ and $p_L < p_{\text{crit}}$). Furthermore assume that insurance companies cannot distinguish between the different risk types, whereas applicants know their own illness risks. All of these parameters and the model conditions are assumed to be common knowledge. The

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27 A more detailed analysis can be found in a previous version of this paper, which is available from the authors on request.
break even pooling insurance premium (everybody is insured at the same premium) is calculated by

$$paT = \left[ q_H p_H + (1 - q_H) p_L \right] aT$$

(12)

where $p$ is the average illness risk and $a$ is the share in the treatment costs that the insurance company refunds (with $0 \leq a \leq 1$, in case of full insurance $a = 1$).

Under the asymmetric informational distribution, pooling contracts cannot form an equilibrium in a free competitive market. 28 However, in order to reach a social optimum, the government could be willing to install a pooling equilibrium, 29 and as an alternative to a compulsory national health insurance could oblige private insurance companies by law to exclusively offer pooling contracts. 30 This is what we will assume now.

As people will only get insured if they receive a nonnegative benefit, i.e., $EU(p,a,p) \geq EU(p,0)$, the following participation constraints must be fulfilled:

$$(1 - p_L)U_i(W_0 - paT) + p_L U_i(W_0 - T + (1 - p) aT) \geq (1 - p_L)U_i(W_0)$$

$$+ p_L U_i(W_0 - R(W_0)), \ i = L, H$$

With only full insurance contracts allowed, the low risk types participation constraint becomes:

$$U_i(W_0 - pT) \geq (1 - p_L)U_i(W_0) + p_L U_i(W_0 - R(W_0))$$

(13)

The low risk types participation constraint here 31 is more restrictive than the high risk types participation constraint, since low risk types have a higher expected utility without insurance. For a given $p_L$ let $p_{\text{max}}$ be defined as the maximum pooling probability that fulfils the low risk types participation constraint so that $EU(p_L,0) = U_i(W_0 - p_{\text{max}}T)$. If $p > p_{\text{max}}$, then low risk types will choose not to sign an insurance contract. High risk types under these conditions can only be offered contracts at the risk equivalent premium rate. They will become insured if

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28 Insurance companies could offer profitable contracts that would attract only low risk types as long as competitors do not draw back their pooling contract offers from the market. See also Dionne and Doherty (1992).

29 Different attempts to rectify the problems of adverse selection by governmental intervention have been discussed in Neudeck and Podczeck (1996).

30 As a matter of fact, German private insurance companies have committed themselves do not change anyone more than twice the average premium.

31 As is evident from Fig. 3, the low-risk types participation constraint is always more restrictive than the high-risk types participation constraint, since high risk types would prefer any point on the segment $AP$ of indifference curve $EU(p_L,0)$ at least weakly to a point on indifference curve $EU(p_H,0)$. 
If $p_H < p_{\text{crit}}$, i.e., if their participation constraint is fulfilled. If $p_H > p_{\text{crit}}$, however, it is possible to find values for $p$ so that the whole insurance market breaks down, although average illness probability $p$ is below $p_{\text{crit}}$. An example for this is shown in Fig. 1. Low risk types will choose not to insure, since their expected utility in case of no insurance ($y$-value of point L) is higher than their expected utility signing a full insurance pooling contract ($y$-value of point C). High risk types will prefer not to become insured, because if low risks do not insure, they are only offered insurance contracts at the risk equivalent premium, which lies below point H. As a result there is no possibility of insuring anyone, though low risk individuals could be made better off by risk equivalent insurance contracts, and though every individual would choose to be insured, if he did not know his risk type.

The results are not much different if also partial insurance contracts at the average pooling premium are allowed. In standard insurance models under these conditions the so-called Wilson E2 equilibrium is established, if sufficiently many low risks exist. See Fig. 3 for a graphic analysis. Uninsured individuals reach point A [$W_0, W_0 - R(W_0)$]. Hence, in order to make somebody sign an insurance contract he has to be offered at least the expected utility of his indifference curve.

32 Note that $EU(p_{\text{crit}}, 1, p_{\text{crit}}) = EU(p_{\text{crit}}, 0) < EU(p_{\text{crit}}, 0)$.
33 See Wilson (1976; 1977), and Hoy (1982).
through point A. Fair insurance lines, however, are drawn through point A [\(W_0; W_0 - T\)], since insured individuals in case of illness receive the treatment. Low risk types reach their highest possible indifference curve at the tangency point (point \(P^*\) in Fig. 3) with the pooling insurance line. For a Wilson E2 equilibrium to exist, for a given \(p_L\) the low risk types participation constraint (13) requires that \(p \leq p_{\text{max}}\), where \(p_{\text{max}} > p_{\text{max}}\). Conditions for the existence of a Wilson E2 equilibrium therefore are more slack than for a full insurance pooling equilibrium. If \(p_{\text{crit}} \geq p_U > p > p_{\text{max}}\), however, only high risk types are insurable. The premium then has to be risk equivalent. In case of \(p_U > p_{\text{crit}}\) and \(p_{\text{crit}} \geq p > p_{\text{max}}\) again no one can be insured, though uninformed individuals would choose full insurance.

As an important conclusion these results suggest that a health insurance regulation obliging firms to exclusively offer pooling contracts can cause severe market failure, if insureds have information about their risk types. In contrast to the findings of standard insurance models, where at least high risks are always insured, the market can even break down although uninformed individuals would choose to sign a fair insurance contract. At a fair pooling premium the low risks may not be willing to buy insurance, which could also hold in standard insurance models under asymmetric information. However, high risks, if offered their fair premium, might rationally decide not to buy insurance, therefore the market breaks down.

3.2. Existence of a separating contracts–market equilibrium

3.2.1. Rothschild–Stiglitz-type equilibrium

In this section, the assumption that only pooling contracts are allowed is dropped. If firms can offer separating insurance contracts, in standard insurance models a Rothschild–Stiglitz-type market equilibrium exists, if the proportion of high risk individuals is sufficiently high. However, this is not the case if treatment costs exceed the willingness to pay. There are two effects which work against this even if the number of high risk types is large: first, high risks may choose not to become insured and second, the participation constraint of the low risk type is more restrictive, as in case of non-insurance he does not bear the full cost of treatment \(T\) but only \(R(w)\), his willingness to pay. Let us proceed to show how these effects interact.

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34 The fair insurance life is defined as the set of points offered by insurance contracts which earn zero expected profit.
35 \(p_{\text{max}}\) here is defined as the value for \(p\), at which the low risk types participation constraint (13) holds as an equality, given that the insurance market is in a Wilson E2 equilibrium.
36 For the results obtained by standard insurance models see Neudeck and Podczeck (1996).
37 For a detailed analysis see Rothschild and Stiglitz (1976).
In the separating equilibrium, the contracts must satisfy the incentive constraint to prevent high risk types from choosing the low risk types contract:  

\[ \text{EU}(p_H, a_L, p_L) \geq \text{EU}(p_H, a_L, p_L) \]  

In addition to this the participation constraints for both risk types must be fulfilled. Individuals will sign the insurance contracts only if expected utility is at least as high as without insurance:

\[ \text{EU}(p_i, a_i, p_i) \geq \text{EU}(p_i, 0) \Rightarrow (1 - p_i)U_i(W_0 - p_i a_i T) + p_i U_i(W_0 - T) 
+ (1 - p_i) a_i T \geq (1 - p_i) U_i(W_0) + p_i U_i(W_0 - R(W_i)), \quad i = L, H \]  

In case of treatment costs higher than willingness-to-pay, the participation constraint for low risk individuals makes the conditions for the existence of a Rothschild–Stiglitz-type equilibrium more restrictive, as is evident from the corresponding Fig. 4. The intersection point L between the zero-profit insurance line AL and indifference-curve EU(p_L, 0) marks the minimum accepted partial insurance contract for low risk individuals at their risk equivalent premium (a_L p_L T). To prevent high risk individuals from choosing the low risk types

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The incentive constraint for low risk types is never binding, see Rothschild and Stiglitz (1976).
contract, their own contract must provide them at least with \( \text{EU}(p_H^*_1,1,p_H^*) \), where \( \text{EU}(p_H^*_1,1,p_H^*) = \text{EU}(p_H^*,a_L,p_L) \). Therefore, for a given \( p_L \), the necessary condition (which is also sufficient if the proportion of high risk types is large) for the existence of a Rothschild–Stiglitz-type market equilibrium is \( p_H \leq p_H^* \), where \( p_H^* < p_{\text{crit}} \).

3.2.2. Wilson–Miyazaki–Spence equilibrium (WMS-equilibrium)

In this market equilibrium concept cross-subsidies between separating contracts are allowed, which leads to a second best Pareto efficient outcome in the standard adverse selection models.

The analysis of this equilibrium concept will be restricted to a short graphical discussion. As can be seen in Fig. 5, the conditions for the existence of a WMS-equilibrium are less restrictive than for the existence of pooling contract equilibria.

By subsidizing high risk types contracts low risk types can realize points on the feasible set (i.e., the line that connects the points K, L’ and A in Fig. 5). In the WMS-equilibrium the low risk types contract is given at tangency point L between the low risk types indifference curve \( \text{EU}(p_L^*,d_L,p_L^*) \) and the feasible set, while the high risk type obtains full insurance and is indifferent to this contract. The WMS-equilibrium can only exist if the low risk type is better off at contract L than with his reservation utility.

For a given \( p_L \), the necessary condition is therefore that \( p \leq p_{\text{max}}^* \), where \( p_{\text{max}}^* > p_{\text{max}}^* > p_{\text{max}}^* \). If \( p_{\text{crit}} > p_H > p > p_{\text{max}}^* \), however, only high risk types are insurable (full insurance at risk equivalent premium). If \( p_H > p_{\text{crit}} > p > p_{\text{max}}^* \), neither low nor high risk types will choose to sign an insurance contract, and the insurance market breaks down.

3.3. Efficiency effects of informational asymmetry

Here we summarize the efficiency effects genetic tests will have on the insurance market, if their results are not available to the insurer. Assume that

\[ \text{EU}(p_L^*,a_L,p_L) = \text{EU}(p_H^*,0) \Rightarrow \text{EU}(p_H^*,a_L,p_L) > \text{EU}(p_H^*,0) \Rightarrow \text{EU}(p_H^*,1,p_H^*) > \text{EU}(p_H^*,0) \Rightarrow p_H^* < p_{\text{crit}}. \]

\[ p_{\text{max}}^* \text{ is defined as the maximum value for } p_H, \text{ at which the high risk types incentive constraint is fulfilled, provided that the low risk types contract offers minimal accepted partial insurance } (a_L). \]

\[ \text{For detailed analysis see Wilson (1977), Miyazaki (1977), Spence (1978), and Crocker and Snow (1986).} \]

\[ p_{\text{max}}^* \text{ is defined as the value for } p, \text{ at which the low risk types participation constraint (13) holds as an equality, given that the insurance market is in a WMS equilibrium.} \]

\[ \text{The contracts of a WMS-type market equilibrium can be regarded as the combination of a partial insurance pooling contract and in addition contracts of a Rothschild–Stiglitz-type equilibrium, see Neudeck and Podczeck (1996). Hence, the low risk types indifference curve does not touch the pooling insurance line.} \]
individuals are initially uninformed about their risk type. Now they undergo a test such that everyone is informed whether he is a low risk or a high risk type.

As the benchmark case consider the standard model, where willingness-to-pay is larger than treatment costs: in this case, individuals are indifferent between the two regimes if in the latter one the pooling outcome at full insurance is offered. In all other market equilibria (Wilson E2, Rothschild–Stiglitz, WMS) individuals are worse off through genetic tests. The market will not break down.

If willingness-to-pay is below treatment costs, the first and the last results may not longer hold. First, even if firms are obliged to offer the same pooling contract to everyone, individuals may be worse off. This might happen because low risks may not buy insurance at the pooling premium so that high risks have to pay their fair premium. Second, in all equilibrium concepts, the market may break down. The reason for this result is that the contract possibility curve for the low risks (see Fig. 5) may not contain a contract which the low risks prefer to not being insured. If that is the case, the high risks can only obtain insurance at their fair premium. If however, their risk is large, high risks might not buy insurance at this price.

4. Discussion and policy considerations

4.1. Health insurance market and health insurance market models

The health insurance model presented in this paper is different from standard insurance models that have been widely used to study problems of informational
asymmetry and efficiency effects of categorical discrimination. While in liability insurance most of the time there is a definite financial loss, this is not the case in health insurance. In case of illness at first there is a loss of quality of life. This loss can only be transformed into a financial loss by undertaking a treatment. However, most of the time there are many alternatives for treatment, which might differ a lot in respect of their costs and effects. In fact, there is always another diagnostic measure or step of treatment that still has a marginal positive effect but causes such high costs that uninsured individuals would not be willing to pay for it, especially in treatment of chronic diseases. Besides that, treatment of manifested chronic diseases sometimes is also preventive treatment, and successful treatment is often part of the diagnosis. Therefore, in contrast to liability insurance companies, health insurance companies only refund treatment costs and do not pay out money to sick patients who reject undergoing treatment.

Building a model for the health insurance market, these characteristics have to be integrated and simplified without being too restrictive. The use of state contingent utility functions seems to be quite an appropriate way of substantiating the transformation of the loss of well-being into a financial loss. The only restriction caused by this assumption might be the exclusion of acute life-threatening diseases from the analysis. However, if treatment only reduces mortality marginally, the model can also be applied to acute diseases.

The quality of the results obtained would not be different, if the assumptions were dropped that treatment provides perfect restoration of health. In fact, it is the assumption that treatment costs are higher than willingness-to-pay which drives the main results. Still, rational individuals with low risks will demand insurance that refunds costs of those kinds of therapies where $T > R(W_0)$, although they would not be willing to pay for the treatment in case they were ill. This might be quite an important aspect in health insurance that so far has not received much attention in the analysis of insurance markets under asymmetric information. As has been shown in this paper, results from standard insurance market models may not simply be transferred to health insurance markets. On the basis of the present model, policy conclusions for the regulation of health insurance markets have to be thought over.

4.2. Efficiency effects of new methods for risk classification

In Section 2.3, it has been argued that under certain conditions costless categorical discrimination can enhance efficiency on private health insurance

\[\text{45} \text{As an example, consider diabetes: Regular application of insulin relieves symptoms as well as it prevents subsequent organic diseases like the diabetic nephropathy. For details see Wilson et al. (1992).}\]

\[\text{46} \text{In angina pectoris, e.g., the diagnosis is based on the effect of the application of nitrovasodilators, see Wilson et al. (1992).}\]

\[\text{47} \text{As pointed out by one referee, dread disease life insurance is an exception.}\]
markets. In contrast to standard models, making the results of genetic tests available to the insurer might be welfare improving. The efficiency gain is maximized if carrier have a very large illness risk, while non carriers still face some non-negligible risk. This is a characteristic that some genetic tests seem to have in deed, since many common diseases (e.g., osteoarthritis 48) have a hereditary, genetically detectable variant as well as a genetically not detectable variant. Efficiency gains from risk classification concerning these diseases have to be regarded as relatively high.

National health insurance fails to reach efficiency in cases where costless categorical discrimination is able to enhance welfare. Under national insurance, the insurance contract for high risk types covers treatment methods that informed high risk types would not want to be included in their optimal health risk insurance bundle, so that high risk types have to be regarded as overinsured. In contrast, low risk types to this extent remain underinsured.

As follows from the analysis in Section 3, results from predictive tests can have disastrous efficiency effects on private insurance markets if there is asymmetric distribution of information. Depending on the legal framework, insurance market equilibria can be of the Rothschild–Stiglitz–Wilson E2- or Wilson–Miyazaki–Spence-type, in all of which the ex ante expected utility is lower than under the condition of no information about risk types. 49 In case of treatment costs higher than willingness-to-pay, the insurance market can even collapse.

Now, if we try to draw conclusions from the health insurance model, we have to be aware that in the real situation there are many different kinds of diseases and treatment possibilities so that there is a multidimensional problem. Indeed, we can regard real health insurance as a bundle of numerous unique health insurance contracts each covering costs of one specific way of treatment applicable in one specific diagnosis. If we assume that individuals are able to freely and independently combine essential contracts in order to form their optimal health insurance bundle, then the feasible bundle will become smaller if the market collapses for one of those essential contracts. In the case of asymmetric information this leads to an efficiency loss because of underinsurance of low risk individuals, since they cannot include all the desired essential contracts into their insurance bundle. As has been shown in Section 3.1, this underinsurance of low risk individuals is even more distinctive if the legislation framework admits only pooling (and no separating) contracts. In those cases, forcing insurance companies to sell pooling contracts in health insurance has to be considered as an inadequate way to reach efficiency.

48 See Keen et al. (1997).
49 See also Doherty and Thistle (1996) for an analysis where willingness to pay is equal to treatment costs.
4.3. The characteristics of an optimal health insurance system

In the introduction it already has been explained that the rapid development in the area of genetic testing forces economists to be concerned about efficiency in health insurance. Moreover, medical research has produced several commonly used tests with a similar predictive power as genetic tests have (e.g., tests for cholesterol or high blood pressure).

The analysis in the previous sections leads to conclude that efficiency can neither be reached in a private insurance system without restrictions concerning risk classification, nor in a purely governmental insurance system free from risk classification. Without restrictions, the insurance market will carry out categorical discrimination even in cases where it is inefficient (in case of $T < R(W_0)$, where discrimination leads to inefficient premium risk, or in case of high information costs 50). On the other hand, a national health insurance system will fail to provide low risk types with insurance against very expensive treatment methods while high risk types may be overinsured.

Taken all these observations together, a combination of a market solution and a governmental solution seems to be the best feasible way to organize the health insurance market. To cover treatment of all acute life threatening diseases and those treatment methods for chronic diseases where $T < R(W_0)$ can be supposed, a basic compulsory national insurance without risk classification or a compulsory private insurance scheme where firms are required to offer the same full insurance contract to everyone should be kept or implemented. Besides this, private insurance contracts using categorical discrimination to a certain extent should be admitted to cover demand of low risk types for additional health insurance.

However, within this analysis the question of whether private insurers should generally be allowed only to gather all already available risk relevant information from applicants, or if they should also be allowed to require applicants to undertake some specific tests as a prerequisite for certain insurance contract offers, remains unsolved.

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50. See Crocker and Snow (1986), Hoy (1982), and Borenstein (1989).
References

Ad Hoc Committee on Genetic Testing/The Insurance Issues, 1995. Background statement: genetic
American College of Medical Genetics/American Society of Human Genetics Working on Apoe and
JAMA 274 (20), 1627–1629.
diabetes mellitus using CASPAR, a software and statistical program for conditional analysis of
Cook, P.J., Graham, D.A., 1977. The demand for insurance and protection: the case of irreplaceable
commodities. Q. J. Economics 91, 143–156.
Crocker, K.J., Snow, A., 1986. The efficiency effects of categorical discrimination in the insurance
329–348.
Dionne, G., 1983. Adverse selection and repeated insurance contracts. Geneva Papers on Risk and
Insurance 8, 316–332.
Doherty, N.A., Thistle, P.D., 1996. Adverse selection with endogenous information in insurance
Edenberg, H.J., Foroud, T., Conneally, P.M., Sorbel, J.J., Carr, K., Crose, C., Willig, C., Zhao, J.,
Miller, M., Bowman, E., Mayeda, A., Rau, N.L., Smiley, C., Rice, J.P., Goate, A., Reich, T., Stine,
O.C., McMahon, F., DePaulo, J.R., Meyers, D., Detera-Wadleigh, S.D., Goldin, L.R., Gershon,
E.S., Blehar, M.C., Nurnberger, J.J., 1997. Initial genomic scan of the NIMH genetics initiative
Giardiello, F.M., Brensinger, J.D., Petersen, G.M., Luce, M.C., Hylind, L.M., Bacon, J.A., Booker,
Goellner, G.M., Tester, D., Thibodeau, S., Almqvist, E., Goldberg, Y.P., Hayden, M.R., McMurray,
C.T., 1997. Different mechanisms underlie DNA instability in Huntington disease and colorectal
polyposis tumor suppressor locus at 10q22 is deleted from nonepithelial cells in the lamina propria.
Gastroenterology 112 (4), 1398–1403.


