Genetic testing in competitive insurance markets with repulsion from chance: a welfare analysis

Michael Hoel\textsuperscript{a, c, d}
\texttt{m.o.hoel@econ.uio.no}

Tor Iversen\textsuperscript{b, c, d}
\texttt{tor.iversen@medisin.uio.no}

Tore Nilssen\textsuperscript{a, c, d}
\texttt{tore.nilssen@econ.uio.no}

Jon Vislie\textsuperscript{a}
\texttt{jon.vislie@econ.uio.no}

\textsuperscript{a}Department of Economics, University of Oslo, P.O. Box 1095 Blindern, N-0317 Oslo, Norway
\textsuperscript{b}Department of Health Management, University of Oslo, P.O. Box 1089 Blindern, N-0317 Oslo, Norway
\textsuperscript{c}HERO – Health Economics Research Programme at the University of Oslo
\textsuperscript{d}The Ragnar Frisch Centre for Economic Research, Oslo

Revised version June 2005

Abstract
A central theme in the international debate on genetic testing concerns the extent to which insurance companies should be allowed to use genetic information when offering insurance contracts. We provide a welfare analysis of this issue within a model of an insurance market with asymmetric information, having the following crucial feature: In addition to a state-contingent consumption profile, a person’s well-being depends on her attitude towards resolution of future health uncertainty, and this attitude varies across the population. We present stylized facts that motivate this approach. In the formal analysis, we find that both tested high-risks and untested individuals are equally well off whether or not test results can be used by insurers. Individuals who test for being low-risks, on the other hand, are made worse off by not being able to verify this to insurers. This implies that, in terms of welfare, a regulatory regime in which the use of genetic information by insurers is allowed is better than one in which it is not allowed.

JEL Classification: I11, D82, I18

* We have received valuable comments from Simon Grant, Aanund Hylland, and, in particular, from an anonymous referee, whose suggestions for improvement are highly acknowledged. We gratefully acknowledge financial support from the Research Council of Norway through HERO – Health Economic Research Programme at the University of Oslo.
1. Introduction
The mapping of the human genome creates a potential for revealing individuals’ susceptibility to disease and for preventing the outbreak of disease by means of genetic engineering. Hence, this research offers a promise of huge health improvements. At the same time, however, a central theme in the international debate on genetic testing concerns who should have access to an individual’s genetic information. The question of whether insurers should be allowed to ask for genetic information for underwriting purposes is at the forefront of the discussion. Presently, regulations vary between countries, and the need for knowledge about properties of alternative information regimes seems to be urgent.

Our analysis adds to the discussion by drawing attention to the importance of individuals’ intrinsic desire to know (or not know) about their future risk status. An individual’s perceived risk of future disease may influence the anxiety about the future and, hence, today’s utility status. Compared to an individual’s situation as untested, testing may result in either an upward or a downward adjustment of the risk. Hence, the test is like a lottery, and the decision to take a test is likely to be influenced by the estimated risk in the alternative states and the individual’s attitude towards risk. Because of a dislike for knowing the test result, an individual may choose to stay uninformed even if becoming informed would be beneficial for the purpose of buying insurance. The preference for either remaining ignorant or being informed is obviously an important issue, as seen from what a director of a genetic counseling program reported in The New York Times Magazine:

“[T]here are basically two types of people. There are “want-to-knowers” and there are “avoiders”. There are some people who, even in the absence of being able to alter outcomes, find information of this sort beneficial. The more they know, the more their anxiety level goes down. But there are others who cope by avoiding, who would rather stay hopeful and optimistic and not have the unanswered questions answered.”

1 For a brief overview of regulations and policy statements, see Hoel and Iversen (2002).
2 September 17, 1995. We have taken this from Grant, Kajii and Polak (1998).
In this paper, we want to analyze welfare effects of genetic testing in a competitive insurance market under alternative regulations of insurers’ access to testing information, when the preference for learning about future health risks varies among individuals.

Motivated by stylized facts reported in the medical literature reviewed in section 2, our modeling approach highlights two features not analyzed simultaneously in the literature until now. The first feature is the utility loss related to the anxiety of receiving information about the probability of a future disease, while the second feature is the role of the verifiability of test results for the attainment of beneficial insurance. An individual chooses to test prior to buying insurance if the expected utility with a test is greater than the expected utility without it.\(^3\) Her expected utility depends not only on income in the healthy and the unhealthy states, but also on the loss of utility related to information about the probability of a future disease. The importance of this probability is assumed to vary among individuals. While some are attracted to chance, others are repelled from chance, as indicated by the above quote. Naturally, the more attracted to chance one is, the more reluctant one is to choose testing. In an insurance market with asymmetric information about individuals’ probabilities of having a disease, we find that the fraction of individuals taking a genetic test is higher when test results are verifiable, and so can be used by insurers, than when they are not. The outcome in the verifiability case is also more efficient, in a second-best sense. Thus, allowing insurers to use test results when they can be made verifiable is welfare improving.

There have been attempts in earlier literature at capturing individuals’ intrinsic preferences for information. An early contribution is the dynamic non-expected utility model of Kreps and Porteus (1978), which was recently generalized by Grant, et al.

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\(^3\) We consider tests that are predictive in the sense that the occurrence of a future disease is uncertain even after the test is done. Furthermore, we consider voluntary health insurance and disregard possible preventive actions against disease. We also disregard information prior to the test, for instance based on family history.
(1998). These studies highlight the temporal nature of uncertainty resolution. In comparison, our aim is a practical one and we model preference for information in the simplest possible way. In particular, we do not distinguish between early-resolution and late-resolution preferences, as done in Kreps and Porteus (1978), and in Grant, et al. (1998). We rather represent individuals’ attraction to, respectively repulsion from, chance by introducing a utility loss from the probability of disease. In doing so, we follow the lead of a little known paper by Meginniss (1976). The precise relationship between our notion of attraction to chance, Grant, et al.’s (1998) notion of information aversion, Kreps and Porteus’ (1978) intertemporal aggregator, and other concepts, such as Chew and Ho’s (1994) notion of hope, is, however, left unexplored in the present analysis.

The decision to undertake genetic testing and the potential interaction with the insurance market have also been analyzed by Doherty and Thistle (1996). Like us, they assume that a consumer’s information about her risk status is endogenous, in that an individual decides whether or not to obtain information from testing, and find that the menu of insurance contracts an individual is offered depends on the verifiability of test results. In their set-up, there is no heterogeneity in the population, however, apart from differences in the probability of getting ill. This lack of heterogeneity is why Doherty and Thistle report non-existence of equilibrium when the cost of a genetic test is positive but low.

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4 See also the discussions in Pope (1983, 1998). Our terminology of attraction to versus repulsion from chance is taken from Pope’s work.

5 A utility loss from the probability of a bad outcome also appears in recent works of Caplin and Eliaz (2003) and Caplin and Leahy (2004), which again are based on Caplin and Leahy (2001). A difference from our work is their focus on social interaction, which does not play a role in our setting.


7 See also Hoel and Iversen (2002) and Fagart and Fombaron (2003), who introduce the possibility of disease prevention following a genetic test. Hoel and Iversen are particularly concerned with the combination of compulsory and voluntary health insurance, while Fagart and Fombaron discuss the value of information under alternative assumptions about what information is available to insurers.
One way out is to assume, at the outset, some heterogeneity in the population with respect to the cost of a test. This is not a very realistic assumption, however. Based on the empirical evidence reported in Section 2 below, we choose here another modeling strategy, by letting testing be costless and consumers differ with respect to the disutility or anxiety of being informed about future health risk. As discussed in the concluding remarks, none of our results are changed if we introduce a positive testing cost.

The paper is organized as follows. Section 2 reviews some stylized facts that motivate our approach. In section 3, we present the theoretical novelties of this paper. The benchmark solution, derived from a setting with uncertain but symmetric information, is provided in section 4, where we focus mainly on a person’s incentive to take a test so as to get information about her future health status. When being offered full-insurance contracts, only individuals sufficiently repelled from chance will choose to take a test. In section 5, we assume asymmetric information coupled with the test outcome being verifiable. Because a tested high-risk person under a regime of full insurance will have an incentive to disguise the test outcome by claiming not to have been tested, the equilibrium contracts will now be modified so as to offer untested individuals only partial insurance. But this modification of the menu of contracts will induce a larger fraction of the group of persons repelled from chance to take a test. Finally, in section 6, we relax the assumption that the test outcome is verifiable. Because untested individuals will have incentives to pretend being low-risk, the insurance contract designed for tested low-risk individuals has to be modified. Hence, in this case, both tested low-risk and untested persons are offered partial insurance. Section 7 concludes.

2. Stylized facts
The empirical literature as found in medical journals provides the stylized facts we need. This literature is based on surveys of people with elevated risks of diseases where genetic tests either are available or are likely to be available in the near future. When issues related to health insurance are disregarded, these surveys highlight the subjects’ attraction to, or repulsion from, chance. Studies are of two types. The ex-ante type examines the
factors contributing to people’s stated intentions to undergo testing. In the ex-post type of study, the factors distinguishing those who actually have been tested from those who have not been tested, are examined. In the ex-post type of study the reviewed surveys contain information from individuals with elevated risk of having one out of five diseases: Hereditary breast cancer (BRCA1 and BRCA2), hereditary nonpolyposis colorectal cancer (HNPCC), hereditary prostate cancer, Alzheimer’s disease, and Huntington’s disease.

The genetic test for Huntington’s disease is presymptomatic in the sense that a positive test implies that the outbreak of Huntington’s disease certainly will occur during a later stage of life. There is no preventive action that can be taken. Codori, et al. (1994) study three groups of at-risk persons. The first group has considered, but not chosen genetic testing; the second group has postponed the decision to a later date; and the third group has previously been tested. Of the two untested groups, a significantly larger number of the No group had chosen not to be tested because they anticipated problems associated with their emotional reactions. In our terminology, they are attracted to chance. The persons in the tested group had less often anticipated problems with their emotional reactions if they should be adversely informed.

This result corresponds to the summary by Marteau and Croyle (1998) of empirical knowledge about factors influencing intentions to undergo testing. They suggest that the fraction of people who wish to undergo testing is higher for diseases where the test result may have positive consequences for prevention (BRCA1 and BRCA2, HNPCC) than for diseases without known preventive actions (Huntington’s disease). They also emphasize that, for some people, living in ignorance is worse than knowing the facts, even if the facts should turn out to be bad news. In our terminology, they are repelled from chance. Watson, et al. (2004) show for BRCA 1-2 that people who choose to be tested in fact are able to cope when the test displays that they are carriers. Several studies demonstrate that reducing uncertainty is one of the most common reasons for undergoing a predictive DNA test (e.g., Codori and Brandt (1994), Roberts (2000)). This result, combined with
the fact that some people choose to remain untested, emphasizes the importance of an individual’s attitude to health risk for the testing decision.

3. The model
Consider a continuum of individuals where each individual faces a risk of getting ill. In particular, each individual will end up in one of two states: In the good state 1, she is healthy with an income equal to \( y \); in the bad state 2, she is ill and suffers an income loss \( d \) such that income equals \( y - d \), where \( 0 < d < y \). There are two types of individuals, high-risks and low-risks, with probabilities of getting ill equal to \( p^H \) and \( p^L \), respectively, where \( 0 < p^L < p^H < 1 \). The fraction of high-risk individuals in the population is given by the parameter \( \lambda \in (0, 1) \). Initially, any individual is uninformed about her risk and thus has a probability \( \lambda \) of being high-risk and a probability of getting ill as given by

\[
p^U := \lambda p^H + (1 - \lambda)p^L
\] (3.1)

Insurance is provided by a set of risk-neutral firms. Buying insurance from one of these firms means trading the state-contingent income \( (y, y - d) \) for an income mix \( (y - a_1, y - d + a_2) \), where \( a := (a_1, a_2) \) is an insurance contract with a premium \( a_1 \) payable in state 1 and a net indemnity \( a_2 \) received in state 2. An insurer’s profit from selling a contract \( a \) to an individual who is believed to become ill with a probability \( p \) equals:

\[
\pi(a, p) = (1 - p)a_1 - pa_2
\] (3.2)

Individuals are risk averse. An individual with a probability \( p \) of becoming ill and an attraction to chance given by \( \theta \) obtains the following expected utility when buying contract \( a \):

\[
u(a, p; \theta) := V(a, p) - g(p, \theta) = (1 - p)v(y - a_1) + pv(y - d + a_2) - g(p, \theta)
\] (3.3)
where \( v \) is a strictly increasing, twice continuously differentiable, and strictly concave Bernoulli utility function. The attraction to chance is modeled through the utility loss \( g(p, \theta) \), where \( p \) is the probability, possibly after testing, that a \( \theta \)-individual becomes ill, and \( \theta \) is a measure of the importance of this probability for the individual’s well-being.

One obvious interpretation of \( g(p, \theta) \) is the following: While the term \( V(a,p) \) in (3.3) is a standard expected utility function for the second period in a two-period framework, the term \( g(p, \theta) \) is the first-period anxiety cost function, i.e., it is part of a first period utility function (with the remaining part of this function being equal and exogenous for everyone). This anxiety cost function measures the disutility experienced in the first period from the knowledge that there is some chance that one will be ill in the second period.\(^8\) It is reasonable to assume that this disutility is larger the more likely one believes it is that one will become ill in the second period.\(^9\) We therefore assume \( g(p, \theta) \) is increasing in \( p \). Moreover, we assume that the dependence of anxiety on the probability \( p \) varies across individuals. Formally, we assume that \( \theta \) is distributed across individuals independently of accident probabilities. In particular, it varies according to a cumulative probability distribution \( F(\theta) \), which is strictly increasing and twice continuously differentiable on the fixed support \( [\theta, \bar{\theta}] \).

Whether an individual is attracted to or repelled from chance is determined solely by the curvature of \( g \) with respect to \( p \). In particular, let:

\[
\Delta_g(\theta) := g(p^U, \theta) - [\lambda g(p^H, \theta) + (1 - \lambda)g(p^L, \theta)]
\]  

(3.4)

\(^8\) For ease of exposition we have assumed a state-independent second-period utility function. To justify current anxiety of getting ill in the future, there should in principle be a genuine utility loss of getting ill beyond the compensation provided by the insurance contract. The utility loss could simply be modeled as a constant; hence we can ignore it in the formal analysis.

\(^9\) The separable representation resembles the formulation found in Caplin and Eliaz (2003) and Caplin and Leahy (2004).
Loosely speaking, $\Delta g(\theta) > [\,] 0$ if $g(\cdot,\theta)$ is concave [convex] around $p^U$, from using Jensen’s inequality. It is perhaps most convenient to interpret the term $\Delta g(\theta)$ by considering the type of genetic test we have in mind: An individual may take a test at no cost. If she does not take a test, nothing more is learnt than what she already knew with a probability of getting ill, still equal to $p^U$. Assigned to this event is a utility loss of illness, given by $g(p^U,\theta)$. On the other hand, by taking a test she will learn her risk to be in one of the two categories $\{H, L\}$, with $p \in \{p^H, p^L\}$. The post-test utility loss will be either $g(p^H,\theta)$ or $g(p^L,\theta)$. Hence, the expected utility loss prior to the test is $\lambda \cdot g(p^H,\theta) + (1 - \lambda) \cdot g(p^L,\theta)$. The term $\Delta g(\theta)$ is thus the difference between the expected utility loss without and with a test and can be interpreted as the direct utility gain from taking the test.

We impose restrictions on $g(p,\theta)$ so as to have a divided population regarding the propensity to take a test. A set of sufficient conditions for the existence of a critical type, $\theta^* \in (\theta, \bar{\theta})$, obeying $\Delta g(\theta^*) = 0$ is: $g(p,\theta)$ is sufficiently differentiable, satisfying the regularity conditions $\frac{\partial^2 g(p,\theta)}{\partial p^2} > 0$, $\frac{\partial^2 g(p,\bar{\theta})}{\partial p^2} < 0$, and $\frac{\partial^3 g(p,\theta)}{\partial p^2 \partial \theta} < 0$. For an individual of type $\theta^*$, there is no direct utility loss or gain from taking a test. The decision whether or not to take a test will thus be based purely on economic considerations for this person.\textsuperscript{11} Our regularity conditions imply that a person with $\theta < \theta^*$ will have $\Delta g(\theta) < 0$, i.e., a direct utility loss from taking the test. If there were no economic consequences of the test, this person would therefore choose not to be tested. When this condition holds, we say the individual is attracted to chance. The opposite is true for an individual with $\theta > \theta^*$; i.e., for whom $\Delta g(\theta) > 0$: the individual now has a direct utility gain from taking the test, and we say such an individual is repelled from chance. If there were no economic consequences of the test, this person would therefore choose to be tested. We

\textsuperscript{10} The multiplicative functional form of anxiety used in Meginniss (1976), Caplin and Eliaz (2003), and Caplin and Leahy (2004) does not satisfy our regularity conditions.

\textsuperscript{11} We will return to such economic considerations in the subsequent sections.
assume the diversity in the population to be so large, formally, $\bar{\theta}$ so high, that individuals of type $\bar{\theta}$ in all cases discussed below choose to test because of their high repulsion from chance.

If all insurance decisions were made prior to any testing, there would be no economic consequences of taking a test. The same is true in an economy with compulsory insurance where everyone pays an actuarially fair premium corresponding to the pre-test probability $p_U$ (and where no voluntary supplementary insurance is available after a test has been taken). For these cases, everyone will base their test decisions on whether a test gives a direct utility gain or loss: Individuals attracted to chance, *i.e.*, of type $\theta \in (\theta, \bar{\theta})$, will choose not to be tested, while individuals repelled from chance, *i.e.*, of type $\theta \in (\theta', \theta)$, will choose to be tested.

In the subsequent sections, we consider cases where insurance may be purchased after having taken a test. This option implies that there may be economic consequences of testing. In the next section, we derive the equilibrium for the benchmark case of symmetric information, where no individual can disguise her risk category. We then proceed by considering the case where insurance companies only know the test result of individuals who *voluntarily are disclosing their private information*. At last, we discuss the equilibrium contracts in the case where the companies are restricted from using the test outcome when designing their menus of contracts, which amount to test results being non-verifiable.

### 4. Symmetric information

From now on, let insurance decisions be made after test decisions. Consider first the case where the available information about an individual’s risk is public. In other words, what the individual herself knows is also shared by insurance companies. In this case, each individual is offered a full-insurance, zero-profit contract. In particular, an individual
with a probability \( p^K; K \in \{U, K, L\} \), of getting ill is offered the contract \([p^Kd, (1-p^K)d]\)
and obtains an expected utility equal to

\[
v(y - p^K d) - g(p^K, \theta)
\]

\[(4.1)\]

A risk-averse individual who is attracted to chance will not take the test in this case. To see this, note that the net benefit for an individual from taking a test is:

\[
\Delta_s(\theta) = \lambda u(a_s^H, p^H; \theta) + (1-\lambda)u(a_s^L, p^L; \theta) - u(a_s^U, p^U; \theta)
\]

\[
= \lambda[v(y - p^H d) - g(p^H, \theta)] + (1-\lambda)[v(y - p^L d) - g(p^L, \theta)]
\]

\[-[v(y - p^U d) - g(p^U, \theta)] = \Delta_g(\theta) - \Delta_s^V,
\]

where the subscript \( S \) denotes the present case of symmetric information, \( \Delta_g(\theta) \) is defined in the previous section, and

\[
\Delta_s^V := v(y - p^U d) - \left[ \lambda v(y - p^H d) + (1-\lambda)v(y - p^L d) \right].
\]

\[(4.3)\]

Due to strict concavity of the utility function, we have, from Jensen’s inequality, that \( \Delta_s^V > 0 \). From the definition of attraction to chance in Section 2, it thus follows:

**Proposition 1:** With symmetric information about risk, full insurance will prevent an individual who is attracted to chance from taking a test; i.e., \( \forall \theta \in \left[\theta, \theta^*\right] \), \( \Delta_s(\theta) < 0 \).

Thus, in order for an individual to be willing to take a test in the case of symmetric information, she must be sufficiently repelled from chance. Moreover, under our assumption of a sufficiently diverse population, we can state:
**Proposition 2:** There exists a critical value of $\theta$, denoted $\theta_s \in (\theta^*, \bar{\theta})$, such that, in the case of symmetric information, an individual of type $\theta$ will take the test if and only if $\theta \in [\theta_s, \bar{\theta}]$.

**Proof:** This result follows from the observation that $\Delta_s(\theta)$ is continuous and strictly increasing in $\theta$. □

Compared to the case when taking a test has no economic consequences (cf. Section 3), the fraction of the population that takes a test, is smaller. In particular, some of the persons who are repelled from chance choose to stay untested, as a test now has negative economic consequences: Although expected income (prior to a test) is the same whether one takes a test or not, the income will depend on the test result if a test is taken. Due to risk aversion, there is thus a negative economic consequence of taking a test, as there is no uncertainty regarding one’s income if no test is taken.

Note that welfare, in an *ex-ante* sense, is lower in this case of symmetric information than in the previous case. To see this, we split the population into three subsets, according to individuals’ attraction to chance. (See Figure 1.)

---

12 There are two notions of efficiency of potential relevance to our analysis. In cases where an individual’s risk, if she knows it, is private information, we are in a state of asymmetric information, and the relevant notion would be what Holmström and Myerson (1983) denote *interim efficiency*. One equilibrium outcome interim dominates another if it has individuals of each type at least as well off, and one type strictly better off; because of competition, insurers earn zero profits and are equally well off in all equilibrium outcomes under consideration. Before any tests have been performed, however, the relevant efficiency notion is that of *ex-ante efficiency*. One equilibrium outcome *ex-ante* dominates another if all individuals are at least as well off, and some individuals strictly better off. Because we want to make comparisons between cases where an individual’s information differs, interim efficiency is not appropriate for our purposes. All welfare results are therefore expressed in terms of *ex-ante* efficiency.
Figure 1

Individuals with $\theta < \theta^*$ are in the same situation in the two cases: they remain untested and are offered the contract $[p^{ul}d_s(1 - p^{ul})d]$. Individuals with $\theta > \theta_S$ are tested in both cases, but they are worse off in the present case due to risk aversion. Finally, individuals with $\theta \in (\theta^*, \theta_S)$ choose in the present case to stay untested. These individuals would prefer testing to non-testing if they could get full insurance at price $p^{ul}$ in both cases. But testing is now an inferior alternative for these individuals, relative to compulsory insurance, because of the uncertainty about whether they will get the high-risk or the low-risk contract. This revealed-preference argument shows that these individuals are worse off in the present case than when insurance is compulsory, as it were in section 3. All in all, we have one group unaffected and two groups with lower welfare in the present case as compared to the case with compulsory insurance. We therefore have:

**Proposition 3:** When information is symmetric, a compulsory insurance regime dominates, in terms of ex-ante efficiency, a regime with insurance after testing.
5. Asymmetric information – verifiable test result

Suppose now that an individual’s risk is private information if she has been through a test, and that the test result is verifiable. An individual who has tested low-risk obviously wants to reveal her test outcome, since this ensures her the contract, if full insurance should be offered. The situation is different for one who has tested high-risk. As long as there are individuals around who have not tested and therefore have no idea about their risk beyond what is provided by $p_U$, a high-risk individual may have an incentive to pretend to be untested by not revealing her test outcome. Insurers will have to cope with this problem by offering a contract for untested individuals that satisfy a self-selection constraint: Individuals who know they are high-risk must find it in their own interest to choose the high-risk contract instead of the no-test contract. This constraint results in a partial-insurance contract for untested individuals, i.e., one where $a_1 + a_2 < d$. In addition, competition ensures that the no-test contract earns zero expected profit, with the expectation being taken with respect to a population of uninformed individuals.

The insurance market for tested high-risks and untested ones works exactly as the insurance market for high-risks and low-risks in Rothschild and Stiglitz (1976). Thus, similarly to their analysis, a pure-strategy equilibrium exists only if the number of tested high-risk individuals is sufficiently high relative to the number of uninformed. In our case, this will be ensured if the fraction of tested individuals is sufficiently high, which will hold with suitable assumptions on $g$ and $F$. We have:

**Proposition 4:** With asymmetric information, verifiable test result, and with $g$ and $F$ such that the ratio of tested high-risks to untested is sufficiently high, the following set of contracts will be offered in equilibrium:

- the low-risk contract $a_L = [p_L d, (1 - p_L) d]$ to individuals who verify they are low-risk; and
the menu \( \{a^H, a^L \} \) to others, where \( a^H = [p^H d, (1 - p^H)d] \) is chosen by high-risks and 
\( a^L \) is chosen by no-test individuals, and \( a^U \) is defined as the unique contract 
satisfying:
\[
V(a^U, p^H) = V(a^H, p^H), \quad \text{and} \\
\pi(a^U, p^U) = 0.
\]

**Proof:** The result follows from the self-selection constraint for a tested high-risk 
individual, who should be prevented from disguising herself as untested. □

When comparing the two cases of symmetric information and the one with asymmetric, 
but verifiable, information on the other hand, we note that tested individuals, both high-risks and low-risks, are equally well off in the two cases. The difference is with respect to 
the uninformed individuals, who clearly are worse off under asymmetric information, 
since the zero-profit contract they now get is one of partial rather than full insurance. 
Thus, the incentive to take the test is higher in the case of asymmetric and verifiable 
information than in the case of symmetric information. We have:

**Proposition 5:** With asymmetric, but verifiable information, there exists some \( \theta_v < \theta_s \), so 
that an individual of type \( \theta \) will take the test if and only if \( \theta \in [\theta_v, \theta_s] \).

In terms of welfare, the present case of asymmetric information and verifiable test results 
is worse than the case of symmetric information discussed in Section 4. (See Figure 2). 
Let us again split the population in three subsets: Individuals with \( \theta < \theta_v \) stay untested in 
both cases but are worse off in the present case because untested individuals are offered 
partial insurance only. Individuals with \( \theta > \theta_s \) are equally well off in the two cases; they 
are tested and receive the contract \( a^L \) if low-risk and the contract \( a^H \) if high-risk, 
irrespective of whether information is symmetric or not, as long as test results are 
verifiable. In the case of symmetric information, individuals with \( \theta \in (\theta_v, \theta_s) \) prefer to 
remain untested. Since testing is equivalent in terms of outcome in the two cases, this
implies that individuals in this group are better off under symmetric information. Thus, two subsets of individuals are worse off in the present case than in the case discussed in Section 4, while the third subset of individuals are equally well off.

<table>
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Figure 2

We therefore have:  

**Proposition 6**: In terms of ex-ante efficiency, symmetric information dominates asymmetric information and verifiable test results.

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13 Propositions 4 and 6 focus on situations where a pure-strategy equilibrium exists. Otherwise, a mixed-strategy equilibrium exists, according to Dasgupta and Maskin (1986). However, giving up the pure-strategy equilibrium makes it impossible to undertake the welfare analysis of genetic testing in the simple way that has been done here.
6. Asymmetric information – non-verifiable test results

Suppose now, as in the previous case, that an individual’s risk is private information. However, we let test results be non-verifiable; the non-verifiability could for example follow from regulations making it infeasible to offer contracts contingent upon test results. It is no longer possible to offer the low-risk individuals an actuarially fair full-insurance contract, since the low-risk contract now will have to satisfy a self-selection constraint, as well. As demonstrated by Doherty and Thistle (1996, p. 90: contract menu $C^*$), the binding incentive constraint is the one making sure that individuals who are untested do not pick the low-risk contract. But this is the only contract that will be affected by non-verifiability. We therefore have:

**Proposition 7:** With asymmetric information about risk after a test, test results being non-verifiable, and $g$ and $F$ being such that both the ratio of tested high-risks to untested and the ratio of untested to tested low-risks are sufficiently high, insurers offer the following set of contracts in equilibrium:

$$\{a^H, a^U, a^L\},$$

where

$$a^H = [p^H d, (1 - p^H) d]$$ is chosen by tested high-risks;

$a^U$, defined in Proposition 4, is chosen by untested individuals;

while $a^L$ is chosen by tested low-risks and defined as the unique contract satisfying the two conditions:

$$V(a^L, p^U) = V(a^U, p^U)$$

$$\pi(a^L, p^L) = 0.$$

Note that conditions for existence of this equilibrium are quite strict, a problem overlooked by Doherty and Thistle (1996). In order to avoid the existence of a pure-strategy equilibrium being destroyed by cross-subsidizing deviations, there have to be, for each adjacent pair of types, sufficiently many of the higher-risk type; see Rothschild and Stiglitz (1976) for details in the two-type case. Presently, there are three types: tested low-risks, untested, and tested high-risks. What we need is a sufficiently high fraction of high-risks to untested individuals, and a sufficiently high fraction of untested to low-
risks. Note that the former calls for a sufficiently high number of individuals taking the
test, while the latter calls for the opposite. Thus, we cannot be sure that the equilibrium
proposed in Proposition 7 actually exists for a non-empty set of primitives. It is, however,
easy to verify that the existence problem is less severe, the less risk-averse individuals
are.

Leaving the existence problem aside, we can compare the incentives to take the test with
verifiable and non-verifiable test results. Both tested high-risks and untested individuals
are equally well off whether the test results are verifiable or not, since they are offered
and choose the same contracts in both cases. Individuals who test for being low-risks, on
the other hand, are made worse off by not being able to verify this result to insurers,
because they are offered only partial insurance. Thus, incentives to take the test are lower
with non-verifiable than with verifiable test results. Invoking again our assumption of a
sufficiently diverse population, we have:

**Proposition 8:** There exists some critical type \( \theta_N > \theta_V \) such that, in the case of
asymmetric information and non-verifiable test results, an individual of type \( \theta \) will take
the test if and only if \( \theta \in [\theta_N, \bar{\theta}] \).

In terms of welfare, we can now compare the two cases of asymmetric information, with
and without verifiable test results. (See Figure 3.) We consider three groups of
individuals: those who don’t test in either case (i.e., those with \( \theta < \theta_V \)), those who choose
to test in both cases (\( \theta > \theta_N \)), and those who test in the case of verifiable test results but
not in case of non-verifiable test results (\( \theta \in (\theta_V, \theta_N) \)). The first group is equally well off
in the two cases. The second group is better off with verifiable test results, because they
fare better with verifiability if they end up testing low-risk: Under non-verifiability,
tested low-risks are offered only partial insurance, while they are offered full insurance
with verifiable test results. The last group is also better off with verifiable test results,
because they prefer testing to no testing, and because individuals without a test are
offered the same contract in the two cases. We have the following result:
Figure 3.

**Proposition 9:** The case of verifiable test results dominates the one with non-verifiable test results, in terms of ex-ante efficiency.

The last result has an important policy implication: Society would be better off if insurers were allowed to make use of the information that genetic testing can offer. This is because people gain from the verifiability of such test results if they show a low risk of becoming ill, without suffering if they show a high risk.
7. Concluding remarks

An important feature of our model is that, during a time period in which a person is in perfect health, the person’s well-being depends on the perceived probability of becoming ill in the future. Moreover, the exact property of the relationship between this probability and the person’s well-being (or anxiety) varies among individuals. We believe that the references we gave in Section 2 justify this assumption.

Formally, we model the feature above by introducing the term \( g(p, \theta) \) representing the utility loss associated with facing the probability \( p \) of future illness. It is the heterogeneity of a particular property of this function among the individuals, given by the term \( \Delta g(\theta) \) defined by (3.4), that makes people differ in their attitude towards taking a genetic test. The main results of our paper would be valid also if we had not included the feature represented by the term \( g(p, \theta) \) but instead had assumed heterogeneous test costs across individuals. While there is a lot of empirical evidence that people differ in their anxiety or fear of becoming ill in the future, there is, however, no empirical justification for assuming potentially large variations in test costs across individuals.

In our formal model, we have assumed that there are no costs of taking a test. However, extending the analysis to include test costs would be straightforward. If these costs were \( c \) for everyone, we would simply need to include the term \(-c\) in expression (3.3) giving the net benefit for an individual from taking the test. Nothing of substance would be changed if we were to introduce a test cost in this way. Note that this is in sharp contrast to what Doherty and Thistle (1996) find: In their model, there exists an equilibrium when test results are non-verifiable and there are no test costs, and in this equilibrium, everyone gets tested. However, if a small but positive test cost is introduced, an equilibrium no longer exists in their model.

In addition to the benchmark case of symmetric information, we have considered two cases of asymmetric information. While the case of symmetric information is useful as a benchmark, it is unlikely to be of any empirical relevance. In practice, it is difficult to imagine any policies enabling an insurance company to obtain the test result of a person
who has taken a test but who wishes to conceal this fact (which will be the case for tested high-risk persons). The politically interesting cases are thus the two cases with asymmetric information.

The difference between the two cases with asymmetric information is whether or not an insurance company can verify a test result showing that a person is tested and found low-risk. This is, in turn, a policy issue. As mentioned earlier, and discussed in more detail in Hoel and Iversen (2002), several countries have introduced (or are considering to introduce) legislation that prevents insurers from using genetic information when designing insurance contracts. One reason frequently given for such legislation is that a person has the right not to know his or her genetic make-up. In our model, persons who are attracted to chance – i.e., persons with a negative $\Delta_g(\theta)$ – will prefer to stay untested if there are no economic differences between being tested or not. Comparing our two cases of asymmetric information, we have shown that more people take a test when test results are verifiable than when they are not. If some of the people taking a test when test results are verifiable are attracted to chance (i.e., if $\theta_V < \theta^*$, in our notation) and thus take the test only for economic reasons, one could argue that legislation making test results non-verifiable is to the advantage of these people. However, our results have shown that this is not necessarily the case: We have shown that, in terms of efficiency, the verifiable regime dominates the non-verifiable one. In particular, those who have such a high attraction to chance that they do not test themselves whatsoever are equally well off in the two cases. Those who test themselves only when test results are verifiable, do so because, if they test low-risks, they are better off in the verifiable case than in the non-verifiable case. On the other hand, if they end up as high-risks, they will be unaffected by whether or not the test result is verifiable.

When the cost of a test is zero, Doherty and Thistle (1996) find that all individuals will choose to be tested when insurers cannot distinguish between untested individuals and tested individuals who are high-risk (corresponding to the two cases discussed in our Sections 5 and 6). This is hardly in accordance with the stylized facts we have described in Section 2. From our model, we are able to explain why some people choose to stay
uninformed even when information on test status is asymmetric. This feature of our model adds realism and thus increases our understanding of people’s genetic-testing decisions.

References


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