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GENETIC TESTING WHEN THERE IS A MIX OF COMPULSORY AND VOLUNTARY HEALTH INSURANCE*

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Abstract

Genetic insurance can deal with the negative effects of genetic testing on insurance coverage and income distribution when the insurer has access to information about test status. Hence, efficient testing is promoted. When information about prevention and test status is private, two types of social inefficiencies may occur; genetic testing may not be done when it is socially efficient and genetic testing may be done although it is socially inefficient. The first type of inefficiency is shown to be likely for consumers with compulsory insurance only, while the second type of inefficiency is more likely for those who have supplemented the compulsory insurance with substantial voluntary insurance. This second type of inefficiency is more important the less effective prevention is. It is therefore a puzzle that many countries have imposed strict regulation on the genetic information insurers have access to. A reason may be that genetic insurance is not yet a political issue, and the advantage of shared genetic information is therefore not transparent.

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Keywords: Genetic testing insurance, private information, compulsory/voluntary mix.

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1 Introduction

On June 26, 2000, the leaders of both the publicly and the privately funded human genome projects announced that a draft of the human genome has been made. During the next few years, this knowledge is likely to be applied in the development of predictive tests for many diseases. The tests will be able to distinguish between high risk and low risk individuals at a presymptomatic stage of disease. Presently, around fifteen to twenty tests are offered, including tests for Huntington's disease and cystic fibrosis. Recently, two important breast cancer genes (BRCA1 and BRCA2) have been identified, and the U.S. Food and Drug Administration has approved a gene-based test that may help to predict the recurrence of breast cancer. The number of tests is expected to increase rapidly in a few years, in parallel to the mapping of the human genes. For instance, tests for genes that imply an elevated risk of several types of cancer, cardiovascular diseases, and Alzheimer’s disease are already available or are expected to be available in the near future.

The information from gene-based tests may be important for initiating measures for postponement and prevention of disease. Genetic tests are also expected to have an important impact on the organization of health systems and, in particular, health insurance. There is a concern that insurers can make use of information to deny coverage for individuals with an increased risk of disease or require them to pay prohibitively high insurance premiums. Regulation of the access to, and the use of information from, genetic testing is therefore an important health policy issue in many countries, and the regulations imposed vary between countries. In the U.S., a majority of the states have banned the use of genetic information by insurers. The Congress in 1996 passed legislation that forbids group health organizations from denying coverage on the basis of genetic information. Efforts are also being made to extend the prohibition to all health insurers and to ban insurers from raising premiums based on genetic data (Schwartz, 1998). Recently (February 2001), a bill to prohibit discrimination on the basis of genetic information with respect to health insurance was introduced in the US Senate and referred to the Committee on the Health, Education, Labor, and Pensions.

In Europe, there is mixed attitude. For instance, the Council of Europe, recommends (R(92)3 and R(97)5) that predictive genetic tests should not be used when the terms of insurance is

decided. Among European countries[1], Belgium, Denmark, France, the Netherlands, Norway and Austria has approved restrictive laws while other countries have less formal regulation and might prepare regulation by law. In Finland, France, Germany, Sweden, Switzerland and the Netherlands insurance companies have chosen to impose a moratorium. In Norway, the majority of a public commission (Ministry of Health and Social Affairs, 2000) has suggested that insurance companies should have the right to require information about health status, including genetic information, for life insurance contracts exceeding a certain amount. The suggestion has led to much public debate and no support among political parties. Recently, also the Norwegian Biotechnology Advisory Board advised the government to turn down the commission's suggestion. In the UK, the Genetics and Insurance Committee (GAIC) has been established by the Department of Health to give advice related to the use of genetic test results in insurance risk assessment. The Association of British Insurers (ABI) has given an assurance that if tests are not approved by the GAIC then their member companies will cease to use the results of the test and will retrospectively recalculate any insurance premiums affected. In September 2000 GAIC approved the use of genetic test results for Huntington's disease in the underwriting of life insurance. GAIC (2000) expect that they in the near future will review all ten tests currently approved by the ABI[2].

Given these conflicting trends of international policy, the challenge emerges whether economics has something to offer concerning the regulation of the insurance industry's access to information from genetic tests. In particular, an important question is whether some institutions are better suited than others to reap the benefits and avoid the costs of genetic testing. Benefits accrue from testing as a precondition for prevention and postponement of disease, while social costs are both related to inefficient testing (as defined below) and less insurance coverage (due to adverse selection). In addition testing may imply a premium risk and hence, an increased costs of insurance for high-risk persons.

The purpose of this paper is to put together and apply central elements of economics to shed light on these questions. The focus is on two regulatory issues. Firstly, there is the regulation of access to information about a person's test status. If access is restricted to the person

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[1] This is according to information in Ministry of Health and Social Affairs (2000) and European Society of Human Genetics Public and Professional Policy Committee (2000)

[2] These are for the seven conditions: Huntington's disease, hereditary breast cancer, familial adenomatous polyposis, myotonic dystrophy, early-onset Alzheimer's Disease, multiple endocrine neoplasia, hereditary motor and sensory neuropathy.

concerned, we denote information as private. We denote information as public if the insurer has access to as much information relevant for risk assessment of a potential policy-holder as the policy-holder has himself. Notice that in this case the existence of private or public information is a policy issue, while in many other situations it is a characteristic of the market. Secondly, there is the regulation of the insurance market and especially the mix of compulsory and voluntary insurance[3]. In particular, we are interested in the extent to which possible inefficiencies depend on the mix of compulsory and voluntary insurance in a system of health insurance[4]. Two types of inefficiencies may occur. Firstly, tests may not be undertaken when testing is socially efficient, in the sense that testing implies a Pareto-improvement. Secondly, tests may be undertaken when testing is socially inefficient. We show that the first type of inefficiency is likely for systems with a high proportion of compulsory insurance while the second type of inefficiency is likely for systems with substantial voluntary supplementary insurance We show that inefficiencies are more likely to occur when information about a person's test status is private than it is when the information is public. In relation to these results it is a puzzle that the legislation in many countries emphasises the privacy of information.

The paper draws on previous literature on this and related topics. Section 2 introduces the basic insurance model and section 3 defines genetic testing and the main assumptions to be used in the analysis. Tabarrok (1994) offers a discussion of the potential benefits and costs related to genetic testing. He proposes a compulsory insurance against the consequences of being identified as a high-risk person through genetic testing. We derive Tabarrok's main conclusion in section 4 of this paper, and use the full information case as a benchmark for our further analysis. In section 5 we assume private information of costs of prevention. In accordance with initiatives in many countries, we also impose the institutional constraint that insurers have no access to genetic information. Our analysis makes use of results from Doherty and Thistle (1996). In contrast to what is assumed in most of the literature, Doherty and Thistle (1996) assume that a consumer's information about his risk status is endogenous. A consumer decides whether or not he wishes to obtain the information from testing. The

[3] Typically, the compulsory insurance will be public, while the voluntary supplement will be private. However, it is the distinction between compulsory and voluntary that is important for our analysis, not the distinction between public and private.

[4] Hence, our analyses depart from Hoy and Polborn (2000), who considers a life insurance model. According to the authors the life insurance market differs from other insurance policies because price-quantity contracts are

optimal decision from the consumer's point of view is shown to depend on the insurer's access to information about test status and result. In this paper we take the analysis further by introducing the following two new features:

- Prevention: An important motive for testing is the prospects of a reduction in risk of disease my means of prevention. The effect of self –protection technologies on social welfare under alternative assumptions of access to information is studied by Hoy (1989). Hoy assumes that the consumers' information about their risk status is exogenous. In the present paper the information is made endogenous by the consumer's decision about whether to be tested or not.
- The compulsory/voluntary mix of health insurance: Everyone is assumed to have compulsory insurance, with everybody paying the same premium. In addition, a person may have voluntary insurance, with a premium adjusted to individual risk of illness. The mix of compulsory and voluntary insurance is an important health policy issue in most countries. It is highly relevant for policy makers to know whether the availability of genetic testing is likely to influence the properties of alternative systems.

An important distinction is whether voluntary insurance is considered to be a supplement or an alternative to compulsory insurance. A few examples may clarify the distinction. A person with symptoms of disease is likely to make use of the compulsory insurance in the first contact with a physician. The visit may result in diagnosis and treatment or a referral to a specialist for further diagnostics and treatment. A referral may be accompanied by a waiting time before a specialist can be seen. The waiting time may be shortened by means of privately funded provision of health services. A privately funded specialist is then an alternative to a publicly funded. Once a diagnosis is made, treatment may or may not be provided by the public sector. For instance, expensive treatment may be rationed and some patients with treatment indications may be turned down. The private sector may then be a supplement for those patients experiencing rationing in the public sector. Also, a waiting time for publicly funded treatment may occur. The waiting list may be bypassed by means of privately funded treatment. In this case private care is an alternative to the publicly funded care. Hence, we see that some parts of privately funded health services may be considered an alternative to publicly funded services, while others may be considered a supplement. For instance, Besley,

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not a feasible means against adverse selection. There is neither a natural choice for the size of the loss and a change in the probability of death may well influence the amount of insurance demanded.

Hall and Preston (1998) consider UK private health insurance to be somewhere between the two stylised alternatives.

Section 6 discusses implications for public policy. *A high degree of compulsory insurance* seems to imply a disincentive to socially beneficial testing and prevention, in particular with private information about prevention. On the other hand, full insurance with premium independent of risk status is achieved. *A high degree of voluntary insurance seems* to imply an incentive to beneficial testing and prevention under public information and genetic insurance, and under private information also without genetic insurance. On the other hand, with private information there is also an incentive to undertake testing that is socially inefficient.

Given the unfavorable effects of private information about test status, it is a puzzle that the policy of international organizations and individual countries referred to earlier is against making the information from genetic tests open to insurers.

An important reason behind the privacy of information is that a person has a right not to know his genetic make-up. We show the incentive to undergo genetic testing is in fact greater with private information than with public information. Hence, the right not to know seems to be better protected with public information about test status than with private information. Hence, the British decision of using the genetic test result for Huntington's disease in the underwriting of life insurance, may in fact be less threatening to the right not to know than if privacy of information had been imposed. Another matter is that this specific test is not socially beneficial, as defined in section 3, since no effective prevention for Huntington's disease is known.

In the concluding remarks we suggest that an inefficiently high level of testing is likely to occur in the coming years, since genetic therapy is likely to lag behind the development of genetic diagnostics, and hence, limit the scope for effective prevention. Limitations of the analysis and suggestions for future research are also given. In particular, we argue that the analysis should be extended to incorporate group health insurance and health maintenance organizations, which are major institutions in the US.

2 The basic model

Individuals are assumed to differ along two dimensions: The risk of having a disease in the future, and the loss of income, ℓ, if disease strikes. These two characteristics are assumed to be unrelated.

The level of risk is assumed to be related to genetic disorders that may be revealed by means of genetic testing. Individuals belonging to group H have a risk, p_H, while individuals in group L have the risk, p_L, where $0<p_L< p_H<1$. The proportion of low risk individuals in the population is θ_L and the proportion of high risks is θ_H, where $0< \theta_L, \theta_H <1$ and $\theta_L+ \theta_H =1$. The parameters p_L, p_H, θ_L and θ_H are assumed to be common knowledge.

All individuals are assumed to have the same exogenously determined income, w, when sick. The loss of income related to disease differs between individuals because their income or productivity when healthy is assumed to differ. The higher the productivity when healthy, the greater is the loss of income, ℓ, when sick. As mentioned above, the distribution of ℓ is the same in the group H as it is in the group L.

By means of insurance, income can be transferred from the healthy state to the state of poor health. In this specific context insurance can be thought of as covering the costs of medical treatment necessary to (partly or fully) compensate the loss of income due to illness.

In this paper we consider voluntary health insurance as a supplement to compulsory insurance. Compulsory insurance is assumed to cover a portion $x \leq \ell$ of the loss, where x is assumed to be exogenous and equal for all[5]. Hence, the higher the productivity when healthy, the lower is the proportion of the loss covered by compulsory insurance. The loss from poor health is in the analysis restricted to the loss of income. Good health obviously has a value in itself, but this component is not drawn into the analysis at the present stage.

[5] It is assumed that the lowest ℓ-value in the distribution is equal to or larger than x. Nothing of importance would be changed if we instead had assumed that some ℓ-values were lower than x, and that the public insurance for these cases covered the whole loss ℓ.

In a competitive insurance market where insurers are risk neutral expected profit maximisers, expected profits will be driven to zero. If the insurer is the public sector or a private non-profit institution, the zero expected profit is imposed as an institutional constraint or by the implication of funding from public budgets. Since we ignore administrative costs, insurance can then be offered at actuarially fair rates.

The premium paid for compulsory insurance is assumed to be independent of individual risk. Each individual is assumed to pay an equal premium, with a calculated risk equal to the average population risk, $Q= \theta_H p_H + \theta_L p_L$, and a premium equal to Qx.

Voluntary insurance covers loss in excess of x. A voluntary insurance policy, (q, k), is characterised by the premium as a proportion of the covered loss, denoted by q, and the proportion of the loss, $k \in [0,1]$, that is covered. Consumers are assumed to choose the policy that maximise their expected utility, given the compulsory coverage.

We assume that, prior to the introduction of genetic testing, nobody knows his true risk type. Hence, initially, as uninformed, the whole population is assumed to have an identical perception of their own risk equal to a weighted average of the actual risk of the two groups; $Q= \theta_H p_H + \theta_L p_L$. From the assumption of actuarially fair insurance rates it thus follows that the premium rate for voluntary insurance is equal to the premium rate for compulsory insurance. Assuming that all individuals are risk averse, it follows that everyone is fully insured. Everyone with a potential income loss higher than the compulsory coverage (i.e. ℓ>x) will supplement the compulsory insurance with voluntary insurance equal to ℓ-x. (For details, see the Appendix.)

3 Genetic testing

The purpose of genetic testing is to discover disease in an asymptomatic stage, in order to take preventive measures to reduce the probability of contracting the disease. Whether prevention is available and likely to be demanded, is therefore an important factor in determining the demand for predictive testing. Two cost components may be involved in prevention. The first

component is the costs of providing professional medical care. To simplify the exposition, we shall without any substantial loss set these costs equal to zero. The second cost component is personal costs related to preventive measures. These costs are of two kinds. The first kind is costs related to activities that can easily be observed, for instance travelling and absence from work to attend disease prevention programs. The other kind of personal costs are unobservable for others than the person who carries the costs. Examples are time used in preparation of a special diet and pain and discomfort experienced from preventive measures as healthy diet and physical exercise. We assume that these costs are positive, and denote the monetary equivalent of personal costs of prevention by γ.

In the subsequent analysis, we shall make the following simplifying assumptions about testing and preventive measures:

(a) Test costs are zero.
(b) Preventive measures reduce the risk of illness for a high-risk person, but cannot make the illness risk as low as it is for the low-risk person. Preventive measures are assumed to have no effect on the illness risk for a low-risk person.
(c) Prevention is socially efficient for high-risk persons.
(d) For a person who can buy unlimited supplementary insurance at an actuarially fair price and who does not know whether he/she is high-risk or low-risk, it is not worthwhile to undertake prevention.

Assumption (b) is formalized by assuming that preventive measures reduce the risk of a high risk person from p_H to sp_H, where s is a parameter smaller than 1.[6] Moreover, assumption (b) implies that

$$sp_H > p_L \tag{1}$$

Assumption (c) may be formalized as

$$\gamma < (1-s)p_H\ell \tag{2}$$

The interpretation of this inequality is that the cost of prevention is lower than the increase in expected income due to prevention for a person who is high-risk. Notice that this assumption

[6] Hoy (1989) considers the slightly more general case: the amount of prevention is a continuous variable z, and z is assumed to affect probability of illness both for high- and low-risk persons.

in combination with assumption (a) and $\gamma>0$ implies that testing is socially efficient. In order for preventive measures to be undertaken by high-risk persons, but not by low-risk persons, one needs the information of who belongs to which group.

In the Appendix, it is shown that assumption (d) implies that

$$\gamma > (1-s)\theta_H p_H (\ell - x) \tag{3}$$

The interpretation is straightforward: The left-hand side is the cost of preventive measures, while the right-hand side is the reduction a fully insured uninformed person gets in the actuarially fair insurance premium as a consequence of the preventive measures he/she undertakes.

It is obviously possible for γ to be so low that the inequality in (3) is violated, especially for persons with high income when healthy, i.e. high ℓ. However, since the focus of this paper is the efficient use of genetic testing, we choose to rule out this case.

At the initial, uninformed state each person has four options:

1) Do not test and do not undertake preventive measures
2) Do not test, but undertake preventive measures
3) Test, but do not undertake preventive measures even if the test reveals that one is high-risk
4) Test, and undertake preventive measures if the test reveals that one is high-risk

We can immediately rule out alternative 2 due to assumption (d). As for the remaining options, we shall now discuss how the choice depends on what insurance contracts are available. We show that in the full information case, either the first or the last of the four options above will be chosen. If there is private information about test status, test result and prevention, option number 4 will be chosen.

4 The case of full information

We first consider the case of full information. In this case insurance companies know whether or not a person is tested, and if tested, knows the person's risk class. Moreover, preventive

measures undertaken by a person are also observable to the insurer. This full information case is considered as a benchmark for the further analysis where private information is assumed either because of characteristics of the preventive activities or because of regulation imposed on the insurance market.

Consider first alternative 1, as described in the end of the previous section. Denote expected income under alternative 1 by y^1. Since we in this section assume full information, full insurance will be chosen at an actuarially fair premium. The income is y^1 whether healthy or not, and is given by

$$y^1 = w + \ell - (\theta_L p_L + \theta_H p_H^*)x - (\theta_L p_L + \theta_H p_H)(\ell - x) \qquad (4)$$

where p_H^* is the share of high-risk persons who become ill. If no one undertakes preventive measures, we of course have $p_H^* = p_H$. If a share α of the high-risk persons undertake preventive measures, $p_H^* = \alpha s p_H + (1-\alpha)\, p_H$.

Consider next alternative 3. Since there is full insurance, one can never be better off by choosing alternative 3 instead of 1. Had there been a positive cost of taking a test, one would obviously be worse off under alternative 3 than 1. Even with our assumption of a test being available at no costs, one is worse off under 3 than under alternative 1. The reason is that by choosing alternative 3, a person will get an income that depends on the test result. Given the risk class, income is independent of whether one is healthy or not (as in alternative 1). Expected income y^3 is in this case

$$y^3 = \theta_L\left[w + \ell - (\theta_L p_L + \theta_H p_H^*)x - p_L(\ell - x)\right] + \theta_H\left[w + \ell - (\theta_L p_L + \theta_H p_H^*)x - p_H(\ell - x)\right] \qquad (5)$$

The first term in brackets is the income the person will get if he/she turns out to be low-risk, and the second term in brackets is the income the person will get if he/she turns out to be high-risk. It is straightforward to verify that $y^3 = y^1$. Since we have assumed risk aversion, it is therefore clear that alternative 1 will be preferred to alternative 3.

Alternative 4 gives the same income as 3 if the test reveals that one is low-risk. If the test reveals that one is high-risk, the income is different from alternative 3. The expected income y^4 is

$$y^4 = \theta_L\left[w + \ell - (\theta_L p_L + \theta_H p_H^*)x - p_L(\ell - x)\right] + \theta_H\left[w + \ell - \gamma - (\theta_L p_L + \theta_H p_H^*)x - s p_H(\ell - x)\right] \qquad (6)$$

where the first term in brackets is identical to the first term in brackets in (5).

An individual will choose alternative 4 instead of alternative 1 if the expected utility with testing and prevention is greater or equal than the expected utility as uninformed. A *necessary* condition for this to be the case is that $y^4>y^1=y^3$. Subtracting (5) from (6) we find

$$y^4 - y^1 = (1-s)p_H(\ell - x) - \gamma \tag{7}$$

so that $y^4>y^3=y^1$ if and only if

$$\gamma < (1-s)p_H(\ell - x). \tag{8}$$

Even if the inequality (8) holds, the existence of risk aversion may still imply that a person chooses to stay uninformed. To undertake the test is for an individual a lottery, since the income under alternative 4 is uncertain, while the income under alternative 1 is certain. Testing is more likely to be chosen the larger y^4-y^1 is. From (7) we therefore see that testing is less likely to be chosen the larger s is and the larger γ is, since the loss that comes from a positive test is then larger. Likewise, testing is less likely to be chosen the more risk averse a person is. Finally, it follows from (7) that testing is less likely the lower income the person has when healthy, and the larger is the coverage of the compulsory health insurance.

Compulsory insurance offers full coverage independent of test status and prevention. The premium reduction from prevention is divided equally among all individuals. For a large population an individual's share in the premium reduction is negligible. Each person therefore considers the insurance premium (as a percent of coverage) as given. For a person who is fully covered by the compulsory insurance (i.e. ℓ=x) prevention will therefore not be undertaken (since γ >0, cf. also (8) for ℓ=x), although prevention may be socially efficient.

In the full information case the government can encourage socially efficient testing and prevention by compensating individuals for personal costs. A person with only compulsory insurance will only undertake preventive measures if the costs of these measures are fully compensated. Problems in practice are likely to arise since individual variation in γ is likely to occur.

Notice that (7) is a stricter condition than the condition for testing to be socially efficient (given by (2)), since $(1-s)p_H(\ell - x) < (1-s)p_H\ell$. Hence, although our assumptions imply that testing is socially efficient, not everyone will undertake such a test. This inefficiency is caused in part by the existence of compulsory insurance. But even without this (i.e. for x=0) risk aversion may cause some persons to choose to not test themselves.

To encourage a person with mixed compulsory and voluntary insurance to undertake testing and prevention, the government may offer insurance against the costs of being identified as a high-risk person. Since the costs of being identified as a high-risk person compared to a low risk person is $(sp_H - p_L)(\ell - x) + \gamma$, actuarially fair insurance can be offered at the cost $\theta_H[(sp_H - p_L)(\ell - x) + \gamma]$. With fair insurance against the loss of being identified as high risk, an uninformed person will choose the testing and prevention option since this option now offers the highest expected income and utility.

This result supports the policy statements in Tabarrok (1994). He argues that the potentially negative effects of predictive testing on insurance coverage and income distribution could be avoided by introducing compulsory insurance against the financial consequences of becoming high risk when a person decides to be tested, i.e. genetic insurance. He claims that this suggestion would make the implementation of socially beneficial testing more likely.

The analysis above was done under the assumption that there is no cost of taking a test. In the more realistic case of a positive cost of a test, it is no longer obvious that it is socially efficient for everyone to be tested. It is straightforward to verify that if testing is not socially efficient, it will not be undertaken. However, alternative 1 (no test) may be chosen also for the case in which it is socially efficient to be tested.

5 Test status, test result and prevention as private information

In this case the prevention an individual undertakes is assumed to be his private information. Accordingly, also the personal cost of prevention is private information. Hence, an insurance contract cannot be made contingent on whether prevention is undertaken. We also impose the institutional constraint that insurers have no access to information about whether a person is tested. Since those tested then cannot be distinguished from those not tested, insurance contracts can neither be contingent on whether a person is tested nor on the test result.

The premium for a person with only compulsory insurance is assumed to be independent of the individual risk. This means that the self-selection mechanism used in the voluntary insurance is not applicable in the compulsory insurance. Hence, when preventive costs are

private information, socially efficient testing is not likely to be undertaken by those with only compulsory insurance when personal costs of prevention occur.

We consider next the optimal decisions for a person with voluntary supplementary insurance. Assume first that insurers expect consumers to be informed of whether they are H (high-risk) or L (low-risk). Clearly, if there were full insurance coverage, there would be no incentive to undertake prevention, since prevention has a cost. The actuarially fair premium for a high-risk person who has undertaken prevention is sp_H, and the insurance coverage k that can be offered to such a person is constrained by a condition stating that with this insurance contract a person cannot be better off without preventive measures than with. From the analysis in the Appendix it follows that for persons with sufficiently low values of ℓ-x, it is not possible to offer insurance satisfying this condition. In this case the insurance contract offered will have full coverage, but at the premium that is actuarially fair under the assumption of no preventive measures, i.e. at the premium p_H. In this case prevention will not be undertaken. The intuition is that for low values of ℓ-x, it is better to pay a higher premium for full insurance of a small loss than to undertake prevention at a cost that is independent of the magnitude of the loss. For higher values of ℓ-x, there may exist positive values of k satisfying the incentive constraint described above. Denote the highest value of k satisfying the incentive constraint by by k'. The insurance contract (sp_H,k') is thus the insurance contract offered to the high-risk persons, inducing them to undertake prevention.

The low-risk persons are offered insurance at a premium p_L. The coverage they are offered cannot be too high, otherwise high-risk persons would prefer this contract to the more expensive contract (sp_H,k'). In the Appendix we show that this self-selection constraint is violated for k≥k'. Denote the highest value of k satisfying the self-selection constraint by k'' (which must be below k'). The insurance contract (p_L,k'') is thus the insurance contract that will be chosen by the low-risk, but not the high-risk, persons.

In the Appendix we show that a consumer's best choice is to acquire information through testing. The intuitive reason is this: Each person is offered two alternative insurance contracts. Which one is best depends on the risk class this person belongs to. If a choice is made without knowing the risk class, there is a chance that the "wrong" choice is made, giving the person a welfare loss. Since this welfare loss can be avoided at no cost by

undertaking a test, everyone will take such a test. We therefore have an equilibrium (a Nash equilibrium) where the insurer's expectations of testing is fulfilled, with all the low-risk persons choosing the insurance contract (p_L,k'') and all the high-risk persons choosing the insurance contract (sp_H,k') and undertaking prevention, if such a contract is offered. If such a contract is not offered, the high-risk persons will be offered full insurance at the premium $p_H(\ell\text{-x})$. In this case they will not undertake preventive measures.

Doherty and Thistle (1996) show that if the insurer does not expect consumers to be tested, no Nash equilibrium exists. Doherty and Thistle do not consider the availability of preventive measures. Since availability of prevention makes testing more attractive, their result also applies to the present model.

Compared to the full information contract there is a social loss since the insurance coverage for both groups declines. If there are not too many high-risk individuals in the population, even the low-risk group is worse off because the loss from less insurance coverage outweighs the gain from fewer subsidies to the high-risk group. Even if everyone is tested in the present case, some of those tested and found high-risk may not undertake preventive measures. We argued above that this would typically occur for low values of ℓ-x. An increase in the compulsory insurance (x) will thus tend to increase this inefficiency.

If we had introduced a positive, but small, cost of testing, the results above would remain unchanged. Clearly, such a cost will increase the social inefficiency of some persons getting tested, but not taking preventive measures even if found high-risk.

6 Policy implications

The preceding analysis has identified three potential social inefficiencies:

- Genetic testing and prevention may not be undertaken although it is socially efficient
- Adverse selection may prevent full insurance from being implemented
- High risks may be forced to pay a higher insurance premium than what is considered to be just according to distributional norms of a society.

We will sum up how each of them relates to the two regulatory issues we focus on: compulsory/voluntary insurance and public/private information.

Inefficiencies related to genetic testing and prevention

An implication of the analysis is that compulsory insurance can only encourage efficient testing if individual prevention costs are public information, so that individuals can be compensated for these costs. If the individuals' cost of prevention is private information, there is a bias towards not undertaking socially efficient testing because an individual will only have a negligible proportion of the social benefit.

With public information, a reduction in the amount of compulsory insurance (i.e. a reduction in x) may discourage efficient testing because of the risk of an increased insurance premium if identified as a high-risk person. In principle, this risk can be dealt with, for instance by means of a compulsory insurance against the consequences of being identified as a high risk (genetic insurance). For instance, the basic rules for income taxation could be combined with rules for tax reductions (according to a publicly known set of standards) that are given to persons who can document that they are of high-risk types and undertake preventive efforts. Such tax reductions according to criteria beyond the control of the individual are often used, e.g. for age or disability in Norway. A tax system of this kind would to a large extent eliminate the distributional consequences of being identified as a high risk, and hence promote socially efficient testing and prevention.

With private information about test status and prevention, the analysis in section 5 implies that a reduction in the amount of compulsory insurance initiates more socially efficient testing and prevention. The reason is that the price of voluntary insurance as untested increases when the insurer cannot distinguish the truly uninformed from the high-risk persons who pretend to be uninformed. Hence, it pays to be tested and to do preventive efforts if identified as a high risk and if the potential loss not covered by compulsory insurance is big enough.

A second potential inefficiency should now be mentioned. Assume, contrary to assumption (c) in section 3 that prevention is not socially efficient; $\gamma > (1-s)p_H\ell$; i.e. the cost of prevention is greater than the increase in expected social income due to prevention for a high risk person. The reason may for instance be that effective prevention does not exist (s=1). With private information and voluntary insurance testing is still an equilibrium solution because of the lower premium obtained if identified as low risk.

Adverse selection may prevent full insurance from being implemented
Under public information full coverage can be implemented regardless of the mix of compulsory and voluntary insurance. With private information full coverage can only be maintained for all groups under compulsory insurance. Under voluntary insurance, due to adverse selection full coverage can only be maintained for high-risk individuals who choose not to prevent. The high-risk individuals who are engaged in preventive efforts and the low risk people all end up with less than full coverage.

Higher insurance premium for high-risk individuals than what is considered to be just according to norms of distribution
Since the premium under compulsory insurance by definition is not risk adjusted, a high degree of compulsory insurance implies little variation in premiums according to risk.

With voluntary insurance an identified high-risk individual will pay the high-risk premium under both information regimes. This means that a high-risk person cannot obtain better terms of insurance in the private information case than he does in the public information case. In fact, the terms are likely to be worse, because the terms of insurance for staying uninformed worsens and he cannot be offered full insurance if cost of prevention is private information. Additionally, genetic insurance is not possible with private information about test status.

To sum up: *A high degree of compulsory insurance* seems to imply a disincentive to socially beneficial testing and prevention, in particular with private information about prevention. On the other hand, full insurance with premium independent of risk status is achieved. *A high degree of voluntary insurance seems* to imply an incentive to beneficial testing and prevention under public information and genetic insurance, and under private information also without genetic insurance. On the other hand, with private information there is also an incentive to undertake testing that is socially inefficient. A premium independent of risk status requires genetic insurance, which can only be implemented with public information about risk status. Only partial insurance for the low risk group is achieved under private information.

An important reason behind the privacy of information is that a person has a right not to know his genetic make-up. But, as showed in section 5, the incentive to undergo genetic testing is in fact greater with private information than with public information. Hence, the right not to know seems to be better protected with public information about test status than with private

information. Hence, the British decision of using the genetic test result for Huntington's disease in the underwriting of life insurance, may in fact be less threatening to the right not to know than if privacy of information had been imposed. Another thing is that this specific test is not socially beneficial, as defined in assumption (c) in section 3, since no effective prevention for Huntington's disease is known.

Given the unfavorable effects of private information about test status, it is a puzzle that the policy of international organizations and individual countries referred to in the introduction is against making the information from genetic tests open to insurers. A reason may be that genetic insurance is not yet a political issue, and the advantage of shared genetic information is therefore not transparent.

7 Concluding remarks

If we, despite of what is said above, take for granted that the privacy of information is a concern that health policy must adhere to, then a high degree of compulsory insurance has a virtue regarding both income distribution and access to comprehensive insurance. However, a high degree of compulsory insurance makes it less likely that socially efficient testing is done. On the other hand, a low degree of compulsory insurance makes it more likely that also socially inefficient testing is initiated due to incentives for risk sorting. The optimal mix of compulsory and voluntary insurance therefore depends on the kind of mistakes one is most eager to avoid.

The second type of inefficiency is likely to be more important the less effective prevention is. Genetic tests are likely to be offered before effective treatment of genetic disorders are available (see for instance, Schwartz, 1998). The test for Huntington's disease is an example. The potential social inefficiency attached to this uneven development of technologies is likely to be more prevalent the less compulsory insurance that a system contains.

Among observers opinions differ regarding the importance of the issues that this paper has raised. The Economist (2000) argues that because of adverse selection the existence of insurance markets requires that genetic information be shared. The government is said to have a role to play in compensating the unfortunate in the lottery of the gene pool. On the other

hand, Watts (1999) and Bonn (2000), refer geneticists who argue that the fears of the impact of genetic testing on insurance are unfounded. The predictive power of genetics is said to be exaggerated. Although there are some useful predictive genetic factors for multifactorial diseases, the associated risks are said to be too difficult to assess for underwriting purposes.

This paper contains assumptions that should be modified and explored in future research. As described in the introduction, some parts of privately funded health services may be considered an alternative to publicly funded services, while others may be considered a supplement. We assumed that voluntary insurance is a supplement to compulsory insurance. It should be studied whether it makes any difference for our conclusions if voluntary insurance is assumed to be an alternative. We also considered the level of compulsory insurance as exogenously determined. An interesting extension would be to allow for an interaction between the level of voluntary insurance and compulsory insurance. For instance, the decision to buy voluntary insurance may have an impact on the level of compulsory insurance a consumer prefers and hence, his voting behaviour.

We also assumed that all consumers consider their health risk to be average prior to genetic testing. As mentioned above in connection with the possibility of insurance against the financial consequences of testing, this is not quite realistic. For instance, family history may be used to distinguish between high risk and low risk individuals. An important modification is then to allow for consumers to have some ex-ante information of their risk type.

We assumed no preferences for good health, per se. The motivation for good health was confined to preferences for income. The consequences of including health as a separate argument in the utility function should be explored in future work. Hence, the introduction of state dependent utility functions, as in Strohmenger and Wambach (2000), will be an important analytic tool in future work.

Finally, the type of voluntary insurance was confined to individual contracts. Hence, we disregarded group contracts, which is the main type of health insurance for employees in the US and also constitute a considerable proportion of voluntary insurance in Europe. Group insurance has some similarities with compulsory insurance, since the premium is often related to average risk. On the other hand, the insurance is often voluntary in the sense that employees are not forced to join. Research challenges involve the study of possible

interactions genetic testing and simultaneous employment and insurance decision. Also, the specific functioning of health maintenance organizations, where insurance and provision of health services are integrated, should be further explored in this context.

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Appendix: Mathematical details

The basic insurance model

The expected utility of an insurance policy for a person with probability of disease equal to p, is:

$$v(w,p,q,k,\ell,x) = (1-p)u(w-Qx-qk(\ell-x)+\ell)+ \\ pu(w-Qx-qk(\ell-x)+x+k(\ell-x)) \qquad \text{(A1)}$$

where $w+\ell$ is the gross income in the healthy state and $w+x+k(\ell-x)$ is the gross income when unhealthy. In both states, the insurance premium (compulsory public plus supplementary private) is $Qx+qk(\ell-x)$. We assume risk aversion, implying that $u(\cdot)$ is strictly concave. As uninformed, the whole population is assumed to have an identical perception of their own risk equal to a weighted average of the actual risk of the two groups; i.e. $p=Q=\theta_H p_H+\theta_L p_L$. Moreover, actuarially fair supplementary insurance implies that q=Q. Maximization of v with respect to insurance coverage then gives k=1, implying equal income in the two states.

Assumptions about testing and preventive measures

Assumption (c): If unlimited insurance possibilities exist (i.e. no moral hazard or adverse selection problems), testing will increase utility levels. This is the same as saying that testing will increase average income in society. Clearly, testing in itself cannot increase average income. However, average income can be increased if preventive measures can be undertaken that increase the average income of the high-risk group. Without preventive measures the average income of the high-risk group is $w+(1-p_H)\ell$, and with preventive measures it is $w-\gamma+(1-sp_H)\ell$. Our definition of efficiency is thus that $w-\gamma+(1-sp_H)\ell > w+(1-p_H)\ell$, which can be written as (2).

Asumption (d): Using the function v defined in (A1), assumption (d) may be written as

$$v(w-\gamma,\theta_L p_L+\theta_H sp_H, c(\theta_L p_L+\theta_H sp_H,1),\ell,x) < v(w,\theta_L p_L+\theta_H p_H, c(\theta_L p_L+\theta_H p_H,1),\ell,x) \quad \text{A2}$$

Using (A1), it is straightforward to verify that this inequality may be rewritten as $-\theta_H p_H(\ell-x) > -\gamma-\theta_H sp_H(\ell-x)$., which gives (3).

Insurance contracts when test status, test result and prevention is private information

The actuarially fair premium for a high-risk person who has undertaken prevention is sp_H, and the insurance coverage k that can be offered to such a person is constrained by

$$v(w-\gamma, sp_H, sp_H, k, \ell, x) \geq v(w, p_H, sp_H, k, \ell, x) \qquad \text{(A3)}$$

If this constraint were not satisfied, a person would be better off without preventive measures than with. From the definition of the function v given by (A1), it is clear that this inequality will be violated if k=1 (since, by assumption, $\gamma>0$). Using (A1), it is easy to see that if ℓ-x is sufficiently small, there is no positive k satisfying (A3). For higher values of ℓ-x, there may exist positive values of k satisfying the inequality (A3). For a given value of ℓ, denote the highest value of k satisfying (A3) by k'. The insurance contract (sp_H,k') is thus the insurance contract offered to the high-risk persons, inducing them to undertake prevention. Notice that

k' in general will depend on ℓ, i.e. the coverage as a per cent of the income loss will depend on the income loss. However, without making further assumptions on the utility function u we cannot say whether k' is increasing or decreasing in ℓ.

The low-risk persons are offered insurance at a premium p_L. The coverage they are offered cannot be too high, otherwise high-risk persons would prefer this contract to the more expensive contract (sp_H,k'). More precisely, the self-selection constraint is given by

$$v(w-\gamma, p_H, p_L, k, \ell, x) \leq v(w-\gamma, p_H, sp_H, k', \ell, x) \qquad \text{(A4)}$$

Since we have assumed $p_L<sp_H$ (eq. 1), it follows directly from the definition of the function v that this inequality is violated for k≥k'. Provided ℓ-x is positive, there will always exist positive values of k satisfying (A4). Denote the highest value of k satisfying (A4) by k'' (which must be lower than k'). The insurance contract (p_L,k'') is thus the insurance contract that will be chosen by the low-risk, but not the high-risk, persons. Just like k', k'' will in general depend on ℓ, but we cannot say whether k'' is increasing or decreasing in ℓ.

The consumers' choice regarding testing and preventive measures under private information

For a consumer with ℓ>x, the consumer's choice is among the two alternatives staying uninformed with insurance contract (sp_H,k') or (p_L,k'') or do testing and prevention and choose the contract contingent on the test result. Let I be the difference between the expected utility of doing the test and the expected utility of being uninformed and assume that the individual chooses (sp_H, k') as uninformed:

$$\begin{aligned}
I &= \{\theta_H v(w-\gamma, sp_{H,} sp_H, k', \ell, x) + \theta_L v(w, p_L, cp_L, k'', \ell, x)\} \\
&-v(w-\gamma, \theta_L p_L + \theta_H sp_{H,}, sp_H, k', \ell, x) \\
&= \theta_H \{sp_H u(w-\gamma+(1-Q)x+(1-sp_H)k'(\ell-x)) + \\
&(1-sp_H)u(w+\ell-\gamma-Qx-sp_H k'(\ell-x))\} \\
&+\theta_L\{p_L u(w+(1-Q)x+(1-p_L)k''(\ell-x)) + \\
&(1-p_L)u(w+\ell-Qx-p_L k''(\ell-x))\} \\
&-(\theta_H sp_H + \theta_L p_L)u(w-\gamma+(1-Q)x+(1-sp_H)k'(\ell-x)) \\
&-(1-\theta_H sp_H + \theta_L p_L)u(w+\ell-\gamma-Qx-sp_H k'(\ell-x)) \\
&= \theta_H \{sp_H u(w-\gamma+(1-Q)x+(1-sp_H)k'(\ell-x)) + \\
&(1-sp_H)u(w+\ell-\gamma-Qx-sp_H k'(\ell-x))\} \\
&+\theta_L\{p_L u(w+(1-Q)x+(1-p_L)k''(\ell-x)) + \\
&(1-p_L)u(w+\ell-Qx-p_L k''(\ell-x))\} \\
&-\theta_H\{sp_H u(w-\gamma+(1-Q)x+(1-sp_H)k'(\ell-x)) \\
&+(1-sp_H)u(w+\ell-\gamma-Qx-sp_H k'(\ell-x))\} \\
&-\theta_L\{p_L u(w-\gamma+(1-Q)x+(1-sp_H)k'(\ell-x)) \\
&+(1-p_L)u(w+\ell-\gamma-Qx-sp_H k'(\ell-x))\} \\
&-u(w+\ell-\gamma-Qx-sp_H k'(\ell-x)) \\
&+(\theta_H+\theta_L)u(w+\ell-\gamma-Qx-sp_H k'(\ell-x)) \\
&= \theta_L\{v(w, p_L, p_L, k'', \ell, x) - v(w, p_L, sp_H, k', \ell, x)\} > 0
\end{aligned}$$

since (p_L,k'') is the insurance contract that will be chosen by a low- risk person.
By similar reasoning it may be shown that I>0 also if the consumer chooses (p_L, k'') as uninformed.