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University of Technology, Sydney
City campus, Haymarket
PO Box 123 Broadway NSW 2007
Tel: +61 2 9514 4720
Fax: + 61 2 9514 4730
Email: mail@chere.uts.edu.au
www.chere.uts.edu.au

Genetic Testing, Income Distribution and Insurance Markets[1]

Ray Rees
University of Munich

Patricia Apps
University of Sydney

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Abstract

This paper analyses the policy implications for health insurance markets of the development of genetic testing. A central issue surrounding this development is whether insurers should be allowed access to the information provided by such tests. The paper first shows that on efficiency grounds alone, insurance buyers should be allowed voluntarily to supply this information to insurers. The source of the considerable opposition to this proposal is really the distributional implications: those with the worst genetic endowments will as a result have to pay the highest insurance premiums. The paper then goes on to analyse possible redistributional policies that can remedy this. In doing so, it makes a significant departure from the mainstream literature on adverse selection in insurance markets, by assuming that individuals have differing income endowments.

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1. Introduction

Developments in the technology and cost of genetic testing have led in a number of countries, especially the US, to considerable debate about the effects on the welfare of individuals arising out of the use of test results in insurance markets.[1] Fears that testing could lead to a "genetic underclass" of individuals who find it very costly, or even impossible, to buy health and life insurance, have prompted concerned interest groups to demand that insurers should be prevented by law from requiring genetic testing as a condition of insurance, from requesting the results of tests already taken, or even from requiring to be told whether an individual has taken such a test. A further concern is that if individuals fear that taking a test would have adverse consequences for them on insurance markets, they will be deterred from taking the tests, thus losing possible benefits from having the test information. For example it may be possible to change one's life style or undergo medical treatment, in ways that reduce the risk of illness. Those concerned with the ethical aspects of testing emphasise the individual's right to privacy in respect of one's genetic makeup, and also the right not to know whether one has a bad genetic endowment[2] Both these rights would be infringed if insurers are allowed

[1] For a very good survey of this debate and further references see Hoy and Ruse (2004).

[2] A number of authors have pointed to the empirical evidence that a large proportion of individuals offered a costless genetic test for certain kinds of conditions actually choose not to

to mandate testing as a condition for insurance.

Insurers on the other hand argue that not being able to have access to the results of genetic testing causes problems of adverse selection, with the implication drawn from standard insurance market models, that low risk individuals are made worse off.[3] They also stress that genetic tests are qualitatively speaking nothing new, since use of medical testing and family history in premium rating have long been routine. Their argument is that premium differentiation according to risk class is no more discriminatory than basing prices of goods on marginal costs of supply, which is an essentially correct argument. The case for reflecting risk probabilities in premia is exactly that for marginal cost pricing: It induces a Pareto efficient market equilibrium, at least in the absence of the standard kinds of second best considerations that would require changes to this rule.

However, Pareto efficient allocations can be very inequitable, and at bottom, abstracting also from purely rights-based objections, this seems to be the source of opposition to premium differentiation. Individuals with the worst initial endowments, in terms of genetic makeup, are asked to pay the highest prices and

be tested, simply preferring not to know.

[3] Assuming the standard Rothschild-Stiglitz-Wilson equilibrium represents the solution to the problem. Cutler and Zeckhauser (1997) give an interesting case study of how failure to adopt this solution can cause the insurance market to collapse because of the withdrawal of low risk individuals.

hence, ceteris paribus, have the lowest standards of welfare.[4] But the question of redistribution is an old one in economics, and one we are well equipped to discuss. Given that society might well want to improve the position of those individuals who, through no fault of their own, are endowed with a bad set of genes, what is the best way of doing so? Is it by restricting insurers' access to information, by compulsory uniformity of insurance premiums, or, as this paper will argue, by an appropriate tax/subsidy policy without either of these other measures.[5]

This paper is organised as follows. In the next section I review the issue of policy toward information transmission, concluding that the best policy (again abstracting from rights-based issues) is to allow voluntary provision of test results by individuals to insurers. Depending on whether or not insurers can observe the informational status of individuals, *i.e.* whether individuals know their own risk type, there may or may not be a full information separating equilibrium without adverse selection. However, in either case, it has long been known in the insurance

[4]Strohmenger and Wambach (2000)make the important point that in connection with health insurance, the usual assumption in the insurance literature, that the value of loss is less than endowed income, is often violated, when "loss" is interpreted as the cost of medical treatment. It is easy to show that in that case high risks may simply not buy insurance, again a very inequitable result.

[5]Hoy et al (2003) make the valid point that currently, the welfare losses due to compulsory pooling of insurance premiums are extremely small, and this is therefore the appropriate way to deal with the problem. The relevance of this paper is to a point in time when that may no longer be the case.

literature[6] that, where the endowed incomes of individuals are all equal, there is a simple tax/subsidy policy that can redistribute welfare at least cost. This paper extends that analysis by asking what the nature of the redistribution policy should be when individuals' endowed incomes differ, in a way that may or may not be correlated with risk type, and when an individual's income is unobservable.

2. The Incentive to Acquire Information

The set of all individuals is partitioned into subsets H, U, and L. H and L consist of those individuals who already know that they are high and low risk respectively, while U consists of those who do not know whether they are high or low risk.[7] The following exogenous parameters are common knowledge to all market participants:

π_H, π_U, π_L, the proportions of the total population in the respective subsets, with $\pi_U, \pi_H, \pi_L \geq 0$, $\sum_{i=H,U,L} \pi_i = 1$;

$\theta \in (0,1)$, the proportion of the individuals in U who are high risk;

$\lambda \in (0,1)$, the proportion of high risks in the total population. Thus $\lambda = \pi_H + \theta\pi_U$;

$p_H, p_L \in (0,1)$, the loss probability of an individual of type H or L respectively,

[6] See for example Hoy (1982), (1984), and Crocker and Snow (1985), (1986).
[7] The standard adverse selection model assumes that U is always empty.

with $p_H > p_L$;

$\bar{p} = \lambda p_H + (1-\lambda)p_L$, the average loss probability across the entire population;

$p_U = \theta p_H + (1-\theta)p_L$, the average loss probability over the subset U.

Individuals in each subset take decisions with respect to the loss probability p_i, $i = H, U, L$ appropriate to that subset. In particular, individuals in U take p_U as their loss probability. Everyone has the same utility function $u(.)$, $u^{'} > 0$, $u^{''} < 0$, with the same endowed income y_0, and faces the same loss $d \in (0, y_0)$. An insurance contract offers an amount of cover or compensation c in the event of a loss, at a premium r. We refer to the case in which $r_i = p_i c$, $i = H, U, L$, as the case of a *fair premium for type* i.

We assume that the insurance market is perfectly competitive and that there are no costs of supplying insurance. This implies that in any equilibrium insurers break even in expected value, and equilibrium contracts maximise expected utility of insureds, *given* the informational conditions that prevail. We are interested in the market equilibria under various assumptions about the distribution of information in this market. A test exists which gives verifiable information that an individual is either certainly in H or certainly in L, i.e. it establishes verifiably an individual's risk type. We assume initially:

- the test is costless

- there are no early treatment benefits, in the sense discussed in the Introduction, associated with the test.

Thus the test would allow individuals in U to determine, costlessly and with certainty, if they are in fact $H-$ or $L-$ types, and it would also allow $L-$ types costlessly to prove to insurers that they were in fact low risk. This implies that if insureds are allowed voluntarily to provide insurers with test results, and they know their types, in no equilibrium can $L-$types be offered a contract that yields them lower expected utility than the contract[8] $\{p_L d, d\}$, because, if offered a worse contract, every $L-$ type would take the test and provide the results to an insurer. Competition among insurers would then lead to $\{p_L d, d\}$ for these insureds.

We now want to explore the relationship between information and market equilibrium. It is common knowledge that the individuals know which of the subsets H, U, or L they are in. We have three possible cases of interest, corresponding to what insurers are assumed to know.

2.1. Symmetric Information

Figure 1 about here.

Suppose that insurers can costlessly observe which of the three subsets any

[8] In the contract $\{x, y\}$ x is the premium and y is the cover.

individual is in. Then the market equilibrium is shown in Figure 1. The equilibrium contracts H^*, U^*, L^* correspond to full cover at the fair premium for the respective types. The absolute values of the slopes of the lines E_H, E_U and E_L are the fair odds ratios $(1-p_i)/p_i$, $i = H, U, L$, these lines being effectively budget constraints for the exchange of state contingent incomes for each type. The effects of the assumption of a competitive insurance market with no costs of supplying insurance are first, that each type must in equilibrium pay its fair premium (otherwise an expected loss or profit would be made on that type's contract), and secondly, that the equilibrium contract for a given type must, given the fair premium, maximise expected utility for that type (otherwise competition would produce a better contract). These then imply the equilibrium shown in the figure.

Consider now the social value of a genetic test that identifies with complete accuracy whether someone has a loss probability of p_H or p_L. It is a long-established result[9] that, from a positive point of view, no insurance buyer will want to take the test, and from a normative point of view, the ex ante social value of the test is negative. The basis for this result is:

[9] For general analysis of the value of information in market economies under uncertainty see for example Arrow (1970), Hirshleifer (1971), Harris and Townsend (1981), and Milgrom and Stokey (1982).

Proposition 1: *Any individual in U has a lower expected utility from taking the test than from not taking the test.*

Proof: Before testing, someone in U buys full cover at the fair premium $p_U d$, while after testing, since insurers can observe everyone's type, the premium will be $p_L d$ or $p_H d$ respectively, depending on the outcome of the test. Thus she has a utility of $u(y - p_U d)$ if not tested, and $u(y - p_H d)$ with probability θ, and $u(y - p_L d)$ with probability $(1 - \theta)$, if tested. Then strict concavity of utility implies

$$u(y - p_U d) > \theta u(y - p_H d) + (1 - \theta) u(y - p_L d) \tag{2.1}$$

since

$$y - p_U d = \theta(y - p_H d) + (1 - \theta)(y - p_L d) \tag{2.2}$$

Intuitively, each individual in U prefers the certainty of premium $p_U d$ to the gamble on premia, with the same expected value, that the test represents. This phenomenon is known as *premium risk.* Then, since individuals in H and L gain nothing from taking the test, while those in U lose in expected utility, nobody takes the test. We now show that this result does not depend on the assumption

of complete symmetry of information.

2.2. Asymmetric Information in Respect Only of Risk Type

Suppose now that insurers can observe whether or not someone is in U, but not which of H or L she may be in. In the terminology of Doherty and Thistle (1996), they can observe *informational status,* the fact of knowing or not knowing one's risk type, but not the risk type itself. Now, it might be argued that the market equilibrium consists of the three contracts H^*, U^* and $\hat{L}$, in Figure 1. Individuals in U receive the same contract as before, U^*. However, for individuals known to know their type, insurers face an adverse selection problem. The contracts that solve this problem on a competitive market are H^* and $\hat{L}$, the Rothschild-Stiglitz equilibrium pair of contracts.[10] It follows immediately that the premium risk facing individuals in U is now increased, as compared to the previous case.

[10]It is well known that if the proportion of high risks in the population is sufficiently small, no equilibrium may exist in this model. To focus on the issues raised by genetic testing it is usual in the literature to assume this problem does not arise. As a referee points out, at the present time, in the genetic testing context only very small proportions of high risks are indeed involved, so the assumption of the existence of a Rothschild-Stiglitz equilibrium could well be problematic. On the other hand, although there exist possible approaches to the analysis of insurance markets in this case, for example that based upon the equilibrium concepts of Wilson and Riley, there is little general consensus on how to deal with cases in which the Rothschild-Stiglitz equilibrium does not exist. Indeed, as Hoy et al (2003) point out, when the proportion of high risks is so small, one might as well pool and ignore the whole problem with which this literature is concerned. It is perhaps best thought of as applying to a time when genetic testing is so widespread that those it identifies as high risks are no longer a trivially small proportion of the insured population.

The expected utility resulting from testing falls, because with probability $1-\theta$ the individual post-testing will buy the contract $\hat{L}$, which yields a lower expected utility than L^*. Thus the right hand side of (2.1) falls, and the disincentive to be tested rises.

However, the fact that the test is costless and verifiable must imply that in this case the adverse selection problem disappears. Insurers will offer the contract L^* to anyone producing the test results, and H^* to anyone not in U and not reporting test results. Thus all individuals in L take the test, which has a positive value to them, equal to the difference in expected utilities from contracts $\hat{L}$ and L^* respectively. Essentially, they no longer have to incur the costs of signalling their type. This is of course a genuine welfare gain resulting from existence of the test. On the other hand, the previous conclusions on the value of the test to individuals in U are unchanged: they are faced with exactly the same premium risk in this case, and will not take the test. Thus the equilibrium contracts are again $[H^*, U^*, L^*]$.

2.3. Completely Asymmetric Information

Figure 2 about here

Assume now that insurers cannot observe which of the three subsets an indi-

vidual is in. If insurers cannot observe information status, they cannot offer the contract U^*, since they would not be able to prevent individuals in H from taking this contract. In effect, they have an adverse selection problem with respect to the subsets H and U. As shown by Doherty and Thistle, this has a dramatic effect on the existence of premium risk. The competitive market equilibrium contracts that solve this adverse selection problem are H^* and $\hat{U}$ as shown in Figure 2. On the other hand, on the same argument as we just made, insurers will offer the contract L^* to anyone producing test results establishing that they are low risk. This will be done by everyone in L. Consider then an individual in U. Because the no-test contract for this individual is now $\hat{U}$ and not U^*, we can show that premium risk disappears and she will now have a positive gain from taking the test.

Proposition 2: *If offered the contract $\hat{U}$, every individual in U is strictly better off taking the test.*

Proof: If she takes the test, with probability θ she will be high risk and will receive the contract H^*, which she will regard as just as good as $\hat{U}$, by construction of $\hat{U}$. With probabilty $1-\theta$, on the other hand, she will be low risk and will receive the contract L^*, which she will strictly prefer to $\hat{U}$. Thus her expected utility associated with taking the test must increase.

This means that the situation shown in Figure 2 cannot be the equilibrium. There will be no takers for the contract $\hat{U}$. Instead, firms will offer the two contracts H^* and L^*, the latter available only to those who present negative test results. All those in U will take the test, since the gamble with probability θ of H^* and $1-\theta$ of L^* is strictly better than the certainty of H^*. Likewise all those in L will take the test since it is costless and brings them the contract L^*. Thus the only equilibrium of the insurance market in this case, is that everyone in U and in L takes the test, test results are provided to insurers, those proving they are low risks receive the contract L^*, the remainder receive H^*. The end result is therefore the separating equilibrium $[H^*, L^*]$.

2.4. Equilibrium under Information Restrictions

As discussed in the Introduction, the policy debate so far has been concerned with the question of what information insurers may be allowed to require or be given. We can use the preceding analysis to derive the consequences of each of the main policy alternatives.

A1: Insurers can require buyers to take the test and supply them with the results. In that case, the resulting market equilibrium is $[H^*, L^*]$.

A2: Insurers cannot require buyers to take the test, but can require that the

buyer inform them truthfully of whether a test has been taken, and buyers may voluntarily supply the test results.[11] In that case the equilibrium is in effect again $[H^*, L^*]$. Those who know they are low risk can costlessly signal this and so receive L^*. A buyer who reveals that she has been tested but does not provide the results reveals herself as high risk and so receives H^*. Someone who has not been tested would be offered a choice between H^* and $\hat{U}$, since it could be someone who knows she is high risk without having taken the test,[12] or someone in U. In that case it pays those in U to take the test, and those with good results will report them. Thus we have in effect[13] the two-contract equilibrium.

A3: Insurers can neither require testing nor to be told that testing has been carried out, but a buyer may voluntarily supply test results.[14] The equilibrium is then again $[H^*, L^*]$. Those in L again use the test to signal their type. These receive L^*. Someone not doing so must be in H or U. H^* and $\hat{U}$ would separate these, but anyone in U then finds it worthwhile to take the test.

[11] Again, as discussed in the Introduction, we do not need to consider the case in which the insurer may require the test results, since low risks always have an incentive to report them if they receive a lower premium as a result.

[12] It is here assumed that it is common knowledge that some buyers know they are high risk without having taken the test. If this is not the case, anyone who has not taken the test would be offered U^* and the equilibrium is $[H^*, U^*, L^*]$.

[13] The contract $\hat{U}$ must still be on offer to anyone who reports themselves as uninformed, but no-one will take it in equilibrium.

[14] We ignore the case in which someone would voluntarily report a bad test result.

A4: Information relating to genetic testing may neither be required by insurers nor voluntarily provided by buyers. In this case the equilibrium will be the Rothschild-Stiglitz $[H^*, \hat{L}]$ shown in Figure 3. The argument can be made in terms of the figure. Insurers are initially faced with the three subsets, among which they cannot distinguish, and so a candidate for a separating equilibrium would be $[H^*, \hat{U}, L^{'}]$ in the figure. However, in that case it pays each buyer in U to be tested, because a lottery involving H^* and $L^{'}$ yields higher expected utility than $\hat{U}$. If she turns out to be high risk she is no worse off than at $\hat{U}$, and if low risk she will be better off (an L-type indifference curve drawn through point L' lies above $\hat{U}$). Thus insurers can conclude that everyone will either be in H or L, but low risks are no longer able to signal their type by the test. Hence we have the more costly signalling of the Rothschild-Stiglitz equilibrium.

The interesting thing is that these equilibria can be Pareto-ranked. $[H^*, L^*]$ is unambiguously Pareto superior to $[H^*, \hat{L}]$ since high risk types are no worse off and low risks are better off. Thus this analysis, essentially due to Doherty and Thistle, implies that policies **A1**, **A2** and **A3** are strictly Pareto superior to **A4**.

Figure 3 about here

2.5. Normative Implications of the Equilibria

To fix ideas, assume that the subsets H and L are empty - everyone is initially uninformed about their type. In the absence of testing, the market equilibrium will be as shown in Figure 4, at the point P^*. There is complete pooling with everyone receiving full cover at the fair premium. This is a Pareto efficient allocation, since all insureds are receiving full cover. The allocation $[H^*, L^*]$ just discussed is also Pareto efficient, and the only difference between the two is in terms of the distribution of expected utility: in one case everyone is paying their respective fair premium, in the other there is a cross-subsidisation from low to high risk insureds. Recall that the loss probabilities are in some sense innate initial endowments, rather than the consequences of individual actions, and this may well influence society's evaluation of the fairness of this allocation.[15] Certainly, any statement that the separating equilibrium is better than the pooling one, or conversely, must be based on a judgement about the relative fairness of the two allocations.[16]

[15] Thus Brockett et al (2000) report the results of surveys that show that people strongly agree that automobile insurance rates should reflect the degree of risk they represent to insurance companies, but significantly disagree that this should be the case in health insurance. The most likely explanation is that people associate risk in motoring with moral hazard and that in health with adverse selection.

[16] A referee makes the valuable point that although under full information the pooling and separating equilibria are both Pareto efficient and cannot be ranked on efficiency grounds, in the context of genetic testing, where people may well not know their type, the separating equilibrium is associated with premium risk, and so is Pareto inferior to the pooling equilibrium. It is not possible to Pareto-rank the equilibria only if as a result of genetic testing the equilibria discussed

Figure 4 about here

If now at least some insureds know their types, so that H and L are non-empty, P^* is no longer sustainable as a market equilibrium. If offered a choice of cover at the premium rate $\bar{p}$, $H-$types will over-insure, $L-$types will under-insure, and insurers are likely to go bankrupt. Insurers will have to adjust their contract offers to the possibility of adverse selection, and the analysis just set out applies. In that case we saw that there are two possible types of equilibrium, depending on whether or not insurers can observe the information status of insureds. If so, we will have the three-contract separating equilibrium $[H^*, U^*, L^*]$ and only those who know they are low risks take the test (as a zero cost form of signalling), while if not we will have the two-contract separating equilibrium $[H^*, L^*]$. Both these equilibria are again Pareto efficient, and differ only in their distributional implications. Note, however, that P^* is achievable as a market equilibrium, whether or not there is adverse selection, by a policy of offering contracts containing premia that are fair for each type, and with a lump sum subsidy or tax, calculated so as to be feasible, and which induces each insurance buyer to choose the allocation at P^*. Moreover, since the tax/subsidy is associated with a contract, and not an individual, the policy does not require that the planner be able to observe risk type, and so could

here are achieved *ex post*. This is assumed in the next section.

also be used even if there were an adverse selection equilibrium. The interesting point is the following: suppose the planner has a utilitarian social welfare function defined on the expected utilities of the individuals in the economy. Then it is straightforward to demonstrate:

Proposition 3: *the planner will choose the allocation at P^*as the social optimum.*

Proof: Consider the following planner's problem:

$$\max_{c_i,s_i} W = \sum_{i=H,L} \lambda_i[(1-p_i)u(y-p_ic_i+s_i)+p_iu(y-d+(1-p_i)c_i+s_i)] \quad (2.3)$$

$$s.t. \sum_{i=H,L} \lambda_i s_i = 0 \quad (2.4)$$

where λ_i is the population proportion of type i and s_i are the transfers. Then from the first order conditions it is straightforward to show that the optimal solution has $c_H^* = c_L^* = d$,and $y - p_h d + s_h^* = y - p_L d + s_L^*$.

A corollary of this is that any planner with a social welfare function exhibiting positive equity aversion will also want to have the allocation P^*. Moreover, note that this solution is incentive compatible under asymmetric information about types, so that even if genetic testing did not allow high and low risk types to be identified, this solution could be implemented. Each type receives full cover $c_i^* = d$,

and the lump sum tax/subsidy per contract s_i^* is chosen so as to equalise the certain incomes. Thus the standard incentive compatibility constraint is satisfied trivially. These conditions characterise point P^*.Thus this full pooling equilibrium has rather a compelling attraction as a social optimum.

All this however assumes that individuals have the same incomes. This is not a very appealing assumption, and neither is the assumption that in the presence of differing incomes the income type of an individual would be costlessly observable. Thus in the next section we go on to examine the optimal tax/subsidy policy in the presence of differences in unobservable income.

3. Unobservable Income Differences

As we suggested earlier, the real grounds for opposition to genetic testing are related to equity rather than to efficiency. Efficiency considerations, as analysed in the previous section, suggest that the argument that allowing people to supply the results of genetic tests to insurers brings efficiency gains by eliminating adverse selection problems, is essentially correct. But this could lead to very unfair market equilibria, in which people with, through no fault of their own, poor genetic endowments are made much worse off than others with better endowments. But if this is the real motivation for policy intervention, surely it is better to consider

policies that remedy this inequity in a way that creates the minimum of economic efficiency. It is really a problem in optimal redistributive taxation. This is the view that motivates the analysis of this section. In it, we make an extension to the insurance market model that is relatively rare, since most of the literature is based on models in which individuals are identical except for their risk probablilities: We assume that they differ also in their income endowments.[17]

Let us continue to assume that the existence of genetic testing allows identification of risk types. However, there are two income types, labelled $j = H, L$, and income is not observable to the planner.[18] If it were, being utilitarian she would again choose the point of equal certain incomes for all individuals in the economy. To see this just solve the problem

$$\max_{c_{ij},s_{ij}} W = \sum_{i=H,L} \sum_{j=H,L} \lambda_{ij}[(1-p_i)u(y_j-p_ic_{ij}+s_{ij})+p_iu(y_j-d+(1-p_i)c_{ij}+s_{ij})] \quad (3.1)$$

$$s.t. \quad \sum_{i=H,L} \sum_{j=H,L} \lambda_{ij}s_{ij} = 0 \quad (3.2)$$

where λ_{ij} is now the proportion of individuals with risk type $i = H, L$ and income

[17] For papers that also assume wealth heterogeneity see Smart (2000), Villeneuve (2003) and Wambach (2000).

[18] Note that we are assuming that income is exogenously given and not determined say by an individual's labour supply. It would be quite easy however to extend the model in this direction, and to consider income taxation rather than just cross-subsidisation of insurance contracts as a redistributive mechanism. The results look fairly predictable.

type $j = H, L$.

Now notice that in this solution, the high income types are being required to make transfers to the low income types in each risk class. That is, using the property of the optimum that all incomes across risk and income types are equalised, we can show

$$s^*_{iL} - s^*_{iH} = y_H - y_L > 0 \quad i = H, L \tag{3.3}$$

Thus if income type were non-observable, a high income individual in each risk class would choose the contract designed for a low income individual in that risk class (recall that risk type is, because of genetic testing, observable). It follows that in the case of asymmetric information[19] we have to impose the two incentive compatibility constraints:

$$\bar{u}_{iH}(c_{iH}, s_{iH}) \geq \bar{u}_{iH}(c_{iL}, s_{iL}) \quad i = H, L \tag{3.4}$$

[19]Note that the existence of genetic testing spares us the complications of a two-dimensional screening model.

where

$$\bar{u}_{iH}(c_{ij}, s_{ij}) \equiv (1-p_i)u(y_H - p_i c_{ij} + s_{ij}) + p_i u(y_H - d + (1-p_i)c_{ij} + s_{ij}) \quad i, j = H, L \tag{3.5}$$

The basic result for this case is of course that the existence of asymmetric information makes redistribution costly, in the sense of distorting allocative efficiency, and so redistribution does not go as far as the planner would like. Moreover the "no distortion at the top" result implies that the high income individuals obtain full cover at a fair premium.

What is perhaps not so obvious, at least *ex ante*, is that low income households also obtain full cover: distortion of the insurance contract is not required as an instrument to achieve incentive compatibility with respect to income distribution. This is done entirely by means of adjusting the lump sum transfers between income groups. Thus from the fist order conditions for the above problem we can derive, for Lagrange multipliers μ_i attached to the relevant incentive constraints

$$u'(y_L - d + (1-p_i)\hat{c}_{iL} + \hat{s}_{iL}) - u'(y_L - p_i\hat{c}_{iL} + \hat{s}_{iL}) \tag{3.6}$$

$$= \frac{\mu_i}{\lambda_{iL}}[u'(y_H - d + (1-p_i)\hat{c}_{iL} + \hat{s}_{iL}) - u'(y_H - p_i\hat{c}_{iL} + \hat{s}_{iL})] \quad i = H, L \tag{3.7}$$

which is satisfied at $\hat{c}_{iL} = d$. But this then has immediate implications for the solution for income transfers. Since $\hat{c}_{iL} = \hat{c}_{iH} = d$, the fact that the incentive constraints must bind implies that $\hat{s}_{iH} = \hat{s}_{iL} = \hat{s}_i$, so that within a given risk group high and low income households must be treated identically. This implies in turn that low income low risks contribute to the transfer to high income high risks, which to the utilitarian planner is a not particularly desirable result, but it is the best she can do given the non-observability of incomes. Income disparities persist, since members of risk group i at the optimum have incomes $y_j - p_i d + s_i$, so the initial income difference is precisely preserved. The sizes of the transfers are determined by the overall proportions of the risk types in the population, since the resource constraint implies

$$\hat{s}_H = -\frac{\lambda_{LL} + \lambda_{LH}}{\lambda_{HL} + \lambda_{HH}} \hat{s}_L \tag{3.8}$$

4. Conclusion

The topic of genetic testing appears to arouse considerable emotion and genuine concern. One response could be to pass legislation forbidding insurers to make use of the results of genetic tests. This rests on a classical confusion of equity

with efficiency. On the assumptions set out in this paper, such a ban makes no insurance buyers better off and some worse off. It is Pareto dominated by a policy of allowing people voluntarily to provide the results of genetic tests to insurers (who can still be forbidden to require that such tests be taken and the results provided). The real problem is one of equity, which is actually what motivates the concerns. Individuals who for no fault of their own have poor genetic endowments will be possibly much worse off than those with good endowments. This suggests the need for redistributive policies. In fact any policy maker who is at least as inequality averse as a utilitarian (who has zero inequality aversion) would always prefer the equilibrium in which all insureds receive full cover at the pooled fair premium.

However, once we begin to consider distributional issues, it seems unreasonable to maintain the standard assumption of equal incomes among insureds. If incomes are observable, the pooling equilibrium is easy to achieve by appropriate transfers, but a more reasonable assumption would be that incomes are unobservable. We are however rescued from the horrors of a two-dimensional screening model by the existence of genetic tests that resolve the asymmetry of information in respect of health risk. The results are that within a given risk group high and low income households must be treated identically, implying in turn that low income low risks

contribute to the transfer to high income high risks. The initial income difference is precisely preserved. The sizes of the transfers are determined by the overall proportions of the risk types in the population.

Aside from what have been called here "rights-based concerns", the two major omissions in this paper are first, that it should be recognised that genetic tests do not typically establish conclusively that an individual is definitely of one risk class or another, and secondly that income taxation creates incentive effects on labour supplies. In testing, there is always the chance of false positives and false negatives. That is, one should regard genetic tests as providíng information which allows one to change a prior probabilty of an individual contracting a disease into a posterior probability according to Bayes' Rule. However, provided insurers are assumed to use these probabilities appropriately in their premium setting, we conjecture that nothing essential in the above analysis would change as a result. More substantively, the assumption that income can be transferred among risk and income types in a lump sum way should be replaced by an explicit income tax analysis. Again, however, we conjecture that the results of such an analysis can be pretty accurately guessed *ex ante*.

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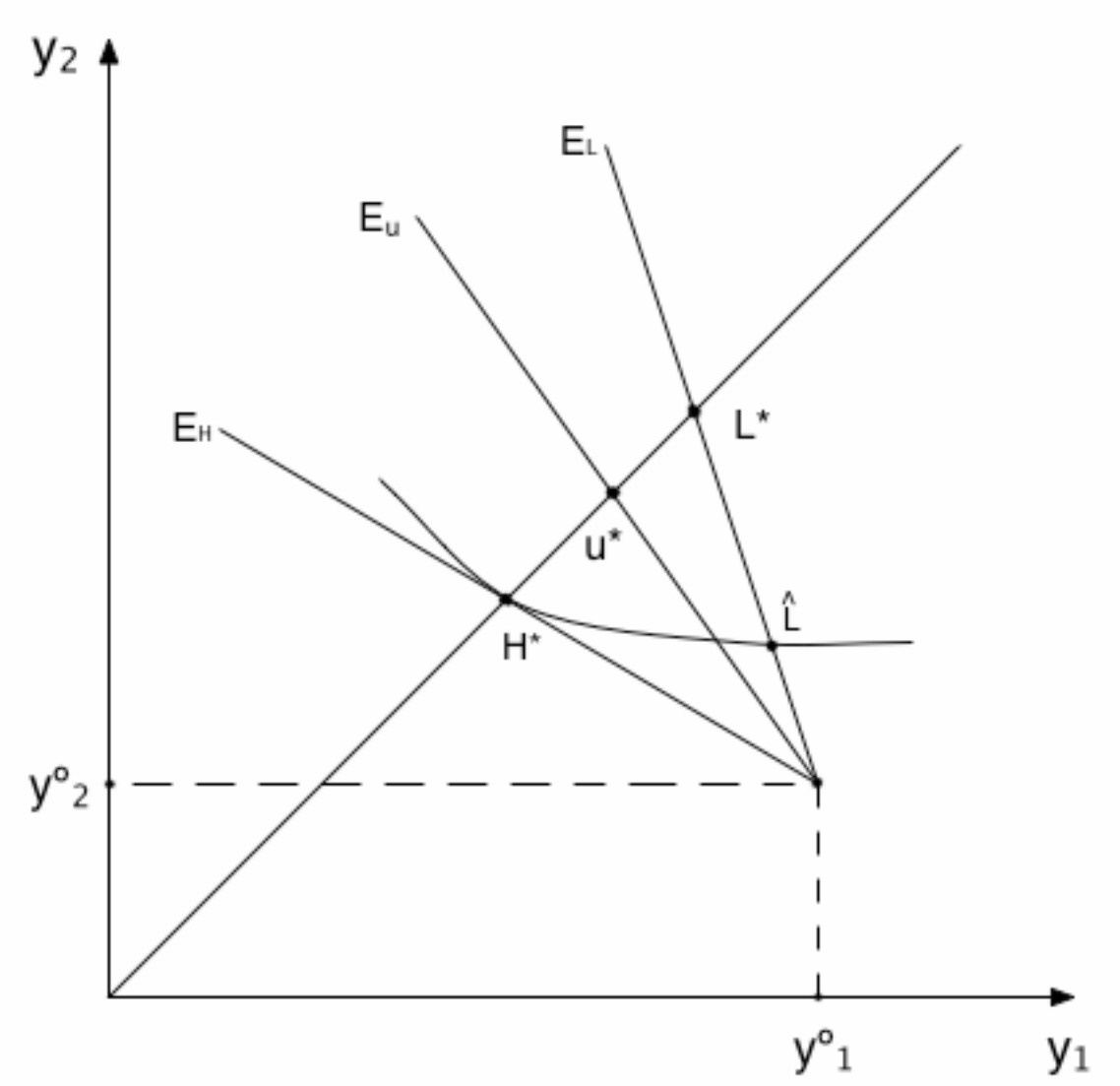

Figure 1

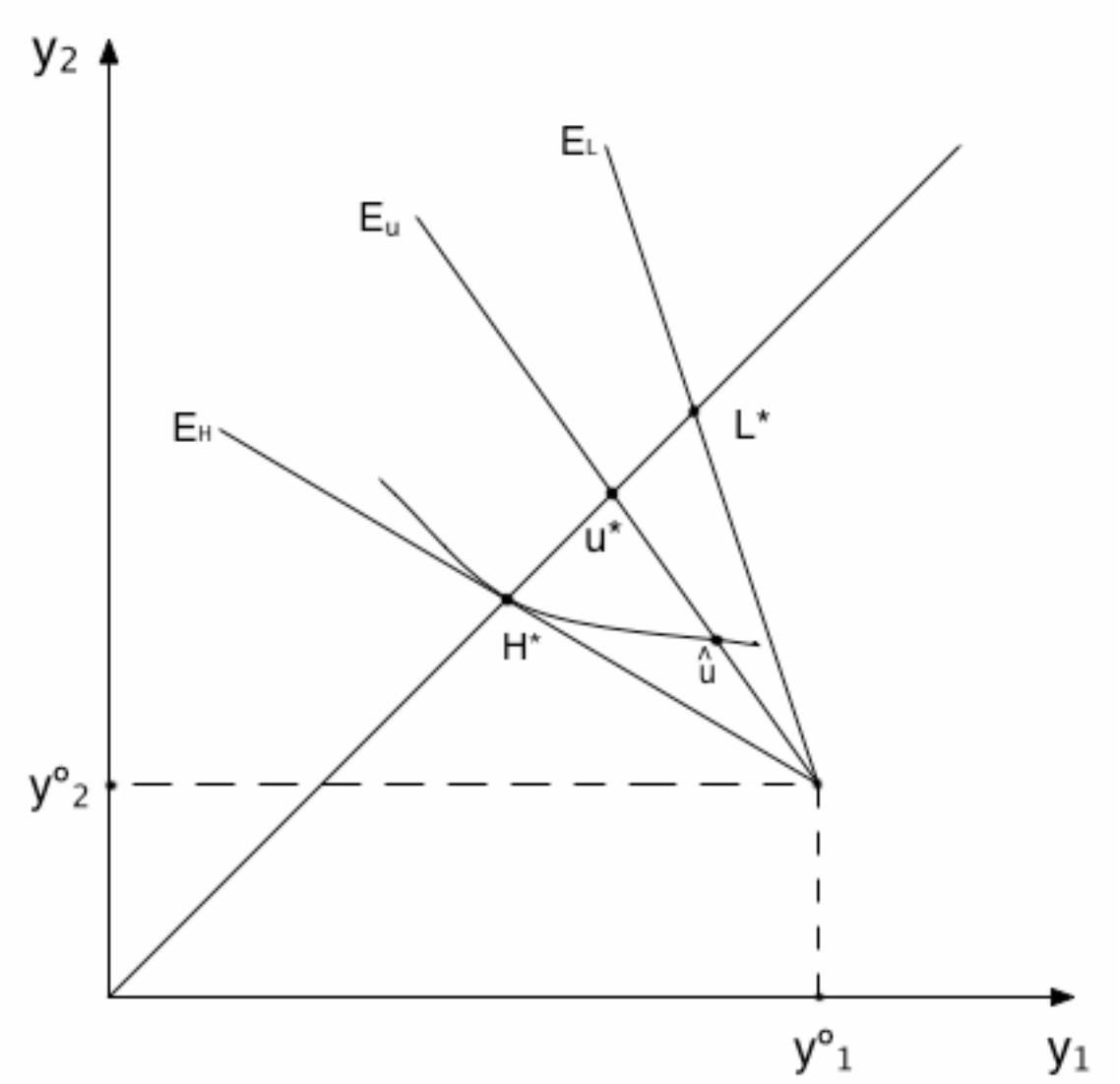

Figure 2

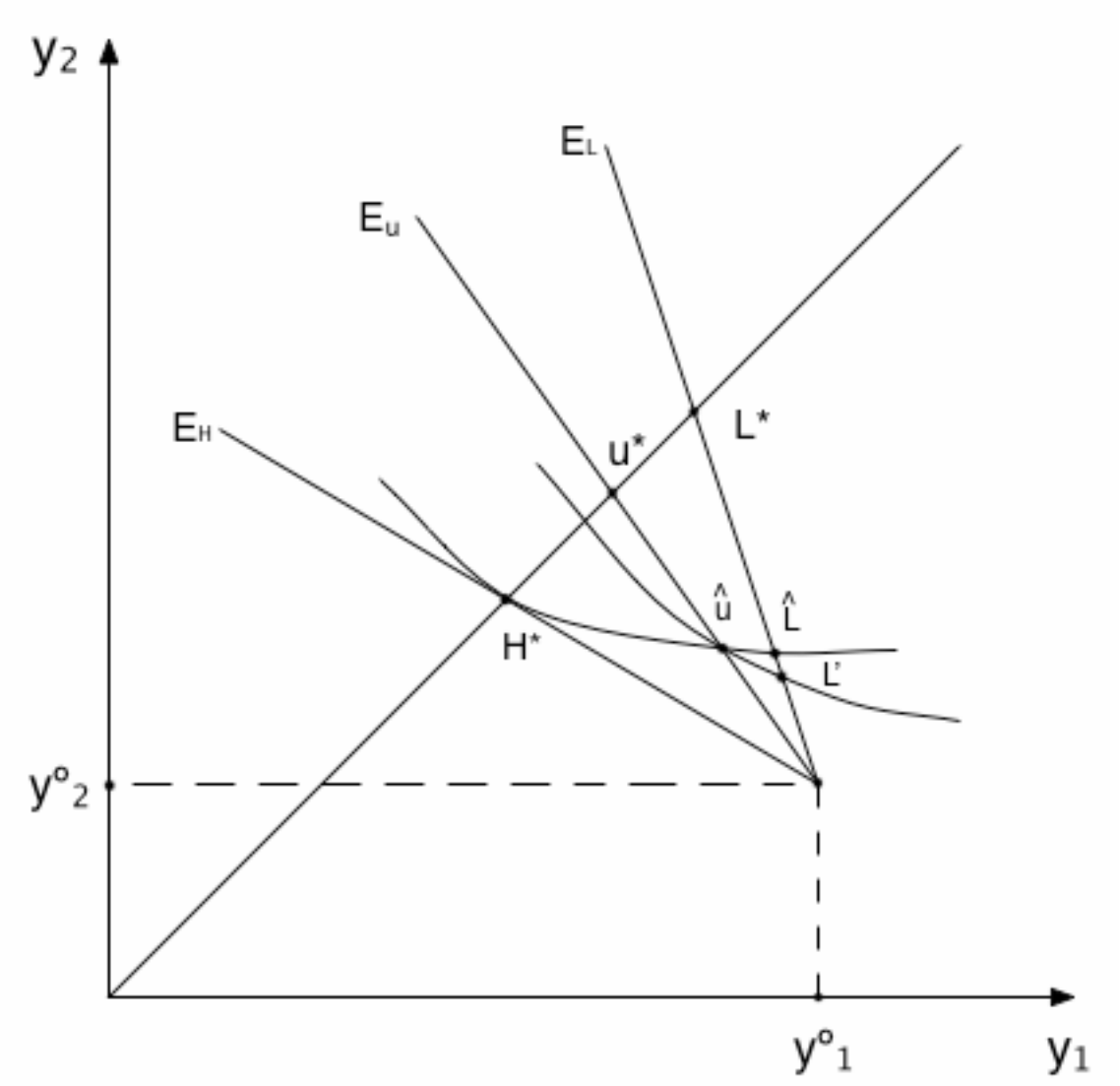

Figure 3

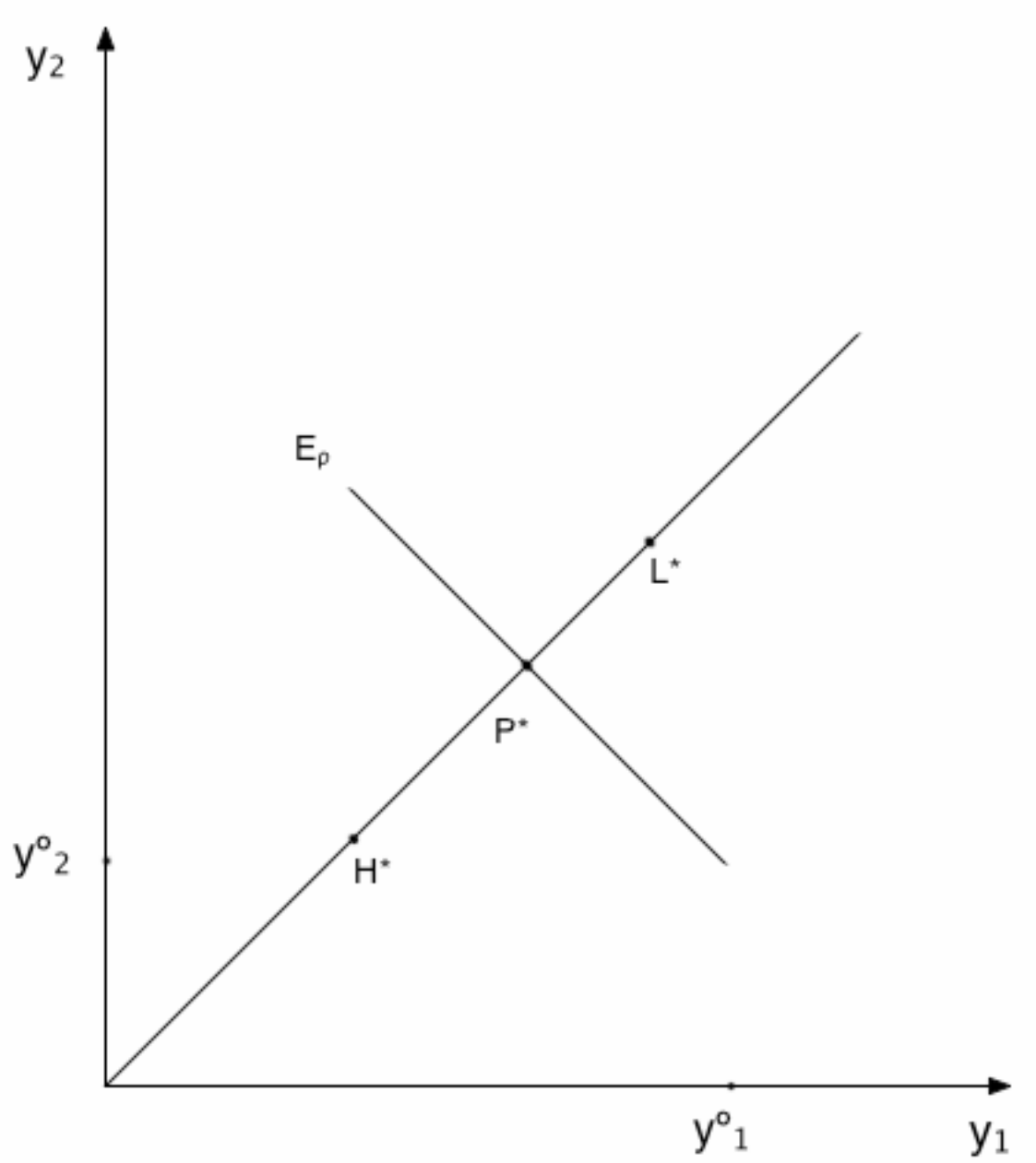

Figure 4