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Moral hazard and adverse selection in health insurance market: an application to genetic testing

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Abstract: The simultaneous presence of adverse and moral hazard reflects the insurance market in the presence of genetic tests. With these two problems (adverse selection and moral hazard), companies offer partial coverage for each agent. Our contribution to this model is to show the different conditions in which these contracts can be offered. Under marginal productiveness of self-protection activity, we show that it is sometimes less costly for insurance companies to offer a pooling contract than a menu of separating contracts. This result is possible only under the single crossing property of Milgrom Shannon (1994) redefined by Edlin and Shannon (1998). We show that the pooling contract is possible even if the Spence-Mirrlees condition fails in particular when the difference in the marginal productiveness of self-protection decreases. But when the difference in the marginal productiveness of self-protection activity is constant or increases, the pooling contract is not an option. In this case, if a contract is possible it is necessarily a separating one, in which insurers offer more coverage to high-risk than to low-risk agents.

Keywords: *Genetic testing – adverse selection – moral hazard*
J.E.L. Classification: *D82 – D83 – D63 – G22*

Aléa Moral et antisélection sur le marché d'assurance-maladie : Une application aux tests génétiques

Résumé : La présence simultanée d'antisélection et d'aléa de moralité reflète le marché d'assurance en présence de tests génétiques. Avec ces deux problèmes (l'antisélection et l'aléa moral), les compagnies d'assurance offrent une couverture partielle à chaque agent. Notre contribution à ce modèle est de montrer les différentes conditions dans lesquelles ces contrats peuvent être offerts. En situation de productivité marginale d'auto-protection, nous montrons qu'il est parfois moins coûteux pour les compagnies d'assurance d'offrir un contrat mélangeant qu'un menu de contrats séparateurs. Ce résultat n'est possible que sous la propriété d'intersection unique de Milgrom-Shannon (1994) redéfinie par Edlin et Shannon (1998). Nous montrons que le contrat mélangeant est possible, même si la condition de Spence-Mirrlees échoue en particulier lorsque la différence de la productivité marginale d'auto-protection décroît. Mais lorsque la différence de la productivité marginale d'auto-protection est constante ou augmente, le contrat mélangeant n'est pas une option. Dans ce cas, si un contrat est possible, il est nécessairement un contrat séparateur, dans lequel les assureurs offrent une couverture partielle plus élevée aux agents hauts risques qu'aux agents à faible.

Mots Clés *: Genetic testing – adverse selection – moral hazard*
Classification J.E.L: *D82 – D83 – D63 –G22*

1. Introduction

Thanks to genetic testing, people have access to information about their risk status. Since multifactorial diseases are correlated with the environment, individuals having a predisposition could reduce their risk level by investing in self-protective activity. For this reason, many countries plan to set up screening programmes in order to encourage, and sometimes to constrain these individuals to preventive action. However, in such situations two main problems arise for insurance companies: adverse selection and moral hazard.

In previous studies, these two problems have often been studied separately. In the principal-agent model, the consequence of moral hazard is a deductible contract. In fact, partial coverage could induce individuals to reduce their risk level by investing in self-protection activity (Ehrlich and Becker, 1972; Pauly 1974; Shavell 1979; Dionne and Eeckhoudt 1985; Briys and Schlesinger 1991; Jullien, Salanié and Salanié 1999). On the other hand, adverse selection (starting with Akerlof (1970); Rothschild and Stiglitz (1976); Stiglitz (1977), and recently Lemmens (2000) with respect to genetic tests) has been studied in order to show market imperfection due to asymmetric information on individual risk types. In this case, contracts, when there are any, may be pooling and/or separating contracts with full coverage for high-risk and partial coverage for low-risk.

However, as suggested by Arnott (1991), insurers often deal with these two problems simultaneously. Whinston (1983) studied this phenomenon with a government in charge of social insurance for labour forces. As regards both adverse selection and moral hazard, he showed that the government's insurance programme is a pooling contract in which the labour force is indifferent between whether or not to work when able to do so.

Most recent papers study these problems in a competitive setting. Stewart (1994) shows that the individuals most at risk choose the moral hazard contract which could be offered in absence of adverse selection, while low-risk individuals could accept lower coverage. Fagart and Kambia-Chopin (2003) expatiate upon Stewart's main conclusions by comparing the adverse selection and the moral hazard equilibriums when prevention is observable.

In the seminal paper of Chassagnon and Chiappori (1995), individuals have different unobservable risk levels with different moral hazard degrees. Moral hazard degree is defined as the difficulty of inducing an individual to self-protective activity. In such situations, the individuals' indifference curves may cross more than once. This breaks the single crossing property. Chassagnon and Chiappori show a positive profit, making it possible to separate individuals on equilibrium, but in their analysis the perfect sub-game pooling equilibrium of Nash

is not verified. However De Meza and Webb (2001) conclude that the insurance market allows a pooling equilibrium even if indifference curves cross twice and even when individuals differ in their risk aversion degree.
Our model attempts to study the different types of contracts which could be offered on the insurance market with both adverse selection and moral hazard. In the presence of genetic tests, we show that on equilibrium, both pooling and separating contracts could be offered on the insurance market. For this, we use the Milgrom and Shannon (1994) single crossing property, and when necessary, the Spence-Mirrlees condition to show the existence of equilibrium.

In the first section, we describe some stylised facts and in section 2 we determine our framework and make some assumptions which allow us to show optimal effort and optimal contracts in the last section.

2. Stylised Facts

Currently, legislation protects people against genetic discrimination but at the same time allows them to undergo genetic tests. Most countries plan, as in France, to organize systematic genetic testing for cancer. These screening programmes allow individuals to know their predisposition to the gene responsible for the disease and, if need be, to invest in self-protection activity. However, the success of these programmes supposes that the government take responsibility for the financial cost of the genetic tests, and also implies a free psychological follow-up for these individuals. If these two necessary but not sufficient conditions are fulfilled, the only expense for the agents will be the prevention costs.

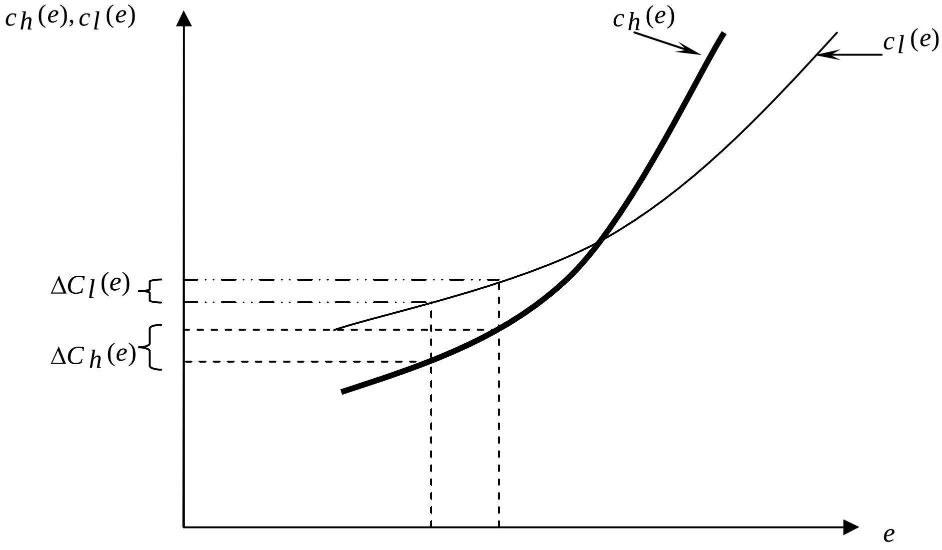
It should be born in mind that customers are prompted to undergo genetic tests only for multifactorial diseases correlated with their environment and lifestyles. Indeed, for this kind of disease it is sometimes possible to organize prevention and sometimes efficient treatment is available. Most studies, like those of Marteau and Croyle (1998), confirm this intuition. In their study, they show that the uptake rate for DNA predictive testing revolves around 10% for Huntington's disease, a monogenic disease for which there is no treatment at the moment. The same study shows that this percentage increases and is around 50% when it is for a disease like breast cancer with a possibility of prevention and/or treatment. Lastly, they show that 80% of individuals undergo genetic testing for family adenomatous polyposis, a disease for which there is efficient treatment. Therefore, it is absolutely relevant to assume that for multifactorial diseases, individuals will undergo a genetic test when these diseases can be prevented and/or treated in most cases.

3. Framework

Let us suppose that individuals, faced with a disease like breast cancer, undergo a genetic test. The people who do not have the gene identified as responsible for the disease in their genetic inheritance, can nevertheless underwrite an insurance contract. Indeed, the development of the genetic disease could be caused by other elements in nature. Consequently, some individuals could be interested in insurance contracts even though they are, *a priori*, not predisposed to the disease. Regarding breast cancer, the BRCA 1 and BRCA2 genes have been identified as partly responsible for this disease. Nevertheless, geneticists are still exploring the possibility of a third gene "BRCA 3" which could in fact be the cause for the confirmed disease for which genes BRCA 1 and BRCA 2 are not responsible. Therefore, people with antecedents could be considered as low-risk or high-risk when they purchase coverage.

Let us suppose that low-risk individuals have a probability (p_l) of developing the disease lower than that (p_h) associated with high-risk people ($p_l < p_h$). We also assume that there is a (λ) proportion of high-risk in the insurance market and a ($1-\lambda$) proportion of low-risk. These two groups of people make either a positive preventive effort or no preventive effort. When the effort level is nil, the probability (p_l, p_h) associated with low- and high-risk individuals does not change. On the other hand, due to their preventive activity (e), these people can reduce their risk so that their *a priori* probabilities turn into endogen probabilities $p_i(e)$ (with $i = h, l$). The efficiency of the preventive effort also shows through a lower occurrence of disease: in other words, we suppose that $p_i(e)$ is a decreasing and convex function with $p_i'(e) < 0$ and $p_i''(e) > 0$. e can be interpreted as the recommended action in the contract. The effort made by the individual has a cost noted $c_i(e)$ confirming the following properties: $c_i'(e) > 0$ and $c_i''(e) > 0$. This means that the cost rises with the preventive effort of individuals. Besides, the increase in marginal cost of effort for high-risk people is higher than the marginal cost of effort for low-risk people $c'_h(e) > c'_l(e)$ (graph 1).

Figure 1 – Marginal cost of effort

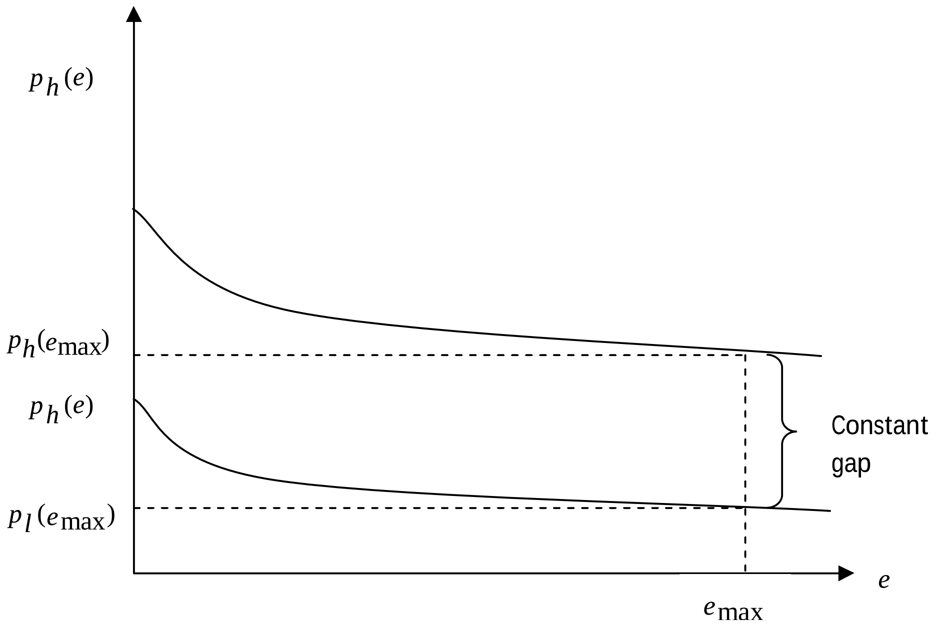


Yet the situation in figure 1 does not mean that the marginal risk-reduction (expressed by the variation of the probability of disease occurrence) is more important for high-risk than for low-risk individuals. Moreover, our assumptions go the same way as Hoy's (1989) but we assume that there is an $e_{\max}$ beyond which agents have no interest in increasing their self-protective activity: $\lim_{e\to\infty} p_i(e) = \lim_{e\to e_{\max}} p_i(e) = p_i(e_{\max})$.

Like Hoy, we suggest below three situations for positive effort:

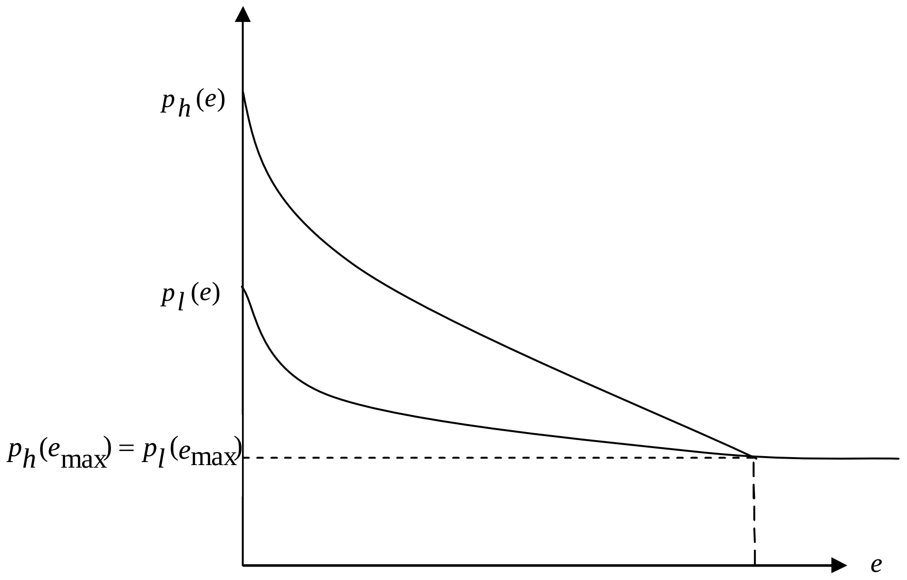
- The first one concerns the case in which there is no difference in the marginal productiveness of self-protection between high-risk and low-risk ($\frac{d\,p_h(e)}{de} = \frac{d\,p_l(e)}{de}$). Consequently, whatever the self-protective activity, the high-risk person is always more at risk than the low-risk person $\left(p_h(e) > p_l(e)\right)$ in the same proportion (figure 2).

Figure 2 – No difference in the marginal productiveness of self-protective activity



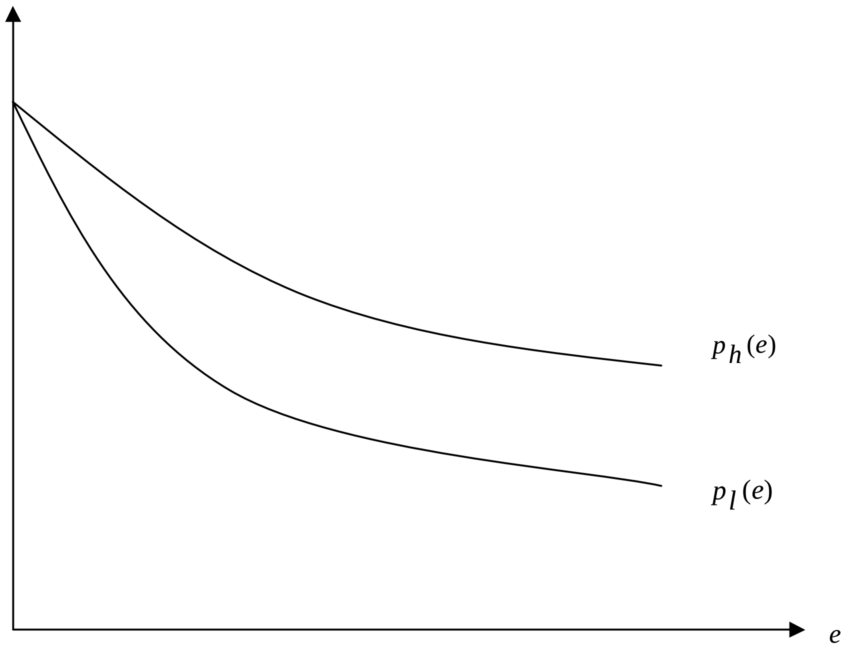
- The second situation concerns the case in which there is a decreasing difference in the marginal productiveness of self-protection ($\frac{d\ p_h(e)}{de} < \frac{d\ p_l(e)}{de}$ or $\left|\frac{d\ p_h(e)}{de}\right| > \left|\frac{d\ p_l(e)}{de}\right|$). This case is very interesting: this means that there could be an e_{max} and when it is reached, the risk associated with the low-risk is identical to that associated with the high-risk. Beyond e_{max} we would not be able to dissociate high-risk from low-risk people: $p_h(e_{max}) = p_l(e_{max})$.

Figure 3 – Decreasing difference in the marginal productiveness of self-protection



- Some genetic tests are sometimes difficult to interpret (complex gene, irrelevant test…). We might not able to distinguish high risk from low risk people when the test results are not relevant. Self-protective activity may help us to identify more easily the risk class to which an individual belongs but also helps us to lift the indeterminacy on people. In this case, we discriminate between individual after they have invested in self-protective activity. The situation in which people are distinguished depending on their preemptive efforts is called the third solution. In other words, the increasing difference in the marginal productiveness of self-protection activity: $\left|\frac{d\,p_h(e)}{de}\right| < \left|\frac{d\,p_l(e)}{de}\right|$ hence $p_h(e) > p_l(e)$.

Figure 4 – Increasing difference in the marginal productiveness of self-protection



In addition, self-protective activity as well as the initial risk level of people is considered as private information[1]. We can easily understand this situation since legislation and/or a moratorium in most countries prevent insurers from using or asking for the results to people's genetic tests[2]. This situation entails a bilateral asymmetry of information[3] in which insurers would have to manage adverse selection, i.e. on the one hand information on the risk type of individuals and on the other hand moral hazard, the action taken by people to alter their probability.

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[1] Hoel and Iversen (2002), Strohmenger and Wambach (2000).

[2] Customers fear that insurers use genetic tests in order to exclude those with the defective gene (Le Pen (2003), Chiappori (1997)). However Fall (2004) relativizes this result and says that this risk certainly exists but only for monogenic diseases with a strong rate of penetration. So he suggests that the insurance market is not so threatened if we consider the introduction of the genetic tests for multifactorial diseases, diseases strongly correlated with the environment and lifestyle. This result agrees with the result of Hoy and al. (2003). They show, through simulation, that the use of genetic tests for breast cancer does not entail the collapse of the insurance market, i.e. a better knowledge of the risks should not affect the market negatively.

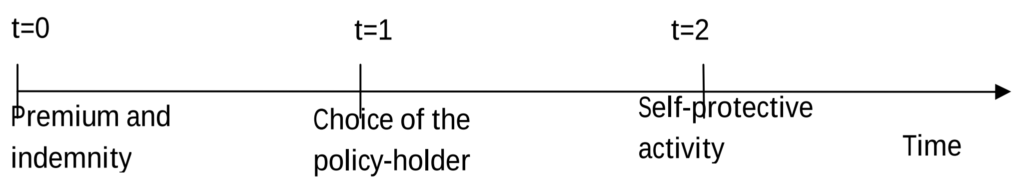
[3] The bilateral asymmetry of information means asymmetry of information in the risk type as well as the action taken. This notion differs from Anderson's (2001) the bilateral asymmetry of information.

In our model, we assume that all individuals undergo a genetic test for a multifactorial disease. From the individuals' points of view, this means that they have already worked out a trade-off between costs and benefits. Tabarrok (1994, 1996), Grann and Jacobson (2002) suggest that the net benefit of the test would exceed its cost since genetic tests could lead to early diagnosis and treatment. Moreover, genetic tests could lead to gene therapy and reduce unwanted side-effects (Caulfield et al., 2001). From the point of view of insurers, the expected benefit of genetic tests is to end uncertainty about individuals' risk type by reducing the risk classification. Indeed, risk classification would no longer be based on immutable characteristics (like sex, age…) but rather on scientific characteristics.

The interest of undergoing genetic tests is to encourage predisposed people to take preventive measures in order to reduce the probability of having the disease. However, some people will not invest in the activity of self-protection, taking fatalistic stance (Hoy and al., 2003). Among people who take preventive measures, some will want to invest more than others in their efforts to avoid the disease. Consequently, we say that because of risk-aversion and the terms of contracts, both high-risk and low-risk people can invest more or less in self-protective activity (Briys and Schlesinger, 1991). Investment in self-protective activity actually depends on the contracts. According to Arnott and Stiglitz (1988), people are especially encouraged to invest in high self-protective activity when the coverage offered is low. On the other hand, for high coverage, people make a small effort.

We assume like Fagart and Kambia-Chopin (2003) that insurance companies are in perfect competition and offer contracts simultaneously to policy-holders who, after examining the terms of the contracts, determine the one which gives them maximum satisfaction. People subsequently decide to choose their effort level, under the terms of the contracts, i.e. the premium and the indemnity. This allows us to define market equilibrium.

Figure 4 – Sequence of decisions



Definition 1:
Market equilibrium is a set of contracts such as:

1. *Each company offers a menu of contracts which make no gain and no loss.*
2. *Each policyholder chooses a contract which maximizes his or her expected utility.*
3. *The contract chosen is compatible with the optimal effort level.*
4. *People are induced to participate in the insurance market.*

In what follows, we establish our model and show that the optimal contract could be either a pooling or a separating contract. In the presence of adverse selection and moral hazard, we show that, whatever the risk type, the only contract inducing people to preventive measures is a deductible contract. Moreover under some conditions, we show that it is sometimes less costly for insurers to offer a pooling contract rather than a separating one.

4. The impact of genetic tests on contracts

In our model, we solve the problem by backward induction. We first determine the optimal effort level and secondly the optimal contract associated with this effort.

4.1. Optimal effort

In the Rothschild and Stiglitz[4] model (1976), the optimal contract does not induce individuals to invest in self-protective activity. One of the objectives of genetic testing is to reduce the associated risk in the general population. In order to reach this objective, authorities must encourage insurance companies to offer contracts inducing low-risk and high-risk people to take self-protective measures.

Let us suppose that the policy-holders have the same initial wealth w and let us denote (u) a Von Neumann Morgenstern utility function $(u' > 0$ and $u'' < 0)$. This means that the policy-holders are risk-averse and will want to underwrite an insurance against a loss D due to the occurrence of the disease ($D < w$). Let us denote $s_i = \{\alpha_i, \beta_i\}$ the menu of contracts offered by insurance companies where α_i, β_i represent the premium and the net indemnity respectively. The expected utility of the individuals having self-protective activity is given by:

$$EU(p_i(e), \alpha_i, \beta_i) = p_i(e)u(w - d + \beta_i) + (1 - p_i(e))u(w - \alpha_i) - c_i(e)$$

When people choose this contract without taking preventive measures, their expected utility becomes:

$$EU(p_i, \alpha_i, \beta_i) = p_i u(w - d + \beta_i) + (1 - p_i)u(w - \alpha_i)$$

with $p_i = p_i(e = 0) = p_i(0)$

[4] Here-in-after referred to as R&S.

From this relation, it should be pointed out that individuals cannot lower their risk level without previously investing in self-protective activity.

On equilibrium, individuals will optimize their preventive efforts. The high or low marginal cost of prevention obviously depends on the insurance contract. However, we must bear in mind that it is more costly for high-risk people to make an additional effort for risk reduction than it is for the low-risk (figure 1).

On equilibrium, a type $i = l, h$ subject maximizes his or her expected utility considering the contract as given:

$$e_i^* \text{ solves } \max_e [p_i(e)u(w - D + \beta_i) + (1 - p_i(e))u(w - \alpha_i) - c_i(e)] \qquad \text{(P1)}$$

Since the expression in brackets is a concave function, we can determine a local optimum[5]. The first order condition is:

$$f_i(e) = \frac{c'_i(e)}{p'_i(e)} = [u(w - D + \beta_i) - u(w - \alpha_i)] \qquad (1)$$

Function $f_i(e)$ is increasing and continuously differentiable, so the inverse function of $f_i(e)$ denoted $\delta_i(.)$ allows us to determine the optimal effort level of individuals for different values of α_i and β_i.

On equilibrium, people choose their efforts, such as for any contract $S_i = \{\alpha_i, \beta_i\}$, we have:

1. For high-risk subjects $e_h^* = \delta[u(w - D + \beta_h) - u(w - \alpha_h)]$, which gives us an equivalent cost of $c_h(e_h^*) = c_h\{\delta[u(w - D + \beta_h) - u(w - \alpha_h)]\}$.
2. For low-risk subjects $e_l^* = \delta[u(w - D + \beta_l) - u(w - \alpha_l)]$, and the prevention cost is equal to $c_l(e_l^*) = c_l\{\delta[u(w - D + \beta_l) - u(w - \alpha_l)]\}$.

Let us consider an insurance market with a single pooling contract ($\overline{\alpha}, \overline{\beta}$) (with $\overline{\alpha}$ the premium and $\overline{\beta}$ the net indemnity). In view of this contract, each individual will determine which effort enables him or her to maximize its expected utility. However, the question is to know whether individuals are encouraged to make the same effort for the ($\overline{\alpha}, \overline{\beta}$) single contract.

Now, we get a new maximization programme equal to:

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[5] See also Chassagnon and Chiappori (1995) for the properties of the function.

$\bar{e}_i{}^*$ solves $\underset{e}{\mathrm{Max}}[p_i(e)u(w-D+\bar{\beta})+(1-p_i(e))u(w-\bar{\alpha})-c_i(e)]$ (P1')

The first order condition can provide information on the kind of effort made by people. For a $(\bar{\alpha},\bar{\beta})$ given contract, we get:

- $f_h(e)=\dfrac{c'_h(e)}{p'_h(e)}=[u(w-D+\bar{\beta})-u(w-\bar{\alpha})]$ for high-risk agents (a)
- and $f_l(e)=\dfrac{c'_l(e)}{p'_l(e)}=[u(w-D+\bar{\beta})-u(w-\bar{\alpha})]$ for low-risk agents (b)

Since all individuals have the same monetary utility function and the same arguments related to this utility function, it is easy to point out that expressions (a) and (b) are identical. In other words, $f_h(e)=f_l(e)$ or else $\dfrac{c'_h(e)}{p'_h(e)}=\dfrac{c'_l(e)}{p'_l(e)}$. This would mean that contract $(\bar{\alpha},\bar{\beta})$ could induce all individuals to make the same effort while maximizing their expected utility.

First of all, let us consider the constant difference in the marginal productiveness of self-protective $p'_h(e)=p'_l(e)$.

By assumption, the marginal cost of prevention for high risk is always higher than for low risk $c'_h(e)>c'_l(e)$. As the constant difference in marginal self-protection demands that $p'_h(e)=p'_l(e)$ (graph 2), then the expression $\dfrac{c'_h(e)}{p'_h(e)}=\dfrac{c'_l(e)}{p'_l(e)}$ actually means that $c'_h(e)=c'_l(e)$. This obviously contradicts hypothesis $c'_h(e)>c'_l(e)$. Consequently, whatever the pooling contract with a preventive effort, condition $\dfrac{c'_h(e)}{p'_h(e)}=\dfrac{c'_l(e)}{p'_l(e)}$ is never fulfilled. In other words, the pooling contract offered will not encourage individuals to make the same effort, hence $\bar{e}_h{}^*\neq\bar{e}_l{}^*$. This contract then may not maximize the expected utility of at least one individual.

Let us consider the decreasing difference in the marginal productiveness of self protective activity $p'_h(e)>p'_l(e)$

In this situation people could be encouraged to make the same preventive effort $(\bar{e}_h{}^*=\bar{e}_l{}^*)$ for the pooling contract $(\bar{\alpha},\bar{\beta})$. As for low-risk individuals, they lose less in terms of disutility whatever the effort made. In other words, a low-risk individual is willing to consent a preventive effort $\bar{e}_l{}^*$ on condition that $(\bar{\alpha},\bar{\beta})$

contract maximizes his or her expected utility. As regards high-risk people, if ($\overline{\alpha}, \overline{\beta}$) maximizes their expected utility then the effort $\overline{e}_h*$ is optimal. We know that $c'_h(e) > c'_l(e)$ but $p'_h(e) > p'_l(e)$, this means that the cost for high-risk individuals in terms of disutility is counterbalanced by the reduction of his or her probability falling ill. Thus if ($\overline{\alpha}, \overline{\beta}$) contract enables to maximize the expected utility for low-risk as well as high-risk individuals then these individuals could make the same effort. This effort level can only go up to $e_{\max}$, since if $\overline{e}_i* \neq e_{\max}$ high-risk people are more at risk (graph 3), they are encouraged to seek more coverage. To sum up, if ($\overline{\alpha}, \overline{\beta}$) maximizes all agents' expected utility then the condition $\frac{c'_h(e)}{p'_h(e)} = \frac{c'_l(e)}{p'_l(e)}$ is fulfilled. Hence the effort $\overline{e}_h*$ is equal to $\overline{e}_l*$: we get $\overline{e}_h* = \overline{e}_l* = e_{\max}$.

Lastly, a hypothesis with increasing difference in the marginal productiveness of self-protective activity $p'_l(e) > p'_h(e)$.

Whatever the effort, by definition we get $c'_h(e) > c'_l(e)$ and $p'_l(e) > p'_h(e)$. This implies that expression $\frac{c'_h(e)}{p'_h(e)} = \frac{c'_l(e)}{p'_l(e)}$ is never fulfilled because it is easy to prove that $c'_h(e).\,p'_l(e) > c'_l(e).\,p'_h(e)$. Consequently, individuals cannot make the same effort ($\overline{e}_h* \neq \overline{e}_l*$).

In addition, insurers may be able to anticipate the optimal effort of the people who participate in the insurance market. We also have to bear in mind that preventive measures may reduce the risk but do not preclude the likelihood of developing the disease. Indeed, the risk of developing the disease is still present whatever the effort level of the subject. That is why we suppose that people will have an interest in underwriting insurance. In other words, if the effort level cancelled the risk, people would have no interest in entering the insurance market. Consequently, insurers are ensured to deal with risk-averse agents who will necessarily underwrite an insurance policy.

In order to show a pooling contract and a separating one, some notions must be clearly defined: the single crossing property of Milgrom and Shannon (1994) and the Spence-Mirrlees condition. According to Edlin and Shannon (1998) the strict single crossing property may help to find either a pooling or a separating contract while the strict Spence-Mirrlees condition excludes all pooling contracts.

Definition 2:

1. *The strict single crossing property according to Milgrom and Shannon (1994).*
   Consider two subjects (high-risk and low-risk) who underwrite an insurance contract. The subjects' preference is expressed by their expected utility function: $EU(p_h(e),\alpha,\beta)$ *for the high-risk one and* $EU(p_l(e),\alpha,\beta)$ *for the low-risk one. Let* $\Re^2$ *be the lexicographic order, with* $(\alpha',\beta') \geq (\alpha,\beta)$ *if either* $\beta' > \beta$ *or* $\beta' = \beta$ *and* $\alpha' \geq \alpha$*. These preferences satisfy the strict single crossing property of Milgrom and Shannon if and only if:*
   - *When* $EU(p_l(e),\alpha',\beta') \geq EU(p_l(e),\alpha,\beta)$ *then* $EU(p_h(e),\alpha',\beta') \geq EU(p_h(e),\alpha,\beta)$ *for all* $p_h(e) > p_l(e)$.
   - *When* $EU(p_l(e),\alpha',\beta') > EU(p_l(e),\alpha,\beta)$ *then* $EU(p_h(e),\alpha',\beta') > EU(p_h(e),\alpha,\beta)$ *for all* $p_h(e) > p_l(e)$.
2. *The strict Spence-Mirrlees condition is fulfilled if the marginal rate of substitution between the premium and the indemnity (*$\frac{\partial Eu / \partial \beta}{\left| \partial Eu / \partial \alpha \right|}$*) increases with the probability.*

Definition (1) means that all contracts preferred by low-risk people are also preferred by high-risk ones. And definition (2) means that coverage increases proportionally to the premium when the likelihood of disease increases.

Edlin and Shannon (1998) show that the strict single crossing property of Milgrom and Shannon may work even if the strict condition of Spence-Mirrlees fails. This result is particularly interesting insofar as it could allow us to show whether, in certain conditions, a pooling contract and/or a separating contract may both be offered.

4.2. Existence of a pooling contract?

With the insurance contract, the insurers anticipate the choice of optimal effort of individuals on equilibrium. If we consider on the one hand the effort level as given and on the other the difference in the marginal productiveness of self-protection, we can show that insurance companies could offer a unique pooling contract.

Let us suppose that $(\overline{\alpha},\overline{\beta})$ is the only pooling contract proposed by insurers in the insurance market. In other words, $\overline{\alpha}$ and $\overline{\beta}$ are calculated by using the average risk of the population. We let $\bar{p}(e)$ denote the average probability of the population:

$$\bar{p}(e) = \lambda\, p_h(\bar{e}_h{}^*) + (1-\lambda)\, p_l(\bar{e}_l{}^*).$$

The pooling contract $(\bar{\alpha}, \bar{\beta})$, if it is possible, would be such as, on equilibrium, the expected utility provided by making an effort is higher than the expected utility procured without taking any self-protective activity. Formally, this incentive constraint to the optimal effort can be written as:

$$\bar{e}_i{}^* = \arg\max_e \,[\, p_i(e)u(w-d+\bar{\beta}) + (1-p_i(e))u(w-\bar{\alpha}) - c_i(e)] \qquad (2)$$

Constraint (2) means that an individual of type $i = l, h$ makes an effort depending on the terms of the contract $(\bar{\alpha}, \bar{\beta})$. This constraint, as suggested by Rogerson (1985), is the result of a maximization programme. It makes it possible to determine the optimal effort for each policy-holder present on the insurance market[6].

Furthermore, insurance companies have to make sure individuals enter the market. For this reason, the participation constraint will be fulfilled. This constraint shows the conditions on which individuals agree to participate in the insurance market and to choose the contract offered by insurers. In general, a rational individual of type $i = l, h$ has the choice between contract $(\bar{\alpha}, \bar{\beta})$ with a necessary positive effort and, on the other hand being out of the market, and choosing self-protective activity or not. The rationality constraint is given by:

$$EU(p_i(\bar{e}^*), \bar{\alpha}, \bar{\beta}) - c_i(e) \geq \max[EU(p_i, 0, 0); EU(p_i(e), 0, 0) - c_i(e)] \qquad (3)$$

When individual $i = l, h$ does not participate in the market, he has the choice whether to have self-protective activity or not. Let us denote e^* the optimal effort made by the individual outside the insurance market with a cost $c_i(e^*)$. In such a situation, an individual makes a preventive effort if and only if:

$$c_i(e^*) \leq (p_i - p_i(e^*))[u(w) - u(w-D)]$$

Let us suppose that this situation is realized; this would mean that the individual makes an effort even though he does not participate in the insurance market. One necessary condition to satisfy the constraint (3) is, *in fine*:

$$p_i(e)[u(w-D+\bar{\beta}) - u(W-D)] + (1-p_i(e))[u(w-\bar{\alpha}) - u(w)] \geq 0$$

---

[6] We assume that the monotone likelihood ratio property (MLRP) and the convexity of the distribution function condition (CDFC) are fulfilled.

With the structure of the model, insurance companies are in perfect competition. This implies that insurers are restricted to zero expected profits so that a new competitor could not offer a contract without a negative profit. Given the optimal effort level, the zero-profit constraint of the companies becomes:

$$(1-\overline{p}(e))\overline{\alpha}-\overline{p}(e)\overline{\beta}=0 \tag{4}$$

The maximization programme of the individual becomes as follows:

$$\begin{cases} \underset{\overline{\alpha},\overline{\beta}}{Max}\ p_i(e)u(w-D+\overline{\beta})+(1-p_i(e))u(w-\overline{\alpha})-c_i(e) & \text{(P2)} \\ \text{s.c } \overline{e}_i^* = \underset{e}{\arg\max}[p_i(e)u(w-d+\overline{\beta})+(1-p_i(e))u(w-\overline{\alpha})-c_i(e)] \\ EU(p_i(\overline{e}_i^*),\overline{\alpha},\overline{\beta})-c_i(\overline{e}_i^*) \geq \max[EU(p_i,0,0);EU(p_i(e),0,0)-c_i(e)] \\ (1-\overline{p}(e))\overline{\alpha}-\overline{p}(e)\overline{\beta}=0 \end{cases}$$

The resolution of this problem gives us the optimal contract proposed by insurance companies. On equilibrium, both low-risk and high-risk subjects receive the same deductible pooling contract on condition that:

- $(1+\lambda).[\overline{p}(e)-p_l(\overline{e}_l^*)] > \mu\, p'_l(\overline{e}_l^*)$, and
  $(1+\lambda).[\overline{p}(e)-p_h(\overline{e}_h^*)] > \mu\, p'_h(\overline{e}_h^*)$ and simultaneously (appendix 1)
- $c'_h(e).\,p'_l(e) = c'_l(e).\,p'_h(e)$. This last condition is the result of the incentive effort constraint (maximization programme P1').

Coverage is written as $\overline{\beta} < D-\overline{\alpha}$ and the premium paid by policy-holders as $\overline{\alpha} = \overline{p}(e).\overline{\beta}'$ with $\overline{\beta}'$ the gross indemnity. The specificity of this contract is to pool both high-risk and low-risk people. Using the implicit function theorem, we have this property:

$$\frac{\partial \overline{e}_i^*}{\partial \overline{\beta}} = -\frac{u'(w-D+\overline{\beta})}{p_i''(e)c_i'(e)-p_i'(e)c_i''(e)} < 0 \text{ with } \quad p_i''(e)c_i'(e)-p_i'(e)c_i''(e) > 0$$

because $p_i'(e) < 0$

The prevention effort is a decreasing function of coverage. In order to pool high-risk and low-risk, companies should encourage agents to take preventive measures. But at this stage, we have to discuss the existence of the equilibrium with our assumptions.

Proposition 1

1. *The strict Spence-Mirrlees condition fails in the decreasing difference in the marginal productiveness of self-protective activity. In this situation the pooling contract is possible:*

- *when subjects reach the high effort level and,*
- *independently from the proportions of high and low risks.*

2. *The strict Spence-Mirrlees condition is always satisfied in the constant or in the increasing difference in the marginal productiveness of self-protective activity. Consequently, if a pooling contract is possible, it can neither be contract $(\overline{\alpha}, \overline{\beta})$ nor any other contract with preventive effort.*

As described by Edlin and Shannon (1998), the strict single crossing property gives either a pooling or a separating contract. In our model, if a unique contract is offered then subjects will make the same effort or take the same recommended action. Under the assumption of marginal productiveness of self-protective activity, the risk level of high-risk subjects may be greater or equal to that of the low-risk subjects (figures 2-3-4). This could have an incidence on the Spence-Mirrlees condition.

First, let us consider the decreasing difference in the marginal productiveness of self-protective activity.

The pooling contract will induce people to make the same level of effort. Being aware of these facts, we can make a comment on the premium. Since the individual's risk is private information, rational policy-holders will compare the premium with what they would have to pay if the premium was calculated on the basis of their real risk: $\overline{\alpha} = p_h(e_{\max}).\overline{\beta}'$ for the high-risk and $\overline{\alpha} = p_l(e_{\max}).\overline{\beta}'$ for the low-risk groups. So, we have to compare the probability of having the disease.

Insurance companies calculate the premium according to the average probability $\overline{p}(e) = \lambda\, p_h(\overline{e}_h{}^*) + (1-\lambda)\, p_l(\overline{e}_l{}^*)$, now for contract $(\overline{\alpha}, \overline{\beta})$ individuals make the same high level effort: in other words $p_h(e_{\max}) = p_l(e_{\max})$ (figure 3). It means that average probability can be written independently from the proportions of low-risk and high-risk people such as $\overline{p}(e) = p_h(e_{\max}) = p_l(e_{\max})$ (because $\overline{e}_h{}^* = \overline{e}_l{}^* = e_{\max}$). The equilibrium conditions are written as follows:

- $(1+\lambda).[\overline{p}(e) - p_l(e)] > \mu\, p'_l(e)$, $(1+\lambda).[\overline{p}(e) - p_h(e)] > \mu\, p'_h(e)$ on the one hand,
- $c'_h(e).\, p'_l(e) = c'_l(e).\, p'_h(e)$ for $e = \overline{e}_i{}^*$ on the other hand.

Note that the first order condition $c'_h(e).\, p'_l(e) = c'_l(e).\, p'_h(e)$ foresees that the Spence-Mirrlees condition fails. But for any other contract $(\alpha, \beta) \geq (\overline{\alpha}, \overline{\beta})$[7] for

[7] This contract (α, β) does not induce agents to do the high effort level. In other words, the high-risk probability is still higher than the low-risk probability.

which $e \neq e_{\max}$ following the lexicographic order, subjects' preferences agree with the strict single crossing property. Indeed for any $e \neq e_{\max}$, $p_h(e) > p_l(e)$ (figure 3).

So, if $EU(p_l(e), \alpha, \beta) \geq EU(p_l(e), \overline{\alpha}, \overline{\beta})$ then $EU(p_h(e), \alpha, \beta) \geq EU(p_h(e), \overline{\alpha}, \overline{\beta})$. The strict relation is obviously verified and in the same way the Milgrom and Shannon's (1994) single crossing property works. On the other hand, for $e = e_{\max}$ we have $\overline{p}(e) = p_h(e_{\max}) = p_l(e_{\max})$ and then the strict Spence Mirrlees condition fails. We can easily verify that the marginal rate of substitution between the premium and the indemnity of the low-risk group is exactly equal to the marginal rate of substitution of the high-risk group.

$$\frac{\partial EU_h / \partial \overline{\beta}}{\partial EU_h / \partial \overline{\alpha}} = \frac{\overline{p}(e) u'(w - D + \overline{\beta})}{(1 - \overline{p}(e)) u'(w - \overline{\alpha})} = \frac{\partial EU_l / \partial \overline{\beta}}{\partial EU_l / \partial \overline{\alpha}} \text{ since } \overline{p}(e) = p_h(\overline{e}_h *) = p_l(\overline{e}_l *).$$

At the $(\overline{\alpha}, \overline{\beta})$ point, the indifference curves of both high-risk and low-risk groups and the insurer's isoprofit line are tangent. This is pointed out by the pooling contract (figure 6).

Now, let us show that the pooling contract is not possible in the constant marginal productiveness of self-protective activity.

In this case, the feasibility of the pooling contract $(\overline{\alpha}, \overline{\beta})$ is put into question. As shown in paragraph 3.1, people are not willing to invest in the same preventive efforts. Indeed, with this pooling contract at least one individual on the market may not maximize his or her expected utility. Besides, whatever the effort made, we can verify that the Spence-Mirrlees condition is always satisfied[8]. Indeed whatever the preventive effort, the high risk individual is still more at risk $p_h(e) > p_l(e)$:

$$\frac{\partial EU_h / \partial \overline{\beta}}{\partial EU_h / \partial \overline{\alpha}} = \frac{p_h(\overline{e}_h *) u'(w - D + \overline{\beta})}{\left|(1 - p_h(\overline{e}_l *)) u'(w - \overline{\alpha})\right|} \neq \frac{p_l(\overline{e}_l *) u'(w - D + \overline{\beta})}{\left|(1 - p_l(\overline{e}_l *)) u'(w - \overline{\alpha})\right|} = \frac{\partial EU_l / \partial \overline{\beta}}{\partial EU_l / \partial \overline{\alpha}}$$

Thus as Edlin and Shannon suggest, this condition shows that it is impossible to offer a pooling contract.

Lastly, we have to verify the feasibility of the pooling contract for the increasing difference in the marginal productiveness of self-protection $\left|\frac{d\, p_h(e)}{de}\right| < \left|\frac{d\, p_l(e)}{de}\right|$ **(figure 4).**

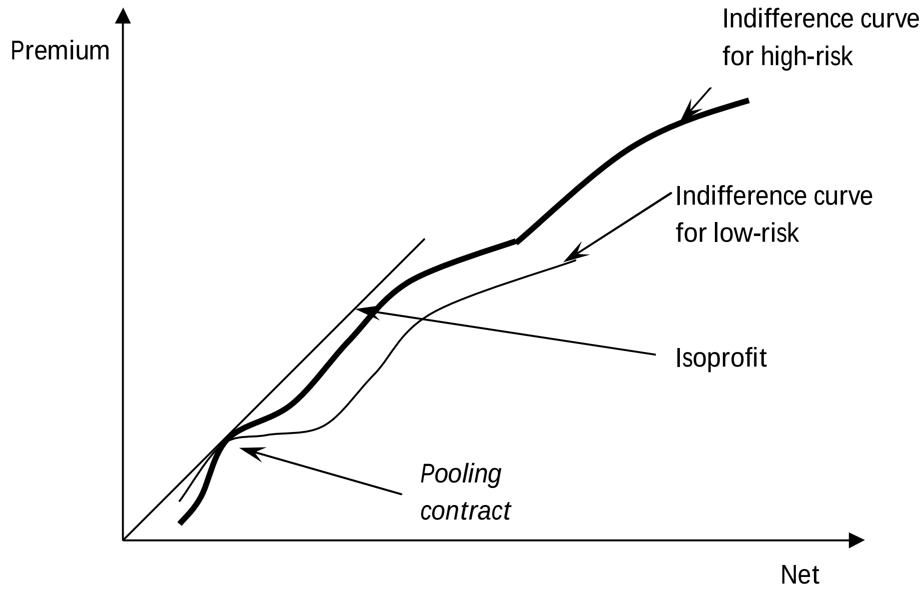
[8] We can easily verify that the single crossing property of Milgrom and Shannon and the Spence-Mirrlees condition are fulfilled.

In this situation, we know that individuals are unwilling to invest in the same level of effort. Anyway whatever the effort made $p_h(e) > p_l(e)$, the marginal rate of substitution between premium and indemnity for low- and high-risk individuals is different. From a formal point of view, we have:

$$\frac{\partial EU_h / \partial \overline{\beta}}{\partial EU_h / \partial \overline{\alpha}} = \frac{p_h(\overline{e}_h *)u'(w - D + \overline{\beta})}{\left|(1 - p_h(\overline{e}_h *))u'(w - \overline{\alpha})\right|} \neq \frac{p_l(\overline{e}_l *)u'(w - D + \overline{\beta})}{\left|(1 - p_l(\overline{e}_l *))u'(w - \overline{\alpha})\right|} = \frac{\partial EU_l / \partial \overline{\beta}}{\partial EU_l / \partial \overline{\alpha}}$$

Obviously, this rules out the existence of a pooling contract.

Figure 6 – Pooling contract[9]



To conclude, under both adverse selection and moral hazard, the pooling contract is only possible in the case of a decreasing difference in the marginal productiveness of self-protective activity (figure 6). During the designing of the contract, insurers must separate monogenic diseases from multifactorial diseases. And among multifactorial diseases, insurers have to distinguish those for which recommended action could permit the designing of an adequate pooling contract.

Finally, the pooling contract in the decreasing difference in the marginal productiveness of self-protection activity induces individuals to make a big effort ($e_{\max}$). This constraint of maximum effort is, indeed, possible in an environment in which authorities try to reduce the global risk of the population and at the same time maintain equity between people. Furthermore, in a framework in which the

[9] For the particular shape of the indifference curve see Arnott and Stiglitz (1988).

main goal of the government, the insurers and the subjects is risk-reduction, a unique contract does not seem to be the optimal solution because it excludes some categories of people. Indeed, as pointed out, a pooling contract that induces policy-holders to effort is possible only in the case of decreasing marginal productiveness of self-protection activity. So, if we want to cover the whole population, it is better to offer separating contracts as well.

4.3. The use of genetic testing for a separating contract

Under the decreasing difference in the marginal productiveness of self-protective activity, we show that pooling contracts are possible independently of the proportion of the low- and high-risk people. In this case, the Spence-Mirrlees condition fails because there is equality between the marginal rates of substitution of low- and high–risk people. However, under constant and increasing difference in the marginal productiveness of self-protective activity, companies cannot pool both high and low-risk people: in this case, the Spence-Mirrlees condition is satisfied. That is why in this section, the setting up of the separating contract may be an alternative to the pooling contract in order to cover the whole population.

The effort level is considered as given, as for the pooling contract. Consequently, the problem consists in separating high-risk from low-risk individuals when they enter the insurance market. In other words, this becomes an adverse selection problem[10].

Let $s_i = \{\alpha_i, \beta_i\}$ denote the menu of contracts. Since effort is made once an individual chooses the contract, insurers must ensure that these contracts induce policy-holder to take preventive measures. Once again, we assume that the effort constraint is saturated. Otherwise, the expected utility with prevention is higher than the expected utility with no self-protective activity. The incentive optimal effort constraint reads as follow:

$$e_i^* = \arg\max_e \,[p_i(e)u(w-d+\beta_i)+(1-p_i(e))u(w-\alpha_i)-c_i(e)] \quad (5)$$

This constraint induces individuals to self-protective activity. Since insurers cope with the bilateral asymmetry of information, self-selection may help to distinguish high-risk from low-risk individuals. So the contracts satisfy the traditional self-selection constraints.

$$EU(p_h(e_h^*),\alpha_h,\beta_h) \geq EU(p_h(e_h^*),\alpha_l,\beta_l) \quad (6)$$

$$EU(p_l(e_l^*),\alpha_l,\beta_l) \geq EU(p_l(e_l^*),\alpha_h,\beta_h) \quad (7)$$

[10] The backward induction allows us to consider, henceforth, this situation as an adverse selection problem.

Constraint (6) stipulates that it is in the high-risk individual's best interest to choose a high-risk contract rather than a low-risk contract. As in the adverse selection problem, only constraint (6) is saturated. The rationality assumption will incite low-risk individuals to choose their specific contract.

Beyond self-selection constraints, the participation constraint must be fulfilled. It is like constraint (3) but, here, each subject decides whether or not to participate according to his contract. We have:

$$EU(p_i(e_i^*),\alpha_i,\beta_i)-c_i(e) \geq \max[EU(p_i,0,0);EU(p_i(e),0,0)-c_i(e)] \qquad (8)$$

Insurance companies are subject to zero expected profits. These zero expected profits avoid market skimming in a static setting, i.e. new competitor could not attract good subjects in its portfolio without negative profit.

$$(1-p_l(e_l^*))\alpha_l - p_l(e_l^*)\beta_l = 0 \qquad (9)$$

$$(1-p_h(e_h^*))\alpha_h - p_h(e_h^*)\beta_h = 0 \qquad (10)$$

Now, the problem consists in finding the contract (α_i,β_i) that maximizes each individual's expected utility.

$$\left\{\begin{array}{ll} & \underset{\alpha_i,\beta_i}{Max}\ p_i(e)u(w-D+\beta_i)+(1-p_i(e))u(w-\alpha_i)-c_i(e) \qquad (P3) \\ \text{s.c} & e_i^* = \arg\max_e [p_i(e)u(w-d+\beta_i)+(1-p_i(e))u(w-\alpha_i)-c_i(e)] \\ & EU(p_h(e_h^*),\alpha_h,\beta_h) \geq EU(p_h(e_h^*),\alpha_l,\beta_l) \\ & EU(p_l(e_l^*),\alpha_l,\beta_l) \geq EU(p_l(e_l^*),\alpha_h,\beta_h) \\ & EU(p_i(e_i^*),\alpha_i,\beta_i)-c_i(e_i^*) \geq \max[EU(p_i,0,0);EU(p_i(e),0,0)-c_i(e)] \\ & (1-p_l(e_l^*))\alpha_l - p_l(e_l^*)\beta_l = 0 \\ & (1-p_h(e_h^*))\alpha_h - p_h(e_h^*)\beta_h = 0 \end{array}\right.$$

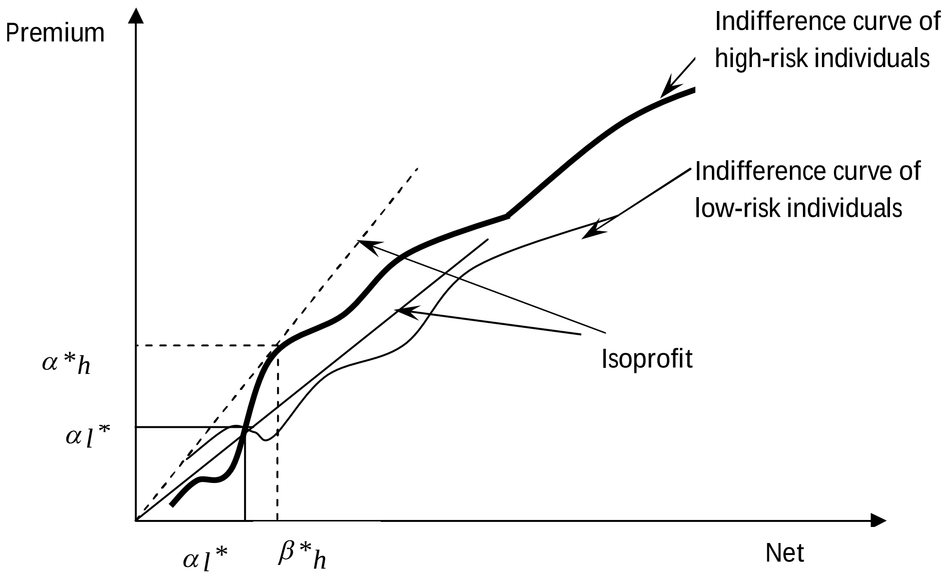
Henceforth, an insurer offers partial coverage corresponding to the new risk level of the high-risk individual with both moral hazard and adverse selection: on equilibrium, we have $\beta_h^* < D-\alpha_h$ if and only if: $p_h(e_h^*)-p_h(e) > \mu_h p_h'(e_h^*)$ (appendix 2).

Low-risk individuals are also encouraged to have self-protective activity. Indeed being predisposed increases the chance of the low-risk individual of developing the disease even if his or her probability is lower than for the high-risk. We have to bear in mind that the marginal cost of effort for risk-reduction is lower for low-risk than for high-risk individuals: $c'_h(e) > c'_l(e)$.

For the same reasons, we show that the objective of insurers consists in maximizing the expected utility of low-risk people under the incentive, participation and zero-profit constraints. On equilibrium, low-risk people choose partial coverage:

$\beta_l{}^* < D - \alpha_l$ only if $p_l(e_l^*) - p_l(e) + \gamma_h(p_h(e_h^*) - p_l(e_l^*)) > \mu_l\, p_l{}'(e_l^*)$ (appendix 2).

Figure 7 – Separating contracts



A high-risk policy-holder receives more coverage than a low-risk one (figure 7). This can be easily explained, particularly in the case of constant or increasing difference in the marginal productiveness of self-protective activity. In these two cases, high risk is always higher than low risk for any e, (figure 2 and 4). This means that we can separate the high-risk from the low-risk individuals. For example, let us suppose that a high-risk individual has lower coverage than a low-risk one. To maximize their utility, high-risk subjects will pay a preventive cost higher than the one paid by low-risk subjects if the latter decide to maximize their utility according to this contract. This contract could become a pooling contract because the low-risk subjects could reduce their risk under this contract with less disutility. But as pointed out in the previous section, the pooling contract is not possible under the assumption of constant or increasing difference in the marginal productiveness of self-protective activity. Consequently, if companies decide to discriminate between policy-holders then they will always offer more coverage for the high-risk than for the low-risk ones.

The contract as it is designed by insurers will encourage people to self-protective activity only if constraint (5) is fulfilled. Moreover, the effort level could reduce the risk of disease at a cost $c_i(e)$. The results show that low-risk, like high-risk individuals will choose the contracts designed for them. These contracts are partial insurance which effectively induces policy-holders to invest in self-protective activity. At this stage, it is clear that if the incentive effort constraint is not satisfied, then individuals will prefer contracts proposed in "pure adverse selection" like the contracts offered in the model of R&S (1976). In that model, high-risk agents will choose full coverage or will opt to stay out of the insurance market and try to protect themselves by adopting preventive measures.

These contracts have non-negligible consequences on prevention. It is clear that no government could encourage people to take preventive measures without encouraging insurers to design adequate contracts. With partial coverage, both high and low-risk individuals do invest in self-protective activities.

With both moral hazard and adverse selection, insurers do not have full information about the risk type and the subjects' action, thus the contracts might have many constraints. Our model is relevant since it mixes both self-selection constraints and incentive effort. Constraint (5), as defined, gives the subject a possibility of making a positive effort or not. When agents prefer the latter after choosing these contracts, they will be penalized by the coverage and especially by the non-reduction of their risk. In this case it is better to seek a pure adverse selection contract with full insurance for high-risk individuals and partial coverage for low-risk ones with no prevention. But if risk-reduction seems necessary to the individuals, these contracts will maximize their expected utility. We now have to show the existence of the equilibrium.

Proposition 2

1. *Separating contracts are only possible under constant or increasing difference in the marginal productiveness of self-protection activity.*
2. *Under decreasing difference in the marginal productiveness of self-protection activity, the pooling contract $(\overline{\alpha}, \overline{\beta})$ can destabilize the separating contracts.*

Under constant marginal productiveness of self-protective activity, the high-risk subject is always more at risk than the low-risk one for any given effort level of prevention. In the previous section, we showed that a pooling contract is not possible under this condition since individuals are not ready to make the same identical effort level under this assumption. This information enables insurers to discriminate between people by offering more coverage to high-risk than to low-risk subjects. This means high-risk people will make little effort because they have more coverage. But what happens if the proportion of high-risk subjects is below that of low-risk proportion? Is it possible for a pooling contract to destabilize the separating contract? By using the conception of Edlin and Shannon (1998) we can say that a pooling contract is not possible even if there is a low proportion of high-risk people. The reason for this is that the Spence-Mirrlees condition is always fulfilled under the constant difference in the marginal productiveness of self-protective activity. Indeed, when this condition is fulfilled then there will be no pooling contract.

In the case of increasing difference in the marginal productiveness of self-protection activity, we have the same problem as the one previously mentioned. If there is such a thing as an optimal contract it can only be a separating one, in such a way that high-risk subjects receives the higher coverage.

Lastly in the case of decreasing marginal productiveness of self-protective activity, insurers can of course offer a separating contract. But the pooling contract may destabilize the existence of the separating equilibrium contract. Let us imagine, under this assumption, that a competitive company offers a separating contract. The others competitive companies can threaten to introduce the pooling contract $(\overline{\alpha}, \overline{\beta})$ which induces both high-risk and low-risk individuals to the same effort level. The introduction of this pooling contract may be a credible threat since it improves the subjects' well-being by reducing their risk (figure 3) more than the separating contract would do for at least one subject. In this case, it is not optimal to offer a separating contract. The following table sums up our main results.

	Marginal productiveness of self-protection activity		
	$\left\|\frac{d\,p_h(e)}{de}\right\| = \left\|\frac{d\,p_l(e)}{de}\right\|$	$\left\|\frac{d\,p_h(e)}{de}\right\| > \left\|\frac{d\,p_l(e)}{de}\right\|$	$\left\|\frac{d\,p_h(e)}{de}\right\| < \left\|\frac{d\,p_l(e)}{de}\right\|$
Type of equilibriums	R&S (1976) separating equilibrium	Pooling contract	R&S (1976) separating equilibrium

A separating contract may be offered to both low-risk and high-risk subjects under constant or increasing difference in the marginal productiveness of self-protective activity. However, in the case of decreasing difference in the marginal productiveness of self-protection activity, companies would have to offer a pooling contract.

5. Conclusions

With both adverse selection and moral hazard, companies offer partial coverage for each subject. This kind of contract strongly induces people to invest in self-protective activity. The net benefit of the contract with prevention must be higher than the net benefit of the contract without prevention. For this reason, the incentive effort constraint must be fulfilled.

Our contribution is to show the different conditions in which these contracts can be offered. Under marginal productiveness of self-protective activity, we show that it is sometimes less costly for insurance companies to offer a pooling contract than a menu of separating contracts. In particular, under decreasing difference in the marginal productiveness of self-protective activity, the pooling contract can be offered:

1. independently of the proportion of the high and low-risk subjects,
2. and only if individuals make a high-level effort.

This result is possible only under the single crossing property of Milgrom Shannon (1994) redefined by Edlin and Shannon (1998). We show that the pooling contract is an option even if the Spence-Mirrlees condition fails. But under constant and increasing difference in the marginal productiveness of self-protective activity, the pooling contract is not possible. In this case, if a contract is made, it is necessarily a separating one, in which insurers offer more coverage to high-risk than to low-risk subjects.

In an environment in which authorities will try to encourage people to take preventive measures, the implication of insurers is necessary. In other words, there is no guarantee for a government that predisposed individuals will invest in self-protective activities if the contracts offered by insurers are not adequate.

The presence of moral hazard and adverse selection reflects the reality in which genetic tests are taken. In fact, legislation and/or moratorium force about genetic tests raises these two problems. However, even when there is asymmetry of information, insurers will have to offer policies which satisfy the self-selection constraint.

Appendixes

Appendix 1

Let denote μ, λ, ϕ be the Lagrange multipliers respectively associated with the incentive effort constraint, the participation constraint and the zero profit constraint. The Lagragian is as follow:

$$L = EU(p_i, \overline{\alpha}, \overline{\beta}) - c_i(e) + \mu\left\{p_i'(\overline{e}_i^*)[u(w - D + \overline{\beta}) - u(w - \overline{\alpha})] - c_i'(\overline{e}_i^*)\right\}$$

$$+ \lambda[EU(p_i(\overline{e}_i^*), \overline{\alpha}, \overline{\beta}) - c_i(\overline{e}_i^*) - const] + \phi[(1 - \overline{p}(e))\overline{\alpha} - \overline{p}(e)\overline{\beta}]$$

with $const = \max[EU(p_i, 0, 0); EU(p_i(e), 0, 0) - c_i(e)]$

By derivation

$$\begin{cases} \phi = [\dfrac{p_l(\bar{e}_l*)}{\bar{p}(e)} + \mu \dfrac{p_l'(\bar{e}_l*)}{\bar{p}(e)} + \lambda \dfrac{p_l(\bar{e}_l*)}{\bar{p}(e)}]u'(w - D + \bar{\beta}) \\ \phi = [\dfrac{1 - p_l(\bar{e}_l*)}{1 - \bar{p}(e)} - \mu \dfrac{p_l'(\bar{e}_l*)}{1 - \bar{p}(e)} + \lambda \dfrac{1 - p_l(\bar{e}_l*)}{1 - \bar{p}(e)}]u'(w - \bar{\alpha}) \end{cases}$$ partial coverage is offered

if and only if $\dfrac{u'(w - D + \bar{\beta})}{u'(w - \bar{\alpha})} > 1$, i.e. $(1+\lambda).[\bar{p}(e) - p_l(\bar{e}_l*)] > \mu\, p'_l(\bar{e}_l*)$.

The result is the same for high-risk individuals. We replace the index l by h. The condition of equilibrium becomes: $(1+\lambda).[\bar{p}(e) - p_h(\bar{e}_h*)] > \mu\, p'_h(\bar{e}_h*)$.

Appendix 2: the Lagrangian is:

$$L = EU(p_i(e), \alpha_i, \beta_i) - c_i(e) + \lambda_i[EU(p_i(e_i^*), \alpha_i, \beta_i) - c_i(e_i^*) - const]$$
$$+ \mu_i \left\{ p_i'(e_i^*)[u(w - D + \beta_i) - u(w - \alpha_i)] - c_i'(e_i^*) \right\}$$
$$+ \gamma_h[EU(p_h(e_h^*), \alpha_h, \beta_h) - EU(p_h(e_h^*), \alpha_l, \beta_l)] + \phi_i[(1 - p_i(e_i^*))\alpha_i - p_i(e_i^*)\beta_i]$$

with $\lambda_i, \mu_i, \gamma_h, \phi_i$ the Lagrange multipliers associated with the constraint of participation, of effort, of self-protection for the high-risk group and the zero profit. The First order condition (foc) for the low-risk group is:

$$\begin{cases} \phi_l = [\dfrac{p_l(e)}{p_l(e_l^*)} + \mu_l \dfrac{p_l'(e)}{p_l(e_l^*)} - \gamma_h \dfrac{p_h(e_h^*)}{p_l(e_l^*)} + \lambda_l]u'(w - D + \beta_l) \\ \phi_l = [\dfrac{1 - p_l(e)}{1 - p_b(e_l^*)} - \mu_l \dfrac{p_l'(e_l^*)}{1 - p_l(e_l^*)} - \gamma_h \dfrac{1 - p_h(e_h^*)}{1 - p_l(e_l^*)} + \lambda_l]u'(w - \alpha_l) \end{cases}$$ hence

$\beta_l* < D - \alpha_l$ if and only if

$$\frac{1 - p_l(e)}{1 - p_l(e_l^*)} + \mu_l \frac{p_l'(e_l^*)}{1 - p_l(e_l^*)} - \gamma_h \frac{1 - p_h(e_h^*)}{1 - p_h(e_h^*)} + \lambda_l > \frac{p_l(e)}{p_l(e_l^*)} + \mu_l \frac{p_l'(e_l^*)}{p_l(e_l^*)} - \gamma_h \frac{p_h(e_h^*)}{p_l(e_l^*)} + \lambda_l ,$$

i.e. $p_l(e_l^*) - p_l(e) + \gamma_h(p_h(e_h^*) - p_l(e_l^*)) > \mu_l\, p_l'(e_l^*)$. For the high-risk we have:

$$\begin{cases} \phi_h = [\dfrac{p_h(e)}{p_h(e_h^*)} + \mu_h \dfrac{p_h'(e_h^*)}{p_h(e_h^*)} + \gamma_h + \lambda_h]u'(w - D + \beta_h) \\ \phi_h = [\dfrac{1 - p_h(e)}{1 - p_h(e_h^*)} - \mu_h \dfrac{p_h'(e_h^*)}{1 - p_h(e_h^*)} + \gamma_h + \lambda_h]u'(w - \alpha_h) \end{cases}$$ we have

$\beta_h* < D - \alpha_h$ if and only if

$$\frac{1-p_h(e)}{1-p_h(e_h^*)}+\mu_h\frac{p_h'(e)}{1-p_h(e_h^*)}+\gamma_h+\lambda_h>\frac{p_h(e)}{p_h(e_h^*)}+\mu_h\frac{p_h'(e)}{p_h(e_h^*)}+\gamma_h+\lambda_h \text{ i.e.}$$

$$p_h(e_h^*)-p_h(e)>\mu_h\, p_h'(e_h^*).$$

References

Akerlof, G., 1970. The market for lemons: quality uncertainty and the market mechanism. The Quarterly Journal of Economics **84**: 488-500.

Andersson, F., 2001. Adverse selection and bilateral asymmetric information. Journal of Economics **74**(2): 173-195.

Arnott, R. J., 1991. Moral hazard and competitive insurance markets, in: G. Dionne (Eds), Contributions to Insurance Economics, Boston, Kluwer Academic Publishers**:** 325-358.

Briys, E., Schlesinger, H., 1991. Aversion au risque et prévention. Risques **4**: 27-36.

Caulfield, T. A., Burgess, M.M., Williams-Jones, B., 2001. Offrir des services de dépistage génétique par le biais du secteur privé : un point de vue canadien. Revue Canadienne de Recherche sur les Politiques **2**(3): 78-88.

Crocker, K. J., Snow, A., 1986. The efficiency effects of categorical discrimination in the insurance industry. Journal of Political Economy **94**: 321-344.

Crocker, K. J., Snow, A., 1992. The social value of hidden information in adverse selection economies. Journal of Public Economics: 317-347.

Chassagnon, A., Chiappori, P.A., 1995. Insurance under moral hazard and adverse selection: the case of pure competition. Document de travail **28**.

Chiappori, P. A., 1997. Risque et assurance, Dominos, Flammarion.

De Meza, D., Webb, D.C., 2001. Advantageous selection in insurance markets. The Rand Journal of Economics **32**(2): 249-262.

Dionne, G., Eeckhoudt, L., 1985. Self-insurance, self-protection and increased risk aversion. Economics Letters **17**: 39-42.

Edlin, A. S., Shannon, C., 1998. Strict single crossing and the strict Spence-Mirrlees condition: a comment on monotone comparative statics. Econometrica **66**(6): 1417-1425.

Eeckhoudt, L., 1991. Théorie de la prévention. Risques **4**: 19-25.

Ehrlich, I., Becker, G., 1972. Market insurance, self-insurance, and self-protection. The Journal of Political Economy **80**(4): 623-648.

Fall, M., 2004. Le marché d'assurance est-il si menacé par les Tests Génétiques? Risques **59**: 147-153.

Fagart, M. C., Kambia-Chopin, B., 2003. Aléa moral et sélection adverse sur le marché de l'assurance. Mimeo.

Grann, V. R., Jacobson, J.S., 2002. Population screening for cancer-related germline gene mutations. The Lancet Oncology **3**: 341-348.

Hoel, M., Iversen, T., 2002. Genetic testing when there is a mix of compulsory and

voluntary health insurance. Journal of Health Economics **21**: 253-270.
Hoy, M., 1982. Categorizing risks in the insurance industry. The Quarterly Journal of Economics **97**: 321-336.
Hoy, M., 1989. The value of screening mechanisms under alternative insurance possibilities. Journal of Public Economics **39**: 177-206.
Hoy, M., Orsy, F., Eisinger, F., Moatti, J.P., 2003. The impact of genetic testing on healthcare insurance. The Geneva Papers on Risk and Insurance **28**(2): 203-221.
Hoel, M., Iversen, T., 2002. Genetic testing when there is a mix of compulsory and voluntary health insurance. Journal of Health Economics **21**: 253-270.
Lemmens, T., 2000. Selective Justice, genetic discrimination and insurance: should we single out genes in our laws? McGill Law Journal **45**: 347-412.
Le Pen, C., 2003. Risque génétique et assurance. Risques **54**: 95-99.
Marteau, T. M., Croyle, R.T., 1998. The psychological responses to genetic testing. British Medical Journal **316**: 693-696.
Milgrom, P., Shannon, C., 1994. Monotone comparative statics. Econometrica **62**(1): 157-180.
Pauly, M. V. 1974. Overinsurance and public provision of insurance: the roles of moral hazard and adverse selection. Quarterly Journal of Economics **88**: 44-62.
Rothschild, M., Stiglitz, J.E., 1976. Equilibrium in competitive insurance market: an essay on the economics of imperfect information. Quarterly Journal of Economics **90**: 629-650.
Shavell, S., 1979. On moral Hazard and insurance. Quarterly Journal of Economics **93**(4): 541-562.
Spence, M. (1973). Job market signaling. Quarterly Journal of Economics **88**: 355-74.
Stewart, J., 1994. The welfare implications of moral hazard and adverse selection in competitive insurance markets. Economic Inquiry **32**: 193-208.
Stiglitz, J. E., 1977. Monopoly, nonlinear pricing and imperfect information: the insurance market. Review of Economic Studies **44**(3): 407-430.
Strohmenger, R., Wambach, A., 2000. Adverse selection and categorical discrimination in health insurance markets: the effects of genetic tests. Journal of Health Economics **19**: 197-218.
Tabarrok, A., 1994. Genetic testing: an economic and contractarian analysis. Journal of Health Economics **13**: 75-91.
Tabarrok, A., 1996. Genetic testing and human welfare: Reply to Hall. Journal of Health Economics **15**: 381-384.
Whinston, M. D., 1983. Moral hazard, adverse selection, and the optimal provision of social insurance. Journal of Public Economics **22**: 49-71.