Privacy and Information Value in Adverse Selection Markets.

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Abstract

In this paper we study the impact of genetic testing, and the use of test results in health insurance markets – a market that exhibits adverse selection. We characterize the existence and nature of insurance contracts when individuals can reveal genetic information to insurers but where revelation of genetic information is associated with a loss of privacy. We then examine the welfare implications of different policy proposals regarding genetic testing, with the decision of the consumer to take a genetic test, and to reveal genetic information, being endogenous.

Keywords: Privacy, Adverse Selection, Information Value, Genetic Testing, Insurance

Introduction

Markets exhibiting adverse selection[1] are characterized by asymmetry in information among market participants. Examples include but are not limited to credit markets [Townsend, 14], labor markets [Spence, 11] and insurance markets [Stiglitz, 12]. It has been suggested that an effective way to obtain the first best outcome in these markets would be to make the information structure more symmetric by sharing information [Doherty and Thistle, 4; Laudon, 8]. Laudon [8] describes a National Information Market (NIM), where information about individuals can be bought and sold at a market-clearing price. This market would provide a constant source of consumer information to the firms. Such a market where consumers can trade in potentially useful personal information, has been termed as an 'information market' [Laudon, 8]. Companies such as Lumeria (www.lumeria.com) are creating technologies that allow consumers to create their own profiles, which they can share with marketers for the right price. This business model places personal data under the auspices of the individual, which can then be used as a new form of currency to enable the Identity Commerce (I-Commerce) marketplace.

An example of such personal data is the vast amounts of genetic information created by the Human Genome Project and Genetic Testing. Genetic tests attempt to detect the presence of genes that are associated with disease or predispose those who inherit the genes to disease [Meslin et al., 9]. Genetic testing exacerbates the adverse selection existing in insurance markets, if the results of the test are not made accessible to the insurers. However the insurers' request for a level playing field contrasts with efforts of consumer groups to increase the privacy protection of genetic information [Subramaniam et al., 11). Since the DNA molecule is stable, once removed from a person's body and stored, it can become the source of an increasing amount of information as more is learned about how to read the genetic code [Edwin, 5]. In other words stored genetic samples will provide more genetic information than was

[1] Adverse effect on profitability of the uninformed due to asymmetric information.

imagined when the samples were originally collected. Threats to individual privacy may therefore be presented due to secondary use of the collected information[2].

In this paper we study the impact of genetic testing and the use of test results on health insurance markets. Consumers who have taken a genetic test, are assumed to be informed about their risk of a genetic disease. The informed low risk consumers have an incentive to reveal genetic information/test results to the insurer, so as not to be clubbed with the high risk types. We characterize the existence and nature of insurance contracts when individuals can reveal genetic information to insurers, but where revelation of genetic information is associated with a loss of privacy. We then examine the welfare implications of different policy proposals regarding genetic testing, with the decision of the consumer to take a genetic test and to reveal genetic information, being endogenous. The rest of the paper is organized as follows: Section 1 covers the background literature on privacy and genetic testing. Section 2 covers the assumptions, model framework and the main results. Implications of the results obtained are summarized, and limitations and directions for future research are discussed in Section 3.

1. Background

Privacy is defined as the moral claim of the individuals to be left alone and to control the flow of information about themselves [Coase, 1; Westin, 15]. Revealing genetic information to insurers constitutes a loss of privacy because of the inherent loss in control over the use of this information after it is released.

It is well known that insurance markets are characterized by adverse selection see [Rothschild and Stiglitz, 10; Stiglitz, 13] - asymmetry in information on risk types between the informed or partially informed consumers and uninformed insurers has an adverse impact on the profits of insurers. Genetic testing increases the asymmetry in information if the results are available only to consumers, thus making the adverse selection more acute. There is a lot of debate on how and whether the results of the genetic

[2] Secondary use of the information could be any use other than the primary purpose for which the information was collected. For example the insurance companies could sell the information to other firms interested in the information.

tests should be used see [Tabarrok, 14]. There are four broad policy proposals regarding the use of genetic tests for insurance purposes. Under the first proposal, insurers do not inquire, and are not permitted to inquire, whether applicants have been tested. In the second proposal, genetic information is revealed to the insurer only with the consent of the consumer. The third policy alternative is to permit insurers to inquire whether applicants have been tested and to get genetic information/test results with the consent of the consumer. The fourth policy alternative is to require, or permit insurers to require that applicants be tested, and allow insurers to use the test results-i.e. mandatory release of genetic information for insurance purposes [Doherty and Thistle, 4].

Hirshleifer [6] distinguishes between private information (available only to a single individual) and public information (available to everyone). Our work is closer to the private information stream of literature – Cremer and Khalil [2], Crocker and Snow [3] and Doherty and Thistle [4]. Agents receive a private signal in our model and they choose whether to make the signal public or not[3].

Crocker and Snow [3] have shown that if the insurers know whether the consumers are informed or uninformed about their risk type, then the private value of information to uninformed consumers, is negative. Doherty and Thistle [4] have looked at the case where insurers cannot distinguish between informed and uninformed agents and the case where information on risk type can be concealed or revealed to the insurers. In their setting uninformed can take a test (both costless and costly) to get informed about their risk type, and can reveal information to insurers are zero cost. The policy holders' knowledge of their risk type is therefore endogenous. They characterize the nature of equilibrium in all these cases, and find primarily that with costly information, some uninformed may choose to remain uninformed. They also examine the welfare implications of the endogenous information model for public policy regarding genetic testing.

In our setting, revelation of information has positive costs associated with it as in Jaisingh and Chaturvedi [7] and in contrast to Doherty and Thistle [4]. The difference between our setting and that of Jaisingh and Chaturvedi [7] is that, the insurance market setting is competitive in their case and

[3] We also consider a purely public signal in last section.

monopolistic in ours[4]. We characterize the cost to revealing information to be the loss of privacy – the fear of discrimination because of being classified as a high-risk type in a later period, due to better genetic tests or just the disutility due to loosing control over personal information. All genetic testing policy proposals except the first one where insurers are neither permitted to inquire nor use genetic information are affected if the loss of privacy is taken into account. As far as the impact on consent law (Proposal 2), we need not consider the privacy concerns of the high risk type since presumably only the low risk types are affected. However in the case of mandatory testing and revelation of information, the loss in privacy of the high risk type is also taken into account.

2. Model

The insurance market setting is monopolistic. There is a continuum of risk-averse consumers, identical in all respects except for accident probabilities, and a risk neutral insurer. All consumers possess identical von Neumann-Morgenstern state independent utility functions U (.), which are twice continuously differentiable and strictly concave. Their wealth is W in state 1 (no loss) and $W-D$ in the loss state 2, where $W>D$. $\pi_i; i=H,L$ are the probabilities of accident of the high and low risk consumers. We also assume that $\pi_H > \pi_L$ and $0<\pi_H,\pi_L<1$, and that these probabilities are out of the agent's control, so that no moral hazard problem arises[5]. We assume that each agent knows her risk type[6]. The proportion of low risk (high risk) consumers in the economy is θ_L (θ_H). If agents do not purchase insurance they obtain expected utility, $V(0,\pi_i)$ for $i=H,L$; where

$$V(0,\pi_i)=\pi_i U(W-D)+(1-\pi_i)U(W); i=H,L \tag{1}$$

[4] Insurance markets are monopolistic in several environments and hence there is a motivation to study the setting, separately from the competitive setting. There is a also the added motivation to look at the monopoly setting from a benchmarking perspective and to compare the results with the competitive setting.
[5] Moral hazard problem arises due to the fact that insurers cannot observe the consumers actions – how much care she takes to avoid a loss. By assuming that consumers cannot affect the probability of an accident by their actions we assume away the moral hazard.
[6] Informed consumers can be justified by the fact that they could have taken a genetic test previously for some other purpose and hence are fully aware of their risk of loss.

The insurance contract specifies the premium P and the net indemnity I[7] paid incase of a loss. The use of coinsurance rates and/or deductibles is not permitted. We use the notation $\delta_i = \{P_i, I_i\}$ to denote the single period insurance contract offered to type $i = H, L$. The expected utility of a consumer with the probability of loss π_i, under the insurance policy δ_i, is

$$V(\delta_i, \pi_i) = \pi_i U(W - D + I_i) + (1 - \pi_i) U(W - P_i); i = H, L \tag{2}$$

If consumer releases genetic information to the insurer, then the consumer faces a loss γ due to loss of privacy. The loss of privacy could be the fear of secondary use of the information revealed or the fear of discrimination at a later date due to some information present in the genetic information, which the consumer is not aware of currently or just the disutility at loosing control over the personal information. This loss is thus a non-monetary loss and is separable from the utility from the insurance contract. The net utility is

$$V(\delta_i, \pi_i) - \gamma \tag{3}$$

Initially let us assume that consumers cannot reveal information to the insurers, i.e. $\gamma = 0$. Insurer chooses contracts that maximize profits.

In the first best case (no asymmetry in information on risk types), the insurer chooses contracts that extract the entire surplus of both types of consumers. Both risk types get complete insurance. The contract in the first best case are (δ_H^*, δ_L^*) (see Fig. 1), and satisfy the constraints

$$V(\delta_i^*, \pi_i) = V(0, \pi_i) \tag{4}$$

$$I_i^* = D - P_i^* \forall i = H, L \tag{5}$$

The first constraint – equation (4) - specifies that the consumers are left indifferent between buying and not buying insurance, and the second constraint (5) specifies that both agents get complete insurance.

[7] Net Indemnity is the payment made to the consumer in case of loss, minus the premium

However under asymmetric information (Consumers have a priori knowledge of risk types while insurers don't), the first best contract can't be achieved [Stiglitz, 13]. The second best contract satisfies the constraints

$$V(\delta_i, \pi_i) \geq V(\delta_j, \pi_i); i = (H, L), i \neq j \tag{6}$$

$$V(\delta_i, \pi_i) \geq V(0, \pi_i); i = H, L \tag{7}$$

Equation 6 is the incentive compatibility constraint, while equation (7) is the individual rationality constraint. The separating contracts are $\{\delta_H^{'}, \delta_L^{'}\}$ (see Fig. 1). The high risk consumers get complete insurance and are better off than in the full information case, while the low risk agent get less than full insurance.

We now assume that a proportion λ_U $0 < \lambda_U \leq 1$ of the consumers does not have a priori knowledge of its risk type. Out of these uninformed consumers a proportion p_H (p_L) are high risk (low risk). The proportion of informed high risk type (low risk types) is λ_H (λ_L), $0 < \lambda_H, \lambda_L < 1$ [8]. Informed consumers in our setting are consumers who have taken a genetic test in a previous period for some non-insurance related reason e.g. job screening.

$$\theta_H = \lambda_H + p_H \lambda_U \tag{8}$$

$$\theta_L = \lambda_L + p_L \lambda_U \tag{9}$$

All these proportions are assumed to be common knowledge. The prior probability of loss for the uninformed is

$$\pi_U = \sum_{i=H,L} p_i \pi_i \tag{10}$$

The timing is as follows, the insurer first chooses the set of contracts to offer, based on her beliefs on the actions by the uninformed (take genetic test or not) and the informed low risk (reveal information or not). The uninformed then decide whether to take a genetic test or not, and the informed consumer decide whether to reveal information to the insurer or not. The choice at each node affects the payoffs of

[8] Strict inequalities are assumed here for simplicity. Thus there are always informed high and low risk consumers.

all agents. We denote the aggregate profit of the monopolist if she offers the menu of contracts $(\delta_H, \delta_U, \delta_L)$, to the high risk informed, the uninformed and the low risk informed respectively, by $\Pi(\delta_H, \delta_U, \delta_L)$. If the insurer does not design a contract for a specific type of consumer for e.g. if the insurer wants to offer insurance only to the informed high risk consumers then the menu of contracts she offers is denoted by $(\delta_H, ., .)$. The insurers profit in this case is denoted by $\Pi(\delta_H, ., .)$. Similarly if the insurer designs contracts only for the informed high risk and the uninformed the corresponding notation for the menu of contracts and profits are $(\delta_H, \delta_U, .)$ and $\Pi(\delta_H, \delta_U, .)$

Insurance contracts for the different risk types under different information structures are shown in Fig. 1. W_1 and W_2 are the wealth in the no loss and loss state respectively. The 45^0 line is the complete insurance line. V_H, V_U, and V_L are the indifference curves for the high risk, uninformed and the low risk agents respectively that pass through the initial endowment point E[9]. $V_H^{'}$ and $V_U^{'}$ are indifference curves of the high risk and the uninformed consumer respectively where they are left with a positive surplus. $V_L^{'}$ is the shifted indifference curve of the low risk consumer - insurer gives a surplus to the low risk consumer so as to compensate her for her loss of privacy. Under full information the contracts offered are $(\delta_H^*, \delta_U^*, \delta_L^*)$. Under asymmetric information, with no uninformed the contracts are $(\delta_H^{'}, \delta_L^{'})$, while with uninformed consumers the contracts are $(\delta_H^{'}, \delta_U^{''}, \delta_L^{''})$. With asymmetric information, only the high risk consumers get full insurance. It is easy to see that the following constraints should be satisfied (see Fig. for an intuitive understanding).

$$V(\delta_L^{''}, \pi_L) > V(\delta_U^{''}, \pi_L) \tag{11}$$

$$V(\delta_L^{''}, \pi_L) > V(\delta_H^{'}, \pi_L) \tag{12}$$

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[9] The slope of the indifference curves of low risk, uninformed and high risk consumers at the full insurance line are $-\frac{(1-\pi_L)}{\pi_L} > -\frac{(1-\pi_U)}{\pi_U} > -\frac{(1-\pi_H)}{\pi_H}$

$$V(\delta_U'',\pi_U) = V(\delta_L'',\pi_U) \tag{13}$$

$$V(\delta_U'',\pi_U) > V(\delta_H',\pi_U) \tag{14}$$

$$V(\delta_H',\pi_H) = V(\delta_U'',\pi_H) \tag{15}$$

$$V(\delta_H',\pi_H) > V(\delta_L'',\pi_H) \tag{16}$$

$$V(\delta_H',\pi_H) = V(\delta_L',\pi_H) \tag{17}$$

$$V(\delta_L',\pi_L) > V(\delta_H',\pi_L) \tag{18}$$

In our model we model the loss of privacy due to revelation of information to insurer, and this differentiates our work from Crocker and Snow [3] and Doherty and Thistle [4] – so from now on $\gamma > 0$. The fact that we look at a monopolistic setting differentiates our work from Jaisingh and Chaturvedi [7]. In section 3.1 we consider the case where all consumers are informed and low risk consumers have an incentive to reveal genetic information to insurers. Then in section 3.2, we look at the case where uninformed consumers are present, the information status is not directly observable, there is an incentive for consumers to reveal verifiable information (negative test result or genetic information that reveals that the consumer is a low risk consumer) and testing is costly for the uninformed. The observable information status case with costly revelation and costly testing is considered in section 3.3. The mandatory testing and revelation of genetic information is considered in section 3.4.

2.1 Unreported positives, verifiable negatives, costly revelation and unobservable information status.

We first consider the case where all consumers are informed about their risk type i.e. $\lambda_U = 0$. By consent law, the consumers can choose who gets to see the results of the test. It is clear that only the low risk agents have an incentive to release information to the insurers. We look at the case where all low risk consumers are expected to reveal information.

The insurer would design the contracts to maximize her expected profits subject to the Individual Rationality (IR) constraints of the agents. Thus the problem for the insurance company is:

Max. $\theta_L[(1-\pi_L)P_L - \pi_L I_L] + \theta_H[(1-\pi_H)P_H - \pi_H I_H]$

w.r.t. $(P_L, I_L), (P_H, I_H)$

s.t.

$V(\delta_L, \pi_L) - \gamma \geq V(0, \pi_L)$

$V(\delta_H, \pi_H) \geq V(0, \pi_H)$

We need not worry about the incentive compatibility constraints, since for the low type they would not be binding, and for the high risk type she would not be able to pass off as a low risk type, if she reveals information to the insurer. The individual rationality constraints of both consumers would bind.

Lemma 1: *Assuming all consumers are informed about their risk types, insurer cannot observe risk type and insurer expects all low risk consumers to report verifiable information to the insurer at non-zero cost* γ *then in equilibrium, (a) Low risk and High Risk types obtain full insurance, and (b) the unique equilibrium contract is* $\{\delta_H^*, \delta_L^{**}\}$

Proof See Appendix

Stiglitz [13] has ruled out the possibility of the existence of a pooling equilibrium because the monopolist can always get a higher profit by offering a separating contract. Keeping this property in mind we obtain the following result.

Proposition 1 *Assuming all consumers are informed about their risk types, insurer cannot observe risk type, and consumers can report verifiable information to the insurer at non zero cost* γ *, the equilibrium contracts are*

i) $(\delta^{*}_{H},\delta^{**}_{L})$

ii) $(\delta'_{H},\delta'_{L})$ *if* $\Pi(\delta^{*}_{H},.)\leq\Pi(\delta'_{H},\delta'_{L})$

iii) $(\delta^{*}_{H},.)$ *if* $\Pi(\delta^{*}_{H},.)>\Pi(\delta'_{H},\delta'_{L})$

Proof. See Appendix

When low risk consumers don't reveal information then either $(\delta^{*}_{H},.)$ or $(\delta'_{H},\delta'_{L})$ can be an equilibrium. $(\delta^{*}_{H},.)$ is an equilibrium if the profits from serving the high risk type alone is greater than the profits from offering insurance to both types. When the low risk consumers reveal information the equilibrium is $(\delta^{*}_{H},\delta^{**}_{L})$ - both consumer types get complete insurance and the low risk type are compensated for their loss of privacy.

For the case, $\lambda_U > 0$ (uninformed consumers), if we assume that testing is costless, then testing is a weakly dominant strategy for the uninformed since information status is unobservable. All uninformed consumers would take the test and become informed. Thus with costless testing, there is no impact on the above results if we assume that there are some consumers who are uninformed.

2.2 Unreported positives, verifiable negatives, costly revelation, uninformed consumers, costly testing and unobservable information status.

Uninformed consumers can take a costly test to know their risk type. Also by consent law, the consumers can choose who gets to see the results of the test. It is clear that only the low risk agents have an incentive to release information to the insurers.

Lemma 2. *Assuming that some consumers are uninformed about their risk type, insurers cannot distinguish between informed and uninformed consumers and also cannot observe the risk types directly, then a partial pooling or a pooling contract cannot be an equilibrium*[10].

Proof: See Appendix

Lemma 2 simplifies the calculation of all the possible equilibrium by narrowing down the set of possible equilibrium, to separating contracts.

Proposition 2. *Assuming uninformed consumers can observe their risk type at cost c, informed and uninformed consumers cannot be distinguished, risk type is not directly observed by insurer and consumers can report verifiable information to insurers at non-zero cost* γ *. Denoting* $\frac{c}{p_L}$ *by* c'*, five contracts are feasible:*

i) $(\delta_H^{'},\delta_U^{'},\delta_L^{**})$ *if* $\gamma > V(\delta_L^{**},\pi_L) - V(\delta_L^{'},\pi_L) - c'$ *and* $\Pi(\delta_H^{'},\delta_U^{'},\delta_L^{**}) \geq \Pi(\delta_H^{*},.,\delta_L^{**})$

ii) $(\delta_H^{*},.,\delta_L^{**})$ *if* $\gamma > V(\delta_L^{**},\pi_L) - V(0,\pi_L) - c'$ *and* $\Pi(\delta_H^{'},\delta_U^{'},\delta_L^{**}) < \Pi(\delta_H^{*},.,\delta_L^{**})$

iii) $(\delta_H^{'},\delta_U^{''},\delta_L^{''})$ *if* $c' > V(\delta_L^{''},\pi_L) - V(\delta_U^{''},\pi_L)$, $\Pi(\delta_H^{'},\delta_U^{''},\delta_L^{''}) > \Pi(\delta_H^{*},.,.)$ *and* $\Pi(\delta_H^{'},\delta_U^{''},\delta_L^{''}) > \Pi(\delta_H^{'},\delta_U^{'},.)$

iv) $(\delta_H^{*},.,.)$ *if* $\Pi(\delta_H^{'},\delta_U^{''},\delta_L^{''}) < \Pi(\delta_H^{*},.,.)$ *and* $\Pi(\delta_H^{*},.,.) > \Pi(\delta_H^{'},\delta_U^{'},.)$

v) $(\delta_H^{'},\delta_U^{'},.)$ *if* $c' > V(0,\pi_L) - V(\delta_U^{'},\pi_L)$ *and* $\Pi(\delta_H^{*},.,.) < \Pi(\delta_H^{'},\delta_U^{'},.)$ *and* $\Pi(\delta_H^{'},\delta_U^{''},\delta_L^{''}) < \Pi(\delta_H^{'},\delta_U^{'},.)$

Proof. See Appendix

[10] Pooling contracts are contracts where all consumer types choose the same contract, while partial pooling contracts are contracts where at least two types choose the same contract.

Thus we see that depending on the profits the insurer gets from different contracts, which depends on the relative number of uninformed consumers, and informed low and high risk consumers , five different contracts are feasible. Some of the contracts exist only if the aggregate disutility due to loss of privacy and due to testing is greater than a certain value. For example if we denote $V(\delta_L^{**},\pi_L)-V(\delta_L^{'},\pi_L)=\gamma_1$ and $V(\delta_L^{**},\pi_L)-V(0,\pi_L)=\gamma_2$, then the contract $(\delta_H^{'},\delta_U^{'},\delta_L^{**})$ only exists if the aggregate utility exceeds γ_1, i.e. $\gamma + c' > \gamma_1$. c' can be considered to be a scaled cost of testing. The contract $(\delta_H^{*},.,\delta_L^{**})$ exists for $\gamma + c' > \gamma_2$. If the informed low risk consumer decide to reveal information then the contracts that are feasible are $(\delta_H^{'},\delta_U^{'},\delta_L^{**})$ and $(\delta_H^{*},.,\delta_L^{**})$ - the equilibrium $(\delta_H^{'},\delta_U^{'},\delta_L^{**})$ corresponding to the case where the uninformed don't get informed, but still get insurance while the equilibrium $(\delta_H^{*},.,\delta_L^{**})$ corresponding to the case where the uninformed remain uninformed and uninsured. The other three equilibrium are for the case when the informed low risk don't reveal information to the insurer. In two of these equilibriums $(\delta_H^{*},.,.)$ and $(\delta_H^{'},\delta_U^{'},.)$, the low risk consumer remains uninsured. The uninformed consumer remains uninsured in the equilibrium $(\delta_H^{*},.,.)$

2.3 Unreported positives, verifiable negatives, costly revelation, uninformed consumers and observable information status.

Everything is same as in section 2.2, except that now the information status can be observed by the insurers i.e. the insurers know which consumers are informed and which consumers are uninformed about their risk type.

Proposition 3. *Assume uninformed consumers can observe their risk type at cost c, informed and uninformed consumers can be distinguished, risk type is not directly observed by insurers and consumers can report verifiable information to insurers at non-zero cost* γ *. Denoting* $\frac{c}{p_L} = c'$*, three contracts are feasible:*

i) $(\delta_H^*, \delta_U^*, \delta_L^{**})$

ii) $(\delta_H^{'}, \delta_U^*, \delta_L^{'})$ *if* $c' > V(\delta_L^{'}, \pi_L) - V(\delta_U^{'}, \pi_L) - c'$ *and* $\Pi(\delta_H^{'}, \delta_U^*, \delta_L^{'}) \geq \Pi(\delta_H^*, .,.)$

iii) $(\delta_H^*, \delta_U^*, .)$ *if* $\Pi(\delta_H^*, \delta_U^*, .) > \Pi(\delta_H^{'}, \delta_U^*, \delta_L^{'})$

Proof. See Appendix

If the informed low risk consumers decide to reveal information then the only contract feasible is $(\delta_H^*, \delta_U^*, \delta_L^{**})$, where the uninformed continue to remain uninformed. Note that all agents receive complete insurance in this equilibrium, and the low risk informed is compensated for her loss in privacy. When the informed low risk don't reveal information, then two contracts are feasible - $(\delta_H^{'}, \delta_U^*, \delta_L^{'})$ where the low risk informed only get partial insurance and $(\delta_H^*, \delta_U^*, .)$ where the low risk informed consumer remains uninsured. There are no equilibrium where the uniformed become informed by taking a genetic test. Reason being that they always prefer the contract δ_U^* to a lottery over $\delta_H^*, \delta_L^{**}$ or a lottery over $\delta_H^{'}, \delta_L^{'}$. Thus with observable information status, uninformed have no incentive to get tested and become informed.

2.4 Mandatory testing and release of information for insurance

All consumers have to take a mandatory test, and then reveal the results of the genetic test to the insurer, in order to get insurance. This implies that all uninformed have to get informed in order to get insurance. We now also need to consider the privacy loss of the high risk consumer type. The privacy loss of the high risk (low risk) consumer due to release of information is, γ_H (γ_L), where $\gamma_H > \gamma_L$.

Proposition 4. *Assume uninformed consumers can observe their risk type at cost c, risk type is not directly observed by insurer and high risk (low risk) consumers can report verifiable information to* *insurer at non-zero cost γ_H (γ_L) where $\gamma_H > \gamma_L$ and reporting information is mandatory for insurance, then denoting $V_i^{'} = V(\delta_i^{**}, \pi_i) - \gamma_i$ and $\overline{V_i} = V(0, \pi_i) \forall i = H, L, U$*

i) If $V_H^{'} < \overline{V_H}$ and $V_L^{'} < \overline{V_L}$ nobody buys insurance.

ii)If $V_H^{'} < \overline{V_H}$; $V_L^{'} \geq \overline{V_L}$ and $p_H V_H^{'} + p_L V_L^{'} - c < \overline{V_U}$, uninformed remain uninformed, only informed low risk buy insurance and the only contract offered is δ_L^{**}.

iii) If $V_H^{'} < \overline{V_H}$; $V_L^{'} \geq \overline{V_L}$ and $p_H V_H^{'} + p_L V_L^{'} - c > \overline{V_U}$, then uninformed become informed and the low risk buy the only contract offered δ_L^{**}.

iv) If $V_H^{'} \geq \overline{V_H}$ and $V_L^{'} \geq \overline{V_L}$ and $p_H V_H^{'} + p_L V_L^{'} - c < \overline{V_U}$, then uninformed remain uninformed and remain uninsured, both high risk and low risk reveal information and are offered the contracts $(\delta_H^{**}, \delta_L^{**})$.

v) If If $V_H^{'} \geq \overline{V_H}$ and $V_L^{'} \geq \overline{V_L}$ and, $p_H V_H^{'} + p_L V_L^{'} - c \geq \overline{V_U}$ then uninformed become informed, both high risk and low risk reveal information and are offered the contracts $(\delta_H^{**}, \delta_L^{**})$

Proof: Straightforward comparison of the utilities of each type of agent with or without insurance with the clause that insurance requires mandatory testing leads to above results.

The menu of contracts $(\delta_H^{**}, \delta_L^{**})$, compensates both the high risk and low risk for the loss of privacy. Mandatory testing and release on information imposes additional costs on all agents in some cases. The monopolist may be worse off if there are a large number of uninformed who decide to remain uninformed and uninsured.

3. Discussion

In this paper we have looked at the tradeoff between the value of information and the value of privacy in a market exhibiting adverse selection – health insurance market. Nature of insurance contracts under each of the policy proposals has been summarized in the propositions. Under the first proposal, where insurers are neither permitted to ask whether the consumer has undergone any test nor ask for test results, the contracts offered are - full insurance for the high risk, and incomplete insurance for the uninformed and the low risk. These contracts rely on pure self-selection a la Stiglitz. Contracts of this form impose a signaling cost on the uninformed and the informed low risk type –they have to signal their type by accepting less then full insurance.

If release of information is allowed by consent law, and insurers cannot observe the information status (Proposition 2), then there are a number of possible candidate equilibriums. These equilibriums depend on the relative profitability of the menu of contracts, which in turn depends on the relative number of informed low risk, informed high risk and uninformed consumers. Some of these equilibriums only exist if the aggregate disutilities due to testing and loss of privacy are above a certain value. One of these equilibriums is the separating menu of contract offered under proposal 1. From a welfare perspective, we look at the impact on the welfare of agents individually. It would be difficult to get a measure of overall social welfare without specific numbers on the number of agents of each type. We first do a welfare comparison of proposal 1 and 2. The monopolist insurer is always weakly better off under proposal 2, since she always has the option of offering the separating contract under proposal 1. She can do no worse than the profit that she get under proposal 1. The low risk consumer is better off in some of the equilibriums under proposal 2, than under proposal 1, since she gets complete insurance as opposed to partial insurance under proposal 1. However in some other equilibrium, she is indifferent between the two proposals. Proposal 1 is favorable to the high risk type since she is always left with a positive surplus. Under proposal 2 she still continues to get complete insurance but in some equilibrium is left with zero surplus. Similarly, the uniformed consumer is better off under some equilibriums under proposal 2, while she is indifferent in some other equilibriums compared to the contract she obtains under proposal 1.

The results of Proposition 3 are relevant to Proposal 3, where the insurer always knows the information status of the consumers. The results suggest that the uninformed can also get full insurance. The key difference between proposals 2 and 3 is that the insurers can identify the informed high risk from the uninformed. Since this information is conveyed to the insurers without any inherent loss to the consumers of any type, from a welfare perspective Proposal 3 dominates Proposal 2 – additional information is available without a cost. The additional information on the information status also reduces the number of possible candidate equilibriums to three. Since the insurer can design insurance contracts based on the information status, none of the uninformed take a genetic test and prefer to remain uninformed. This is a result of the risk averseness of the consumers because of which they prefer the first best contract designed for the uninformed, over a lottery of the first best contracts designed for the informed low risk and informed high risk types.

Now comparing proposal 1 and proposal 3, we find that of the three candidate equilibriums under proposal 3, the low risk consumer is better off in one, and indifferent in the other two, compared to her contract in proposal 1. The high risk consumer is worse off in two of the equilibriums under proposal 3 and indifferent in the other compared to her contract in proposal 1. The uninformed consumer gets the first best contract in all the equilibriums under proposal 3. Since the first best contract leaves her with zero surplus, she ends up being worse off then than under proposal 1, where she is left a positive surplus. Mandatory testing and mandatory revelation of information does the worst in terms of social welfare, since it imposes additional costs on the high risk and uninformed agents without providing any benefits to the high risk, and providing benefits to the uninformed only in some cases.

In this paper we make the simplistic assumption that there are only two risk types. Extension to a continuum of risk types is a possible direction of future research. It is possible that some of the Nash equilibriums that we have calculated can be eliminated based on some refinement criteria, however we refrain from addressing refinement issues in this paper. The insurance setting is monopolistic, and the study of this setting is important not only because some insurance markets are dominated by a single insurer, but also because it is a benchmark setting to be compared with the competitive setting [Jaisingh and Chaturvedi, 7]. We could have considered better posteriors on the probabilities of losses instead of considering perfect information, from taking a genetic test. However as Doherty and Thistle [4] have shown in their setting, the results don't change by assuming better posteriors. We expect our results to hold true even after modifying the setting to one with better posteriors.

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APPENDIX

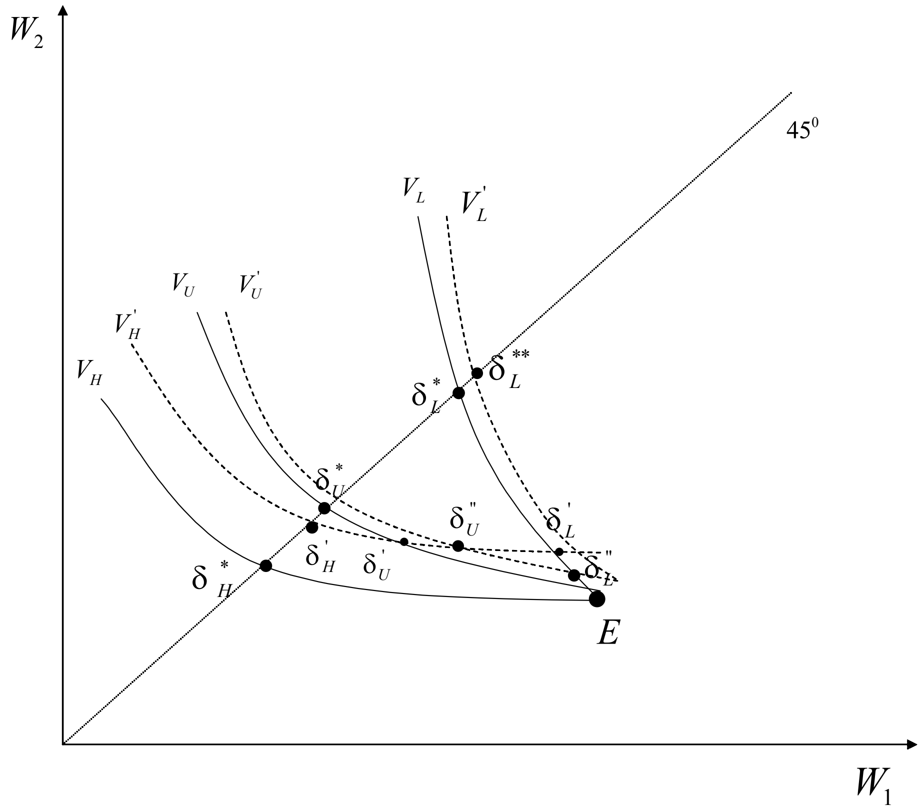

Fig. 1. Insurance Contracts

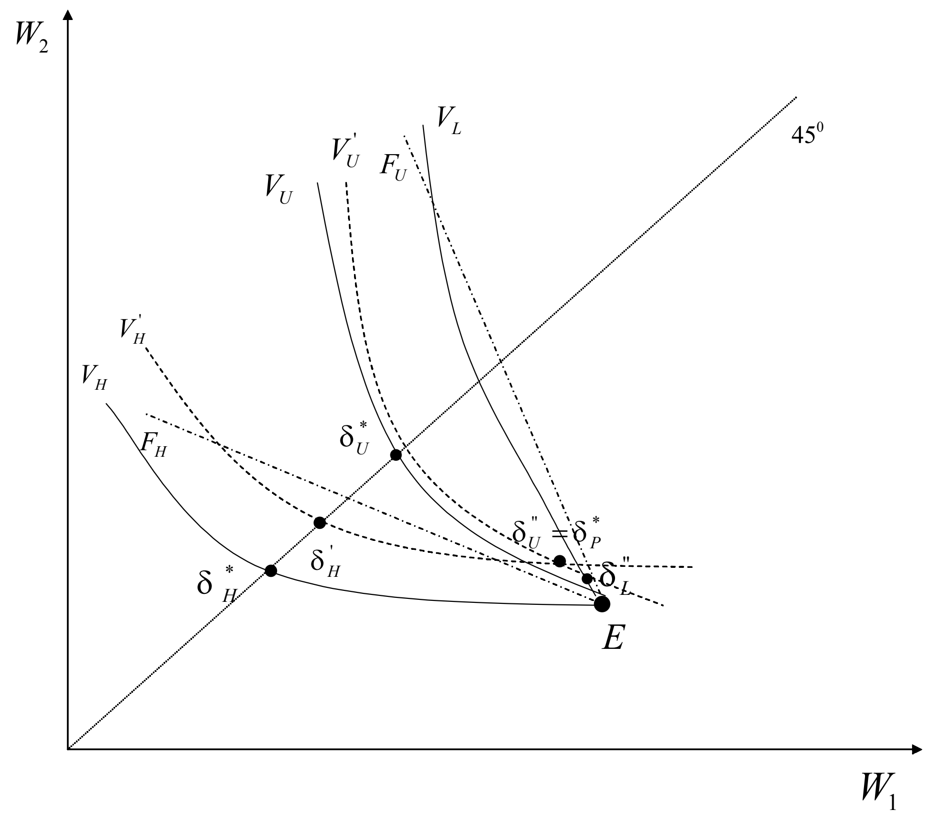

Fig 2 Non Existence of Pooling or Partial Pooling Contracts

Proof of Lemma 1

Setting up the Lagrangian for maximizing the profit of the monopolist, with λ and μ as the multipliers for the IR constraints for the low risk type and high risk types respectively and taking the first order conditions, we obtain.

$$\lambda = \frac{\theta_L}{U'(W - P_L)} = \frac{\theta_L}{U'(W - D + I_L)} \tag{A1}$$

$$\mu = \frac{\theta_H}{U'(W - P_H)} = \frac{\theta_H}{U'(W - D + I_H)} \tag{A2}$$

Since $U'(.) > 0$, $\lambda > 0$ and $\mu > 0$, $U'(W - P_i) = U'(W - D + I_i)$, which implies that $I_i = D - P_i; i = H, L$. Both risk types get complete insurance i.e. they have the same wealth in both states.

The equilibrium contracts are the point of intersection of the indifference curves with the 45^0 equal wealth line. Since the individual rationality constraint of the high risk type binds, she gets the same contract δ_H^* as in the full information case. The low risk agent is compensated for her loss of privacy and so her indifference curve shifts up. The point of intersection of this shifted indifference curve with the equal wealth line is the contract δ_L^{**} (Fig. 1).

Proof of Proposition 1.

We verify that it is an equilibrium for the low risk consumers to reveal information and get the contract δ_L^{**}, and then show that not revealing information can also be an equilibrium.

If insurer expects the low risk to reveal information, then, she offers the contracts $(\delta_H^*, \delta_L^{**})$ (See Lemma 1) . The value of revealing information to the low risk is

$$I' = [V(\delta_L^{**}, \pi_L) - \gamma] - V(0, \pi_L)$$

Since $V(\delta_L^{**}, \pi_L) - \gamma = V(0, \pi_L)$, $I' = 0$. We will make the assumption that the low risk consumer will buy insurance by revealing information, when $I' = 0$.

If the insurer expects the low risk not to reveal information, then she offers the contracts $(\delta_H^{'}, \delta_L^{'})$ or she will provide insurance to only the high risk types by offering the contract δ_H^*. Offering insurance only to the high risk type is always an equilibrium, if the profits to the monopolist from offering $(\delta_H^*, .)$ is greater than the profit offering $(\delta_H^{'}, \delta_L^{'})$ i.e.

$$\Pi(\delta_H^*, .) > \Pi(\delta_H^{'}, \delta_L^{'}).$$

$(\delta_H^{'}, \delta_L^{'})$ can be an equilibrium if the insurers' profit under this menu of contracts is higher than the profit under δ_H^*.

$$\Pi(\delta_H^{'}, \delta_L^{'}) \geq \Pi(\delta_H^*, .)$$

The value of revealing information for the low risk types is

$$I'' = [V(\delta_L^{'}, \pi_L) - \gamma] - V(\delta_L^{'}, \pi_L) = -\gamma$$

Since value of information is negative, low risk do not reveal information. The high risk types are indifferent between $\delta_H^{'}$ and $\delta_L^{'}$, so $(\delta_H^{'},\delta_L^{'})$ is also an equilibrium.

Proof of Lemma 2

Stiglitz [13] has ruled out the existence of pooling contracts. In the Stiglitz [13] environment there are only high and low risk consumers. Here we show graphically that the result doesn't change when uninformed consumers are present, and also rule out partial pooling contracts using the same logic The separating menu of contracts is $(\delta_H^{'},\delta_U^{''},\delta_L^{''})$ in Fig. 2. EF_U and EF_H are the zero profit curves for the uninformed and high risk consumers. Profit curves of the monopolist from the high risk and the uninformed when the she offers the menu of contracts $(\delta_H^{'},\delta_U^{''},\delta_L^{''})$ are parallel to EF_H and EF_U respectively, and pass through the points $\delta_H^{'}$ and $\delta_U^{''}$ respectively. If the monopolist offers the partial pooling contract $(\delta_P^{*},\delta_P^{*},\delta_L^{''})$, where $\delta_P^{*}=\delta_U^{''}$ then there always exists a separating contract $(\delta_H^{'},\delta_U^{''},\delta_L^{''})$ such that the monopolist makes a higher profit on the high risk agent. This can be seen by looking at the iso-profit line of the monopolist for the high risk consumer through every possible $\delta_H^{'}$ and δ_P^{*}. The monopolist continues to make the same profit on the low risk and the uninformed. The same logic extends to pooling contracts. Thus for every possible partial pooling or pooling contract, there exists a separating contract that makes a higher profit. Using this fact a partial pooling or pooling contract cannot be an equilibrium.

Proof of Proposition 2.

There are three players in the game – the uninformed consumer, the informed low risk type and the insurer[11]. The strategy space for the uninformed is to get informed or to remain uninformed. The strategy space for the informed low risk is to reveal information or not to reveal information. The strategy space for the insurer is to design the set of contracts. We adopt the following approach to calculate the equilibriums - the insurer picks the most profitable menu of contracts given one of the four possible combinations of strategies of the other two players. If none of the other two players has an incentive to deviate given the contract offered by the insurer and the strategy

[11] The informed high risk consumer always end up with the contract δ_H^{*} and are not part of the game.

of the other player, then the contract is an equilibrium. We calculate all the equilibriums in four steps; each step corresponds to the insurers' belief on the four possible strategy combinations of the other two players.

Step 1: Assume that the insurer expects the informed low risk type to reveal information and the uninformed type to become informed, then it would offer the contracts $(\delta^*_H, \delta^{**}_L)$. The value of revealing information for the informed low risk types is

$$u^* = [V(\delta^{**}_L, \pi_L) - \gamma] - V(0, \pi_L)$$

Since $V(\delta^{**}_L, \pi_L) - \gamma = V(0, \pi_L)$, $u^* = 0$ and all informed low risk types would reveal information. The value of getting informed for the uninformed is

$$I^* = \{p_H V(\delta^*_H, \pi_H) + p_L[V(\delta^{**}_L, \pi_L) - \gamma] - c\} - V(0, \pi_U)$$

Using the fact that $V(\delta^*_H, \pi_H) = V(0, \pi_H)$, adding and subtracting $p_L V(0, \pi_L)$ and using the fact that $p_H V(0, \pi_H) + p_L V(0, \pi_L) = V(0, \pi_U)$

$$I^* = p_L[V(\delta^{**}_L, \pi_L) - V(0, \pi_L) - \gamma] - c$$

Since $V(\delta^{**}_L, \pi_L) - \gamma = V(0, \pi_L)$, $I^* = -c < 0$. Since the value of information is negative, all uninformed would remain uninformed and so $(\delta^*_H, \delta^{**}_L)$ cannot be an equilibrium.

Step 2: Assume now that the insurer expects the informed low risk not to reveal information, and the uninformed to get informed. In this case, the insurer offers the contracts $(\delta^{'}_H, \delta^{'}_L)$ or just the contract δ^*_H. The insurer is better off offering the contract $(\delta^{'}_H, \delta^{'}_L)$ if $\Pi(\delta^{'}_H, \delta^{'}_L) \geq \Pi(\delta^*_H, .)$ and she is better off serving just the high risk by only offering the contract $(\delta^*_H, .)$ if $\Pi(\delta^{'}_H, \delta^{'}_L) < \Pi(\delta^*_H, .)$. We look at the case $\Pi(\delta^{'}_H, \delta^{'}_L) \geq \Pi(\delta^*_H, .)$ in step 2.a and the case $\Pi(\delta^{'}_H, \delta^{'}_L) < \Pi(\delta^*_H, .)$ in step 2.b.

2.a Insurer offers $(\delta^{'}_H, \delta^{'}_L)$

The value of revealing information for the informed low risk is

$$u^* = [V(\delta^{'}_L, \pi_L) - \gamma] - V(\delta^{'}_L, \pi_L) = -\gamma$$

Since the value of revealing information is negative, the informed low risk will not reveal information. The value of getting informed for the uninformed is

$$I^* = \{p_H V(\delta_H^{'}, \pi_H) + p_L V(\delta_L^{'}, \pi_L) - c\} - V(\delta_L^{'}, \pi_U)$$

Using the fact that $V(\delta_H^{'}, \pi_H) = V(\delta_L^{'}, \pi_H)$ and $p_H V(\delta_L^{'}, \pi_H) + p_L V(\delta_L^{'}, \pi_L) = V(\delta_L^{'}, \pi_U)$

$$I^* = -c < 0$$

Since I^* is negative, uninformed will not become informed and $(\delta_H^{'}, \delta_L^{'})$ cannot be an equilibrium.

2.b. Insurer offers $(\delta_H^{*}, .)$

The value of revealing information for the informed low risk is

$$u^* = [V(0, \pi_L) - \gamma] - V(0, \pi_L) = -\gamma$$

Since the value of revealing information is negative, the informed low risk will not reveal information. The value of getting informed for the uninformed is

$$I^* = \{p_H V(\delta_H^{*}, \pi_H) + p_L V(0, \pi_L) - c\} - V(0, \pi_U)$$

Using $V(\delta_H^{*}, \pi_H) = V(0, \pi_H)$ and $p_H V(0, \pi_H) + p_L V(0, \pi_L) = V(0, \pi_U)$, $I^* = -c < 0$. Uninformed will not become informed and so $(\delta_H^{*}, .)$ cannot be an equilibrium.

Step 3: Assume now that the insurers expect the informed low risk type to reveal information and the uninformed to remain uninformed. In this case the, insurers there can be three possible best strategies for the insurer. Using Lemma 2 we can rule out pooling and partial pooling contracts.

3.a. Offer insurance to all three $(\delta_H^{'}, \delta_U^{'}, \delta_L^{**})$

3.b. Offer insurance to the high risk and low risk and uninformed remain uninsured $(\delta_H^{*}, ., \delta_L^{**})$

3.a Insurers' best strategy is $(\delta_H^{'}, \delta_U^{'}, \delta_L^{**})$ if $\Pi(\delta_H^{'}, \delta_U^{'}, \delta_L^{**}) \geq \Pi(\delta_H^{*}, ., \delta_L^{**})$

The value of revealing information for the informed low risk types is

$$u^* = [V(\delta_L^{**}, \pi_L) - \gamma] - V(0, \pi_L)$$

Since $V(\delta_L^{**}, \pi_L) - \gamma = V(0, \pi_L)$, $u^* = 0$, and all informed low risk reveal information. The value of getting informed for the uninformed is

$$I^* = \{p_H V(\delta_H^{'}, \pi_H) + p_L [V(\delta_L^{**}, \pi_L) - \gamma] - c\} - V(\delta_U^{'}, \pi_U)$$

Using the fact that $V(\delta_H^{'}, \pi_H) = V(\delta_U^{'}, \pi_H)$, adding and subtracting $p_L V(\delta_U^{'}, \pi_L)$ and using $p_H V(\delta_U^{'}, \pi_H) + p_L V(\delta_U^{'}, \pi_L) = V(\delta_U^{'}, \pi_U)$

$$I^* = p_L [V(\delta_L^{**}, \pi_L) - V(\delta_U^{'}, \pi_L) - \gamma] - c$$

If $\gamma < V(\delta_L^{**}, \pi_L) - V(\delta_U^{'}, \pi_L) - c'$, where $c' = c / p_L$, then the value of getting information is positive, the uninformed choose to become informed and so the contract $(\delta_H^{'}, \delta_U^{'}, \delta_L^{**})$ cannot be an equilibrium. If $\gamma > V(\delta_L^{**}, \pi_L) - V(\delta_U^{'}, \pi_L) - c'$, then uninformed continue to remain uninformed, and $(\delta_H^{'}, \delta_U^{'}, \delta_L^{**})$ is an equilibrium.

3.b Insurers' best strategy is to offer $(\delta_H^{*}, ., \delta_L^{**})$ if $\Pi(\delta_H^{*}, ., \delta_L^{**}) > \Pi(\delta_H^{'}, \delta_U^{'}, \delta_L^{**})$

The value of revealing information for the informed low risk types is

$$u^* = [V(\delta_L^{**}, \pi_L) - \gamma] - V(0, \pi_L).$$

By the same argument as in 3a. all low risk consumers will reveal information. The value of getting informed for the uninformed is

$$I^* = \{p_H V(\delta_H^{*}, \pi_H) + p_L [V(\delta_L^{**}, \pi_L) - \gamma] - c\} - V(0, \pi_U)$$

It is easy to show that the value of getting informed reduces to

$$I^* = p_L [V(\delta_L^{**}, \pi_L) - V(0, \pi_L) - \gamma] - c$$

$(\delta_H^{*}, ., \delta_L^{**})$ is an equilibrium only if uninformed remain uninformed i.e. $\gamma > V(\delta_L^{**}, \pi_L) - V(0, \pi_L) - c'$ where c' is same as before.

Step 4: Assume now that the insurer expects the informed low risk type not to reveal information, and the uninformed to remain uninformed. In this case the possible best strategies for the insurer could be one of the following

4.a. Insurer offers the separating menu of contract $(\delta_H^{'}, \delta_U^{''}, \delta_L^{''})$.

4.b. Offer insurance only to the high risk by only offering the contract $(\delta_H^{*}, ., .)$

4.c. Offer insurance to only the high risk and the uninformed- $(\delta_H^{'}, \delta_U^{'}, .)$

We will only outline the steps to check whether each of these strategies can be an equilibrium. In each of the following steps we will assume that the contract offered by the insurer is her best strategy i.e. the monopolist maximizes her profits by offering the contract.

4.a. $(\delta_H^{'}, \delta_U^{''}, \delta_L^{''})$

$$u^* = [V(\delta_L^{''}, \pi_L) - \gamma] - V(\delta_L^{''}, \pi_L) = -\gamma$$

$$I^* = \{p_H V(\delta_H^{'}, \pi_H) + p_L V(\delta_L^{''}, \pi_L) - c\} - V(\delta_U^{''}, \pi_U)$$

$$I^* = p_L [V(\delta_L^{''}, \pi_L) - V(\delta_U^{''}, \pi_L)] - c$$

If $c' > V(\delta_L^{''}, \pi_L) - V(\delta_U^{''}, \pi_L)$, then $(\delta_H^{'}, \delta_U^{''}, \delta_L^{''})$ is an equilibrium.

4.b. $(\delta_H^{*}, ., .)$

$$u^* = [V(0, \pi_L) - \gamma] - V(0, \pi_L) = -\gamma$$

Using $V(\delta_H^{*}, \pi_H) = V(0, \pi_H)$ and $p_H V(0, \pi_H) + p_L V(0, \pi_L) = V(0, \pi_U)$

$$I^* = \{p_H V(\delta_H^{*}, \pi_H) + p_L V(0, \pi_L) - c\} - V(0, \pi_U) = -c$$

Since value of releasing information for the low risk and the value of getting informed for the uninformed is negative $(\delta_H^{*}, ., .)$ is an equilibrium.

4.c. $(\delta_H^{'},\delta_U^{'},.)$

$$u^* = [V(0,\pi_L)-\gamma] - V(0,\pi_L) = -\gamma$$

$$I^* = \{p_H V(\delta_H^{'},\pi_H) + p_L V(0,\pi_L) - c\} - V(\delta_U^{'},\pi_U)$$

$$I^* = p_L[V(0,\pi_L) - V(\delta_U^{'},\pi_L)] - c$$

If $c' > V(0,\pi_L) - V(\delta_U^{'},\pi_L)$, then $(\delta_H^{'},\delta_U^{'},.)$ is an equilibrium.

Proof of Proposition 3.

As before there are three players in the game – the uninformed, the informed low risk type and the insurer. The insurer now can identify the informed consumers from the uninformed. We calculate all the equilibriums in four steps; each step corresponds to the insurers' best response based on beliefs on the four possible strategy combinations of the other two players.

Step 1 and *Step 2*: No uninformed would become informed when the insurer can observe the information status. Reason being that the an uninformed consumer prefers δ_U^*, which is the contract she would get if she remains uninformed, to a lottery over δ_H^* and δ_L^{**}. This is a result of her risk aversion. Thus there are no equilibrium where the uninformed becomes informed.

Step 3: Assume now that the insurers expect the informed low risk type to reveal information, and the uninformed to remain uninformed. Using Lemma 2 we can rule out pooling and partial pooling contracts.

The best strategy for the insurer is to offer the menu of contracts $(\delta_H^*,\delta_U^*,\delta_L^{**})$ The value of revealing information for the informed low risk types is

$$u^* = [V(\delta_L^{**},\pi_L)-\gamma] - V(0,\pi_L)$$

Since $V(\delta_L^{**},\pi_L)-\gamma = V(0,\pi_L)$, $u^* = 0$, and all informed low risk reveal information. The value of getting informed for the uninformed is

$$I^* = \{p_H V(\delta_H^*,\pi_H) + p_L[V(\delta_L^{**},\pi_L)-\gamma] - c\} - V(\delta_U^*,\pi_U)$$

Using the fact that $V(\delta_H^*, \pi_H) = V(0, \pi_H)$ and $V(\delta_U^*, \pi_U) = V(0, \pi_U)$, adding and subtracting $p_L V(0, \pi_L)$ and using $p_H V(0, \pi_H) + p_L V(0, \pi_L) = V(0, \pi_U)$

$$I^* = p_L[V(\delta_L^{**}, \pi_L) - V(0, \pi_L) - \gamma] - c = -c$$

Since value of releasing information for the low risk, and the value of getting informed for the uninformed is negative $(\delta_H^*, \delta_U^*, \delta_L^{**})$ is an equilibrium.

Step 4: Assume now that the insurer expects the informed low risk type not to reveal information, and the uninformed to remain uninformed. In this case the possible best strategies for the insurer could be one of the following

4.a. Insurer offers the separating menu of contract $(\delta_H^{'}, \delta_U^*, \delta_L^{'})$ if $\Pi(\delta_H^{'}, \delta_U^*, \delta_L^{'}) \geq \Pi(\delta_H^*, \delta_U^*, .)$.

4.b. Offer insurance to only the high risk and the uninformed- $(\delta_H^*, \delta_U^*, .)$ if $\Pi(\delta_H^*, \delta_U^*, .) > \Pi(\delta_H^{'}, \delta_U^*, \delta_L^{'})$

We will only outline the steps to check whether each of these strategies can be an equilibrium. In each of the following steps we will assume that the contract offered by the insurer is her best strategy i.e. the monopolist maximizes her profits by offering the contract.

4.a. $(\delta_H^{'}, \delta_U^*, \delta_L^{'})$

$$u^* = [V(\delta_L^{'}, \pi_L) - \gamma] - V(\delta_L^{'}, \pi_L) = -\gamma$$

$$I^* = \{p_H V(\delta_H^{'}, \pi_H) + p_L V(\delta_L^{'}, \pi_L) - c\} - V(\delta_U^*, \pi_U)$$

Using the fact that $V(\delta_U^*, \pi_U) = V(\delta_U^{'}, \pi_U)$, $V(\delta_H^{'}, \pi_H) = V(\delta_U^{'}, \pi_H)$ and $p_H V(\delta_U^{'}, \pi_H) + p_L V(\delta_U^{'}, \pi_L) = V(\delta_U^{'}, \pi_U)$

$$I^* = p_L[V(\delta_L^{'}, \pi_L) - V(\delta_U^{'}, \pi_L)] - c$$

If $c' > V(\delta_L^{'}, \pi_L) - V(\delta_U^{'}, \pi_L)$, then $(\delta_H^{'}, \delta_U^*, \delta_L^{''})$ is an equilibrium.

4.b. $(\delta_H^*, \delta_U^*, .)$

$$u^* = [V(0,\pi_L) - \gamma] - V(0,\pi_L) = -\gamma$$

$$I^* = \{p_H V(\delta_H^*, \pi_H) + p_L V(0,\pi_L) - c\} - V(\delta_U^*, \pi_U)$$

Using the fact that $V(\delta_U^*, \pi_U) = V(0,\pi_U)$, $V(\delta_H^*, \pi_H) = V(0,\pi_H)$ and

$p_H V(0,\pi_H) + p_L V(0,\pi_L) = V(0,\pi_U)$

$$I^* = -c$$

Since value of releasing information for the low risk and the value of getting informed for the uninformed is negative $(\delta_H^*, \delta_U^*, .)$ is an equilibrium.