An Experimental study of Information Markets*

Research in Progress

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Abstract

In this paper we experimentally compare the welfare efficiency of ‘information markets’ – markets where consumer information can be traded, to markets where no trade in information take place. Consumers face a loss in privacy when revealing personal information and take this loss into account before deciding to trade their information. The experimental setting allows us to set up agent incentives, and market institutions, so as to study different policy proposals regarding the use of personal information.

1. Introduction

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. In the future, consumers will be able to share useful information - credit information with lenders, genetic information with insurance firms etc – for the right benefits. This will lead to an ‘information market’ where consumers can trade in potentially useful personal information (Laudon 1996, Sovern 1999).

Laudon (1996) in his paper ‘Markets and Privacy’ proposed a National Information Market (NIM), where information about individuals can be bought and sold at a market clearing

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price. The basic idea in the market is that institutions, which function as brokers, collect personal information (insurance information, medical records etc) from individuals, and then sell them as baskets of information to buyers (companies, government, private individuals etc). The collection and selling of information takes place in a virtual market. Market forces decide the market-clearing price and the cash flow takes place from the buyer to the individual through the broker.

In this essay we evaluate the efficiency of such an information market experimentally and compare it with the efficiency of a conventional market, where consumer information is not available for trade. We consider an insurance market setting. All consumers are assumed to have private information (genetic information) about their risk of a loss. Insurers want access to this information, so that they can charge the consumers the right premiums in order to maximize profits. Consumers, who have private information that their risk of a loss is low, would want to signal their low risk type, by revealing the genetic information to the insurer.

Proposals for the use of genetic information for insurance purposes range from no use, to complete use. Revelation of information however has inherent disutilities associated with it, due to loss of privacy. Privacy loss is the fear of discrimination in a later period, due to better genetic tests or just the disutility due to loss in control over personal information. Consumers take this loss into account before deciding whether to reveal information or not. We propose to compare the efficiency of this market for information with that of a conventional market analyzed in Stiglitz (1977), experimentally. The experimental setting also allows us to compare the different policy proposals concerning the use of genetic information in health insurance markets, in terms of overall social welfare.
In this essay, the research questions we are looking at are: How does an information market compare in terms of efficiency with a market with no trade in personal information? How do the different policy proposals regarding use of genetic information for health insurance purposes compare in terms of overall welfare, experimentally? The rest of the paper is organized as follows: Section 2 covers the background literature on the policy proposal regarding use of genetic information for insurance, and other experimental studies of markets for information. Section 3 covers the experimental design. Section 4 discusses the relevance and contribution of this research.

2. Literature Review

It is well known that insurance markets are characterized by adverse selection (see Rothschild and Stiglitz 1976) - 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 tests should be used (see Tabarrok 1994). 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 1996).
Empirical verification and testing has lagged behind the development of theoretical models of value of information in competitive markets (Sunder 1992). Plott and Sunder (1982), in their study of the value of private information in asset markets, found that, a double oral auction market is capable of transmitting information from informed to uninformed traders. Plott and Sunder (1988) in a similar study found that a double auction market is capable of simultaneously aggregating diverse information in the possession of different traders and transmitting it to all traders. In Plott and Sunder (1982, 1988), information was exogenously assigned to traders. Sunder (1992) extends this framework making the decision to become informed endogenous, and thus creating a market for information.

Experimental studies of insurance markets are limited. Camerer and Kunreuther (1989) look at how trading in insurance, is affected by ambiguity in the probability of the loss. They find that insurance premiums approach expected value for a large range of probabilities and loss amounts, and that the premiums are not affected by ambiguity about the probability of the loss. Schoemaker and Kunreuther (1979) contrast expected utility theory with prospect theory, as an alternate model of choice. As opposed to the above two papers, we are mainly interested in the efficiency improvement, if any, if trade in relevant personal information is allowed. We propose to contrast different policy proposals regarding use of genetic information in health insurance markets in terms of overall welfare. Our experimental design borrows elements from both Camerer and Kunreuther (1989) (insurance market design) and Sunder (1993) (information market design).

3. Experimental Design

The human experiments will be conducted with subjects recruited from the undergraduate program at Purdue University. The software for the experiment is currently being developed at
the Synthetic Environment for Analysis and Simulation (SEAS) Lab, at the Krannert Graduate School of Management, Purdue University. The currency used in the market is francs. All trading and earnings are in terms of francs, and the francs earned by each agent, will be converted to dollars, based on a pre-specified conversion rate. Each experiment would be conducted on a different day, with a different set of parameters and would involve several periods.

There are two types of agents in the market - buyers of insurance (consumers) and a seller of insurance (insurer). All consumers have a one period lifetime. In each period, all consumers have an initial wealth, and can face a potential loss. The monetary value of the loss is common knowledge. Consumers can buy insurance from the insurance company to protect themselves against the loss. Buyers are of two types – high risk and low risk. Each buyer knows his type while the insurer doesn’t know the risk type of consumers. The high-risk consumer has a greater chance of the loss than the low risk consumer. There are two states of the world – the high-risk consumer faces a loss in one state while the low risk consumer faces a loss in the other state.

The market for insurance is set up as a posted offer market. The risk type of each consumer is determined by the roll of a dice at the start of each period. Seller of insurance specifies both the premium and the amount of coverage. After the seller posts the premiums and coverage, the buyers can buy insurance from the seller. Each buyer of insurance is only allowed to buy insurance once during a period. The insurers can however sell insurance to more than one buyer in a period. In the first half of each experiment we replicate the Stiglitz (1977) (Stig 77) setting – pure insurance market with no trade in information on risk type. The insurers sets two contracts with different premiums and coverages. The consumer chooses between the two contracts offered, and not buying insurance at all. At the end of the period the state is revealed.
by the roll of another dice and profits for all agents are calculated. This process is repeated for
each period of the Stiglitz setting.

After the players in the experiment have gained some experience buying and selling
insurance, the setting is changed to one where consumers can reveal information on risk types, to
the insurer, before buying insurance (Information Market, IM02 Setting). The low risk
consumers have an incentive to reveal this information, so as not to be grouped with the high risk
types. By revealing information to the insurer, the consumer faces a privacy loss, whose value is
common knowledge. High risk type consumers face a higher privacy loss due to revealing
information than low risk types. At the beginning of each period, the roll of a dice determines
the risk type of each consumer. Then consumers who want to reveal information on their risk
type to the insurer, do so. The seller then offers an insurance contract (premium and coverage)
for each consumer. The consumer chooses between the contract offered and not buying
insurance at all. At the end of the period the state is revealed and profits for all agents are
calculated. This process is repeated for all periods that make up the information market setting.

Differences in common knowledge, and possibly expectations, lead to the existence of
gains. As long as an individual has a positive utility for money, he or she would like the
redemption value to be as large as possible. This motivation systematically induces values by
virtue of derived demand theory. Running both settings – the Stiglitz setting and the Information
Market setting in the same experiment, allows the comparison of overall social welfare and
efficiency in both the settings with the same set of subjects. By modifying the rules of the
experiment slightly we can make welfare comparisons of the different policy proposals regarding
use of genetic information in health insurance markets. After gaining sufficient knowledge on
how humans behave in such markets, artificial agents would be coded to replace human players.
Each artificial agent would have the individual goal of maximizing profits. The SEAS lab at Krannert, already provides an environment for creating artificial agent with desired characteristics. Artificial agents will provide an opportunity to study larger economies which are not feasible with human players.

### Table 1 Experimental Design

<table>
<thead>
<tr>
<th>No.</th>
<th>Periods</th>
<th>No. of Buyers</th>
<th>Probability</th>
<th>Initial Wealth Buyers</th>
<th>Initial Wealth Insurer</th>
<th>Loss Value</th>
<th>Privacy Loss</th>
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<td>Risk Type</td>
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* Only for IM02 Setting

Each of the 12 experimental sessions would be run on a different day. Each Session would consist of two stages mentioned previously – the Stig77 setting and the Information Market (IM02) Setting. Varying the probability distribution of the risk types, states, and the magnitude of privacy losses due to revealing information, allows us to do welfare efficiency comparisons of the two setting under different set of parameters.

### 4 Relevance and Contribution

Personal information will soon become the currency of online commerce (Sholtz 2000). In the future, consumers will be able to share useful personal information - credit information with lenders, genetic information with insurance firms etc – for the right benefits. This will lead
to an ‘information market’, where consumers can trade in potentially useful personal information. A proper understanding of such markets, is required to evaluate new designs or policy changes prior to implementation. Since such markets don’t exist at present, or exist in a very primitive form, it is difficult to study the efficiency of such markets empirically.

An experimental market with both human and artificial agents, allows us to test different policy proposal regarding the use of personal information in a controlled setting. In this paper we study one such market for information – an insurance market with trade in information on risk type. The results are applicable to an individual insurance market as opposed to an employer sponsored insurance market. The study of such a market experimentally, is relevant not just because of the current interest in genetic testing and the debate over the use of genetic information for health insurance purposes, but also because the results from this study could also possibly be generalized to other information markets – credit markets etc. The results of this experiment would be useful to policy makers, in charge of designing these markets for information.

The designed experiment is a controlled economic environment, which allows us to set up agent incentives, and set up market institutions, in a manner that may not be possible currently in the naturally occurring world. It also provides the advantage that, the experiments are replicable, in contrast to data in the real world. It provides a comparative advantage over other approaches like simulation for example because unlike simulation, the human players are not told what to do. They are given a set of rules that govern the market institution and their incentives are aligned with their objectives.
REFERENCES


APPENDIX

Fig. 1 Seller Screen Stig. 77 Setting

Fig. 2. Buyer Screen Stig. 77 Setting
Fig. 3 Buyer Screen IM02 Setting

Fig. 4 Seller Screen IM02 Setting
Instructions for Experiment

*General:* This is an experiment in the economics of market decision-making. The instructions are simple, and if you follow them carefully and make good decisions, you might earn a considerable amount of money, which will be paid to you in cash.

In this market we are going to simulate a market in which you will either buy or sell insurance. You will be a _______ of insurance.

The type of Currency used in the market is francs. All trading and earnings will be in terms of francs. The francs that you earn will be converted to dollars based on the conversion rate of _____. At the end of the experiment you will be paid in dollars. Notice that the more francs you earn the more dollars you earn.

*Market:*

There are two types of traders in the market, buyers of insurance (consumers) and one seller of insurance (insurer). If you are a buyer of insurance, you will be given an endowment (in francs) at the beginning of each period. If you are a seller you will be given an endowment (in francs) at the beginning of period 1 only. The consumers are of two types – high risk and low risk. There are two states of the world – $X$ or $Y$. Each consumer could face a potential loss. The monetary value of the loss depends on whether you are a high-risk type or a low risk type consumer and the state of world. For e.g. the loss you face in a period if you are a high risk consumer could be 200 if state $X$ occurs or 0 if state $Y$ occurs; and the losses if you are a low risk consumers could be 0 if state $X$ occurs and 200 if state $Y$ occurs. State $X$ occurs more frequently than state $Y$. Consumers can protect themselves against losses by buying insurance from sellers.
**Market Organization:** The market for insurance is organized as follows. The market will consist of two stages of 11 periods each. There will be a 5 min break between each stage. Period 1 in each stage is a trial period. The transactions taking place in this period are not used to calculate the final wealth. Each period lasts for ____ minutes. At the beginning of each session a clue card is given to all players that specifies the loss in each state of the world for both risk types. Note that the information on the clue card is common knowledge. At the beginning of each period the roll of a dice will determine the risk type (high or low) of each consumer for that period. The insurance seller then specifies the premium and coverage for the insurance contracts he offers, on his screen. The consumers observe the contracts offered by the insurance firms and can then accept the contract they choose by clicking on the Accept Contract button on his screen. If he chooses to reject both contracts and remain uninsured, he can click on the Reject contract button on his screen. At the end of the period, the state of the world is determined by the roll of a dice. The risk type and the state together determine the loss that the consumer faces. The wealth of the buyers and sellers are adjusted.

**Stage 1**

**Instructions for potential buyers of insurance (consumers):** You are endowed with ____ francs at the beginning of each period. The money you have in each market period could change due to one of the two reasons – from buying insurance or from losses suffered in the period. Your risk type is determined at the beginning of each period by the roll of a 10 faced dice. Any number between 1 and 5 on the dice roll means that your risk type for the current period is high and any number between 6 and 10 on the dice roll means that your risk type is low. Your loss in a market period will be one of the two values X-loss or Y-loss shown on the clue card. Whether the losses you face in a period is the X-loss or the Y-loss, is determined at the
end of the period by rolling a 10 faced die. If the die is numbered 1 through 4, $X$-loss for you risk type occurs; if the die is numbered 5 through 10, $Y$-loss for your risk type occurs. The value of the loss appears on your screen. You are free to buy insurance from sellers of insurance. Your francs at the end of the period are determined by the initial amount of francs on hand, losses suffered in the period, cost of insurance (price or premium) and coverage received for loss. All francs at the end of period are added up and are yours to keep.

Steps for consumers/buyers

1. Your initial period wealth is shown on the screen

2. At the beginning of the period, a pop up window will inform you that a roll of dice will determine your risk type for the current period. A roll of dice will then be simulated on your screen. Numbers 1-5 on the roll of dice means that your risk type for the current period is high. Numbers 6-10 corresponds to low risk type. The determined risk type appears on your screen. Don’t reveal this information on risk type to anyone.

3. After the values for premiums and coverage appear in the contract box, accept either one of those contracts or reject both of them. Accepting a contract with a given premium and coverage means that you will purchase insurance at the premium stated in the contract, and will be paid the coverage mentioned in the contract, in case of a loss. Note that if you reject both contracts you will remain uninsured i.e. will receive no coverage in case of a loss.

4. After you accept a contract or reject both contracts, a popup window will now appear on the screen informing you that the state of the world will now be determined by the roll of a 10 faced dice. If the numbers on the of the dice turns out to be 1-4 then the state is $X$. 
and if it is from 5-10 then state is \( Y \). The loss shown on your clue card for your risk type and for the state of the world will be shown on your screen.

5. Your end of period wealth is determined as

\[
\text{Period End Wealth} = \text{Initial Wealth} - \text{Premium} - \text{Loss} + \text{Coverage}. 
\]

This calculation is done automatically by the software and is shown on your screen.

6. Your final wealth at the end of the 10 periods is the sum of your period end wealths multiplied by the francs to dollar conversion rate.

**Instruction for seller of insurance:** You are endowed with ____ francs at the beginning of period 1. Your profits in each market period could change due to two reasons – from selling insurance and from payments made to insured to cover their losses. All francs at the end of the experiment are yours to keep.

**Steps for seller/insurer:**

1. Your initial wealth is shown on the screen

2. At the beginning of the period enter the premium and coverage for contracts A and B on your screen. Click the set contracts button once you are done. If a buyer accepts a contract, then she will pay you the premium specified on the contract and if she faces a loss in the period you will have to pay her the coverage specified in the contract.

3. After all buyers have either accepted or rejected a contract and their losses have been determined, your end of period wealth is a calculated automatically by the software as

\[
\text{Period End Wealth} = \text{Initial Wealth} + \text{Total Premium Received} - \text{Total coverage Paid}. 
\]

4. Your period end wealth is the initial wealth for the next period.
Your final wealth at the end of the 10 periods is the period end wealth at the end of 10 periods. Your final wealth in francs is converted into dollars at the specified conversion rate.

Stage 2

In this stage consumers have the option of revealing their information about risk type to the seller of insurance. Note that if a consumer decides to reveal information then she faces the privacy loss specified on the clue card. A high risk consumer faces a higher privacy loss by revealing information to the insurer. The rest of the steps remain the same.

Steps for consumers/buyers

1. Your initial period wealth is shown on the screen

2. At the beginning of the period a pop up window will inform you that a roll of dice will determine your risk type for the current period. A roll of dice will then be simulated on your screen. Numbers 1-5 on the roll of dice means that your risk type for the current period is high. Numbers 6-10 corresponds to low risk type. The determined risk type appears on your screen.

3. Now you have the option to reveal information about your risk type to the insurer. If you want to reveal information then check the ‘Yes’ radio button and click ‘Confirm’- information on your risk type will automatically be conveyed to the insurer. If not then check the ‘No’ radio button, click ‘Confirm’ and your information on risk type won’t be conveyed to the insurer.

4. After the values for premiums and coverage appear in the contract box, either accept it or reject it. Accepting the contract with a given premium and coverage means that you will
purchase insurance at the premium stated in the contract, and will be paid the coverage mentioned in the contract, in case of a loss. Note that if you reject the contract you will remain uninsured i.e. will receive no coverage in case of a loss.

7. After you accept or reject the contract, a popup window will now appear on the screen informing you that the state of the world will now be determined by the roll of a 10 faced dice. If the numbers on the dice turns out to be 1-4 then the state is $X$ and if it is from 5-10 then state is $Y$. The loss shown on your clue card for your risk type, and for the state of the world will be shown on your screen.

8. Your end of period wealth is determined as

   $\text{Period End Wealth} = \text{Initial Wealth} – \text{Premium} – \text{Loss} – \text{Privacy Loss} + \text{Coverage}$. This calculation is done automatically by the software and is shown on your screen. Note that if you do not reveal information to the insurer, then your privacy loss is zero.

9. Your final wealth at the end of the 10 periods is the sum of your period end wealth multiplied by the francs to dollar conversion rate.

*Steps for seller/insurer:*

1. Your initial wealth is shown on the screen

2. At the beginning of the period wait till all buyers make the decision whether to reveal information on risk type or not. When the buyer makes a decision to reveal information the risk type (high or low) will appear on your screen for the corresponding buyer id. If the buyer decides not to reveal information then N/A (Not Available) appears in the risk type field for that particular buyer id. Enter the premium and coverage for each buyer on your screen. Click the set contracts button once you are done. If a buyer accepts a
contract, then she will pay you the premium, specified on the contract and if she faces a loss in the period you will have to pay her the coverage specified in the contract.

3. After all buyers have either accepted or rejected a contract and their losses have been determined, your end of period wealth is a calculated automatically by the software as

\[
\text{Period End Wealth} = \text{Initial Wealth} + \text{Total Premium Received} - \text{Total coverage Paid}.
\]

4. Your period end wealth is the initial wealth for the next period.

Your final wealth at the end of the 10 periods is the period end wealth at the end of 10 periods. Your final wealth in francs is converted into dollars at the specified conversion rate.