1 Akerlof (1970) Lemon Model

1.1 Basic Intuition

- Suppose that the demand of used cars depend on price $p$ and average quality of cars traded $\mu$, thus the demand curve is
  \[ Q^d(p, \mu). \]
  Suppose that for each $\mu$, $Q^d$ is decreasing in $p$. (Also suppose that $Q^d$ increases in $\mu$).

- Let the supply of used cars be
  \[ S(p). \]
• If there is no asymmetric information between the buyers and sellers, there will be a market for each quality index \( \mu \), and the equilibrium market price for quality \( \mu \) cars are simply determined by

\[
Q^d (p^*, \mu) = S (p^*).
\]

The equilibrium price \( p^* \) should be increasing in \( \mu \).

• However, if the quality of the used car is observed only by sellers, but not by buyers, then buyers will have to make an inference of the quality of the car they are getting based on the price, thus they form an expectation of \( \mu \) as a function \( \mu (p) \), which is likely to be increasing in \( p \).

• The market equilibrium will be a price \( p^{**} \) at which

\[
Q^d (p^{**}, \mu (p^{**})) = S (p^{**}).
\]
Because $Q^d(p, \mu(p))$ may not be declining in $p$, the above market may not have an equilibrium and the market for used cars will collapse.

1.2 A Formal Example

- Suppose that there are two groups of traders, group 1 and 2;

- Group 1 has a utility function

$$U_1 = M + \sum_{i=1}^{n} x_i$$

where $M$ is the numeraire consumption goods other than automobiles, $x_i$ is the quality of the $i$th automobile, and $n$ is the number of automobiles.
• The total income of all group 1 traders is $Y_1$ and they have $N$ cars with quality $x$ uniformly distributed in the interval $[0, 2]$;

• Similarly, group 2 has utility function

$$U_2 = M + \sum_{i=1}^{n} \frac{3}{2} x_i$$

and group 2 individuals have total income $Y_2$ and they have no cars.

• Suppose that the price of the numeraire good $M$ is 1.

• Now we can figure out the demand for the cars by each group. The demand
for cars by type 1 traders is:

\[ D_1 = \frac{Y_1}{p} \text{ if } \mu/p > 1 \]
\[ D_1 = 0 \text{ if } \mu/p < 1. \]

and the supply of cars offered by type one trader is

\[ S_1 = \frac{pN}{2} \]

because for any price \( p \), only those whose car quality is less than \( p \) will put it up for sale. Thus at any price \( p \), the average quality

\[ \mu = \frac{p}{2}. \]
• The demand of type two traders is

\[ D_2 = \begin{cases} \frac{Y_2}{p} & \text{if } \frac{3\mu}{2} > p \\ 0 & \text{if } \frac{3\mu}{2} < p \end{cases} \]

and the supply is

\[ S_2 = 0. \]

• Thus the total demand \( D(p, \mu) \) is

\[ D(p, \mu) = \begin{cases} \frac{Y_2 + Y_1}{p} & \text{if } p < \mu \\ \frac{Y_2}{p} & \text{if } \mu < p < \frac{3\mu}{2} \\ 0 & \text{if } p > \frac{3\mu}{2} \end{cases} \]
• Because \( \mu(p) = p/2 \), the demand for the automobiles at any price is 0, thus the only equilibrium is an equilibrium of \( p = 0 \), and no trade.

• This is an extreme form of inefficiency because at any given price between 0 and 3, there are traders of type one who are willing to sell their automobiles at a price which traders of type two are willing to buy.
2 Rothschild and Stiglitz (1976)

2.1 The Basic Model

- Consider an individual with income $W$ if he does not encounter accident; in the event of an accident, his income will only be $W - d$.

- The probability of the accident is $p$, which may vary across individuals in the population.

- Moreover, it is assumed that the accident probability $p$ is known to the individual, but not to the insurance company;
The individual can purchase insurance of the following form: pay a premium \( \alpha_1 \) in return for which he will be paid \( \hat{\alpha}_2 \) if a loss occurs.

Without insurance, his wealth in the two states, “accident” and “no accident” was \((W, W - d)\);

With insurance it is now \((W - \alpha_1, W - d + \alpha_2)\) where \(\alpha_2 = \hat{\alpha}_2 - \alpha_1\).

The vector \(\alpha = (\alpha_1, \alpha_2)\) fully describes the insurance contract.
2.2 Demand for Insurance Contracts

- Define

\[ \hat{V}(p, W_1, W_2) = (1 - p)U(W_1) + pU(W_2) \]

where \( U \) represents the utility of money income and \( p \) is the probability of an accident.

- An insurance contract \( \alpha \) brings the individual with accident probability \( p \) the following level of utility

\[ V(p, \alpha) = \hat{V}(p, W - \alpha_1, W - d + \alpha_2) \]

- From all the contracts an individual is offered, he will choose the one that maximizes \( V(p, \alpha) \).
2.3 Supply of Insurance Contracts

- Suppose that insurance companies are risk neutral and they are concerned only with expected profits.

- The expected profit of selling a contract $\alpha$ to an individual with accident probability $p$ is

$$\pi(p, \alpha) = (1 - p) \alpha_1 - p \alpha_2 = \alpha_1 - p (\alpha_1 + \alpha_2).$$

- Suppose that the insurance market is competitive in that there is free entry. Thus any contract that is demanded and that is expected to be profitable will be supplied.
2.4 Definition of Equilibrium

- Equilibrium in a competitive insurance market is a set of contracts such that, when customers choose contracts to maximize expected utility,
  - no contracts in the equilibrium set makes negative expected profits;
  - there is no contract outside the equilibrium set that, if offered, will make a nonnegative profits.

2.5 Equilibrium with Identical Customers

- If consumers’ accident probability is the same for everyone, then there is no imperfect information.
• The unique equilibrium will be a full insurance outcome. Specifically, the insurance contract \((\alpha_1, \alpha_2)\) are determined as follows:

1. Zero profit condition

\[
\alpha_1 (1 - p) - \alpha_2 p = 0
\]

2. Equal wealth in accident and no accident states:

\[
W - \alpha_1 = W - d + \alpha_2.
\]
2.6 Imperfect Information: Equilibrium with Two Classes of Customers

- Suppose that the market consists of two types of customers: low risk individuals with accident probability $p^L$ and high risk individuals with accident probability $p^H$ with $p^H > p^L$.

- The fraction of high-risk customers is $\lambda$, so the average accident probability is $\bar{p} = \lambda p^H + (1 - \lambda) p^L$.

- Results of Imperfect Information Equilibrium:

  - There can not be pooling equilibrium.
If there exists separating equilibrium, it must be the case that the high risk is offered full insurance, while the insurance for the low risk must be sufficiently bad to make the high risk unwilling to mask as the low risk type;

When the fraction of high risk types is small, the competitive market may not have equilibrium.

Welfare Economics of Equilibrium

One of the interesting properties of the equilibrium is that the presence of the high-risk individuals exerts a negative externality on the low-risk individuals.
• The externality is completely dissipative; there are losses to the low-risk individuals, but the high-risk individuals are no better-off than they would be in isolation.

• If only the high-risk individuals would admit to their having high accident probabilities, all individuals would be made better off without anyone being worse off.

2.7 Summar from the model

• Competition on markets with imperfect information is more complex than in standard models.
Competitive market with imperfect information may not have equilibrium.

“Do these theoretical speculations tell us anything about the real world? In the absence of empirical work it is hard to say. The market on which we focused most of our analysis, that for insurance, is probably not competitive; whether our model may partially explain this fact is almost impossible to say. But there are other markets, particularly financial and labor markets, which appear to be competitive and in which imperfect and asymmetric information play an important role. We suspect that many of the peculiar institutions of these labor markets arise as responses to the difficulties that they, or any competitive market, have in handling problems of information. Establishing (or refuting) this conjecture seems to provide a rich agenda for future research.”
3 Asymmetric Information in Insurance: Some Testable Implications

3.1 A General Framework

- **Data:** Suppose that we observe a population of insurance policy holders, their insurance policies and their insurance claims. What can we learn about the nature of the asymmetric information from such data?

- Suppose that an insurance contract $C_i$ specifies an indemnity $R_i(L) \geq 0$ for every possible claim level $L > 0$, and a premium $P_i$ to be paid up front.
• **Assumption on Contracts**: For all contracts, the net loss $L - R_i(L)$ is non-decreasing in $L$.

• Of course, insurance premium may vary with *observable* individuals characteristics $X$.

Let $P_i(X)$ be the premium for contract $C_i$ as a function of observable individual characteristics estimated from the insurer’s data file; and let $F_i(L|X)$ be the distribution of claims conditional on $X$ for contract $C_i$.

• What can we learn from the data as represented by:

$$\{(P_i(X), F_i(L|X), R_i(L)) : \text{for each } C_i\}.$$
- **Unobserved Heterogeneity and Private Information.** Each potential insured is characterized by a (possibly multidimensional) parameter $\theta \in \Theta$, which is his private information and may affect his preference and/or his risk.

**Interpretation of $\theta$:**

1. The parameter $\theta$ may affect the agent’s preferences; for example, it could represent agents’ degree of risk aversion.

2. It can also represent the risk type both in the form of adverse selection and moral hazard. An agent of type $\theta$ may secretly choose the distribution of losses $G$ from some set $G^\theta$, which will be a singleton in the pure adverse selection models, or will include more than one element as in moral hazard models.
- The agents’ preference is over final wealth, which in the event that a loss $L$ occurs, is given by
  \[ W(L) = W_0 + R(L) - L - P. \]

- Behavioral Assumptions:
  1. Each agent’s preferences can be represented by a state-independent preference ordering over the final distribution of wealth, monotonic with respect to first order stochastic dominance;
  2. Agents are risk averse in the sense that they are averse to mean-preserving spreads on wealth;
  3. “Realistic Expectations.” When agents choose a contract, they correctly assess their accident probability and loss distribution; i.e., if the true loss distribution is $G$, then they use $G$ is contract choice.
3.2 A lemma testing realistic expectations assumption

- Consider different contracts $C_1$ and $C_2$ proposed on the market and bought by some agents for any given observable individual characteristics $X$.

- Def: Contract $C_2$ covers more than contract $C_1$ if $R_2(L) - R_1(L)$ is non-decreasing.

  - Example 1: (Straight deductible contracts): $R_i(L) = \max \{L - d_i, 0\}$. The above condition implies $d_2 \leq d_1$.

  - Example 2: When $L \in \{0, \bar{L}\}$, the above condition amounts to $R_2(\bar{L}) \geq R_1(\bar{L})$. 

Lemma 1: Assume that agent of type $\theta$ prefers contract $C_1$ to $C_2$, and $C_2$ covers more than $C_1$. Let $G$ be the distribution of claims anticipated (or perceived) by the agent under $C_1$. Then

$$P_2 - P_1 \geq \int_0^\infty [R_2(L) - R_1(L)] \, dG(L)$$

Proof: Let $W_i(L) = R_i(L) - L - P_i$ be the resulting wealth under contract $C_i$. Let

$$X_i(L) = W_i(L) - EW_i(L).$$

Both $X_1(L)$ and $X_2(L)$, as random variables, have mean zero; and it can be shown that, if $C_2$ covers more than $C_1$, $X_1(L)$ is a mean-reserving spread of $X_2(L)$.

Now here is the argument. If to the contrary, $EW_1(L) \leq EW_2(L)$,
then let $\Delta = EW_2(L) - EW_1(L) \geq 0$. We have that

$$W_1(L) = X_1(L) + EW_1(L)$$
$$W_2(L) = X_2(L) + EW_2(L)$$

Thus $W_1(L)$ is actually a mean-decreasing spread of $W_2(L)$. Thus according to Assumption 2, the agent would have preferred contract $C_2$ under $G$ over $C_1$ under $G$. A contradiction to the hypothesis of the Lemma. Thus it must be the case that $EW_1(L) > EW_2(L)$. Since

$$EW_i(L) = \int_0^\infty [R_i(L) - L] dG(L) - P_i,$$

we obtain, after canceling the term $\int_0^\infty LdG(L)$ on both sides,

$$P_2 - P_1 \geq \int_0^\infty [R_2(L) - R_1(L)] dG(L).$$
• Note that the above lemma is an implication of rational choice (in the form of revealed preferences) under the agents’ perceived risks. If risk perception $G$ coincides with the actual risk distributions under contract $C_1$, denoted by $F_1$, then we have

• **Proposition 1**: Suppose that contract $C_2$ covers more than contract $C_1$ and that both contracts are sold to indistinguishable individuals with realistic expectations, then

$$P_2 - P_1 \geq \int_0^\infty [R_2(L) - R_1(L)] dF_1(L).$$

• Note that the above proposition does not condition on observable characteristics $X$. It must be the case that for all $X$,

$$P_2(X) - P_1(X) \geq \int_0^\infty [R_2(L) - R_1(L)] dF_1(L|X).$$
Discussion:

- The power of the above test for realistic expectations. Suppose that the agent is pessimistic in their risk perception in the sense that \( G \leq F_1 \) (i.e., the agent puts a higher probability of high losses than the objective loss distribution \( F' \)), then since

\[
\int [R_2(L) - R_1(L)] [dG(L) - dF_1(L)]
= \left[ R_2(L) - R_1(L) \right] \left[ G(L) - F_1(L) \right]_0^\infty
- \int \frac{d}{dL} [R_2(L) - R_1(L)] [G(L) - F_1(L)] dL
\geq 0,
\]

we will also have

\[
P_2 - P_1 \geq \int_0^\infty [R_2(L) - R_1(L)] dF_1(L)
\]
even though the agent has biased (overly pessimistic) risk perceptions.
∗ The test is valid if the null of realistic expectations is tested against the alternative that agents are optimistic in the sense that they systematically underestimate their risk.

– The above test only relies on assumptions about consumer rationality. It does not rely on assumptions on market structure.

– When \( L \in \{0, L\} \), the above test is simply

\[
P_2 - P_1 \geq q_1 \left[ R_2 (L) - R_1 (L) \right]
\]

where \( q_1 \) is the empirical probability of a claim under contract \( C_1 \).

– When \( R_i (L) = \max \{L - d_i, 0\} \) where \( d_i \) is the deductible under contract \( i \), with \( d_1 \geq d_2 \), the above test becomes

\[
P_2 - P_1 \geq q_1 (d_1 - d_2)
\]
where $q_1$ is the empirical probability that $L$ is above $d_1$ under contract $C_1$.

3.3 Positive Correlation Property

- Non-increasing profit assumption (NIP): If $C_2$ covers more than $C_1$, then

\[ \pi (C_2) \leq \pi (C_1) \]

where

\[ \pi (C_i) = P_i - \int R_i (L) dF_i (L) - \Gamma \]

(where $\Gamma$ denotes the fixed costs associated with offering contract $C_i$, independent of $i$).
• Discussion of NIP.

  – NIP clearly holds if competition drives profits to zero on every contract.

  – NIP may hold if situations where cross subsidization from low coverage contracts (attracting low risk customers) to high coverage contracts (attracting high risk customers).

  – NIP may be violated if the market is non-competitive.

  – NIP may be violated in situations where risk preference and risk are correlated.

• Proposition 2. (Positive Correlation Property) Under the three behavioral assumptions and NIP. If two contracts $C_1$ and $C_2$ are bought in
equilibrium, and $C_2$ covers more than $C_1$, then
\[ \int R_2 (L) \, dF_2 (L) \geq \int R_2 (L) \, dF_1 (L). \]

**Proof.** NIP implies that
\[ P_2 - P_1 \leq \int R_2 (L) \, dF_2 (L) - \int R_1 (L) \, dF_1 (L) \]
From Proposition 1, we have
\[ P_2 - P_1 \geq \int_0^\infty [R_2 (L) - R_1 (L)] \, dF_1 (L). \]
Together, we have
\[ \int R_2 (L) \, dF_2 (L) \geq \int \frac{R_2 (L)}{dF_1 (L)} \, dF_1 (L). \]

- **Discussions:**
– This above statement of positive correlation property differs from the standard statement “The ex post risk occurrence from better insurance is higher than the ex post risk occurrence from worse insurance,” which would have translated to

\[ \int R_2(L) \, dF_2(L) \geq \int \frac{R_1(L)}{dF_1(L)}. \]

– Recall that our definition of “\(C_2\) covers more than \(C_1\)” is that “\(R_2(L) - R_1(L)\) is non-decreasing in \(L\).” If moreover we have that \(R_2(L) \geq R_1(L)\) for all \(L\), then we can get a more intuitive version of the positive correlation property

\[
\int R_2(L) \, dF_2(L) \geq \int R_2(L) \, dF_1(L) \\
= \int \{R_1(L) + [R_2(L) - R_1(L)]\} \, dF_1(L) \\
\geq \int R_1(L) \, dF_1(L).
\]
Suppose that $L \in \left\{0, L\right\}$. If $q_i$ is the probability of a claim under contract $C_i$. If $C_1$ and $C_2$ are both purchased in equilibrium and $C_2$ covers more than $C_1$, then $q_1 \leq q_2$. [That is, the ex post riskiness must be positively correlated with coverage.]

If $C_1$ and $C_2$ are both straight deductible contracts with $R_i (L) = \max \{L - d_i, 0\}$, and assume that losses smaller that the value of the deductibles are not claimed, and define the expected claims under contract $C_i$ as $E_i (L) = \int_{d_i}^{\infty} L dF_i (L)$. Then,

$$
\int R_2 (L) dF_2 (L) = \int_{d_2}^{\infty} (L - d_2) dF_2 (L) = E_2 [L] - d_2 q_2
$$

$$
\int R_2 (L) dF_1 (L) = \int_{d_2}^{\infty} (L - d_2) dF_1 (L) = E_1 [L] - d_2 q_1
$$

we have

$$
E_2 [L] - E_1 [L] \geq d_2 (q_2 - q_1).
$$
• Implications:

• If one finds that the positive correlation property does not hold in the sense that \( \int R_2(L) \, dF_2(L) \) is not statistically different from \( \int R_2(L) \, dF_1(L) \), it could be consistent with two possibilities:

  – 1. There is no asymmetric information;

  2. There is asymmetric information, but for whatever reason the Non-increasing profit property is violated.

  – The reasons for the violation of the NIP property could be, as we mentioned, that the market is not competitive, or if there are multi-dimensional private information where th
• However, if one finds evidence that the positive correlation property is rejected in the sense that
\[ \int R_2(L) \, dF_2(L) < \int R_2(L) \, dF_1(L), \]
then it is only consistent with the presence of private information and the violation of NIP. This is the strategy we use in Fang, Keane and Silverman (2007)'s study of advantageous selection in the Medigap insurance market.

3.4 Advantageous Selection Due to Risk Aversion

• Basic idea appeared in Hemenway (1990) which he called “propitious selection.”
• Consider an individual over age 65 (so she has basic Medicare as a baseline level of coverage).

• She has a constant relative risk aversion utility function

\[ u(y) = \frac{y^{1-\gamma}}{1-\gamma}, \]

where \( \gamma \) is the relative risk aversion parameter.

• She has wealth \( Y > 0 \), and faces a risk of incurring a health expenditure shock (over and above what is covered by basic Medicare) of \( L > 0 \) with probability \( p \in [0, 1] \).

• For simplicity, assume that the individual can choose to purchase Medigap insurance at a premium \( m \) that will reduce the out-of-pocket expenditure to 0.
• Her expected utilities from buying and not buying Medigap are respectively given by

\[
V_B (p, \gamma) = u (Y - m) + e
\]

\[
V_N (p, \gamma) = pu (Y - L) + (1 - p) u (Y).
\]

where \( e \) is a fixed cost of buying Medigap (i.e., the time and psychic costs of applying), that has a logistic distribution in the population, independent of \( p \) and \( \gamma \).

• The probability the individual purchases Medigap is then given by the logit expression:

\[
Q (p, \gamma) = \frac{\exp [u (Y - m)]}{\exp [u (Y - m)] + \exp [pu (Y - L) + (1 - p) u (Y)]}
\] (1)
• Simple algebra shows that \( Q(p, \gamma) \) is increasing in \( p \) and \( \gamma \).

  – That is, more risky and more risk averse individuals are more likely to purchase Medigap.

• Now suppose that in the population there is a joint distribution over individuals’ private types \((p, \gamma)\) given by \( F \), and let the CDF of risk aversion conditional on risk type \( p \) be \( F_{\gamma|p}(\cdot|\cdot) \).

• If we do not control for risk aversion \( \gamma \) and look only at the relationship between risk-type \( p \) and the probability of purchasing Medigap, we obtain the marginal probability expression:

\[
\tilde{Q}(p) = \int Q(p, \gamma) dF_{\gamma|p}(\gamma|p).
\]  

(2)
• If $p$ and $\gamma$ are negatively correlated, then $\tilde{Q}(p)$ may or may not increase in $p$.

• We can also compare the average health shock risk $p$ for those with and without Medigap insurance.

• The average risk among those with Medigap insurance is given by

$$A_B = \frac{\int Q(p, \gamma) pdF(p, \gamma)}{\int Q(p, \gamma) dF(p, \gamma)},$$

where the denominator is the measure of individuals who purchase Medigap, and the numerator is the expected number of health shocks that occur to those who purchase Medigap.
• Similarly, the average risk among those without Medigap is

\[ A_N = \frac{\int [1 - Q(p, \gamma)] p\, dF(p, \gamma)}{\int [1 - Q(p, \gamma)] \, dF(p, \gamma)}. \]  

(4)

• Chiappori and Salanié’s (2000) test for asymmetric information is a test of whether \( A_B > A_N \).

• However, if \( p \) and \( \gamma \) are negatively correlated, it is possible that \( A_B \leq A_N \) despite the presence of asymmetric information.
4 Empirical Studies

4.1 Chiaporri and Salanie (2000, JPE)

- In an auto insurance market, Chiappori and Salanié (2000) found that accident rates for young French drivers who choose comprehensive automobile insurance is not statistically different from those opting for the legal minimum coverage, after controlling for observable characteristics known to automobile insurers.

- In contrast, Cohen (2005), using data from Israel, finds that new auto insurance customers choosing a low deductible tend to have more accidents, leading to higher total losses for the insurer.
• Others have examined the evidence of asymmetric information in the choice of insurance contracts such as deductibles and co-payments etc.

• For example, Puelz and Snow (1994) studied automobile collision insurance and argued that, in an adverse selection equilibrium, individuals with lower risk will choose a contract with a higher deductible, and contracts with higher deductibles should be associated with lower average prices for coverage.

4.2 Cawley and Philipson (1999, AER)

• Cawley and Philipson (1999) found that the mortality rate of U.S. males who purchase life insurance is below that of the uninsured, even when
controlling for many factors such as income that may be correlated with life expectancy.

4.3 Finkelstein and McGarry (2006, AER)

- Finkelstein and McGarry’s (2006) study of the long-term care (LTC) insurance market used panel data from a sample of Americans born before 1923 (the AHEAD study).

- They find no statistically significant correlation between LTC coverage in 1995 and use of nursing home care in the period between 1995-2000, even after controlling for insurers’ assessment of a person’s risk type.
• This evidence, alone, is consistent both with “no asymmetric information” and with “multi-dimensional private information.”

• To distinguish between these stories, they first eliminated the “no asymmetric information” interpretation.

  – Specifically, they found that a subjective probability assessment contained in the 1995 AHEAD questionnaire, “What do you think are the chances that you will move to a nursing home in the next five years?”, is positively correlated with both LTC coverage and nursing home use in 1995-2000, even after controlling for insurers’ risk assessment.

  – Since this variable is presumably unobserved by the insurer, these positive correlations suggest private information, and adverse selection by the insured.
Second, they developed a proxy for risk aversion, using information on whether respondents undertake various types of preventive health care.

They found that people who are more risk averse by this measure are both more likely to own LTC insurance and less likely to enter a nursing home – consistent with multi-dimensional private information and advantageous selection based on risk aversion.

In fact, their findings suggest that, on net, adverse selection based on risk and advantageous selection based on risk aversion roughly cancel out in the LTC insurance market.
4.4 Fang, Keane and Silverman (2007)

- Our paper examines the Medigap market which, as we argued above, is especially well-suited for a study of advantageous selection.

- We make three new contributions to the literature:

- First, our method of inference for the presence of multidimensional private information differs from Finkelstein and McGarry’s.
  
  - We find a statistically significant and quantitatively large negative correlation between \textit{ex post} medical expenditure and Medigap coverage, controlling for individual characteristics that are used in pricing.
– The large negative correlation between Medigap coverage and *ex post* medical expenditure is directly inconsistent with either “no asymmetric information” or “single dimensional private information,” thus leading us directly to an interpretation of the results as evidence of “multi-dimensional private information” and at the same time as evidence of advantageous selection.

• Second, our paper is, to our knowledge, the first to examine directly multiple potential sources of advantageous selection.

– Specifically, instead of using behavioral proxies for risk aversion as Finkelstein and McGarry did, we exploit the direct measures of risk aversion elicited from the respondents in the HRS data.

– More important, we examine not just risk preferences as the source of advantageous selection, but also several other potential sources.
• Third, the empirical evidence in our paper suggests that for the Medigap insurance market, risk preferences, which were much discussed in the previous literature, do not appear to be a main source of advantageous selection;

  – instead, our results suggest that cognitive ability plays a prominent role. We also explore various channels through which cognitive ability may lead to advantageous selection.

• The Medicare program provides limited health insurance for U.S. senior citizens. A Medigap policy is health insurance sold by a private insurer to fill “gaps” in coverage of the basic Medicare plan (e.g. co-pays, prescription drugs).

• The Medigap market is ideal for studying multi-dimensional private information and advantageous selection because of two key features:
- First, since 1992, the coverage and pricing of Medigap policies have been highly regulated by the U.S. government.

  - Specifically, in all but three States, insurance companies can only sell ten standardized Medigap policies; moreover, within the six month Medigap open enrollment period – which starts when an individual is both older than 65 and enrolled in Medicare Part B – an insurer cannot deny Medigap coverage, or place conditions on a policy, or charge more for pre-existing health conditions.

  - As shown in the theoretical analysis of Chiappori et al. (2006), in order for multi-dimensional private information to manifest itself in the form of a violation of the positive correlation property, the supply side of the insurance market has to be non-competitive in the sense that the insurance companies are not free to offer any insurance contract they choose.
– Thus, the standardization of Medigap policies and the restrictions on medical underwriting make this market especially well-suited to study the evidence for multi-dimensional private information.

– Second, the Medigap market is closely linked to the Medicare program.

– As a result, one can obtain detailed administrative data on diagnoses, treatments and expenditures of consumers in the Medigap market.

– Specifically, our analysis relies in part on the Medicare Current Beneficiary Survey (MCBS), which combines survey data and Medicare administrative records. The Medicare administrative data on medical expenditure provide perhaps the most accurate measure of health expenditure risk for a large sample of the entire Medicare population. It also contains extensive health measures, that allow us to obtain accurate measures of ex post expenditure conditional on age and health.
Though the MCBS itself does not contain detailed information about risk aversion and other potential sources of advantageous selection, the Health and Retirement Study (HRS), a longitudinal data set covering a large sample of the Medicare eligible population, has information about such variables.

Our empirical strategy uses the MCBS and HRS jointly to examine the sources of advantageous selection.

- We find strong evidence of multi-dimensional private information and advantageous selection in the Medigap market.

- Conditional on controls for the price of Medigap, we find that medical expenditures for senior citizens with Medigap coverage are, on average, about $4,000 less than for those without.
This strong negative correlation between *ex post* risk and coverage cannot be consistent with “no private information” or “one-dimensional private information” models of insurance market; thus it directly indicates the presence of multi-dimensional private information, as well as advantageous selection.

Indeed, we find that, once conditioning on health (which can not, by law, be used in Medigap pricing) expenditures for seniors with Medigap are about $2,000 more than for those without.

These findings indicate that those who purchase Medigap tend to be healthier; i.e., there is advantageous selection.

As important, we investigate several potential sources of this advantageous selection. This analysis points to variation in cognitive ability as a prominent source of advantageous selection.
Panel A: Without Health Controls

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<td>394.5***</td>
<td>355.4*</td>
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<tr>
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<td>(228.5)</td>
<td>(117.2)</td>
<td>(196.8)</td>
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<tr>
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<tr>
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<td>(10.6)</td>
<td>(18.8)</td>
<td>(9.2)</td>
<td>(16.2)</td>
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<td>.07</td>
<td>.47**</td>
<td>.47</td>
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<td>(.21)</td>
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<td>Yes</td>
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Panel B: With Direct Health Controls

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<td></td>
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</tr>
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<td></td>
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</tr>
<tr>
<td>(Age-65)^2</td>
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<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>(Age-65)^3</td>
<td></td>
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</tr>
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<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Year Dummy</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>No. of Obs.</td>
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<td></td>
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<tr>
<td>Adjusted $R^2$</td>
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<td></td>
<td>.211</td>
<td>.252</td>
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</table>

Table 1: OLS Regression Results of Total Medical Expenditure on “Medigap” Coverage in the MCBS. Panel A: Without Health Controls; and Panel B: With Direct Health Controls.

Note: The dependent variable is “Total Medical Expenditure.” All regressions are weighted by the cross section sample weights. Health controls included in Panel B are described in detail in the Data Appendix under the category “Health.” A total of 71 health indicators are included. Robust standard errors clustered at the individual level are in parenthesis. *, **, *** denote significance at 10%, 5%, and 1% respectively.
Table 2: OLS Regression Results of Total Medical Expenditure on “Medigap” Coverage in the MCBS with Controls for Health Factors.

Note: The standard deviations of the factors are in square brackets in the variables column. Factor 2 is the major unhealthy factor; Factor 3 and 4 are the healthy factors; Factor 1 captures non-response; and Factor 5 does not have a clear interpretation.
<table>
<thead>
<tr>
<th>Factors</th>
<th>EXP</th>
<th>PCORR (p-value)</th>
<th>EXP</th>
<th>PCORR (p-value)</th>
<th>EXP</th>
<th>PCORR (p-value)</th>
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<tr>
<td>Factor 1</td>
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<td>-410.7***</td>
<td>.03 (.01)</td>
<td>1097.1*</td>
<td>.03 (.01)</td>
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<td>-.02 (.12)</td>
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<td>.02 (.08)</td>
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<tr>
<td>Factor 5</td>
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<td>436.4*</td>
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<td></td>
<td>8,371</td>
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<td>5,758</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Partial Correlation Between “Medigap” Coverage and Health Factors in the MCBS, Conditional on Gender and Age.

Note: The columns labelled with “EXP” are the regression coefficients from Table 2. They are included in this table for the interpretation of the factors. The columns labelled with “PCORR” lists the partial correlations of “Medigap” with the corresponding factors. The numbers in parenthesis are the significance level of the partial correlations.
– We find that elderly citizens with higher cognitive ability are both more likely to purchase Medigap and are healthier. We also investigate the potential pathways through which cognitive ability may act as a source of advantageous selection.

• Interestingly, we find that variation in risk preferences, which was much discussed in the previous literature, does not appear to be a primary source of advantageous selection the Medigap insurance market.

– Specifically, we find that even though direct measures of risk tolerance are significant predictors of Medigap insurance purchase, those who are more risk averse are not particularly healthy; as a result, risk preferences do not much contribute to advantageous selection.

• Empirical Strategy
• The data in MCBS can be written as

\[ \{E_i, M_i, H_i, D_i\}_{i \in \mathcal{I}_{MCBS}}, \]  

(5)

and the data in HRS as

\[ \{M_j, H_j, D_j, X_j\}_{j \in \mathcal{I}_{HRS}} \]  

(6)

where \( \mathcal{I}_{MCBS} \) and \( \mathcal{I}_{HRS} \) denote the MCBS and HRS sample respectively.

• Note that the variables \( \{M, H, D\} \), which denote Medigap coverage, health measures and demographics, are common to both data sets. But \( E \), total medical expenditure, appears only in the MCBS, while \( X \), the list of variables that we think are potential sources of advantageous selection, appears only in the HRS.

• Our strategy is simple and consists of two steps:
In the first step, we use the MCBS data to estimate prediction equations for total medical expenditure risk, as well as its variance. With the imputed $\hat{E}_j$ and $\widehat{VAR}_j$, our augmented HRS data can now be represented as:

$$\{M_j, H_j, D_j, X_j, \hat{E}_j, \widehat{VAR}_j\}_{j \in \mathcal{I}_{HRS}}.$$  \hspace{1cm} (7)

In the second step, we first regress Medigap coverage on expected expenditure and pricing variables:

$$M_j = \delta_0 + \delta_1 \hat{E}_j + \delta_2 D_j + \varepsilon_j,$$  \hspace{1cm} (8)

where, as before, the variables in $D_j$ include a third order polynomial in age, gender and state of residence, to capture the pricing of Medigap insurance.

We obtain a negative and significant estimate for $\delta_1$, the coefficient on
expected expenditure, implying advantageous selection in the purchase of Medigap in the HRS.

- We then gradually add potential sources of advantageous selection from the list of variables contained in \( \{X_j, VAR_j\} \).

- We will show below that when we estimate the partial correlation between Medigap coverage and health expenditure risk, controlling not only for the determinants of price, \( D_j \), but also for \( \{X_j, VAR_j\} \), the partial correlation will turn positive.

- More precisely, when we estimate

\[
M_j = \theta_0 + \theta_1 \hat{E}_j + \theta_2 \text{risktol}_j + \theta_3 \widetilde{VAR}_j \times \text{risktol}_j + \theta_4 \widetilde{A}(9) + \theta_5 X_j + \theta_6 D_j + \varepsilon_j,
\]
we find that $\hat{\theta}_1$ is positive and significant - consistent with the “positive correlation property” predicted by standard insurance models with uni-dimensional private information.

– This is the sense in which we say we have successfully identified several key sources of advantageous selection.

• Imputation Strategies

• Imputation Using MCBS Subsample with No Medigap Coverage.

  – With the first method, we only use the subsample in MCBS with no Medigap coverage to estimate the mean and variance of medical expenditures.
Suppose the mean and variance prediction equations obtained from the MCBS are:

\[ \hat{E}_{i1} = \hat{\alpha}_0 + \hat{\alpha}_1 H_i + \hat{\alpha}_2 D_i, \]  
\[ \text{VAR}_{i1} = (E_i - \hat{E}_{i1})^2 = \hat{\beta}_0 + \hat{\beta}_1 H_i + \hat{\beta}_2 D_i. \]  

We can then impute the mean and variance of medical expenditures for the HRS sample as follows: for each \( j \in I_{HRS} \), the imputed mean medical expenditure is

\[ \hat{E}_{j1} = \hat{\alpha}_0 + \hat{\alpha}_1 H_j + \hat{\alpha}_2 D_j, \]

and the imputed variance of medical expenditure is

\[ \text{VAR}_{j1} = \hat{\beta}_0 + \hat{\beta}_1 H_j + \hat{\beta}_2 D_j. \] 

• Imputation Using the Whole MCBS.
– With the second method, we use the whole MCBS sample. In this case, we include in the regressions a Medigap status indicator $M_i$. That is,

$$\hat{E}_{i2} = \hat{\gamma}_0 + \hat{\gamma}_1 M_i + \hat{\gamma}_2 H_i + \hat{\gamma}_3 D_i,$$

$$V\hat{AR}_{i2} = (E_i - \hat{E}_{i2})^2 = \hat{\xi}_0 + \hat{\xi}_1 M_i + \hat{\xi}_2 H_i + \hat{\xi}_3 D_i.$$ (14) (15)

– We then impute the mean and variance for each member $j \in I_{HRS}$ of the HRS sample, as follows:

$$\hat{E}_{j2} = \hat{\gamma}_0 + \hat{\gamma}_2 H_j + \hat{\gamma}_3 D_j,$$

$$V\hat{AR}_{j2} = \hat{\xi}_0 + \hat{\xi}_2 H_j + \hat{\xi}_3 D_j.$$ (16) (17)

Note that in the imputation equations (16) and (17), we set $M_j$ equal to zero for the HRS sample.

– Thus the predictions above are for the mean and variance of medical expenditures for a person without Medigap coverage.
- Sources of Advantageous Selection: Main Findings

- Add Table Here
Table 6: Sources of Advantageous Selection.

Note: All regressions include controls for female, a third-order polynomial in age-65 and State of residence.
1. A first potential pathway through which cognitive ability may act as a source of advantageous selection is via its effect of individuals’ ability to evaluate the costs and benefits of purchasing Medigap. This channel is consistent, for example, with earlier literature showing that many senior citizens have difficulty understanding Medicare and Medigap rules, in particular, many fail to understand Medicare cost sharing requirements.

2. Let \((p, c)\) denote health risk and cognitive ability, respectively. Suppose that there is a negative correlation between \(c\) and \(p\), i.e., individuals with higher cognitive ability have lower health expenditure risk. Then one particularly simple model of this channel would have a threshold cognitive ability level \(c^*\) below which individuals are simply unaware of Medigap and therefore do not buy. Alternatively, \(c^*\) might represent
the cognitive ability level below which the costly effort required to determine the optimal Medigap decision is too great. In this latter case, optimal rules of thumb or other psychological forces may lead consumers to more often choose the status quo of no Medigap.

- In either case, those with \( c > c^* \), will purchase Medigap if it is worthwhile, and presumably only those with high health expenditure risk, i.e., \( p > p^* \), will choose to purchase Medigap.

- As a result, the set of individuals who purchase Medigap insurance is given by \( \Omega_{\text{Medigap}} = \{(p, c) : c \geq c^*, p \geq p^*\} \) and the set of individuals who do not purchase Medigap is given by \( \Omega_{\text{No}_\text{Medigap}} = \{(p, c) : c < c^*; \text{ or } (c > c^*, p < p^*)\} \).

- Because of the negative correlation in the population between \( c \) and \( p \), such that \( p \) tends to be larger for those with \( c < c^* \), it is possible that
we observe advantageous selection if we do not condition on cognition $c$.

2. A second potential channel through which cognitive ability may act as a source of advantageous selection is via its effect on search costs.

- We examined two testable implications of this pathway.

- First, if this pathway is important, Medigap premiums paid by individuals with higher cognitive ability should tend to be lower than those paid by individuals with lower cognitive ability.

- Second, the observed extent of advantageous selection should be less pronounced in states with less Medigap price dispersion.
<table>
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<td>.07</td>
<td>.11</td>
<td>.10</td>
<td>.08</td>
<td>.08</td>
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</table>

Table 4: Do High Cognition Individuals Pay Lower Medigap Premiums?
Note: All regressions include controls for gender, State of residence, a third-order polynomial in age, and Medigap plan letters. Robust standard errors are in parenthesis. *, ** and *** denote significance at 10 %, 5% and 1% respectively.
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</table>

Table 5: Comparisons of the Extent of Advantageous Selection Between States with Different Coefficients of Variations for Medigap Plan C Prices.

Notes: All regressions are of the same specifications as the corresponding ones in Table 1. They are weighted by the cross section sample weights. The descriptions of the direct health controls can be found in the Data Appendix.

Robust standard errors in parenthesis are clustered at the individual level. *, ** and *** denote significance at 10%, 5% and 1% respectively.
3. A third potential channel through which cognitive ability may act as a source of advantageous selection is via its effect on individuals’ information about health risks.

- High cognitive ability individuals may be healthier, but they may be more knowledgeable about potential health risks.

- Specifically, consider two individuals with different cognitive ability. The high cognitive ability individual may have better health status now, but he/she is aware of all the potential risks to health; while the one with low cognitive ability thinks there will be no more health shocks beyond what he/she already experienced.

- The first individual may be more likely to purchase Medigap than the second, thus leading to advantageous selection.
• Understanding the pathways for cognitive ability and other variables to act as sources of advantageous selection has important policy implications.

– If the first channel is important, it would suggest a role for educational interventions to facilitate choice, or simplification of Medigap rules to make the cost-benefit calculations simpler (see, e.g., Harris 2002);

– if the second channel is important, then pamphlets with detailed price quotes (products that Weiss Ratings, Inc. currently provide at a cost) directly sent to Medicare recipients may increase Medigap enrollment;

– if the third channel is important, it will call for yet a different kind of information campaign, which is not about Medicare or Medigap, but about various health risks the elderly may be facing.
4.5 Finkelstein and Poterba (2004, JPE)

- In an annuity insurance market, Finkelstein and Poterba (2004) found systematic relationships between ex post mortality and annuity characteristics, such as the timing of payments and the possibility of payments to the annuitants’ estate;

- but they do not find evidence of substantive mortality differences by annuity size.

4.6 Finkelstein and Poterba (2006)

- Finkelstein and Poterba (2006) proposed such use of characteristics of insurance buyers that are observable to the econometrician but not used
by insurers in setting prices as a general strategy to test for asymmetric information in insurance markets.

4.7 Cohen and Einav (2007, AER)

- Cohen and Einav (2007) inferred both accident risk and risk aversion using an estimated structural model of automobile insurance deductible choice and found that they are positively correlated, contrary to what is required for risk aversion to be a source of advantageous selection.