BLS WORKING PAPERS

U.S. DEPARTMENT OF LABOR
Bureau of Labor Statistics

OFFICE OF PRICES AND LIVING CONDITIONS

Is Adverse Selection Simply Moral Hazard?
Evidence from the 1987 Medical Expenditure Survey

Ralph Bradley, U.S. Bureau of Labor Statistics

Working Paper 360
May 2002

Is Adverse Selection Simply Moral Hazard? Evidence from the 1987 Medical Expenditure Survey

Ralph Bradley
US Bureau of Labor Statistics
2 Massachusetts Ave NE
Washington, DC 20212

Jan. 31, 2002

Abstract

There continues to be a lack of consensus about the presence of adverse selection in health plan markets. Previous studies conducted tests using data that covered only a certain segment of the entire population, and none modelled the role that risk aversion plays in the selection of plans. Additionally, none of these studies accounted for the possibility that the probability distribution of future illness could depend on unobserved "preventive" choices made by the policyholder. This study accounts for these characteristics and finds that not only is adverse selection present, but that there is an additional market failure since individuals are not fully compensated for their efforts at preventing both illness and accidents.

1 Introduction

In health plan markets adverse selection occurs when individuals can better predict their future health status than the health plan provider. The main consequence of this asymmetry is that the market fails to allocate insurance coverage and medical goods efficiently. Rothschild and Stiglitz (1976) showed that under traditional plans only a separating equilibrium can exist where healthier individuals either under insure or do not buy insurance. Additionally, they show that if the fraction of sicker individuals goes below a certain threshold point, an equilibrium will not exist. In the managed care context, Frank, Glazer, and McGuire (2000) show that when adverse selection is present, the managed plan will over provide some services and under provide others.

Unfortunately, to date, there is no consensus about the presence of adverse selection. Wolf and Godderis (1991) and Marquis and Phelps (1987) find evidence of adverse selection in the supplemental insurance market. Yet, Dowd et al. (1991) find no evidence of adverse selection. Perhaps one reason that Dowd et al. (1991) do not find adverse selection is that they could observe demographic information that previous studies could not. The studies that did find adverse selection did so perhaps because there was missing demographic information that is both relevant to both health plan choice and medical expenditures and omitted variable bias led the researchers to conclude that there was adverse selection. Another reason that the Dowd et al. study might not have detected adverse selection is that their sample consisted only of employees who were offered employer plans and who accepted them. However, if their sample had included the "outside alternative" of not accepting any available plan, their results might have been different. The results for Dowd et al. only apply to those who both had employer offered health insurance and decided to accept this offer. However, adverse selection could be a factor behind the decision either to reject an employer's offer of health insurance or select a job that does not provide employer coverage.

This study focuses on the decision whether or not to insure rather than the selection of the insurance plan after one has already made the decision to insure. The reason for this is that unlike the other studies mentioned above, I can test if adverse selection is a factor behind the decision for those who choose not to insure. It is possible that adverse selection might not be a factor in the selection of a plan, but could be a factor in whether or not to insure.

None of the studies that test for adverse selection specify the insurance choice based on the trade-off between the premium and the income protection services provided by a health plan. In fact Dowd et al. posit an indirect utility function that is linear in income when they estimate their logit model for insurance choice.[1] Yet, the strict concavity of the indirect utility function with respect to income is an important factor in the choice of plans. One of the parameters in the models in this paper measures the concavity of the utility function.

Another shortcoming is that these studies treat the ability of policy holders

[1] They acknowledge this linear relation and they tested for this by adding a term that "interacted the the employee's out-of pocket premium with after tax income." They found that the term was not significant. However, not rejecting this null is not sufficient evidence that the indirect utility is linear in income. If it were, then there should be no demand for any policy whose premium is greater than its actuarially fair value, and we do observe purchases of policies where the premium does exceed the actuarially fair value.

to better forecast their health care expenditures as an exogenous event. The policy holder in essence gets a random signal that cannot be observed by the insurer, and allows the policy holder to better predict her future health status. However, the policy holder can also make decisions that the insurer cannot observe. Specifically, the policy holder can decide how much effort she will use to prevent either an illness or an accident. Therefore, the ability of the policy holder to better forecast future health care expenditures might be the result of decisions rather than an exogenous signal. In this study, I specify a model where the individual chooses whether or not to purchase a health plan, and at the same time chooses a level of prevention effort. Examples of prevention efforts are maintaining an exercise regiment, driving cautiously, purchasing low cholesterol foods. Finally, it is possible that the policy holder is both receiving an exogenous signal and choosing a level of effort.

Many studies define adverse selection as the health plan provider attempting to discriminate based on observable variables. For instance, the 2002 Economic Report of the President gives as an example a case where an insurer is setting coverage in order to prevent those with previously diagnosed chronic illness from joining its plan. However, historical diagnoses of chronic conditions are observable, and there are both federal and state laws that prohibit insurers from discriminating against those with chronic conditions.[2] In this study, adverse selection only results from random variables that cannot be observed by the insurer.

[2] The 1996 Health Insurance Portability and Accountability Act is the most recent law allowing the chronically ill to continue coverage when they change jobs.

This study hypothesizes that insured individuals will receive a lower return on their efforts than uninsured individuals since the savings of out-of-pocket medical expenditures for the insured individual is less than the savings for the uninsured individual. Furthermore, the rate of return that the insured receives is less than the optimal rate because she is not compensated for the benefits that her effort bestows on other plan members through a reduction in the plan's cost. This will result in an under provision of effort. Thus, unobserved effort induces an additional market failure that is moral hazard instead of adverse selection. It is important to note that this is a different type of moral hazard than that discussed in Pauly (1968). The moral hazard in Pauly (1968) comes from fee for service contracts where the net price paid by the holder is less than the marginal cost of the medical good. The moral hazard in this study comes from the under compensation of effort under any type of policy that protects income.

This study uses the 1987 National Medical Expenditure Survey to estimate both a model where the forecasting signal is completely exogenous, and a model that allows for both an exogenous signal and a choice of effort. In both models, I test for the presence of an exogenous signal that allows the policy holder to better forecast her illness.

When I estimate the econometric models in this paper, I differentiate between the occurrence of an illness and an accident. Healthy individuals are susceptible to accidents, and will have a higher preference for medical goods if they are involved in an accident. Therefore, health status is not the sole determinant of the demand for medical goods. Additionally, I posit that the exogenous signal can only improve the predictive accuracy of illness while the choice of effort can improve the forecasting accuracy of both an illness and an accident.

This paper is organized as follows: in section II, I posit both a general model where the information signal is completely exogenous, and a general model where the consumer chooses both a health plan and an effort level. The models in section II are general. In order to focus on the main idea of this paper, in section II, I do not different between an illness and an accident. In section III, I use the results in section II to specify parametric models that I finally estimate. In this section, I separate the probability distributions of an accident and of an illness. In Section IV, I describe both the data and the results of my estimation.

2 Plan Choice and Medical Expenditures

Similar to previous studies, the models in this paper are two stage models. In the first stage the individual decides whether or not to purchase a plan. In the second stage, the consumer draws a random sickness variable and either chooses a medical expenditure, or in the case of a capitated plan chooses a medical expenditure subject to a constraint. Letting i index the individual and j the choice to insure, I denote s_i as the sickness random variable drawn by individual i. If the individual decides not to purchase a plan then $j = 0$, while $j = 1$ if the individual decides to insure. Individual i has exogenous income

y_i and j's premium is r_j where $r_0 = 0$; medical expenditures under plan j for individual i is $m_j(s_i)$.[3] After the draw of s_i, the *ex post* utility for individual i under insurance choice j is:

$$U(y_i - r_j - C_j(m_j(s_i)) - G(s_i, m_j(s_i))) \tag{1}$$

$C_j(.)$ is the out-of-pocket medical payments where $C_0(m) = m$, and $G(.,.)$ is the equivalent income loss from illness s_i and purchase of m_i medical goods.[4] $G(.,.)$ is a mapping that tells us how medical expenditures restore health. Letting subscripts denote partial derivatives, I posit that $G_s > 0$, $G_m < 0$, $G_{mm} > 0$, $U_s < 0, U_y > 0$, and $U_{yy} < 0$. In most cases $C_j(.)$ is piecewise linear. In a typical fee for service contract, $C_j(.)$ includes a deductible, a coinsurance rate after a deductible is met, and sometimes, a maximum expenditure limit. In a capitated plan, $C_j(.)$ can comprise a co-pay or is zero for certain services.

In past studies of traditional fee for service plans, $m_j(.)$ is the *ex post* solution to (1) with first order conditions:

$$-\partial C_j(m_i)/\partial m - \partial G(s_i, m_i)/\partial m = 0 \tag{2}$$

The moral hazard discussed in Pauly (1968) comes when $\partial C(m)/\partial m < 1$.

For managed care plans, most studies derive $m_j(.)$ as a constrained optimization of (1) where medical expenditures must be below a certain bound.[5]

[3] The employer's "contribution" to the premium receives a tax subsidy. However, I do not specifically account for this in describing the specification since it distracts from the main issues of this study.

[4] This is a "sickness is equivalent to income loss" model. This is used in Friedman and Feldstein (1977), Baumgardner (1991), and Chernew and Frick (1999).

[5] For example, see Bumgardner (1991) and Chernew and Frick (1999).

The first order conditions under a managed care constraint are

$$-\partial C_j(m_i)/\partial m - \partial G(s_i, m_i)/\partial m - \lambda_j = 0 \qquad (3)$$

where λ_j is the shadow price of the expenditure constraint. Again, when $C_j()$ is piecewise linear (3) is not the fully specified constrained optimization of (1).

In the first stage the individual chooses the health plan (or the outside alternative of no plan) before she draws the random sickness variable s. Therefore, she chooses the plan that will maximize her expected utility. Under exogenous adverse selection, the individual will observe an exogenous "signal" denoted as w_i such that $E(s_i - E(s_i|w_i))^2 < E(s_i - E(s_i))^2$. This signal is observed by the individual before deciding on a health plan, and it is not observed by the plan provider. This allows the individual to predict s_i better than the plan provider. The first stage problem is then:

$$\max_j E_{s|w}(U(y_i - r_j - C_j(m_j(s_i)) - G(s_i, m_j(s_i)|w_i))) \qquad (4)$$

where $E_{s|w}$ is the conditional expectation operator of s conditional on w.

However, it is possible that the individual not only observes an exogenous signal but could also choose an optimal income equivalent effort level denoted as e_i. This is an endogenous form of adverse selection. Like w_i, e_i is not observed by the plan. There might not be any incentive for the policy holder to communicate e to the plan provider.[6] In this study I posit that e_i only affects the conditional mean of s_i and I characterize this conditional mean as $\mu(e_i, w_i)$.

[6] Indeed, under pooled group plans there are severe legal constraints to setting premiums that are based on any type of behavior whether it is observed or unobserved.

The following holds:

$$\partial\mu(e, w)/\partial e < 0. \tag{5}$$

In this study, e_i does not affect other moments in the conditional distribution of s_i. The *ex post* utility function in (1) is now augmented as

$$U(y_i - r_j - C_j(m_j(s_i)) - G(s_i, m_j(s_i)) - e_i) \tag{6}$$

and the *ex ante* conditional distribution of s has mean $\mu(e_i, w_i)$ and variance $V(s_i|w_i)$. For each policy j there is an optimal effort level $e_{ij}(w)$ that is the solution to:

$$e_{ij}(w) = \arg\max E_{s|w,e}(U(y_i - r_j - C_j(m_j(s_i)) - G(s_i, m_j(s_i) - e_i) \tag{7}$$

Using the envelope theorem the following first order conditions apply:

$$-E_{s|w,e}(MU) + \{\partial E_{s|w,e}(U)/\partial\mu\}\{\partial\mu/\partial e\} = 0 \tag{8}$$

The first term is the expected value of the marginal utility of income and is the income equivalent loss from an additional unit of effort, and the second term is the expected utility gain from having a lower expectation of sickness. Notice that a change in e will lower the insurer's reimbursements, but the individual is not compensated for this change. Thus, there is a new source of market failure. For policy j let the optimal expected utility function be denoted as

$$V_j(w_i, e_{ij}(w_i)) = E_{s|w,e}(U(y_i - r_j - C_j(m_j(s_i)) - G(s_i, m_j(s_i)) - e_{ij}(w))$$

Then

$$\frac{\partial e_{ij}(w)}{\partial w} = -\frac{\partial^2 V_j/\partial e_{ij}\partial w_i}{\partial^2 V_j/\partial e_{ij}^2}.$$

If $\partial^2 V_j/\partial e_{ij}\partial w_i > 0$, then $\frac{\partial e_{ij}(w)}{\partial w} > 0$. When this occurs and one wishes to test for exogenous adverse selection by estimating the simple covariance between w and s, the result is biased because the effects of effort have been ignored. Specifically,

$$\partial\mu(e_{ij}(w_i), w_i)/\partial w_i = (\partial\mu/\partial e_{ij})(\partial e_{ij}/\partial w_i) + (\partial\mu/\partial w_i|_{e=e_{ij}}) \qquad (9)$$

The first term on the right hand side is negative and the second is positive. These terms could approximately offset each other. This might be reason that Dowd et al. (1991) did not find adverse selection in their study even though it could still be present.

After substituting $e_{ij}(w)$ into (6), the individual selects a plan by solving:

$$\max_j E_{s|w,e_{ij}(w)}(U(y_i - r_j - C_j(m_j(s_i)) - G(s_i, m_j(s_i)) - e_{ij}(w))) \qquad (10)$$

It is entirely possible that the signal w_i does not improve the predictive accuracy of s_i but e_{ij} does. In this situation, the adverse selection problem is completely endogenous where $\partial e_{ij}(w)/\partial w = 0$, and yet $\partial\mu(e_i, w_i)/\partial e_i < 0$.

While this is not a micro theory paper, it seems plausible that optimal interventions will depend on endogeneity of adverse selection. The next section describes how I test for the correct form of adverse selection.

3 Specification of the Econometric Model

When I specify the medical expenditure model, I account for three stylized facts. First, there are individuals who do not make any medical expenditures. Second, even when the coinsurance rate is zero for fee for service plans, individuals spend a finite amount on medical care. Third, the demand for medical goods is affected by two different types of random variables, the first is the severity of illness, and the second is the incidence of an accident. A perfectly healthy person who is involved in an accident will desire more medical expenditure than she would if she had not been in an accident. However, it does not seem possible that the exogenous signal should be able to better predict the incidence of an accident; if an event can be anticipated then it really is not an accident[7]. However, there are efforts that the individual can make in order to lower the probability of an accident. In the second subsection of this section, I attempt to specify a model that has the probability of an accident dependent on the endogenous effort choice. In this study, the accident is a binary variable and is denoted as a. If there is an accident, $a = 1$, and is zero otherwise. I posit that both the plan and the individual have access to the same demographic and historical diagnosis information. For notational convenience, I drop the i subscript for the individual. Only the individual can observe her *ex ante* signal. If this exogenous signal improves the predictive accuracy then there is exogenous adverse selection.

3.1 Adverse Selection as Completely Exogenous

In this subsection, the individual draws both a sickness variable s, and a binary accident variable, a. Since I am introducing a new random variable that affects the preferences for medical goods, I augment the medical restoration function G

[7] The exogenous signal should come mostly from self observation, and perhaps undocumented family history. The endogenous signal comes from choices such as the proclivity to drive recklessly or partake in dangerous recreation etc.

with a third argument for the accident variable. The *ex post* utility is specified as

$$U = -\exp\{-R(y - r_j - C_j(m) - G(s, a, m))\}, \quad m \geq 0. \tag{11}$$

R is the risk aversion parameter and must be strictly positive. In order to keep the specification consistent with the previously mentioned stylized facts, I specify $G(.,.,.)$ as a quadratic loss function:

$$G(s, a, m) = 1/2(s + \alpha a - \gamma m)^2, \text{ if } s + \alpha a > 0 \tag{12}$$

$$= 0, \text{ otherwise}$$

$C_j(m)$ will be equal to m for $j = 0$. For $j = 1$, it is a piecewise linear function of a deductible and coinsurance rate. In the data set used in this study, HMO reimbursements are converted to "fee for service equivalents." If $C_j(m)$ is 0 then $m = (s+\alpha a)/\gamma$ for any draw of $(s+\alpha a)$ that is greater than zero. This guarantees the finiteness of m in cases where the marginal out of pocket payments equal zero.[8] The random sickness variable s depends on demographic variables and the existence of a chronic condition that existed before the individual selects her plan type. These characteristics are contained in the vector x. Thus, one can specify s as

$$s = x\beta + u \tag{13}$$

where $E(u) = 0$ and under the exogenous adverse selection, it is u that is statistically dependent on the *ex ante* signal w. Thus, after accounting for the

[8] There are actually observations in the data that I use where 100% of all medical expenditures are reimbursed.

demographic effects, the draw of s is essentially the random draw of u. The individual's *ex post* medical expenditure will depend on $x\beta,\ a,\ C_j(.)$, and u. In this study, if $\partial C_j(m)/\partial m$ exits, it will be a constant $c_j \in [0,1]$. By substituting (12) and (13) into (11) and optimizing with respect to m, the resulting *ex post* medical expenditure function is

$$m = (x\beta + \alpha a - \frac{1}{\gamma}c_j + u + \lambda HMO_j)/\gamma.$$

λ is a shadow price of the HMO expenditure constraint if j is an HMO ($HMO_j = 1$). This constraint was described in the previous section.

In this study, I posit that the probability of an accident is independently distributed with respect to u. In essence, I am assuming that healthy people have the same chance of getting into an accident as ill people. While this seems restrictive, it allows me to identify the model in the next subsection where there is endogenous adverse selection.

When I do the maximum likelihood estimation of this exogenous adverse selection model, I posit that

$$\begin{pmatrix} w \\ u \end{pmatrix} \tilde{\ } N(0,\Sigma) \tag{14}$$

Under this specification $E(u|w) = (\Sigma_{uw}/\Sigma_{ww})w = \mu_{u|w}$ and $Var(u|w) = \Sigma_{uu} - \Sigma_{uw}^2/\Sigma_{ww}$. When one does not purchase insurance, $j = 0$, and $C_0(m) = m$. After the draw of w but before the draw of u, the expected indirect utility of being uninsured is

$$V_0(w) = \sum_{a=0}^{1}[E_{u|w,m>0}(-\exp\{-R(y - x\beta/\gamma - u/\gamma - \alpha a/\gamma + 1/(2\gamma^2)\} \times \tag{15}$$

$$\Pr(u > -x\beta - \alpha a + 1/\gamma | w)$$

$$- \exp\{-R(y)\} \Pr(u \leq -x\beta - \alpha a + 1/\gamma | w)] \Pr(a)$$

since $\Pr(m > 0|w) = \Pr(u > -x\beta - \alpha a + 1/\gamma|w)$. I show in the appendix that given the specification in (14), u in (15) can be integrated out, and I get the closed form

$$V_0(w) = -\exp\{-R(y))\} \sum_{a=0}^{1} \Pr(a)[\exp\{-R(-x\beta/\gamma + 1/(2\gamma^2) - \alpha a/\gamma)\} \times \tag{16}$$

$$\exp\{R(\mu_{u|w}/\gamma + \frac{1}{2} RVar(u|w)/\gamma^2\} \times (1 - \Phi(\frac{-x\beta - \alpha a + 1/\gamma - \mu_{u|w} - RVar(u|w)}{\sqrt{Var(u|w)}}))$$

$$+\Phi(\frac{-x\beta - \alpha a + 1/\gamma - \mu_{u|w} - RVar(u|w)}{\sqrt{Var(u|w)}})]$$

where $\Phi(.)$ is the standard normal cdf.

Suppose that the individual has the choice between not purchasing a health plan, and choosing a fee for service health plan ($j = 1$) with premium r_1 and coinsurance c_1, where $C_1(m) = c_1 m$. When insurance is purchased, the expected indirect utility function integrates to

$$V_1(w) = -\exp\{-R(y - r_1)\} \sum_{a=0}^{1} \Pr(a)[\exp\{-R(-c_1 x\beta/\gamma + c_1^2 1/(2\gamma^2) - c_1 \alpha a/\gamma\} \times \tag{17}$$

$$\exp\{R(c_1 \mu_{u|w}/\gamma + (c_1^2 R/\gamma^2) Var(u|w)\} \times (1 - \Phi(\frac{-x\beta - \alpha a + c_1/\gamma - \mu_{u|w} - RVar(u|w)}{\sqrt{Var(u|w)}}))$$

$$+\Phi(\frac{-x\beta - \alpha a + c_1/\gamma - c_1\mu_{u|w} - Rc_1Var(u|w)}{\sqrt{Var(u|w)}})]$$

For a draw of w, the individual will not purchase insurance if $V_0 > V_1$. I now have a closed model that explicitly shows the individual's preference for income protection. Notice that with a positive risk aversion ($R > 0$), an increase in the variance of $Var(u|w)$ decreases the expected utility, because there is a higher probability for a greater income loss. In this example, the choice to insure involves the trade-off between paying the premium r_1 and getting the additional income protection from $c_{1.}$ $V_1(w) - V_0(w)$ is monotonic with respect to w only if there is adverse selection (i.e. $\Sigma_{uw} \neq 0$), and there will be a $\overline{w}$ such that $V_1(\overline{w}) - V_0(\overline{w}) = 0$. Any draw of w below $\overline{w}$ will lead the individual to forgo the health plan. Using (16) and (17), the propensity to purchase health insurance is approximated by the magnitude of the following difference:

$$-\gamma r_1/(1 - c_1) + x\beta + \mu_{u|w} - (1 + c_1)(1/2\gamma)(1 - RVar(u|w)) \qquad (18)$$

Notice that (18) shows how the increase in risk aversion, R, increases the propensity to purchase health insurance. It is important to note that (18) is not monotonic with respect to c_1. The reason is that this characterizes the *ex ante* demand for insurance and if $Var(u|w)$ is large, there is a positive probability that the insured would over consume medical goods.

In this study $C_j(m)$ is linear with slope $c_j \in [0, 1]$, and the no insurance slope is $c_0 = 1$. A policy with full insurance has $c_j = 0$. I add back the subscript i to index the individual, and I denote $z_{ij} = \{x_i, a_i, c_j, HMO_j\}$, where $c_0 = 1$ and I set $\Gamma = \{\beta/\gamma, \alpha/\gamma, -1/\gamma^2, \lambda\}$. I cannot observe the signal w_i but if there is positive non zero m_i, I can estimate $u_i = m_i - z_{ij}\Gamma$. If $m_i = 0$, I can only estimate $\Pr(m_i = 0) = \Pr(u_i \leq -z_{ij}\Gamma)$. I normalize $\Sigma_{ww} = 1$ and $\Sigma_{uu} = \sigma_u^2$. Therefore I can estimate the following log likelihood where the i^{th} individual's contribution is:

$$I(m_i > 0) * \ln(\phi(u_i/\sigma_u)/\sigma_u) \tag{19}$$

$$+\sum_{j=0}^{1} I(\text{plan } j \text{ chosen})\{I(m_i = 0)\ln(\Pr(j \text{ is chosen}, u_i \leq -z_{ij}\Gamma)) +$$

$$\mathrm{I}(m_i > 0)\ln(\Pr(j \text{ is chosen}|u_i))$$

$\phi()$ is the standard normal distribution function. Using (18), I specify Pr(plan j chosen$|u_i$) as $\Phi(\delta_1 r_{ij} + x_i\beta/(\gamma\sigma_u) + \delta_2 c_{ij} + \delta_3 d_{ij} + \delta_4 c_{ij} u_i/\sigma_u + .5\delta_5 R(1 + c_{ij})(\sigma_u^2(1 - \delta_4^2))$ where r_{ij}, c_{ij}, and d_{ij} are respectively the insurance premium, the coinsurance rate and the deductible of the j^{th} policy available to individual i. Recall that $r_0 = 0, c_0 = 1$ and $d_0 = 0$. Notice that the last term in this specification accounts for the effect of risk aversion on the demand for insurance. I specify Pr(plan j chosen$, u_i \leq -z_{ij}\Gamma$) as the standard bivariate normal $\Phi(\delta_1 r_{ij} + \delta_2 c_{ij} + \delta_3 d_{ij} + .5\delta_5(1 + c_{ij})R\sigma_u^2, -z_{ij}\Gamma, \delta_4)$. The parameters are then $\Gamma, \delta_1, \delta_2, \delta_3, \delta_4, \delta_5, \sigma_u,$ and R. I test for adverse selection by testing the null hypothesis, $\delta_4 = 0$.

3.2 Endogenous Adverse Selection with Effort

I augment the model from the last section by adding a latent effort variable that neither the plan provider nor the econometrician can observe. In order to identify this model, I impose additional restrictions.[9] In this model, individuals choose an effort level denoted as e before their draw of u. As mentioned in the previous section the mean of u is inversely related to e. The random variable s is now modelled as

$$s = x\beta + e\beta_e + u. \tag{20}$$

$\beta_e < 0$. The probability of an accident is also inversely related to e. As in the previous subsection, $a = 1$ if there is an accident, and $a = 0$ otherwise. In order to model the probability of an accident, I introduce a third latent random accident variable v. An accident does not occur if

$$v < \alpha_0 + \alpha_1 e. \tag{21}$$

Therefore,

$$\Pr(a = 0) = \Pr(v < \alpha_0 + \alpha_1 e). \tag{22}$$

I still assume that the individual gets a draw of the signal, w. If

$$\beta_e < 0 \text{ or } \alpha_1 > 0 \tag{23}$$

then there is endogenous adverse selection. Additionally, if $E(u - E(u|w)^2) < E(u - E(u))^2$, then there is both exogenous and endogenous adverse selection. Notice that w cannot improve the forecasting accuracy of the accident variable v. The individual can only affect the probability of an accident by her choice of e. The *ex post* utility is now:

$$U = -\exp\{-R(y - r_j - C_j(m) - 1/2(\alpha a + s - \gamma m)^2 - e)\} \tag{24}$$

[9] As in the previous section, I start by omitting the supscript i.

Before the draw of u, but after the draw of the exogenous signal w, the individual must choose both an effort level e and insurance status j. The *ex post* medical expenditure is denoted m^*_{ja}. As mentioned in the previous subsection, $C_j(m)$ is always linear with slope c_j. From this I get

$$m^*_{ja} = (\beta x + \alpha a - c_j/\gamma + \beta_e e + u)/\gamma \tag{25}$$

Before the draw of u, but after the draw of the exogenous signal w, the individual must choose both an effort level, e, and insurance status j. I specify that v is independently distributed from u and w. With this assumption, the expected utility of effort after drawing w and choosing both e and plan j is:

$$V_j(e) = \sum_{a=0}^{1} \Pr(a)[E_{u|w,e}(-\exp\{-R(y - r_j - c_j(\beta x + \alpha a + \beta_e e + u)/\gamma \tag{26}$$

$$+1/2(c_j/\gamma)^2 - e)\} \times \Pr(u > -\beta x + \alpha a + \beta_e e - c_j/\gamma | w, e)$$

$$-\exp\{-R(y - e) \times \Pr(u \leq -\beta x + \alpha a + \beta_e e - c_j/\gamma | w, e)]$$

And $\Pr(a = 0) = F_v(\alpha_0 + \alpha_1 e)$, and $\Pr(a = 1) = 1 - F_v(\alpha_0 + \alpha_1 e)$, where F_v is the distribution function for v. Let $e_j(w)$ be the optimal effort chosen for plan j given w. In most cases, the following should hold

$$e_0(w) > e_1(w). \tag{27}$$

The intuitive reason is that under no insurance, the individual is fully compensated for her efforts, and therefore should produce more effort than she would if she were not fully compensated for it. If the insurance plan has a deductible d_1, then e_1 should be increasing in d_1.

The policy holder chooses the plan j' such that

$$V_{j'}(e_{j'}) > V_j(e_j) \;\; \forall j \neq j' \tag{28}$$

When I do maximum likelihood estimation of this model, I posit that

$$\begin{pmatrix} w \\ u \\ v \end{pmatrix} \tilde{} N(0_3, \Psi) \tag{29}$$

I restrict $\Psi_{wv} = \Psi_{uv} = 0$, and normalize $\Psi_{ww} = \Psi_{vv} = 1$.

To specify the likelihood function for this section, I re introduce the subscript i to index the individual. I proxy for e_{ij} by

$$\widehat{e}_{ij} = \alpha_2 I(j > 0) + \alpha_3 d_j I(j > 0)$$

where $I(.)$ is the indicator function. I define $z_{ij} = \{x_i, a_i, c_j, \widehat{e}_{ij}\}$ and $\Gamma = \{\beta/\gamma, \alpha/\gamma, -1/\gamma^2, \beta_e\}$. Using the notation of the last subsection, I get

$$u_i = (m^*_{ija_i} - z_{ij}\Gamma) I(m^*_{ija_i} > 0) \tag{30}$$

The i^{th} individual's contribution to the likelihood function takes the form:

$$\sum_{a=0}^{1} \sum_{j} \ln\{\Psi_{uu}^{-1/2} \phi(u_i/\sqrt{\Psi_{uu}}) \Pr(i \text{ chooses Plan } j|u_i) \Pr(a_i = a|u_i, \text{Plan } j) \times \tag{31}$$

$$I(m^*_{ija} > 0, i \text{ chooses Plan } j, a_i = a)\} +$$

$$\sum_{a=0}^{1} \sum_{j} \ln \Pr(u_{ii} < -z_i\Gamma, i \text{ chooses Plan } j, a_i = a) I(m^*_{ija} = 0, i \text{ chooses Plan } j, a_i = a)$$

where

$$\Pr(i \text{ chooses } j|u_i) = \Phi(\delta_1 r_j + \delta_2 c_j + \delta_3 d_j + \delta_4 c_j u_i/\sqrt{\Psi_{uu}} + .5\delta_5(1 + c_j) R(\Psi_{uu}(1 - \delta_4^2))$$

and using the restrictions on Ψ, and

$$\Pr(a_i = 0|u_i,\ i \text{ chooses } j) = \Phi(\alpha_1 + \widehat{e}_{ij} + \alpha_4 u_i/\sqrt{\Psi_{uu}}).$$

$$\Pr(u_i < -z_i\Gamma, i \text{ chooses } j, a_i = 0) =$$

$$\Pr(u_i < -z_i\Gamma, i \text{ chooses } j)\Pr(a_i = 0|u_i < -z_i\Gamma, i \text{ chooses } j) =$$

$$\Phi(-z_i\Gamma/\sqrt{\Psi_{u_iu}}, \delta_1 r_j + \delta_2 c_j + \delta_3 d_j + .5\delta_5 R(1+c_j)\Psi_{uu}, \delta_4) \times$$

$$\Phi(-z_i\Gamma/\sqrt{\Psi_{u_iu}}, \alpha_1 + \widehat{e}_{ij}, \alpha_4)/\Phi(-z_i\Gamma/\sqrt{\Psi_{u_iu}})$$

where $\Phi(.,.,.)$ is the standard normal bivariate cdf. The likelihood function of the previous subsection where I am only testing for exogenous adverse selection is a restricted form of (31) where $\beta_e = 0, \alpha_2 = 0, \alpha_3 = 0$, and $\alpha_4 = 0$. One way to test the null that endogenous selection is not present is to do a Likelihood ratio test between the two models. If the null of no endogenous adverse selection is rejected and δ_4 is not significantly different from zero while β_e is significantly different from zero, then only endogenous adverse selection is present and the medical expenditure equation is biased because of the omitted effort variable and the endogeneity of the accident variable. α_4 allows for statistical dependency between u_i, and e_{ij}. There is no theoretical reason that it should be either positive or negative even if there is exogenous adverse selection. One might conclude that if both e_{ij} and u_i are dependent on w_i that they should be positively correlated. However, this conclusion does not account for the discontinuity created when w_i reaches a level where one is indifferent between being insured and uninsured. Figure 1 shows how this discontinuity affects the dependence. The graph on the upper left side depicts the relationship between effort and the signal. At some threshold signal $\overline{w}_i$ the individual is indifferent between being insured and uninsured. Once she is insured there is a drop in the optimal effort. The rest of the graphs show how w_i affects u_i, and then on the upper right side the relationship between $E(u_i|w_i)$ and e_i is depicted. Notice that the discontinuity between effort and the signal destroys the monotonic relationship.

4 The Data and Model Results

4.1 The Data

The National Medical Expenditures Survey of 1987 (NMES) is a sample that contains data on health status, medical expenditures, insurance coverage, and sources of medical payments during the period from January 1, 1987, to December 31, 1987. NMES comprises two major surveys. The first is a household survey and the second is a health plan survey. The household survey was conducted with four interviews per household. The health plan survey verified information on both employer and non employer provided private health insurance. It is through the health plan survey that one is able to get information on the plan characteristics such as premiums, deductibles, and coinsurance.

To make HMO characteristics comparable with the characteristics for the traditional fee for service plan, HMO coverage variables were converted to a "fee for service equivalent" policy, the NMES documentation describes the following adjustment:

In constructing the rate variables, copayments and fee allowances were converted into percentages by making assumptions about the average cost of certain services for 1987, the year of the survey.[10]

Additionally, HMOs tended to have deductibles that differed from the deductibles of a fee for service plan. Some services such as inpatient hospital services, generally had a zero deductible, while other services had deductibles as high as $1,000. Therefore, NMES had to average some of these deductibles to create characteristics that could be compared to the fee for service structure.

In this study I estimate the model using only those observations with family size equal to one, and were employed in 1987. This is often done in past studies since it is very difficult to specify how an additional member affects the demand for insurance. Additionally, it was important to exclude the Medicaid eligible population since they were not making any insurance choice.

Table 1 gives summary statistics on selected variables for single households. Medical expenditures varied widely. The smallest expenditure was obviously zero while the largest was $46,366. Approximately, 83% of the sample were offered insurance by their employer. 85% of those who were offered an employer plan, accepted the offer. 6% of the individuals had private non employer insurance. Approximately half of the holders of private non employer insurance were offered employer plans. Finally, 18% of the respondents reported no medical expenditures.

[10] Department of Health and Human Serivices, Agency for Health Care Policy and Research, Center for Cost and Financing Studies, "Research Tape 40R: Data from the Household Survey, the Health Insurance Plans Survey, the Survey of American Indians and Alaska Natives, and the Institutional Population Component," File Documentation, November 1996 , page 252.

Tables 2a to 2c give summary statistics by type of plan. Table 2a gives the statistics for the uninsured, Tables 2b for HMO holders, and Table 2c for fee for service holders. In Table 2a, the offered premium reflects the least expensive plan offered by the employer, or if the employer does not offer a plan, it is the premium of the private insurance alternative. Obviously, the individual payment for those not offered employer insurance is equal to the total premium. When comparing the tables, one notices immediately that the insured had smaller incomes and medical expenditures. For the insured, the difference between the total medical payments and out of pocket payment was made up by debt forgiveness and charitable contributions.

The summary statistics for HMOs defy some conventional wisdom about their cost cutting nature. It is true that most of the managed care cost control programs had not been implemented as early as 1987. Generally, at this time HMOs provided more thorough coverage and were more expensive plans. Both total premiums and total medical expenditures for HMOs are slightly but not significantly more than for fee for service.

The differences between the HMO and fee for service holders are smaller than the difference between the insured and the uninsured. Perhaps, one reason that Dowd et al. (1991) did not find adverse selection is that they were only looking at the insured. It is generally assumed that HMOs are capitated plans with zero deductibles. However, in 1987, as Table 2b shows, there is wide variation in deductibles for HMOs, as was previously mentioned.

In this study a chronic condition is one that could not be cured and was diagnosed before 1985. Since claims must specify a diagnosis, the health plan can easily observe if their holder has a chronic condition; however, group plans are barred from adjusting their premiums to account for the chronic condition. It is quite evident that a disproportionate number of chronically ill individuals did choose insurance coverage.

Tables 3a to 3d give cross tabs for some discrete variables in the study. Table 3a shows that most respondents who were not offered an employer health plan also chose not to purchase a plan from another source. Of the 83% who were offered employer plans 15% (13/82) chose not to accept their employers' offers. A disproportionate share of the uninsured incurred no medical expenditures, and had fewer reported accidents and chronic conditions.

4.2 Results From the Estimation

Table 4a gives the results of the estimation of (19), and Table 4b lists the results from estimating (31). The parameter estimates have their expected signs, except that the parameter for the HMO expenditure constraint is not significant. Since this is 1987 data, most of the cost controls in managed care had not been implemented by then.

In Table 4a, the parameter estimates for the correlation between the exogenous signal and the medical expenditure residual is .51 which would lead one to conclude that there is exogenous adverse selection. This result contrasts sharply with the results of Dowd et al. (1991). As mentioned previously, Dowd et al. do not cover those who are uninsured, and if the "Rothschild-Stiglitz" separating equilibrium separates the insured and uninsured then Dowd et al. should not find any evidence since they are only looking at one part of the separating equilibrium.

Comparing Table 4a to 4b provides interesting results. The parameter estimate for the correlation between the signal and the medical expenditure residual that comes from the model incorporating both exogenous and endogenous adverse selection is much higher (.78 v .51) than it is for the completely exogenous adverse selection model. Since the restricted "exogenous only" likelihood function is not accounting for the negative effects of effort, this is showing up in the lower correlation. The coefficient for the effort variable in the medical expenditure equation in Table 4b is significantly negative. Since this coefficient is restricted to equal 0 in Table 4a, the estimated correlation between the *ex post* residual u and the signal w is biased downward, The Likelihood ratio test for the null that there is no endogenous adverse selection is rejected.

There are other important results. When endogenous effort is not properly modeled, the price coefficient on the coinsurance rate is negative and significant, but it is not significant when endogenous adverse selection is incorporated into the model. When endogenous effort is not incorporated, the coinsurance rate is picking up some of the effects of effort. When one does not account for endogenous adverse selection, one might conclude that *ex post* medical expenditures are sensitive to coinsurance rates, and therefore the moral hazard coming from the underprovision of effort would be interpreted as the moral hazard coming from the reduction in the net price that the consumer pays for medical care. In the endogenous adverse selection estimation one must accept the null that there is no moral hazard coming from the coinsurance rate. However, there is moral hazard coming from the under provision of effort.

Finally, one must conclude that exogenous adverse selection is playing an important role in the decision whether or not to insure. Individuals have additional information that is not observed by the insurer and this additional information is an important choice variable in the decision to purchase a health plan.

5 Conclusions

I have tested the presence of both exogenous and endogenous adverse selection. My estimation explicitly models the benefits of the income protection services that come from the health plan, and accounts for the key features in the medical market such as the finiteness of medical expenditure when the consumer faces a zero price.

Since exogenous adverse selection is present, I conclude that adverse selection is not simply moral hazard. This has important implications in the setting of optimal rates for health plans. Compensating plans for only exogenous adverse selection could help subsidize endogenous adverse selection. In the auto industry, endogenous adverse selection is corrected by additional surcharges to the individual for accidents. This increases the return on the policy holder's efforts to prevent accidents. However, it is unlikely that there is any exogenous adverse selection in the automobile insurance market.

Previous studies that have not found adverse selection have not accounted for effects of choosing a level of unobserved prevention effort, additionally, these studies have not focused on the decision whether or not to insure. Those previous studies that did find exogenous adverse selection did so by only looking at a segment of the market, and could not model adverse selection because the individual chooses his entire health insurance needs and effort levels simultaneously.

A Appendix

I show that (16) holds. I can rewrite (15) as

$$V_0(w) = -\exp\{-R(y - x\beta/\gamma + 1/(2\gamma^2))\} \sum_{a=0}^{1} \Pr(a)[E_{u|w,m>0} \exp\{-R(-u/\gamma - \alpha a/\gamma)\} \times \tag{32}$$

$$\Pr(u > -x\beta - \alpha a + 1/\gamma|w)$$

$$-\exp\{-R(y)\} \Pr(u \leq -x\beta - \alpha a + 1/\gamma|w)] \Pr(a)$$

Given $E(u|w) = (\Sigma_{uw}/\Sigma_{ww})w = \mu_{u|w}$ and $Var(u|w) = \Sigma_{uu} - \Sigma_{uw}^2/\Sigma_{ww}$, it suffices to show that if $u|w\tilde{\ }N(\mu_{u|w}, \Sigma_{\mathrm{u}\,u} - \Sigma_{uw}^2/\Sigma_{ww})$, then

$$E_{u|w,m>0} \exp\{R(u/\gamma\} \times \Pr(u > -x\beta - \alpha a + 1/\gamma|w) =$$

$$\exp\{R\mu_{u|w}/\gamma + (1/2)(R/\gamma)^2 Var(u|w)\} \times (1 - \Phi(\frac{-x\beta - \alpha a + 1/\gamma - \mu_{u|w} - RVar(u|w)}{\sqrt{Var(u|w)}})).$$

The following holds by definition:

$$E_{u|w,m>0} \exp\{R(u/\gamma\} =$$

$$\frac{1}{1 - \Phi(\frac{-x\beta - \alpha a + 1/\gamma - \mu_{u|w}}{\sqrt{|\Sigma_{\mathrm{u}\,u} - \Sigma_{uw}^2/\Sigma_{ww}|}})} \int_{u > -x\beta - \alpha a + 1/\gamma}^{\infty} \frac{\exp\{Ru/\gamma\}}{\sqrt{2\pi|\Sigma_{\mathrm{u}\,u} - \Sigma_{uw}^2/\Sigma_{ww}|}} \exp\{\frac{-(u - \mu_{u|w})^2}{2(\Sigma_{\mathrm{u}\,u} - \Sigma_{uw}^2/\Sigma_{ww})}\} du.$$

The follow transformations hold:

$$\int_{u>-x\beta-\alpha a+1/\gamma}^{\infty} \frac{\exp\{Ru/\gamma\}}{\sqrt{2\pi|\Sigma_{\mathrm{u\,u}} - \Sigma_{uw}^2/\Sigma_{ww}|}} \exp\{\frac{-(u-\mu_{u|w})^2}{2(\Sigma_{\mathrm{u\,u}} - \Sigma_{uw}^2/\Sigma_{ww})}\}du =$$

$$\int_{u>-x\beta-\alpha a+1/\gamma}^{\infty} \frac{1}{\sqrt{2\pi|Var(u|w)|}} \exp\{\frac{-(u-\mu_{u|w})^2 + 2RVar(u|w)(u/\gamma)}{2(Var(u|w))}\}du =$$

$$\exp\{R\mu_{u|w} + 1/2R^2Var(u|w)\} \times$$

$$\int_{u>-x\beta-\alpha a+1/\gamma}^{\infty} \frac{1}{\sqrt{2\pi|Var(u|w)|}} \exp\{\frac{-(u-\mu_{u|w} - RVar(u|w))^2}{2(Var(u|w))}\}du =$$

$$\exp\{R\mu_{u|w} + 1/2R^2Var(u|w)\} \times$$

$$\left(1 - \Phi(\frac{-x\beta - \alpha a + 1/\gamma - \mu_{u|w} - RVar(u|w)}{\sqrt{Var(u|w)}})\right).$$

References

Baumgardner, J.R. 1991 "The Interaction Between Forms of Insurance Contract and Types of Technical Change in Medical Care," RAND Journal of Economics 22, 36-53.

Chernew, M.E. and Frick K.D. 1999 "The Impact of Managed Care on the Existence of Equilibrium in Health Insurance Markets," Journal of Health Economics vol 18 573-592.

Dowd. B., Feldman R., Cassou S., and Finch M. 1991 "Health Plan Choice and the Utilization of Health Care Services," Review of Economics and Statistics 85-93.

Frank R.G., Glazer J., and McGuire T.G. 2000 "Measuring Adverse Selection in Managed Health Care," Journal of Health Economics 19 829-854.

Friedman B. and Feldstein M. 1977 "Tax Subsidies, the rational Demand for Insurance, and the Health Care Crisis", Journal of Public Economics, 7 155-178.

Marquis, S. and Phelps C. 1987 "Price Elasticities and Adverse Selection in the Demand for Supplemental Insurance," Economic Inquiry vol(25) 299-313.

Moffitt, R. 1986 "The Econometrics of Piecewise-Linear Budget Constraints," Journal of Businesss and Economic Statistics 317-328.

Pauly, M.V. 1968 "The Economics of Moral Hazard: Comment," American Economic Review 58 531-537.

Rothschild, M. and Stiglitz, J. 1976 "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information," Quarterly Journal of Economics, 90(4), 630-649.

Wolf and Godderis 1991 "Adverse Selection, Moral Hazard, and Wealth Effects in the Medigap Insurance Market," Journal of Health Economics 10 433-459.

Table 1
Summary Statistics
1987 National Medical Expenditures Survey

Variable	***Mean***	***Standard Deviation***
Age	37.01	13.75
Years of Schooling	13.19	2.91
Income	$21,042	$15,074
%White	77.31%	41.91%
%Male	53.96%	49.87%
% with Chronic Condition	29.64%	45.69%
% in Accident	20.09%	40.09%
Total Medical Expenditures	$824.88	$2,253.71
Out of Pocket Med. Exp.	$286.29	$516.73
% Uninsured	26.71%	19.58%
% Offered Employer Insurance	82.95%	37.61%
% Reject Offer	15.45%	13.06%
% Accept Offer	84.55%	13.06%
% with Non Employer Policy	6.30%	24.31%
% with No Medical Expenditures	18.13%	14.84%

N=921

Table 2a
Summary Statistics
for the Uninsured

Variable	*Mean*	*Standard Deviation*
Age	35.73	14.54
Years of Schooling	11.93	3.23
Income	$13,096	$10,625
%White	71.54%	45.21%
%Male	56.10%	49.73%
% with Chronic Condition	9.76%	29.73%
% in Accident	7.72%	26.75%
Total Medical Expenditures	$199.97	$548.55
Out of Pocket Med. Exp.	$192.46	$494.22
Total Health Plan Premium	$1,027.69	$179.06
Individual Premium Payment	$668.86	$411.77

N=246

Table 2b
Summary Statistics
for HMO Holders

Variable	*Mean*	*Standard Deviation*
Age	37.10	12.89
Years of Schooling	13.74	2.59
Income	$25,754	$15,954
%White	73.84%	44.08%
%Male	54.65%	49.93%
% with Chronic Condition	34.88%	47.80%
% in Accident	22.09%	41.61%
Total Medical Expenditures	$1,171.00	$3,769.20
Out of Pocket Med. Exp.	$205.84	$302.79
Total Health Plan Premium	$953.99	$284.98
Individual Premium Payment	$158.95	$242.47
NonHospital Deductible	$244.51	$324.17
NonHospital Coinsurance	12.86%	11.21%

N=172

Table 2c
Summary Statistics
for Fee for Service Holders

Variable	***Mean***	***Standard Deviation***
Age	37.61	13.62
Years of Schooling	13.61	2.82
Income	$23,316	$15,195
%White	81.31%	39.02%
%Male	52.68%	49.98%
% with Chronic Condition	37.57%	48.48%
% in Accident	25.45%	43.60%
Total Medical Expenditures	$1,012.14	$2,013.63
Out of Pocket Med. Exp.	$369.47	$568.68
Total Health Plan Premium	$953.79	$477.38
Individual Premium Payment	$148.05	$287.71
NonHospital Deductible	$191.87	$165.46
NonHospital Coinsurance	16.64%	13.71%

N=503

Table 3a
Insurance Type and
Availability of
Employer Insurance

Type of Insurance	***Employer Provided Insurance*** Yes	No	Total
No Insurance	12.81%	13.90%	26.71%
HMO	18.35%	0.33%	18.68%
Fee for Serivce	51.79%	2.82%	54.61%
Total	82.95%	17.05%	100%

Table 3b
Insurance Type and
Chronic Condition

Type of Insurance	***Chronic Condition*** Yes	No	Total
No Insurance	2.61%	24.10%	26.71%
HMO	6.51%	12.16%	18.68%
Fee for Serivce	34.09%	20.52%	54.61%
Total	82.95%	17.05%	100%

Table 3c
Insurance Type and
Incidence of Accident

Type of Insurance	***Accident Occurred*** Yes	No	Total
No Insurance	2.06%	24.65%	26.71%
HMO	4.13%	14.55%	18.68%
Fee for Serivce	13.90%	40.72%	54.61%
Total	82.95%	17.05%	100%

Table 3d
Insurance Type and Zero Medical Expenditures

Type of Insurance	***Zero Medical Expenditures*** Yes	No	Total
No Insurance	11.29%	15.42%	26.71%
HMO	1.30%	17.38%	18.68%
Fee for Serivce	5.54%	49.07%	54.61%
Total	82.95%	17.05%	100%

Table 4a
Parameter Estimates of Exogenous Adverse Selection

Parameters (x)	**Estimates**	**Std. err.**	**t-statistic**	**Prob.|t|=0**
Medical Expenditure				
Constant	-0.5328	0.2289	-2.328	0.0199
Age	0.7528	0.2045	3.681	0.0002
Male=1	-0.1165	0.0679	-1.714	0.0865
Years of School	0.3488	0.2223	1.569	0.1167
White=1	0.1206	0.0805	1.497	0.1344
Chronic condition	0.6671	0.0840	7.938	0.0000
Income	-0.0214	0.0372	-0.576	0.5649
Accident	0.3545	0.0882	4.019	0.0001
HMO	-0.0661	0.0913	-0.724	0.4690
Co-insurance c_j	-0.2496	0.1004	-2.486	0.0129
Insurance Demand				
Premium	-2.8208	0.2544	-11.088	0.0000
Coinsurance	-1.4869	0.1096	-13.565	0.0000
Deductible	-4.6601	0.4773	-9.763	0.0000
Additional Parameters				
σ_u^2	0.9984	0.0528	18.893	0.0000
Risk Aversion R	0.00016470108	2.9234503e-005	5.6337909	0.0000
Correlation Signal and Medical Residual δ_4	0.5106	0.0613	8.332	0.0000
Mean log-likelihood	-2.10094			
Number of cases	921			

Table 4b
Parameter Estimates of Both
Exogenous and Endogenous Adverse Selection

Parameters (x)	Estimates	Std. err.	t-statistic	Prob.|t|=0
Medical Expenditure				
Constant	1.0049	0.6433	1.562	0.1183
Age	0.9919	0.2112	4.697	0.0000
male=1	-0.0852	0.0684	-1.246	0.2128
Years of School	0.8171	0.2623	3.115	0.0018
white=1	0.1431	0.0849	1.686	0.0917
chronic cond	0.7246	0.1009	7.179	0.0000
income	-0.0528	0.0394	-1.341	0.1799
Accident	0.1286	0.1164	1.105	0.2690
HMO	0.1408	0.1118	1.259	0.2082
Coinsurance c_j	0.1924	0.1350	1.425	0.1541
Effort	-1.5076	0.4197	-3.592	0.0003
Insurance Demand				
Premium	-1.8155	0.1522	-11.930	0.0000
Coinsurance	-1.1647	0.0893	-13.050	0.0000
Deductible	-4.5805	0.4097	-11.181	0.0000
Effort/Accident				
Constant	1.2948	0.1222	10.597	0.0000
Insured ($j>0$)	-0.8218	0.1469	-5.596	0.0000
Deductible	2.6962	0.6320	4.266	0.0000
Additional Parameters				
var(u)	1.0912	0.0201	54.302	0.0000
Risk Aversion R	0.00009735	5.9085e-006	16.4768	0000
Correlation Signal and Medical Residual δ_4	0.7835	0.0193	40.524	0.0000
Correlation Effort Bound and Medical Residual α_4	-0.0580	0.1035	-0.561	0.5750
Mean log-likelihood	-2.02123			
Number of cases	921			

Figure 1
Relationship between Random
Illness *u* and Effort *e*