ADVERSE SELECTION IN INSURANCE MARKETS: POLICYHOLDER EVIDENCE FROM THE U.K. ANNUITY MARKET

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ABSTRACT

In this paper, we investigate the importance of adverse selection in insurance markets. We use a unique data set, consisting of all annuity policies sold by a large U.K. insurance company since the early 1980s, to analyze mortality differences across groups of individuals who purchased different types of policies. We find systematic relationships between ex-post mortality and annuity policy characteristics, such as whether the annuity will make payments to the estate in the event of an untimely death and whether the payments from the annuity rise over time. These mortality patterns are consistent with models of asymmetric information in insurance markets. We find no evidence of mortality differences, however, across annuities of different size, as measured by the initial annual payment from the annuity. This is surprising, since models of insurance market equilibrium with asymmetric information would predict such differences. We also study differences in the pricing of different annuity products, and find that the pricing of various features of annuity contracts is consistent with the self-selection patterns we find in mortality rates. Our results therefore suggest that selection may occur across many specific features of insurance contracts and that the absence of selection on one dimension of an insurance contract does not preclude its presence on others. This highlights the importance of considering the detailed features of insurance contracts when testing theoretical models of asymmetric information in insurance markets

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Theoretical research on insurance markets has long emphasized the potential importance of asymmetric information and documented the negative welfare implications of adverse selection, which can be one of the consequences of asymmetric information. Yet the empirical evidence of asymmetric information in insurance markets is decidedly mixed. Several recent empirical papers have failed to find evidence of asymmetric information in property-casualty, life, and health insurance markets. These include Cawley and Philipson (1999), who study the U.S. life insurance market, Cardon and Hendel (1999), who study the U.S. health insurance market, and Chiappori and Salanie (2000), who study the French automobile insurance market. In contrast, Cutler (2001) reviews a substantial literature that finds evidence in support of asymmetric information in health insurance markets. These conflicting results raise the question of whether asymmetric information is a practically important feature of insurance markets.

This paper tests two simple predictions of asymmetric information models using data from the annuity market in the United Kingdom. The first is that higher risk individuals self-select into insurance contracts that offer features that, at a given price, are more valuable to them than to lower risk individuals. The second is that the equilibrium pricing of insurance policies reflects the fact that the risk pool varies across different policies. Such self-selection across policies by risk type would not occur if the insurer and the insured had symmetric information.

Most existing empirical work has tested such predictions using only one feature of the insurance contract: the amount of payment in the event that the insured risk occurs. Our detailed data on annuity contracts allow us to consider adverse selection on many different features of insurance contracts. Like several recent studies, we fail to find evidence of adverse selection on the amount of payment in the event that the insured risk occurs. However, we find strong evidence of adverse selection along other dimensions of the insurance contract. Our findings therefore suggest the importance of looking at multiple features of insurance contracts when testing for adverse selection. They also raise the interesting issue of why it seems possible to detect selection on some margins but not on others.

Annuity markets present a particularly appealing setting for studying asymmetric information issues. Most tests for asymmetric information cannot distinguish between adverse selection and moral hazard, even though the welfare implications of the two, and their potential policy implications, are often quite different. Moral hazard seems likely to play a smaller role in annuity markets, however, than in many other insurance markets. While receipt of an annuity may lead some individuals to devote additional resources to life-extension, we suspect that this is likely to be a quantitatively small effect. If the behavioral effects of annuities are small and the associated moral hazard problems are limited, testing for asymmetric information in the annuity market offers a particularly valuable test for adverse selection.

Annuity markets are also of substantial interest in their own right. Mitchell, Poterba, Warshawsky, and Brown (1999) emphasize that annuities, which provide insurance against outliving one's resources, play a potentially important welfare-improving role for retirees. But in spite of the potential value of annuity products for households that face uncertain mortality and have fixed resources, voluntary annuity markets in both the United States and the United Kingdom are small. Adverse selection has often been suggested as a potential explanation for the limited size of these markets.

This paper is divided into six sections. The first describes the theoretical predictions of asymmetric information models that form the basis of our empirical tests, and summarizes the previous literature that has tested for asymmetric information in insurance markets. Section two describes the general operation of annuity markets. It notes several specific features of the annuity market in the United Kingdom that are relevant for our analysis. It also describes how the theoretical predictions of asymmetric information models apply in the specific context of the U.K. annuity market. The third section describes the data set that we have obtained from a large U.K. insurance company, and compares the annuitants at this firm with those in the market at large.

Section four explores the relationship between mortality patterns and annuity product choice. We develop hazard models that relate the probability of annuitants dying after purchasing annuities to detailed characteristics of the annuity policy, as well as other information about the annuitant that is known to the insurance company. The empirical findings indicate that ex-post annuitant mortality varies systematically across annuities with certain characteristics. This variation is consistent with theoretical models of asymmetric information.

The fifth section investigates the pricing of different annuity products. We report hedonic pricing models that include different features of annuity policies. We also present some evidence on the pricing formula used by the insurance company whose data we analyze. We find that annuity pricing is consistent with our estimates of mortality differences across annuity features. Features that our hazard models indicate are selected by low mortality individuals, the "high risk" annuity buyers from the perspective of the insurance company, are priced higher than features that are selected by high-mortality individuals.

We do not, however, find evidence that mortality rates differ, or that marginal prices differ, across annuities with different initial annual annuity payment. The initial annual annuity payment is a crude measure of the size of the annuity policy, and it is our best approximation to the "amount of insurance" that features in most theoretical discussions of adverse selection. This finding underscores the importance of considering adverse selection along a range of different insurance policy attributes.

The final section summarizes our findings and considers whether they can be explained by factors other than adverse selection.

1. Adverse Selection in Insurance Markets: Theory and Evidence

This section describes the general nature of insurance market equilibrium in the presence of adverse selection. The next section applies the analysis to the annuity market. This section also includes a brief summary of existing empirical research on asymmetric information in insurance markets.

1.1 Theoretical Background

The classic models of insurance market equilibrium in the presence of adverse selection share a common assumption that individuals have private information about their risk type. These models differ on many other dimensions, such as the terms of the equilibrium concept used and the restrictions placed on the set of allowable contracts. Chiappori (2000) and Chiappori and Salanie (2000) review many of these models and discuss their common theoretical predictions.

A central shared prediction of models of asymmetric information is that higher risk types will buy more insurance. This is because, under asymmetric information, insurance contracts cannot offer individual-specific prices that reflect individual-specific risk. The consumer therefore acts as a price taker facing an equilibrium set of possible contracts. Since, at a given price, the marginal utility of insurance is increasing in risk type, higher risk individuals will choose to purchase more insurance than the lower risk individuals who face the same set of options.

Most theoretical models of insurance market equilibrium investigate insurance contracts that vary only in terms of price and the amount of payout in the event of a claim. It is straightforward, however, as Smart (2000) points out, to generalize these models to allow for a multi-dimensional vector of insurance product characteristics. Such a generalization is important for empirical work since insurance contracts, in practice, have many features that affect the effective amount of insurance provided. Models of equilibrium with asymmetric information predict a positive correlation between risk type and insurance contract features that increase the effective amount of insurance provided. More generally, the models predict that in an asymmetric information equilibrium, high risk types will select any feature of an insurance contract for which the marginal value, at a given price, is higher for them than for low risk types.

Under asymmetric information, we should therefore observe self-selection based on any feature of an insurance contract that satisfies this single crossing property. This prediction forms the basis of our first set of empirical tests. We examine whether characteristics of the annuity contract that are more valuable to higher risk (longer-lived) individuals are selected in equilibrium by individuals who, ex-post, are observed to have lower mortality rates. A second component of our empirical analysis tests the prediction that insurance companies should charge more for features of insurance contracts that are purchased by higher risk types than for features that are purchased by lower risk types. In practice, insurers may observe some risk features of those who purchase insurance. The stylized models described above therefore apply to individuals who are observationally equivalent to the insurance company, and the foregoing predictions apply <u>conditional</u> on the observed characteristics.

Chiappori (2000) notes that asymmetric insurance models can be classified into two broad types: those that assume individuals must purchase exclusive insurance contracts from a single insurer, and those that allow the purchase of multiple contracts. The latter are known as non-exclusive contracts. The prediction of a positive correlation between risk type and features of an insurance contract that increase its effective amount of insurance is not sensitive to whether contracts are assumed to be exclusive or not. The prediction that pricing should respond to such self-selection is also common to both classes of models, as long as the contract feature cannot be replicated by purchasing some combination of lower-priced features.

The exclusivity assumption generates one additional prediction about the equilibrium pricing relationship: even replicable features of an insurance contract should be priced to reflect risk type. Specifically, the marginal price of an additional unit of insurance should be increasing in the amount of insurance purchased. Non-exclusive contracts rule out such convex pricing schedules, for individuals would respond to such schedules simply by replicating a high-quantity insurance contract with several low-quantity, lower-priced ones.

Exclusivity requires that insurance companies can monitor total insurance purchases. This may be particularly difficult in annuity markets. Unlike home or auto insurance policies, which pay out only infrequently, if ever, annuities are almost certain to make some payments and may make many payments. For most other insurance products, the insurance company can stipulate that the contract is valid only if the insured has not purchased other insurance, and investigate compliance upon submission of a claim. Doing this with an annuity would require continuous monitoring, and could therefore be quite costly. This has led Abel (1986), Brugiavini (1993) and Chiappori (2000), among others, to argue that it would be difficult to offer annuities with marginal prices that rose as a function of the annuity payment.

In our empirical work below, we distinguish between characteristics of contracts that are non-replicable – and for which the pricing prediction holds regardless of whether we assume excludability – and features that are replicable. For the latter, we can directly investigate whether there is evidence of convex pricing. We view such tests as exploring the validity of the popular assumption that annuity contracts are non-exclusive, rather than as testing for the presence of asymmetric information in the annuity market.

1.2. Empirical Tests of Asymmetric Information in Insurance Markets

There is conflicting empirical evidence on the presence of asymmetric information in insurance markets. Most of the evidence in support of asymmetric information comes from the health insurance market. For example, Marquis (1992), in a study of data from the RAND Health Insurance experiment, finds that individuals who select more generous health insurance plans are more likely to have large health expenditures. This matches the empirical prediction of a positive correlation between risk type and insurance coverage under asymmetric information. Cutler (2001) reviews a number of other studies that reach similar conclusions. There are also several examples, notably those documented by Cutler and Reber (1998) and Buchmueller and Feldstein (1997), of "dynamic adverse selection," in which the pool of participants in particular insurance plans becomes more and more selected over time, eventually leading to the disappearance of the plan. Even still, the evidence from the health insurance market is not unambiguous. Cardon and Hendel (1999), for example, fail to reject the null hypothesis of symmetric information in health insurance markets.

In insurance markets other than health insurance, the preponderance of recent research fails to reject the null hypothesis of symmetric information. These papers examine the relationship between ex-post risk type and insurance coverage, conditional on observable characteristics of individuals. In the U.S. automobile insurance market, Pueltz and Snow (1994) find a positive relationship between risk type and the amount of insurance purchased; this supports the prediction of asymmetric information models. They find that higher risk individuals, measured by ex-post accident probabilities, choose policies with lower deductibles, and hence greater insurance coverage.

However, several other studies reach a different conclusion, using data from different insurance markets. Chiappori and Salanie (2000) examine French automobile insurance markets. They relate both quantity of insurance and ex-post risk type to exogenous variables, and then test for a positive correlation between the errors of the two estimating equations. Such a positive correlation is predicted under asymmetric information. However, they cannot reject the null hypothesis that the two sets of residuals are uncorrelated. In another study, Cawley and Philipson (1999) examine the relationship between insurance coverage and risk in the U.S. life insurance market. They too cannot reject the null hypothesis that risk type and amount of insurance coverage are uncorrelated.

One common limitation to most previous studies is their focus on a one-dimensional screening variable: the amount of payment in the event of an accident. Chiappori and Salanie (2000) acknowledge that there are "many different comprehensive coverage contracts on offer," but they focus on a binary measure of whether the individual has anything more than the legal minimum level of coverage. Similarly, Cawley and Philipson (1999) examine the relationship between risk type and the amount the term insurance policy would pay out in the event of death, while ignoring other potential characteristics of the life insurance contract, such as renewability, along which self-selection might occur. In practice, many aspects of insurance contracts may satisfy the single crossing property and therefore induce self-selection on the basis of privately known risk information. Our detailed policy data allow us to test for self-selection on multiple dimensions of the policies.

Some of the studies mentioned above also examine the pricing of insurance contracts. They test a prediction of models of asymmetric information with exclusive contracts, namely that insurance policies with more comprehensive coverage should sell at higher marginal prices. Pueltz and Snow (1994) find evidence in support of this prediction in the automobile insurance market. In the life insurance market, however, Cawley and Philipson (1999) find no evidence that the marginal price of insurance rises with the amount of payment of the event of death. This is consistent with their finding of a lack of correlation between risk type and amount of insurance coverage.

2. Background on Annuities and Annuity Markets

This section presents an overview of the annuity market in the United Kingdom. It then applies the framework developed in the last section to this market, and formalizes the model-based predictions that underpin our empirical work.

2.1 Annuity Market Overview

An annuity is a contract that pays a pre-specified amount to a beneficiary, the annuitant, for as long as the annuitant is alive. It thus insures the annuitant against the risk of outliving his accumulated resources. In some ways, annuities function as reverse life insurance, insuring against the risk of living too long rather than against the risk of dying too soon. From the standpoint of an annuity insurance company, a high-risk individual is an individual who is likely to live longer than his observable attributes, such as age, would otherwise suggest.

Yaari (1965) documented the welfare-improving role of annuities for individuals facing uncertain mortality. In light of this, the small size of the voluntary annuity market in the United States and the United Kingdom has puzzled many researchers. One possible explanation for the small market size is adverse selection. A number of previous studies suggest that annuity markets are characterized by some adverse selection. The pricing of voluntary annuities in both the U.S. and the U.K. implies that, for a typical individual from the population, the expected present discounted value of payouts are only 80 to 85 percent of the annuity's initial premium. Part of the divergence between this expected payout and the cost of the annuity is due to administrative loads, but roughly half appears to be due to adverse selection. If the typical annuitant is longer lived than the typical individual drawn at random from the population, then annuities priced to reflect the longevity of the annuitant population will not be actuarially fair for the typical individual in the population. Indeed, market-wide mortality tables published in the U.S. and the U.K. based on the mortality experience of voluntary annuitants suggest that the typical voluntary annuitant 65-year-old male is expected to live twenty percent longer than the typical 65-year-old male in the population.[1]

While these mortality patterns are consistent with adverse selection into the annuity market, they do not provide evidence on the relationship between mortality rates and the type of annuity purchased. We are not aware of any published mortality tables that distinguish annuitants by the type of policy that they purchase, even though this relationship is the central prediction of models of insurance markets with asymmetric information. Our data permit a direct investigation of this relationship.

The United Kingdom's annuity market provides a particularly rich setting for studying adverse selection. There are effectively two annuity markets in the United Kingdom. One is a compulsory annuity market in which individuals who have accumulated savings in tax-preferred retirement saving vehicles are required to annuitize a large portion of their accumulated balance. There is also a voluntary annuity market in which individuals with accumulated savings may use these assets to purchase an annuity. Finkelstein and Poterba (2001) suggest that adverse selection, as measured by the average price of annuity contracts, is roughly half as great in the compulsory market as in the voluntary market.

A wide variety of annuity products are sold in both the compulsory and voluntary annuity markets. This suggests that there is scope for selection among annuity products in both markets. We focus our analysis on annuities that offer a pre-determined payment stream. We also limit our analysis to annuities that insure a single life, as opposed to joint life annuities that continue to pay out as long as one of several annuitants remains alive.

We pay particular attention to three features of annuity policies that affect the effective quantity of insurance provided. One is the initial annual annuity payment. This is the analog of the payment in the event of a claim, or "quantity" in most stylized theoretical models. We also identify two other features of the annuity contract that affect the effective amount of insurance provided.

One is the annuity's tilt, or degree of backloading. A more backloaded annuity is one with a payment profile that provides a greater share of payments in later years. Most annuities are nominal annuities, which pay out a constant nominal amount each period. In a world with positive expected inflation, the expected real payment stream from such an annuity is declining over time. An escalating annuity, in contrast, provides a payment stream that rises at a pre-specified nominal rate in each year. Annuities escalate at a nominal rate of anywhere from 3% to 8.5% in our data; they may exhibit rising

[1] Finkelstein and Poterba (2001) and Murthi, Orszag, and Orszag (1999) present summary information and mortality comparisons for the U.K. annuity market. Brown, Mitchell, and Poterba (2001), and Poterba and Warshawsky

real payouts, depending on the expected rate of inflation. There are also real (i.e. inflation-indexed) annuities, which pay out a constant real amount in each year. The payments from real annuities and from escalating annuities are both backloaded relative to those from nominal annuities. We therefore refer to escalating and index-linked annuities as backloaded annuities.

A second feature that we focus on is whether the annuity may make payments to the annuitant's estate. Some annuities offer guarantee periods. The insurance company continues to make payments to the annuitant's estate for the duration of the guarantee period even if the annuitant dies before the guarantee period expires. Annuities with guarantee periods of one to fifteen years are present in our data sample, although in the compulsory market, regulations forbid the sale of policies with guarantee periods of more than ten years. "Capital protection" is another form of potential payments to the estate. If at the date of the annuitant's death the sum of nominal annuity payments to date is less than the premium paid for the annuity, a capital-protected annuity pays the difference to the estate as a lump sum. Annuities that make payments to the estate offer less insurance than ones that do not. An extreme example makes this clear: a 50 year guaranteed annuity purchased by a 65 year old male offers effectively no insurance. Its payments will be the same as that of a 50 year bond, since this individual is certain to be dead by age 115.

2.2 Testing for Asymmetric Information in the Annuity Market

Our empirical work explores whether the annuitants who choose different annuity features differ in their mortality experience and whether the pricing of these different features reflects any selection-based mortality differences across features. The models of asymmetric information discussed above predict that annuity features that increase the effective amount of insurance provided should be selected in equilibrium by higher risk individuals. More generally, features of an annuity that at a given price are more valuable to higher risk individuals should be selected by such individuals in an asymmetric information equilibrium.

It is straightforward to see that the amount of insurance is increasing in the initial amount of annuity payment. In addition, backloading increases the effective amount of insurance and payments to

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(2000), present related information for the U.S. market.

the estate decrease the effective amount of insurance in a given annuity contract. A backloaded annuity has more of its payments in later periods than an annuity with a flat payment profile. An annuitant with a longer life expectancy is more likely to be alive in later periods when the backloaded annuity pays out more than the flat annuity. Such an annuitant therefore expects to gain more, at a given price, from a backloaded annuity than does an annuitant with a shorter life expectancy. Similarly, an annuity that pays out more in the event of an early death, either with a guarantee period or with capital protection, is of greater value to an individual who is shorter lived than to one who is longer lived. These features thus satisfy the single crossing property that, at a given price, the marginal value of the various annuity product features vary monotonically with risk type.

The theoretical models of equilibrium with adverse selection therefore make several predictions about the relative mortality patterns of different annuitants. Those who buy more backloaded annuities should be longer lived, conditional on observables, than those who buy less backloaded policies. In a similar fashion, those who buy annuities that make payments to the estate should be shorter-lived, and that those who buy annuities with larger initial annual payments should be longer lived, conditional on what the insurance company observes about the insured, than other annuitants.

The theoretical models also make predictions with respect to the pricing of annuity contracts. Recall that with non-exclusive contracts, features of the annuity that are selected by high risk types should be priced correspondingly higher than those purchased by low risk types provided that the features cannot be replicated by purchasing a combination of lower priced contracts. With exclusive contracts, this pricing prediction holds even if the feature is replicable with a combination of lower priced features. The non-replicability requirement applies to both backloaded and guaranteed annuities. Individuals who desire a backloaded annuity cannot replicate such an annuity buy buying several (cheaper) immediate nominal annuities, and someone who wants a guaranteed annuity cannot create such annuity by purchasing multiple non-guaranteed policies. Similarly, within the class of guaranteed contracts, an individual cannot replicate a short guarantee period by buying several (cheaper) contracts with longer guarantee periods. Thus with or without excludability, under asymmetric information backloaded annuities should be priced higher to reflect the fact that in equilibrium they are purchased by individuals who are longer-lived than the buyers of non-backloaded annuities. Similarly, annuities that make payments to the annuitant's estate should be priced lower than those that do not, to reflect the fact that in equilibrium they are purchased by shorter-lived individuals. Annuities with longer guarantee periods should be priced even lower than annuities with shorter guarantee periods.[2]

Table 1 summarizes our predictions with respect to pricing and mortality patterns in the annuity market when there is adverse selection. These predictions would not obtain in a setting with symmetric information. Consider the case of the degree of backloading of the annuity. With symmetric information, a longer-lived annuitant has no incentive to buy an annuity with backloaded payments. Whatever annuity he buys, the insurance company will adjust the price charged to reflect his individual mortality prospects. Since the price adjusts, any preference for an annuity of a given tilt will be influenced only by discount rates, not by mortality prospects. When the annuitant has private information that he is likely to be long-lived, however, when he chooses to buy a particular annuity the price is not fully adjusted to take account of his mortality prospects. The key difference between the symmetric and asymmetric information scenarios is that under asymmetric information, the annuitant acts as a price taker, while under symmetric information, he does not. With asymmetric information, the price of a backloaded annuity will reflect the average mortality prospects of the annuitants who, in equilibrium, purchase backloaded annuities. This price will not reflect an individual annuitant's mortality prospects.

We test for asymmetric information in the annuity market by considering both mortality patterns and annuity prices. The fact that in practice, unlike in the stylized models, individuals differ on dimensions other than simply their risk type does not pose a problem for the interpretation of our empirical analysis. If product choice is driven not by private information about mortality but rather by (privately known) preference parameters such as discount rates, risk aversion, or bequest motives which

[2] If we also assume that annuities are exclusive contracts between the insurers and the insured, then models of insurance market equilibrium with asymmetric information also predict convex pricing in which the marginal price of insurance rises with the size of the initial payment. We test this prediction below, even though we view the assumption of exclusivity as unlikely to apply to annuity markets.

are correlated with mortality, the effect of such private information is similar to the effect of private mortality information. Anything that is correlated with mortality and is known by the individual but not to the insurance company, even if the individual does not recognize its effect on his mortality, operates just like traditional asymmetric mortality information. A potential annuitant's wealth may operate in just this way: higher wealth annuitants are likely to face lower mortality risks, but insurance companies are not aware of the total wealth of their annuity buyers.

3. Data and Descriptive Statistics

Our data set consists of information on the complete set of both compulsory and voluntary immediate annuities sold by a large U.K. annuity company over a seventeen-year period ending on December 31, 1998. The first year in our sample, 1981, was the first year when the company sold both voluntary and compulsory annuities. At the end of the sample period, the firm was among the ten largest U.K. sellers of new compulsory annuities.[3] The company's sales mix between compulsory and voluntary annuities shifts within our sample, with sales in the compulsory market growing more rapidly than sales in the voluntary market. This in part reflects the expansion in the late 1980s of the set of retirement savings plans that face compulsory annuitization requirements. In recent years, sales of voluntary annuities have been a small share of the company's total annuity sales.

Our data set includes almost everything that the insurance company knows about its annuitants. The only pieces of information that we did not receive from the company were the annuitant's address and his or her birthday. This information was suppressed to protect the confidentiality of the annuitants' identities. We did, however, obtain information on the annuitants' birth month and year. We have information on the type of policy purchased by the annuitant, and on the annuitant's day of death, if the annuitant died within the sample period. Death records are current through December 31, 1998. The insurance company collects very little information – only age and gender – about the personal

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[3] Information on the market share of various U.K. insurance companies in the annuity market may be found at *http://insider.econ.bbk.ac.uk/pensions/annuities/experiences/uk/q97s.htm*

characteristics of annuitants. In particular, it does not collect any information on the annuitants' wealth, income, education, occupation, or another other indicators of socioeconomic status. The information collection practices at the firm we study are typical for insurance companies selling annuities in the U.K.

We restrict our attention to single life annuities, annuities whose payments are based on the mortality of one individual, because the mortality patterns of the single insured lives on each policy provide a straightforward measure of ex-post risk type. Brown and Poterba (2000) note that it is considerably more complicated to analyze the joint mortality patterns of couples with joint life annuities than to analyze the mortality pattern for a single annuitant. Our final sample size is 42,054 annuity policies.

Table 2 provides an overview of the characteristics of the compulsory and voluntary annuities sold by the company that we analyze. The voluntary market accounts for about one tenth of the policies in our sample, and a somewhat higher fraction of premiums. The relative magnitudes of the voluntary and compulsory market sales for our sample company are similar to those reported by the Association of British Insurers (various years) for the aggregate U.K. market. Differences between voluntary and compulsory annuitants in our data sample also appear typical of the U.K. market as a whole. Table 2 shows that voluntary annuitants are substantially older than compulsory annuitants. They are also more likely to be female. This is consistent with tabulations from the Family Resources Survey reported in Banks and Emmerson (1999). The product mix of annuities sold by our sample firm also matches the limited aggregate data that exist on the product mix for the U.K. market as a whole. Index-linked and escalating products together make up less than 10% of the voluntary or the compulsory market, with index-linked policies less than 5% in each market. Murthi, Orzsag, Orszag (1999) report a similar preponderance of nominal annuities in a data set that includes all insurance companies selling annuities in the United Kingdom.

The modal policy in the compulsory annuity market for 1997 and 1998, when compulsory annuity sales peaked for our sample firm, was a nominal annuity with a five-year guarantee period sold to a 65-year-old man. In the voluntary market, the modal policy in 1984 and 1985, which together account for more than one quarter of the voluntary annuity sales in the sample, was a nominal annuity with no guarantee, sold to a 74-year-old woman. These differences underscore the distinct character of the compulsory and voluntary annuity markets.

4. Annuitant Mortality and Annuity Product Choice

To test the predictions of asymmetric information models regarding the relationship between insurance product choice and risk type, we estimate hazard models for the mortality experience of annuitants who purchase different types of annuities. This section presents our empirical findings. In the next section, we investigate whether the variation in prices across different types of annuities accords with the estimated mortality differences.

4.1 A Hazard Model Framework for Studying Annuitant Mortality

We estimate mortality differences among different groups of annuitants using the discrete-time, semi-parametric, proportional hazard model used by Meyer (1990) and Han and Hausman (1990). Our duration measure is the length of time the annuitant lives after purchasing an annuity. We let $l(t, x_i, b, l_0)$ denote the hazard function, the probability that an annuitant with characteristics x_i dies t periods after purchasing the annuity, conditional on living until t.

The proportional hazard model assumes that $l(t, x_i, b, l_0)$ can be decomposed into a baseline hazard $l_0(t)$ and a "shift factor" $f(x_i, b)$ as follows:

(1) $$l(t, x_i, b, l_0) = f(x_i, b)\, l_0(t).$$

The baseline hazard, $l_0(t)$, is the hazard when $f(\cdot)$=1. $f(\cdot)$ represents the proportional shift in the hazard caused by the vector of explanatory variables x_i with unknown coefficients b. The proportional hazard model in (1) restricts the effects of the explanatory variables (x_i) to be duration-independent.

We adopt one of the common functional forms for $f(\cdot)$, $f(x_i; b) = \exp(x_i' b)$. The proportional hazard model is then written as:

$$(2) \qquad l(t, x_i, b, l_0) = \exp(x_i' b)\, l_0(t)\,.$$

Specification of the baseline hazard $l_0(t)$ is a key issue in estimating models like (2). We model the baseline hazard non-parametrically as a step function. This allows us to avoid imposing any restrictive functional form assumptions on the baseline hazard. We have seventeen years of data and we allow for seventeen, annual, discrete, time periods. If we let $d_t = \int_0^t l_0(s)ds$ denote the integrated baseline hazard, the proportional hazard model in (2) becomes:

$$(3) \qquad l(t_i; x_i, b, d) = 1 - \exp\{\exp(x_i' b)(d_t - d_{t+1})\}\,.$$

Models in which the hazard function is given by (3) can be estimated by maximum likelihood with the log likelihood function given by

$$(4) \qquad \ln(L) = \sum_{i=1}^{n} (1 - c_i) \ln(l(t_i; x_i, b, a)) - \int_0^t l(s_i; x_i, b, a)ds$$

where c is an indicator variable that equals 1 if the individual survives until the end of our sample period and 0 otherwise. Eighty-four percent of the voluntary annuitants in our sample, and 47 percent of the compulsory annuitants, survive until the end of our sample.

We estimate hazard models for annuitant deaths as a function of all of the known characteristics of the annuitants and their annuity policies. Our hazard models do not include any measure of "marginal price" because all of the known characteristics of the annuity product and the annuitant, which are in the models, should completely determine both the policy premium and the marginal price. We estimate separate models for annuitants in the voluntary and compulsory markets. In all of the hazard models we include indicator variables for the age at purchase of the annuity (in five-year intervals), the year of purchase of the annuity, and the gender of the annuitant. We also include indicator variables for the frequency of annuity payments (monthly, termly, quarterly, semi-annually or annually).

We include two indicator variables to capture the degree of backloading of the annuity payment. One is an indicator for whether the annuity payments are indexed to inflation, and the other is an indicator for whether the annuity payments are escalating in nominal terms. Nominal annuities are the omitted category. The theory described above suggests that individuals who buy index-linked or escalating annuities should be longer lived than those who buy nominal annuities. They should therefore have a lower hazard and so the predicted coefficients on the indicator variables for “index-linked” and for “escalating” in the hazard model are negative. We cannot predict the relative magnitude of these two coefficients, since the choice that a long-lived individual would make between an escalating and an indexed annuity will depend on the rate of expected inflation and the individual's discount rate.

We also include two indicator variables to capture payments to the estate. One is for whether the annuity is guaranteed, and the other is for whether the annuity is capital protected. An annuity cannot be both guaranteed and capital protected. The omitted category is an annuity that does not make any payments to the estate. The theory described above predicts that individuals who buy annuities with more payments to the estate will be shorter-lived (i.e. have a higher hazard rate) than individuals who buy annuities that do not make any payments to the estate. The predicted coefficients on the indicator variables for "guaranteed" and "capital protected" in the hazard model are therefore positive. There is no prior prediction concerning the relative longevity of guaranteed and capital protected annuitants, as there is no clear measure of which is relatively more attractive to someone with mortality that diverges from the population average. Thus there is no prediction about the relative size of their coefficients.

Finally, we include one other annuity product characteristic that satisfies the single crossing property and along which we might therefore expect to observe self-selection: the initial annual annuity payment. This “payment” variable corresponds to the amount that would be paid out in life insurance in the event of death or the amount that would be paid out from an automobile insurance policy in the event of an accident. The theory described above predicts that individuals who face greater payments in the event of a claim will be longer lived than individuals who face smaller payments in the event of a claim. The predicted coefficient on the “payment” variable in the hazard model is therefore negative. Table 1 summarizes these predictions in columns one and two.

4.2 Basic Results: Annuity Choice and Mortality Patterns

Table 3 presents estimates of the hazard model in equation (3). The first column presents estimates from the compulsory annuity market, while the second column presents estimates from the voluntary market. The results closely match our theoretical predictions of self-selection under asymmetric information.

In both the compulsory and the voluntary market, there is strong evidence that individuals who buy more backloaded annuities are longer-lived. The coefficients on indicator variables for index-linked and escalating annuities are negative and statistically significant at the 1% level in both markets, indicating that all else equal, individuals who buy these annuities have a lower mortality hazard rate than individuals who buy nominal annuities.

There is also evidence that voluntary annuitants who buy annuities that make payments to the estate in the event of an early death are shorter lived than individuals whose annuities do not make such payments. The coefficient on the indicator variable for guaranteed payouts is positive, indicating that individuals who buy guaranteed annuities have higher hazards, and hence are shorter-lived, than observationally similar individuals who buy non-guaranteed, non-capital protected annuities. This coefficient is statistically significantly different from zero at the 1% confidence level in the voluntary market. Additionally, the coefficient on the indicator variable for a capital-protected annuity has the expected positive sign in the voluntary market, indicating that individuals who buy these annuities are shorter lived than observationally similar individuals who buy non-guaranteed, non-capital protected annuities. These mortality differences are not, however, statistically significantly different.

In the compulsory market, the results in Table 3 indicate that although individuals who buy guaranteed annuities are shorter lived than individuals who buy non-guaranteed annuities, the difference in hazard rates is also not statistically significant. However, in the compulsory market we can look separately at hazard rates by length of guarantee period. Of the 28,424 annuitants in the compulsory market who purchased guaranteed annuities, 24,173 purchased five year guaranteed annuities while 4,150 purchased 10 year guaranteed annuities. Less than half a percent purchased some other length of guarantee. In results not reported here, we find that although guaranteed annuitants as a group are not significantly shorter lived than non-guaranteed annuitants, annuitants with 10 year guarantee periods, the longest in the compulsory market, are significantly shorter lived (at the 5 percent level) than annuitants with non-guaranteed annuities. We also find that the hazard increases monotonically from no guarantee period to five years to 10 years and that the mortality differences between individuals with five year guarantee periods and 10 year guarantee periods are also statistically significantly different at the 5 percent level. These results are consistent with the equilibrium models that assume adverse selection in the insurance market. We cannot test similar predictions about selection by amount of escalation for escalating annuities in the compulsory market, or selection by either length of guarantee period or amount of escalation in the voluntary market, due to issues of small sample size.

Table 3 also provides evidence that in the compulsory market, but not in the voluntary market, annuitants with a higher initial annual payment are longer lived than annuitants with a lower initial annual payment. The result in the compulsory market is the one predicted by models of insurance market equilibrium with adverse selection. These results are broadly consistent with market-wide data on the relationship between the size of the annuity and the mortality of the annuitant. For example, the Institute of Actuaries (1999a, 1999b) reports that while those who buy larger compulsory annuity policies tend to live longer than those who buy smaller policies, there is no discernable relationship between annuity size and mortality in the voluntary market.

It is important to note that in both the voluntary and the compulsory market, the estimated effect of the amount of initial payment is extremely small compared to the magnitude of the other screening devices. Thus the difference between positive and negative coefficients in this case is not substantively important. To illustrate this, we translate the hazard model coefficients into survival probabilities for individuals with different types of annuities. This involves using the estimated baseline hazard as well as the coefficients on all of the covariates to estimate survival probabilities for particular types of individuals. Appendix Table A presents the estimated baseline hazard functions used in these calculations.

Table 4 presents information on the probability that a 58-year-old annuity buyer will survive until age 75, conditional on different types of annuity purchases. The "baseline" survival probability, which is shown in the first row, is that for a 58 year old female annuitant who purchases a nominal, non-guaranteed, annual payment, single life annuity in 1981. This annuity is assumed to pay the company's average initial annuity payment, with different averages used in the voluntary and compulsory markets. Subsequent rows show the corresponding survival probabilities that emerge when we change single dimensions of the annuity policy.

The first column of Table 4 shows the results for the compulsory market. The second column of Table 4 shows the results for the voluntary market. Looking across these columns, our estimates indicate substantially lighter mortality in the voluntary market relative to the compulsory market. This is consistent with market-wide mortality tables for the compulsory and voluntary annuity markets (Institute of Actuaries, 1999a and 199b). In results not reported here, we estimate hazard models on the combined sample of voluntary and compulsory annuitants, allowing for a complete set of interactions between whether the annuitant is in the voluntary or compulsory market and all product and individual characteristics. Consistent with market-wide data, we find that in our firm, the mortality of voluntary annuitants is statistically significantly lower at the 1 percent level than the mortality of compulsory annuitants. This is consistent with greater adverse selection into the voluntary market than into the compulsory market.

The rows in Table 4 suggest large mortality differences among certain classes of annuitants within each market. For example, in the compulsory market, the baseline annuitant has a 64% chance of surviving to age 75. The switch to an index-linked but otherwise-identical annuity is associated with a survival probability of 83%, or a 30% increase in the survival probability compared to the baseline (nominal) annuity. In contrast, a one standard deviation increase in the initial annual annuity payment, from the mean, is only associated with a conditional survival probability of 66%, or a 3% increase in the 64% baseline survival probability.

In the voluntary market, we note that the mortality difference associated with guaranteed payments is somewhat smaller than that associated with backloading. For example, the probability that the baseline annuitant survives to 75 is 92% in the voluntary market. It is 97% for those in the index-linked annuity market and 98% for those in the escalating annuity market, but only 90% for those in the guaranteed annuity market. These results suggest that annuitants self-select to a greater degree based on the amount of backloading of payments than on the presence or absence of a payout guarantee.

To facilitate interpretation of these mortality differences, we can compare the mortality differences in Table 4 to the mortality differences between male and female annuitants. The mortality table for compulsory annuitants suggests that a 58-year-old male (female) annuitant has a 42% (64%) chance of surviving until 75. A 58-year-old female annuitant who purchases an escalating annuity has an 86% survival probability to age 75. Therefore the increase in survival probability associated with purchasing an escalating annuity (34%) in the compulsory market is about the same as the increase associated with switching the gender of the annuitant from male to female. In the voluntary annuity market, the increase in survival probability associated with purchasing an escalating annuity (7%) is even larger than the increase associated with being female (2%).

The results in Tables 3 and 4 suggest substantial mortality selection based on the backloading of the annuity, some mortality selection based on payments to the estate, and very little – if any – selection of annuitants based on the initial annual payment of the annuity. The lack of selection on initial annual annuity payment supports results obtained by Cawley and Philipson (1999) for life insurance and by Chiappori and Salanie (2000) for auto insurance. Each of these papers examines only one potential characteristic of the insurance contract along which selection can occur. In the first study it is the amount paid in the event of death, and in the second it is whether the individual has more than the legally-required minimum level of insurance. Both of these variables resemble the initial annual annuity payment in our screening model. While our results, like those in the other studies, suggest little selection on this variable, they suggest substantial screening on other margins of insurance policy choice.

4.3 Sensitivity Analysis

While our initial findings provide substantial support for the role of selection effects in the annuity market, we also developed several tests designed to explore these results – and their robustness – in greater detail. We examined whether the magnitude of selection effects among annuity products varied across groups of annuitants. For example, we tested whether mortality differences across annuity products were of the same magnitude for men and for women. We included a full set of interactions between all of the covariates and the gender of the annuitant in our basic hazard model, while constraining men and women to exhibit the same baseline hazard. We were unable to reject the null hypothesis that selection effects among annuity products were the same for men and for women.

We also subjected the results to a variety of robustness checks. We estimated the hazard models separately for men and women to allow the baseline hazard to be different for these two groups. We estimated the hazard models on several-year subsamples of our complete data set to check whether our results were contaminated by time trends in the annuity market that could be correlated with product characteristics and mortality. And we re-estimated the hazard model using total age rather than years since purchase of the annuity as our duration measure. Virtually all of the results discussed above were robust in sign and significance to these various checks.

One notable finding concerns the variable measuring the initial annuity payment. When we estimated separate hazard models for male and female annuitants, this variable was only statistically significant for men in the compulsory market and for women in the voluntary market, with the signs shown in Table 3. The gender-related difference in this coefficient bears further investigation and underlines the lack of systematic evidence of selection on the amount of the initial annuity payment.

5. Pricing Differences Across Annuity Products

Our hazard model results suggest clear relationships between certain annuity product characteristics and annuitant mortality. We now consider the relationship between annuity product characteristics and annuity prices. Recall that if annuitants self-select among insurance products on the basis of private information about their mortality, then in equilibrium, prices on different annuity features should adjust to reflect feature-specific average mortality.

5.1 Calculating Annuity Prices and the "Money's Worth" Concept

The price of an annuity is not the premium that the annuitant pays when he or she purchases an annuity, but the differential between this premium and the expected present discounted value of annuity payouts. The price is therefore related to the annuity's "money's worth," which earlier studies such as Mitchell, et al. (1999) have defined as the expected present discounted value of annuity payouts divided by the premium. The expected present discounted value is calculated using the mortality curve of a typical individual in the population, so an annuity that is actuarially fair for such an individual will have a money's worth of unity. Money's worth values may be less than one when there are administrative costs associated with the annuity policy, or if the mortality rate of the individuals buying an annuity is lower than that in the population at large. One minus the money's worth value equals the price of the annuity.

If the individuals who buy annuity product j are, on average, longer-lived than individuals who buy annuity product k, then insurance companies will reflect these mortality differences in their pricing. Assuming that an insurance company's costs and markup are the same across products, a given premium should therefore purchase a lower payment stream for product j than for product k since the buyers of product j will, on average, outlive the buyers of product k. From the standpoint of an individual facing a given mortality table, such as the population mortality table, product j should have a lower expected present discounted value of payments, and hence a lower money's worth, than product k. This implies that annuity product j should have a higher price than annuity product k.

The formula for the money's worth of a nominal, non-guaranteed annuity is:

$$MW_{NOM} = \frac{\sum_{t=1}^{T} \frac{A * S_t}{\Pi_{j=1}^{t}(1+i_j)}}{P}. \qquad (5)$$

In this expression, A denotes the per-period payment from the nominal annuity, P denotes the initial premium payment, S_t denotes the probability that the annuitant survives until payment period t, and i_j denotes the expected nominal interest rate at time period j. The above formula is easily adjusted, as in Finkelstein and Poterba (2001), for the case of index-linked or escalating annuities, and for annuities that make payments to the annuitant's estate.

We calculate the money's worth value for each annuity in our data set using a common mortality table, the U.K. population cohort mortality table provided by the Government Actuaries' Department. This mortality table provides current and projected future mortality rates by age and sex, and we use the relevant rates for each individual who buys an annuity in our data set. In each case, we use mortality tables from the year in which the annuity is sold. For example, for a 65-year-old male who purchased an annuity in 1988, we use the 1988 population projections of his survival probability in each successive year. We use the zero-coupon yield curve of nominal U.K. Treasury securities on the day of annuity purchase to measure the term structure of nominal interest rates in equation (5). In calculating the money's worth of inflation-indexed annuities, we use data on the expected rate of inflation, as reported by the Bank of England, on the day of annuity purchase.

To explore how annuity prices are related to product characteristics, we regress the price of the annuity, defined as one minus the money's worth of the annuity, on characteristics of the annuity and the annuitant. The hedonic pricing equation, which we estimate by ordinary least squares, is:

$$\begin{aligned}(6)\quad & \text{PRICE}_i = \alpha + \beta_1 \text{INDEX}_i + \beta_2 \text{ESCALATING}_i + \beta_3 \text{GUARANTEED}_i + \beta_4 \text{CAPITAL}_i \\ & + \beta_5 \text{PAYMENT}_i + \beta_6 \text{PAYMENT}^2{}_i + \beta_7 X_i + \varepsilon_i\end{aligned}$$

X consists of all known features of the annuitant and the annuity product that are not labeled separately. These include the age of the annuitant at time of purchase (in five year groupings), the gender of the annuitant, the year of purchase, and a series of indicator variables for the frequency of the annuity payments. All of these variables were used in our hazard model analysis above.

Equilibrium requires that the prices of various annuity product features are affected by the selection behavior of different mortality types. We therefore expect a positive coefficient on an indicator variable for whether the annuity is index-linked and on an indicator for whether the annuity is escalating. Because we found the mortality of the annuitants who buy these products to be lower than that of nominal annuitants, we expect that the annual payments offered on these products will be lower than those for nominal annuities. This reflects the fact that escalating and indexed annuitants are likely to live longer than the annuitants who buy plain nominal annuities. As a result of the lower annual payments, the money's worth calculated using a common mortality table will be lower, and the price of the annuity will be higher, for escalating or indexed products than for nominal ones. Similarly, we expect a negative coefficient on indicator variables for whether the annuity is guaranteed and whether it is capital protected.

The pricing predictions described in the last paragraph hold whether or not insurance companies can enforce exclusive contracts. If exclusive contracts can be enforced, however, then the models also predict a rising marginal price of the amount of initial annuity payment (i.e. $\beta_6 > 0$). We can test the exclusivity of annuity contracts, indirectly, by studying the coefficients on the variables measuring the amount of the initial annuity payment.

5.2 Empirical Findings

Table 5 reports the hedonic regression results, which are generally supportive of the pricing patterns predicted under asymmetric information. The estimated coefficients on the indicator variables for guaranteed and capital protected annuities indicate that annuities that make payments to the estate have significantly lower prices in both the compulsory and the voluntary market than do annuities that do not make payments to the estate. This is consistent with the foregoing hazard model results that suggest that annuitants who purchase annuities that make payments to the estate are shorter lived (lower risk) than annuitants who purchase annuities that do not make payments to the estate. In results not reported here, we also find that the price of 10 year guaranteed annuities in the compulsory market is statistically significantly lower than the price of five-year guaranteed annuities in this market. This result is consistent with the selection results in the compulsory market reported above by length of guarantee period.

The results for backloading are similarly supportive. Index-linked annuities are priced significantly higher than nominal annuities in both the compulsory and voluntary market, reflecting the fact that the typical annuitant who purchases an index-linked annuity is longer lived (higher risk) than the typical annuitant who purchases a nominal annuity. In the compulsory market, but not the voluntary market, there is also evidence that escalating annuities have higher prices than nominal annuities.

The hedonic pricing equations also include the amount of the initial annuity payment. The negative coefficients on this variable in both markets are indicative of bulk discounts similar to those found by Cawley and Philipson (1999) in the U.S. life insurance market. The positive coefficient on the square of the initial annual payment is consistent with Rothschild and Stiglitz' (1976) prediction of a higher marginal price for larger quantities of insurance. However the magnitude of the coefficient is tiny, which suggests relatively little convexity in pricing.

Chiappori and Salanie (2000) and Chiappori (2000) note that estimation of a firm's pricing policy is notoriously difficult. Fixed costs and economies of scale and scope can introduce non-linearities in a firm's pricing schedule. Such nonlinearities can be difficult to distinguish from the predictions of models of asymmetric information. Fortunately, in addition to the hedonic pricing relationship estimated above, we have direct information on the sample firm's pricing policies. We were told that the insurance firm we are studying prices annuities, within a given class (such as guarantee period, tilt, frequency of payment, gender and age), as follows. If a £10,000 purchase price buys an annual payment of A, then a purchase price of P buys an annual annuity payment of (P*A)/10,000+([P-10,000]*f)/10,000) where f is the fixed policy fee. This formula applies both in the voluntary and the compulsory market.

To illustrate this pricing formula, consider an actual example. With £10,000 in 1999, a 65-year-old man could purchase an index-linked, single life, monthly payment, non-guaranteed annuity with an annual payment of £539.64. The fixed policy fee (f) was £18. This formula indicates the presence of bulk discounts for policies of less than £10,000 and it indicates a constant marginal price. Our estimates suggesting a very small bulk discount and an even smaller rising marginal price of increased annual payments are consistent with the pricing policy. The constant marginal price supports the assumptions made in much of the annuity literature that such products are examples of non-exclusive contracts.

6. Conclusion and Discussion

In this paper, we use a unique data set consisting of annuitants at a large U.K. insurance company to investigate whether mortality and pricing patterns across annuity products are consistent with models of asymmetric information in insurance markets. One of our primary contributions is testing for selection on multiple dimensions of the insurance policy. Our results on both mortality rates, and policy pricing, are consistent with adverse selection on some dimensions of the annuity contract. We nevertheless fail to find evidence for selection on the dimension of the contract most commonly studied in other papers: the amount of payment if the insured event occurs. These results highlight the importance of recognizing the institutional details of actual insurance contracts when testing theoretical models of asymmetric information. They also raise the intriguing question of why our empirical tests detect selection on some dimensions of annuity policies, but not on others. For those features that we do not find to be associated with adverse selection, the open question is whether selection occurs, but cannot be detected because of some confounding factor, or whether selection does not occur.

We find evidence of self-selection on two attributes of annuity policies: the time profile (backloading), and whether the annuity may make any payments to the annuitant's estate. All else equal, annuitants who are longer lived select annuities with payment streams that are backloaded and that therefore pay out relatively more of their value in later years. Similarly, annuitants who are shorter lived select annuities that make payments to the annuitant’s estate in the event of an early death. These selection effects are large. For example, in the compulsory annuity market, the mortality difference between otherwise identical individuals who purchase backloaded and non-backloaded annuities is similar in magnitude to the mortality difference between men and women. In the voluntary market, the mortality difference between backloaded and non-backloaded annuitants is several times larger than that between men and women. We also find evidence that backloaded annuities are priced higher than other annuities. Annuities with payments to the estate are priced lower than annuities that do not make payments to the estate. These pricing results are consistent with insurance companies taking account of selection effects in setting their prices.

Our findings on the differential mortality experience of annuitants who purchase different types of policies are consistent with individual having private information about their mortality experience, and acting on this information in their insurance purchases. These findings are complementary to survey-based studies, such as Hamermesh (1985) and Hurd and McGarry (1997), that have explored the extent to which individuals have informed, and plausible, views about their potential life expectancy. Such studies present evidence that individuals have private mortality information. Our results are not only consistent with individuals having private mortality information but also suggest that they use this information in making financial decisions about their later years.

While our results are consistent with the presence of adverse selection in the annuity market, two other potential explanations of our findings warrant some discussion. The first is that our results are an artifact of the particular firm whose annuity sales we have analyzed. This small sample concern is difficult to address without detailed data from other insurance firms, and we do not have such data. However, our comparison of characteristics of the sample of annuities sold by the insurance company whose policies we study with characteristics of the aggregate U.K. market did not suggest obvious differences in the pool of policyholders. Furthermore, although we only have detailed pricing and mortality data from one insurance company, Finkelstein and Poterba (2001) report on the pricing of annuities with different guarantee periods and different degrees of backloading in a sample of the major U.K. annuity companies. The aggregate patterns match those found for the single firm considered here.

A second concern is that our findings are not the result of adverse selection, but rather moral hazard. If individuals who purchase more insurance change their behavior in a way that results in higher claims against their insurance company, then we would observe the patterns we have documented in the relative mortality of different groups of annuitants. It is notoriously difficult to distinguish empirically between adverse selection and moral hazard. Even without such a distinction, our results provide evidence that is strongly suggestive of some type of asymmetric information in the annuity market. Our findings therefore stand in contrast to the recent claims of symmetric information in insurance markets, such as those by Cawley and Philipson (1999) and Chiappori and Salanie (2000).

Moreover, the case for interpreting findings like ours as due to moral hazard is arguably weaker for annuity markets than for most other insurance markets. For the moral hazard analysis to apply to annuities, the conversion of income to an annuity stream must affect the individual's mortality. It is possible, as Philipson and Becker (1998) note, that the presence of annuity income affects an individual's efforts to extend length of life. Even recognizing this potential effect, we suspect its quantitative importance is small, especially in a developed nation like the United Kingdom. Moreover, Banks and Emmerson (1999) report that among both voluntary and compulsory annuitants in the U.K., annuity income represents less than one fifth of annual income. This reduces the likelihood that the form of the income stream is affecting mortality.

Finally, it is important to note that we do not find evidence of self-selection on the initial amount of the annuity payment. This initial amount of annuity payment is analogous to measures of the accident-induced payment that are used in other empirical papers on asymmetric information in insurance markets. Our finding of a lack of selection on this feature is thus consistent with the evidence found in other insurance markets such as those studied by Cawley and Philipson (1999) and Chiappori and Salanie (2000). However, our findings of selection on other features of the annuity contract underscore the importance of examining multiple features of insurance contracts when testing for asymmetric information in insurance markets. They also raises the interesting question of what determinants whether or not selection occurs on a feature of the insurance contract that satisfies the single crossing property. We regard this as a natural challenge for future work.

BIBLIOGRAPHY

Abel, Andrew B. 1986. Capital Accumulation and Uncertain Lifetimes with Adverse Selection. Econometrica 54 (September), pp.1079-1097.

Association of British Insurers. 1997. Insurance Statistics Year Book: 1986-1996. London: ABI.

Banks, James and Carl Emmerson. 1999. UK Annuitants. London: Institute for Fiscal Studies. http://www.ifs.org.uk/publications/briefnotes.shtml

Brown, Jeffrey, Olivia Mitchell, and James Poterba. 2001. Mortality Risk, Inflation Risk, and Annuity Products. in Z. Bodie, B. Hammond, and O. Mitchell, eds., Innovations for Financing Retirement (Philadelphia: University of Pennsylvania Press, forthcoming).

Brown, Jeffrey and James Poterba. 2000. Joint Life Annuities and Annuity Demand by Married Couples. Journal of Risk and Insurance (forthcoming).

Brugiavini, A. 1993. Uncertainty Resolution and the Timing of Annuity Purchases. Journal of Public Economics, 50, pp.31-62.

Buchmueller, Thomas and Paul Feldstein. 1997. The Effect of Price on Switching Among Health Plans. Journal of Health Economics 16, 231-247.

Cardon, James and Igal Hendel. 1999. Asymmetric Information in Health Insurance: Evidence from the National Medical Expenditure Survey. Unpublished Mimeo, Princeton University Department of Economics.

Cawley, John and Tomas Philipson. 1999. An Empirical Examination of Information Barriers to Trade in Insurance. American Economic Review 89(4), pp.827-846.

Chiappori, Pierre-Andre. 2000. Econometric Models of Insurance under Asymmetric Information. In Georges Dionne, ed. Handbook of Insurance Economics. London: Kluwer (forthcoming).

Chiappori, Pierre-Andre and Bernard Salanie. 2000. Testing for Asymmetric Information in Insurance Markets. Journal of Political Economy, 108, 56-78.

Cutler, David. 2001. Health Care and the Public Sector. In A. Auerbach and M. Feldstein, eds., Handbook of Public Economics, Volume 3 (Amsterdam: North Holland, forthcoming).

Cutler, David and Sarah Reber. 1998. Paying for Health Insurance: The Tradeoff Between Competition and Adverse Selection." Quarterly Journal of Economics 113, 433-466.

Finkelstein, Amy and James Poterba. 2001. Selection Effects in the Market for Individual Annuities: New Evidence from the United Kingdom. Economic Journal (forthcoming).

Friedman, Benjamin, and Mark Warshawsky. 1988. Annuity prices and saving behavior in the United States. In Z. Bodie, J. Shoven, and D. Wise, eds. Pensions in the US Economy. Chicago: University of Chicago Press.

Friedman, Benjamin, and Mark Warshawsky. 1990. The cost of annuities: Implications for saving behavior and bequests. Quarterly Journal of Economics 105 (February), pp.135-154.

Hamermesh, Daniel. 1985. Expectations, Life Expectancy, and Economic Behavior. Quarterly Journal of Economics 100(May), 389-408.

Han, Aaron and Jerry Hausman. 1990. Flexible Parametric Estimation of Duration and Competing Risk Models. Journal of Applied Econometrics. 5:1-28.

Hurd, Michael and Kathleen McGarry. 1997. The Predictive Validity of Subjective Probabilities of Survival. NBER Working Paper 6193.

Institute of Actuaries and Faculty of Actuaries, Continuous Mortality Investigation Committee. 1999a. Continuous Mortality Investigation Reports, Number 16.

Institute of Actuaries and Faculty of Actuaries, Continuous Mortality Investigation Committee. 1999b. Continuous Mortality Investigation Reports, Number 17.

Marquis, M. Susan. 1992. Adverse Selection with a Multiple Choice Among Health Insurance Plans: A Simulation Analysis," Journal of Health Economics 11, 129-151.

Meyer, Bruce. 1990. Unemployment Insurance and Unemployment Spells. Econometrica, 58(4): 757-782.

Mitchell, Olivia S., James M. Poterba, Mark Warshawsky, and Jeffrey R. Brown. 1999. New Evidence on the money's worth of individual annuities. American Economic Review, 89(December), pp.1299-1318.

Murthi, Mamta, J. Michael Orszag, and Peter Orszag. 1999. The Charge Ratio on Individual Accounts: Lessons for the U.K. Experience. Birkbeck College, University of London Working Paper 99-2.

Philipson, Tomas and Gary Becker. 1998. Old-Age Longevity and Mortality-Contingent Claims. Journal of Political Economy, 106: 551-573.

Poterba, James and Mark Warshawsky. 2000. The Costs of Annuitizing Retirement Payments from Individual Accounts. In John Shoven, ed. Administrative Costs and Social Security Privatization. Chicago: University of Chicago Press, 173-200.

Pueltz, Robert and Arthur Snow. 1994. Evidence on Adverse Selection: Equilibrium Signaling and Cross-Subsidization in the Insurance Market. Journal of Political Economy, 102: 236-257.

Rothschild, Michael and Joseph Stiglitz. 1976. An Essay on the Economics of Imperfect Information. Quarterly Journal of Economics 90 (November), pp.629-649.

Smart, Michael. 2000. Competitive Insurance Markets with Two Unobservables. International Economic Review 41 (February), 153-169.

Yaari, Menahem. 1965. Uncertain Lifetimes, Life Insurance, and the Theory of the Consumer. Review of Economic Studies 32: 137-150.

TABLE 1:
PREDICTIONS OF ASYMMETRIC INFORMATION MODELS FOR ANNUITY MARKETS

ANNUITY FEATURE / POTENTIAL SCREENING DEVICE	MORTALITY PATTERN		PRICING RESPONSE	
	(1) Mortality Difference	(2) Coefficient in Hazard Model	(3) Pricing Difference	(4) Coefficient in Hedonic Price Equation
BACKLOADED ANNUITIES	Backloaded annuity buyers will be longer lived than non-backloaded (nominal) annuity buyers	Negative	Backloaded annuities will have higher prices than non-backloaded annuities	Positive
PAYMENTS TO THE ESTATE	Annuitants with annuities that make payments to the estate will be shorter lived than annuitants with annuities that do not	Positive	Annuities that make payments to the estate will have lower prices than annuities that do not	Negative
INITIAL ANNUAL ANNUITY PAYMENT	Annuitants with larger initial annual payments will be longer lived	Negative	Rising Marginal Price *if contracts are exclusive*	Positive coefficient on square of variable *if contracts are exclusive*

TABLE 2: OVERVIEW OF THE COMPULSORY AND VOLUNTARY MARKET

	COMPULSORY MARKET	VOLUNTARY MARKET
Number of policies	38,362	3,692
Number (%) of annuitants who are deceased.	6,311 (16.5%)	1,944 (52.7%)
Number (%) of annuitants who are male	29,681 (77.4%)	1,272 (34.5)
Average age at purchase	63.2	76.4
	Backloaded Annuities	
Number (%) of policies that are index-linked	428 (1.3%)	66 (3.5%)
Number (%) of policies that are escalating in nominal terms	1,492 (3.9%)	175 (4.7%)
	Payments to Estate	
Number (%) of policies that are guaranteed	28,424 (74.1%)	872 (23.6%)
Number (%) of policies that are capital protected	0	843 (22.8%)
	Initial Annual Annuity Payments	
Average Initial Payment (£)	1,151	4,773
Median Initial Payment (£)	627	3,136
Standard Deviation of Initial Payment (£)	1,929	5,229
Average Premium (£)	10,523	25,603

Notes: All monetary figures in the paper are in December 1998 pounds. The first index-linked policy was sold in February 1985; therefore percentage of policies index-linked refers to percentage of policies sold since that date.

TABLE 3: SELECTION EFFECTS AND ANNUITY PRODUCT CHARACTERISTICS

	COMPULSORY MARKET	VOLUNTARY MARKET
Backloaded Annuities		
INDEX-LINKED	-0.839*** (0.217)	-0.894** (0.358)
ESCALATING	-1.085*** (0.113)	-1.497*** (0.253)
Payments to Estate		
GUARANTEED	0.019 (0.029)	0.216*** (0.060)
CAPITAL-PROTECTED	-------------	0.056 (0.051)
Initial Annuity Payment		
PAYMENT (in £100s)	-0.003*** (0.0006)	0.001** (0.0004)
Additional Controls		
MALE ANNUITANT	0.640*** (0.039)	0.252*** (0.051)
N	38,362	3,692
Number of deaths in sample	6,311	1,944

Note: All estimates are from Han-Hausman discrete-time, semi-parametric proportional hazard models. These are estimated using 17 annual discrete time intervals. Baseline hazard parameters are not reported. Indicator variables for five-year intervals for age at purchase, and for year of purchase, are included in all regressions, along with indicator variables for the frequency of payments. Standard errors are in parentheses. The omitted category for the "tilt" dummies (index-linked and escalating) is nominal annuities. The omitted category for the guarantee feature dummies (guaranteed and capital protected) is not guaranteed and not capital protected. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

TABLE 4: INTERPRETING SELECTION EFFECTS: PROBABILITY OF SURVIVING UNTIL AGE 75 FOR DIFFERENT TYPES OF ANNUITY BUYERS

	COMPULSORY MARKET	VOLUNTARY MARKET
Baseline	0.641	0.916
Index-linked annuity	0.827	0.965
Escalating Annuity	0.862	0.981
Guaranteed Annuity	0.635	0.897
Capital Protected Annuity	---------	0.912
Initial Annual Annuity Payment One Standard Deviation Above the Mean	0.657	0.912
Male Annuitant	0.423	0.893

Note: Baseline survival probability is for a 58 year old female annuitant with a nominal, non-guaranteed, annual payment, single life annuity purchased in 1981 and paying the mean initial annual annuity payment for the compulsory or voluntary market. Other rows reflect the survival probability of an annuitant who has the baseline characteristics and the baseline annuity except for the change noted in the first column.

TABLE 5: HEDONIC MODEL OF ANNUITY PRICING: THE EFFECT OF PRODUCT CHARACTERISTICS

	COMPULSORY MARKET	VOLUNTARY MARKET
INDEX-LINKED	0.096***	0.046***
	(0.004)	(0.007)
ESCALATING	0.004*	-0.032***
	(0.002)	(0.005)
GUARANTEED	-0.014***	-0.037***
	(0.0009)	(0.002)
CAPITAL PROTECTED		-0.081***
	----------------	(0.002)
PAYMENT (in £100s)	-0.002***	-0.0003***
	(0.00003)	(0.00003)
PAYMENT Squared (in £100s)	2.56e-06***	5.31e-07***
	(9.24e-08)	(8.78e-08)
Sample Size	38,362	3,692

Note: Coefficient estimates are from linear regressions of price, defined as 1-Money's Worth, on product characteristics. Regressions include indicator variables for five-year intervals of age at time of annuity purchase, year of annuity purchase, gender of annuitant, and frequency of annuity payments. Standard errors are in parentheses. The omitted category for the "tilt" dummies (index-linked and escalating) is nominal annuities. The omitted category for the guarantee feature dummies (guaranteed and capital protected) is not guaranteed and not capital protected. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

APPENDIX TABLE A: BASELINE HAZARD FUNCTION

YEAR	COMPULSORY MARKET	VOLUNTARY MARKET
1	0.0091	0.0011
	(0.0008)	(0.0003)
2	0.0104	0.0018
	(0.0009)	(0.0005)
3	0.0110	0.0022
	(0.0010)	(0.0006)
4	0.0144	0.0024
	(0.0012)	(0.0006)
5	0.0146	0.0030
	(0.0012)	(0.0008)
6	0.0166	0.0027
	(0.0014)	(0.0007)
7	0.0182	0.0032
	(0.0015)	(0.0008)
8	0.0195	0.0036
	(0.0016)	(0.0009)
9	0.0213	0.0032
	(0.0018)	(0.0008)
10	0.0224	0.0038
	(0.0019)	(0.0009)
11	0.0256	0.0042
	(0.0022)	(0.0010)
12	0.0305	0.0039
	(0.0027)	(0.0009)
13	0.0334	0.0039
	(0.0029)	(0.0009)
14	0.0345	0.0063
	(0.0033)	(0.0016)
15	0.0391	0.0056
	(0.0040)	(0.0014)
16	0.0519	0.0060
	(0.0061)	(0.0016)
17	0.0800	0.0260
	(0.0125)	(0.0089)

Note: The estimates are for the baseline hazard parameters from the Han-Hausman hazard models fit to data on the voluntary and compulsory market. Coefficients for most of the covariates in each model are shown in Table 3. Standard errors (computed using the delta method) are in parentheses. The baseline hazard represents the hazard of a 55-60 year old female annuitant who purchased a nominal, non-guaranteed, annual payment, single life annuity in 1981.