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

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Revised August 2002

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 among 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 the presence of asymmetric information in the annuity market. We find no evidence of substantive mortality differences, however, across annuities of different size, even though models of insurance market equilibrium with asymmetric information would predict such differences. We also 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 contract dimension 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.

We are grateful to Jeffrey Brown, Pierre-Andre Chiappori, David Cutler, Jerry Hausman, Paul Milgrom, Michael Orszag, Richard Zeckhauser, an anonymous referee, and many seminar participants for helpful suggestions, and to Jason Abrevaya for providing us with GAUSS code. We are especially grateful to the employees of the U.K. insurance company who generously provided us with the data used in this paper and answered many questions about it. The National Science Foundation and the National Institute of Aging supported this research.

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 studies have failed to find evidence of asymmetric information in property-casualty, life, and health insurance markets. These studies include Cawley and Philipson (1999), who study the U.S. life insurance market, Cardon and Hendel (2001), who study the U.S. health insurance market, and Chiappori and Salanie (2000), who study the French automobile insurance market. In contrast, Cutler (2002) reviews a substantial literature that finds evidence in support of asymmetric information in health insurance markets, and Cohen (2001) offers some evidence for adverse selection in U.S. automobile 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 variation in the risk pool across different policies. Such self-selection across policies by risk type would not occur if the insurer and the insured had symmetric information.

Most empirical research on insurance markets has tested predictions similar to these 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 contract features. Like several recent studies, we do not find substantive evidence of adverse selection on the amount of payment in the event that the insured risk occurs. However, we find strong evidence of substantial adverse selection along other dimensions of the insurance contract. Our findings therefore suggest the importance of considering multiple features of insurance contracts when testing for adverse selection, since adverse selection may affect not only the quantity of insurance purchased but also the form of the insurance contract. Our results also raise the interesting question 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 and public policy implications of the two 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 provides a direct 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, voluntary annuity markets in most nations are small. Friedman and Warshawsky (1990) explain that 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 the asymmetric information models that form the basis of our empirical tests. It also summarizes the previous literature on testing for asymmetric information in insurance markets. Section two describes the general operation of annuity markets. It notes several specific features of the U.K. annuity market that are relevant for our analysis, and it describes how the theoretical predictions of asymmetric information models apply to the U.K. annuity market. The third section describes the data set that we have obtained from a large U.K. insurance company.

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 characteristics of the annuity policy, as well as other information about the annuitant that is known to the insurer. The empirical findings indicate that ex-post annuitant mortality varies systematically with annuity characteristics, in ways that are 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 insurer's perspective, are priced higher than features that are selected by high-mortality individuals. We do not, however, find evidence of differences in mortality rates, or in the marginal price of additional annuity coverage, across annuities with different initial annual payouts. The initial annual annuity payout is a crude measure of the size of an annuity policy. 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

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, because insurance contracts cannot offer individual-specific prices that reflect individual-specific risk. Consumers of different risk levels therefore choose from among the same 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 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. Smart (2000) generalizes these models to allow for a multi-dimensional vector of insurance product characteristics. This generalization is important for empirical work since most actual insurance contracts 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, they predict that high risk types will select any feature of an insurance contract for which the marginal value is higher for them – at all prices and for all possible contracts – 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, have lower mortality rates. A second component of our empirical analysis tests the prediction that insurance companies 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 conditional 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, 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 insurance contracts should be priced to reflect risk type. Specifically, the marginal price of additional 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 by purchasing several small insurance policies rather than a single large one.

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. 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. Abel (1986), Brugiavini (1993) and Chiappori (2000), among others, have argued for this reason that it would be difficult to offer annuities with marginal prices that rose as a function of the annuity payment.

In our empirical work, 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 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 health insurance. 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 (2002) 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 health insurance plans becomes more selected over time. Nevertheless, even the evidence from the health insurance market is not unambiguous. Cardon and Hendel (1999), for example, test for a correlation between medical spending in the National Medical Expenditure Survey and insurance coverage, and they do not reject the null hypothesis of symmetric information.

In insurance markets other than health, the evidence is considerably mixed. 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. Cohen (2001) also finds evidence of asymmetric information in the automobile insurance market, using data on insurance policies in Israel. However, several other recent studies, reach a different conclusion. Chiappori and Salanie (2000) examine French automobile insurance markets. They model two variables, quantity of insurance and ex-post risk type, as a function of exogenous factors, and they test for a positive correlation between the unexplained components of these two variables. Such a positive correlation is predicted under asymmetric information. However, they cannot reject the null hypothesis of independence. In another study, Cawley and Philipson (1999) examine the relationship between insurance coverage and risk in the U.S. life insurance market. They also fail to reject the null hypothesis that risk type and amount of insurance coverage are uncorrelated.

One limitation of 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 only on 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 that a term life insurance policy will 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 information known to the buyer but not the insurer. Our data allow us to test for self-selection on multiple policy dimensions.

Some of the studies mentioned above also examine the pricing of insurance contracts. They test the prediction of asymmetric information models with exclusive contracts, namely that insurance policies with more comprehensive coverage should sell at higher marginal prices. Pueltz and Snow (1994) find support for 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

2.1 Annuity Market Overview

An annuity is a contract that pays the beneficiary, the annuitant, a pre-specified amount for as long as he 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 insurer's standpoint, a high-risk annuitant is one 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. Brown et al. (2001) discuss several possible explanations. Bequest motives may dampen individuals' desire to annuitize resources; they may instead wish to leave assets to their children. The prevalence of annuitized public sector social security programs and private defined benefit pensions, together with a need for buffer stock savings to pay for uninsured medical and long-term care needs, may also reduce the demand for private annuities.

Annuity demand may also be reduced if the expected annuity payments for a typical individual are low relative to the annuity's premium. High administrative costs or insurance company profits may make annuities expensive in this sense. Adverse selection may also make annuities appear expensive for a typical individual in the population. If the typical annuitant is longer lived than the typical individual in the population, and annuities are priced to reflect the longevity of annuitants, then annuities will not be actuarially fair for typical individuals.

While we present direct evidence of adverse selection in annuity markets, several previous studies have provided indirect evidence on this issue. The pricing of voluntary annuities in both the U.S. and the U.K. implies that, for a typical individual, the expected present discounted value of payouts is only 80 to 85 percent of the annuity's initial premium. Part of the divergence between the expected payout and the annuity's cost is due to administrative loads, but roughly half appears to be due to adverse selection. Indeed, mortality tables for voluntary annuitants in the U.S. and the U.K. suggest that life expectancy for a typical 65-year-old male voluntary annuitant is twenty percent longer that for a typical 65-year-old male.[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. It is worth noting, however, that while we interpret our findings as supportive of the presence of adverse selection in private annuity markets, it is unlikely that this adverse selection, and the associated high effective prices for annuities, can fully explain the limited demand for voluntary annuities. Mitchell et al. (1999) show that for lifecycle consumers with plausible risk aversion and mortality uncertainty and no annuity income, even if the effective price of an annuity is 25 percent – which is higher than the 15 to 20 percent prices estimated in voluntary annuity markets in the U.S. and U.K. – purchasing an annuity may raise lifetime expected utility.

The United Kingdom's annuity market provides a particularly rich setting for studying adverse selection. There are effectively two annuity markets in the U.K. One is a compulsory annuity market in which individuals who have accumulated savings in tax-preferred retirement saving accounts 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. Adverse selection is expected to operate differently in these two markets. In the voluntary market, low risk people have the option of not buying at all. As a result, selection on the *extensive* margin (i.e. between annuitants and non-annuitants) should be larger in the voluntary market than in the compulsory market.[2] Because low-risk individuals can opt out of the voluntary market, however, the voluntary annuitant population will be more homogenous than the population in the compulsory market. This could lead to more adverse selection across product types within the compulsory than the voluntary annuity market.

A wide variety of annuity products are sold in both the compulsory and voluntary annuity markets in the U.K. 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. A second is the annuity's 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. Whether they offer rising real payouts depends 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

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[1] Finkelstein and Poterba (2002) and Murthi, Orszag, and Orszag (1999) present summary information and mortality comparisons for the U.K. annuity market. Brown, Mitchell, and Poterba (2002) present related information for the U.S. market.

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 third feature of annuities 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 payment to the annuitant's estate. If at the date of the annuitant's death the cumulative sum of nominal annuity payments 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 almost 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 annuities with different features. The models of asymmetric information discussed above predict that annuity features that increase the effective amount of insurance provided should be selected by higher risk individuals.

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 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

[2] Finkelstein and Poterba (2002) present evidence that adverse selection on this extensive margin, as measured by the average price of annuity contracts, is roughly half as great in the compulsory market as in the voluntary market.

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: at a given price, the marginal value of the various annuity product features varies monotonically with risk type.

Theoretical models of equilibrium with adverse selection 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. Similarly, 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. This presumes that these 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. Both backloaded and non-guaranteed annuities satisfy the non-replicability condition. Buyers who want a backloaded annuity cannot replicate such an annuity buy buying several (cheaper) immediate nominal annuities, and someone who wants a guaranteed annuity cannot create one 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 an 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 those with shorter guarantees.[3]

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. In the presence of asymmetric information, however, when the annuitant has private information that he is likely to be long-lived and he chooses to buy a particular annuity, the price is not fully adjusted to take account of his mortality prospects.

We test for asymmetric information in the annuity market by considering both mortality patterns and annuity prices. While in practice, unlike in the stylized models, individuals differ on dimensions other than simply their risk type, this does not pose a problem for the interpretation of our empirical analysis, provided our data set includes (as it does) all of the information that the insurance company uses in setting prices. If product choice is driven not by private information about mortality but rather by private information on preference parameters such as discount rates, risk aversion, or bequest motives which are correlated with mortality, the ultimate effect is the same as that 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 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 cannot observe the total wealth of their annuity buyers. While insurers could in principle try to obtain information on the wealth of potential

[3] 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: the marginal price of insurance rises with the size of the initial payment. We test this prediction below, even though we view the exclusivity condition as unlikely to be satisfied in annuity markets.

annuitants, they do not, and wealth-related differences in mortality are therefore like other sources of mortality difference that are known to the buyer but not the insurer. Similarly, an annuity that makes payments to the estate may be particularly valued by individuals with strong bequest motives or a desire to make sure a surviving spouse receives adequate income. If these attributes are positively related to mortality risk, they will have the same effect on the market equilibrium as private information about mortality risk.

3. Data and Descriptive Statistics

3.1 Overview of Data from the Sample Firm

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.[4]

Our data set includes almost everything that the insurance company knows about its annuitants. The only pieces of information that were suppressed to protect confidentiality were the annuitant's address and date of birth. We did, however, obtain information on the annuitants' birth month and year. We have detailed information on the type of policy purchased by the annuitant, and on the annuitant's day of death, if the annuitant died before December 31, 1998.[5] The insurance company collects very little information – only age, gender and address – about the personal 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. Moreover, like the rest of the firms in the market, it

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

[5] Sample attrition is unlikely to be a problem in a data set of insurance company records of annuitants. Since premiums are paid up front and the company must pay each annuitant regularly until the he dies, annuitants are unlikely to leave the sample before they die.

varies the annuity price based only on age and gender, and not based on the individual's geographic location.[6]

We restrict our attention to single life annuities, 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 joint life annuities than to study single-life policies. 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 our sample firm. The voluntary market accounts for about one tenth of the policies in our sample, and for 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 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, and more likely to be female, than compulsory annuitants. This is consistent with Banks and Emmerson's (1999) tabulations from the Family Resources Survey. 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 percent of the voluntary or the compulsory market, with index-linked policies less than 5 percent in each market. Murthi, Orzsag, and 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

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[6] The use of only a very limited set of characteristics in pricing annuities is somewhat puzzling given the large variations in mortality by geographic area or socio-economic status, as well as the use of much richer information in the pricing of life insurance contracts in the U.K. This is not due to any regulatory restrictions on characteristic-based pricing in annuity markets. Indeed, two years after the end of our sample period, the largest UK annuity company – Prudential – began offering compulsory annuities whose prices vary based on the annuitant's health characteristics.

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.

3.2 Is the Sample Firm Representative?

A fundamental issue in trying to infer market-wide phenomena such as adverse selection from data from a particular firm is whether this firm is representative. The above discussion suggests that our firm is typical of the insurance industry in terms of the information about consumers that it uses in pricing annuities. In addition, the demographic characteristics and product choices of voluntary and compulsory annuitants in the firm appears representative of industry-wide patterns.

We also examined whether average prices and mortality for the firm's voluntary and compulsory products matched industry-wide aggregates. Our estimates of average mortality patterns in the firm closely match industry-wide actuarial data. For example, we estimate, using the survival rate of annuitants at the firm, that a male aged 61 to 65 who purchased a compulsory annuity in 1992 would have a 92 percent chance of surviving at least five years. This compares to a 90% five-year survival probability in the industry as a whole for a 65 year old male who purchased a compulsory annuity in 1992. In the voluntary market, our estimates for the firm suggest that a female aged 76 to 80 who purchased an annuity in 1992 would have a 75 percent chance of surviving at least five more years; industry-wide data suggest a 74 percent survival probability for an 80 year old female purchasing a voluntary annuity in 1992.[7]

Average prices for the sample firm's products in the compulsory market also closely match available data on industry-wide prices. As we explain below, we measure price as the difference between the expected present discounted value of annuity payouts, and the purchase price of the annuity, scaled as a percentage of the initial purchase price. Finkelstein and Poterba (2002) report that the industry-wide

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Analyzing the determinants and consequences of such richer characteristic-based pricing in annuity markets may be a fruitful area for further work.

[7] We chose genders and age ranges that represent the modal purchasers in each market. See Section four for a description of how we estimate mortality for annuities in the sample firm; we estimate mortality in five-year age bins due to limitations to the degrees of freedom from estimating age-specific mortality rates. Estimates of industry-wide

average price for a nominal, non-guaranteed policy sold to a 65 year old male in the compulsory market in 1998 was ten percent of the purchase price. Using the same pricing formula and the same discount rates, namely the interest rates on government bonds, we find that that the average price of the same policy in our data set in 1998 was eleven percent of the purchase price. Our sample size is too small to permit such comparisons in the voluntary market; our sample firm sold only ten voluntary products in 1998. However, the average price in our entire, 17-year, voluntary annuity sample seems low – two percent – compared to the 15 to 20 percent average prices that Finkelstein and Poterba (2002) estimate for the entire voluntary annuity market in 1998.

Substantial price dispersion in the annuities offered by different companies has been documented elsewhere, for example in Mitchell et al. (1999). However, the fact that the prices of voluntary annuities sold by our sample firm are lower than those of most other insurers suggests caution in interpreting evidence of selection in the voluntary market.

Finally, we investigated whether annuity sales trends for our sample firm mirrored industry-wide trends reported by the Association of British Insurers (various years). To the extent that the firm experienced idiosyncratic growth or declines in certain markets, it may be more difficult to generalize the findings. Figure 1 presents evidence for the compulsory market. On the right-hand axis, we show trends in new premiums collected each year for both the sample firm and the industry as a whole. Because industry-wide data on new premiums are only available in the compulsory market starting in 1991, we also present, on the left-hand axis, trends for our sample firm and the market as a whole in the amount of annuity payments made each year. Industry-wide data on payments are available starting in 1983. This measure combines information on new sales with information on policy terminations (i.e. mortality). For each measure, we denote firm sales with solid lines and industry-wide sales by dashed lines. For ease of comparison, we set industry and firm new premiums equal to 100 in 1991, and industry and firm payments in force equal to 100 in 1983. The scales for the industry and the firm are therefore different, so that only

mortality for voluntary and compulsory annuitants are based on Institute of Actuaries (1999a, 1999b); see Finkelstein and Poterba (2002) for further details on these data.

trends and not levels can be compared; this is done in part to protect the anonymity of our company. Both series show virtually identical trends for the sample firm and the market as a whole. The upward trend in both measures in part reflects the expansion in the late 1980s of the set of retirement savings plans that faced compulsory annuitization requirements.

Figure 2 presents trends in the amount of new premiums in the voluntary market for the sample firm and the industry as a whole.[8] The sample firm and the market experience the same basic pattern of a general decline in sales in the 1990s, although the exact timing is not a perfect match. However, the abnormally high sales that the sample firm experienced in 1984 and 1985 appear to be an isolated feature. The same is true when trends in payments in force are examined for the sample firm and the industry as a whole (not shown). Because 25 percent of the voluntary policies in our data were sold in those two years, we are reluctant to generalize our findings from the sample firm to the voluntary market as a whole. To partially address this concern, we examined the sensitivity of our findings on mortality and pricing in the voluntary market to excluding sales in these two years from the data. The results are unaffected by this exclusion.

In sum, several strands of evidence suggest that our sample firm's compulsory market is typical of the industry as a whole. The evidence on the firm's representativeness of the voluntary market is considerably less compelling, given both the firm's low pricing and the idiosyncratic spike in sales in 1984 and 1985. While we present evidence from both markets in the empirical work below, we therefore believe the results from the voluntary market should be interpreted with caution. The compulsory market represents the quantitatively more important market, as it is roughly ten times the size of the voluntary market. The compulsory market is also the market where, as discussed above, we are more likely to find evidence of selection across annuity contract features.

4. Annuitant Mortality and Annuity Product Choice

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 $\lambda(t, x_i, \beta, \lambda_0)$ 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 $\lambda(t, x_i, \beta, \lambda_0)$ can be decomposed into a baseline hazard $\lambda_0(t)$ and a "shift factor" $\phi(x_i, \beta)$ as follows:

(1) $$\lambda(t, x_i, \beta, \lambda_0) = \phi(x_i, \beta)\lambda_0(t).$$

The baseline hazard, $\lambda_0(t)$, is the hazard when $\phi(\cdot) = 1$. $\phi(\cdot)$ represents the proportional shift in the hazard caused by the vector of explanatory variables x_i with unknown coefficients β. The proportional hazard model restricts the effects of the explanatory variables (x_i) to be duration-independent.

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

(2) $$\lambda(t, x_i, \beta, \lambda_0) = \exp(x_i'\beta)\lambda_0(t).$$

We model the baseline hazard $\lambda_0(t)$ 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 $\delta_t = \int_0^t \lambda_0(s)ds$ denote the integrated baseline hazard, the proportional hazard model in (2) becomes:

(3) $$\lambda(t_i; x_i, \beta, \delta) = 1 - \exp\{\exp(x_i'\beta)(\delta_t - \delta_{t+1})\}.$$

[8] Numbers for industry-wide sales in the voluntary market in 1996 are omitted due to reporting problems in that year.

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

(4) $$\ln(L) = \sum_{i=1}^{n} (1 - c_i) \ln(\lambda(t_i; x_i, \beta, \alpha)) - \int_0^t \lambda(s_i; x_i, \beta, \alpha) ds$$

where c_i is an indicator variable that equals 1 if individual i survives until the end of our sample period and 0 otherwise. Eighty-four percent of the compulsory annuitants and 47 percent of the voluntary annuitants in our data set survived 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 annuity backloading. One is an indicator for whether payments are indexed to inflation, and the other is an indicator for whether 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 on 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 includes annuities that do 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 those who buy annuities that do not make any such payments. The predicted coefficients on the indicator variables for "guaranteed" and "capital protected" in the hazard model are therefore positive. The theoretical models do not offer a 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 observe self-selection: the initial annual annuity payment. This 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 those who face smaller payments. The predicted coefficient on the “payment” variable in the hazard model is therefore negative.

4.2 Basic Results: Annuity Choice and Mortality Patterns

Table 3 presents estimates of the hazard model in equation (3). The first two columns report our core hazard model estimates for the compulsory and voluntary markets, respectively. The results closely match our theoretical predictions of self-selection under asymmetric information. To ascertain whether our mortality estimates are sensitive to the hazard model framework, we also estimated simple linear probability models of whether annuitants who bought annuities at least five years before the end of our sample period died within the first five years after their purchase. The results, which are reported in the third and fourth columns of Table 3, show the same mortality patterns across products as the hazard models. Indeed, mortality differences across products that are statistically insignificant in the hazard model framework are statistically significant in the linear probability model. Given the similarity of the findings, our discussion of the findings focuses on the hazard model specifications.

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. These findings suggest that all else equal, individuals who buy these annuities have a lower mortality hazard rate than individuals who buy level nominal annuities. There is also evidence that voluntary annuitants who buy annuities that make payments to the estate are shorter lived than annuitants 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. Additionally, the coefficient on the indicator variable for a capital-protected annuity has the expected positive sign, although it is not statistically significantly different from zero. The positive sign indicates that individuals who buy these annuities are shorter lived than observationally similar individuals who buy non-guaranteed, non-capital protected annuities.

In the compulsory market, although the results suggest that individuals who buy guaranteed annuities are shorter lived than individuals who buy non-guaranteed annuities, we are again unable to reject the null hypothesis of no difference at standard statistical confidence levels. 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, and 4,150 purchased ten year guaranteed annuities. The remainder, less than one half of one percent of the annuitants, purchased guarantees of other lengths. 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 ten year guarantee periods, the longest in the compulsory market, are significantly shorter lived than annuitants with non-guaranteed annuities. We also find that the hazard increases monotonically from no guarantee period to five years to ten years and that the mortality differences between individuals with five- and ten-year guarantee periods are also statistically significantly different at the 5 percent level.

These results are consistent with models of adverse selection in the insurance market. We cannot test similar predictions about selection by degree of backloading, or by length 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 small sample sizes.

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 those who buy larger compulsory annuity policies tend to live longer than those who buy smaller policies. There is, however, no discernable relationship between annuity size and mortality in the voluntary market, perhaps reflecting the fact that voluntary annuitants are drawn to a substantial extent from the highest wealth strata of the population.

It is important to note that in both the voluntary and the compulsory annuity markets, the estimated effect of the amount of initial payment on mortality is small both in absolute terms and compared to the magnitude of the effect of other annuity features on mortality. 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, which is reported in Finkelstein and Poterba (2000), as well as the coefficients on all of the covariates to estimate survival probabilities for particular types of individuals.

Table 4 presents some illustrative calculations designed to gauge the magnitude of the selection effects. Specifically, we use the results from the hazard model to calculate the probability of various annuitants surviving at least five years, conditional on different types of annuity purchases. Across the columns, we present estimates for three different types of annuitants. Column one presents five-year survival probabilities for a typical compulsory annuitant: a 61-65 year old male purchasing an annuity in 1998. For comparison, the second column presents survival probabilities for the same individual in the voluntary market. In the third column we present survival probabilities for a typical voluntary annuitant: a

76-80 year old female purchasing an annuity in 1984. The first row represents the "baseline" five-year survival probability for an annuitant buying a nominal, non-guaranteed annuity that pays the average initial annuity payment for annuities in that market. Subsequent rows show the corresponding five-year survival probabilities that emerge when we assume that the annuitant purchases an annuity policy that differs from the baseline case along a single dimension.

A comparison of columns one and two indicates that survival probabilities are higher in the voluntary market than in the compulsory market for otherwise-identical annuitants and annuities. This is consistent with market-wide mortality tables such as those reported by the Institute of Actuaries (1999a and 1999b). We estimate, but do not report, hazard models on a sample that combines both voluntary and compulsory annuitants, with separate coefficients for each market for all of the explanatory variables. Consistent with market-wide data, we find that in our sample, voluntary annuitant mortality is statistically significantly lower (at the 1 percent level) than compulsory annuitant mortality. This supports the notion of greater adverse selection into the voluntary than the compulsory annuity market.

A comparison across the rows in Table 4 suggests large mortality differences among certain classes of annuitants within each market. For example, in the compulsory market, column one indicates that the typical annuitant has a baseline 91 percent five-year survival probability. Those who buy index-linked but otherwise-identical annuities have a five-year survival probability of 96 percent. Mortality differences among individuals with different initial annual annuity payments are considerably smaller than mortality differences associated with backloading; a one standard deviation increase in the initial annual annuity payment, from the mean, only raises the five-year survival probability by one percentage point, to 92 percent.

In the voluntary market, we note that the mortality difference associated with a payment guarantee is somewhat smaller than that associated with backloading. Column three indicates that the typical voluntary annuitant has a baseline five-year survival probability of 87 percent, while someone with the same characteristics who purchases an index-linked annuity has a five-year survival probability of 95 percent. In contrast, the five-year survival probability only decreases by three percentage points (to 84 percent) if the baseline annuitant instead purchases a guaranteed annuity.

To facilitate interpretation of these mortality differences, we can compare the mortality differences across individuals who purchase different products to the mortality differences between male and female annuitants. A comparison of the baseline survival probabilities to the survival probabilities when the annuitant changes gender (last row) indicates that a change in gender is associated with a 1 to 4 percentage point change in five-year survival probability. In both markets, the gender differences in survival probabilities are less than the differences in survival probabilities for individuals who purchase nominal vs. backloaded annuities.

The results in Tables 3 and 4 suggest substantial mortality selection based on annuity back-loading, some mortality selection based on payments to the estate, and very little – if any – selection based on the initial annual annuity payment. The lack of selection on this last dimension 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 are similar to the initial annual payment in the annuity context. 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

We developed a number of additional statistical tests to explore the robustness of our findings. We examined whether the magnitude of selection effects among annuity products varied across groups of annuitants. In particular, when 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 estimated our hazard models allowing for unobserved heterogeneity, assuming that this heterogeneity could be parameterized by a gamma distribution. The evidence for selection was sometimes stronger, and never weaker, when we allowed for such unobserved differences across annuitants.

In addition to these tests, we estimated the hazard models separately for men and women to allow the baseline hazard to be different for these two groups. We also estimated the 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. For example, in the voluntary market, where our sample firm had abnormally high sales, relative to industry trends, in 1984 and 1985, we re-estimated the model excluding these years. We also re-estimated the hazard model using length of life rather than length of life since purchase of the annuity as our duration measure. The results discussed above were robust in sign and significance to these various checks.

5. Pricing Differences across Annuity Products

The foregoing results suggest relationships between annuity product characteristics and annuitant mortality. We now consider the relationship between these characteristics and annuity prices. If annuitants self-select among insurance products on the basis of private mortality information, then 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 effective price of an annuity is the differential between the premium paid to purchase the annuity, and the expected present discounted value of annuity payouts. The price is therefore one minus 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 initial premium. We compute the expected present discounted value of future payouts using the mortality rates that apply to a typical individual in the population. An annuity that is actuarially fair for such an individual will have a money's worth of one, and an effective price of zero. Money's worth values may be less than one, and effective prices may be positive, when there are administrative costs associated with the annuity policy, or if the insurer prices the policy to reflect lower mortality rates among the individuals buying the annuity than among the population at large.

If the individuals who buy annuity product j are, on average, longer-lived than individuals who buy annuity product k, and if an insurance company's costs and markup are the same across products, then a given premium should in equilibrium purchase a lower payment stream for product j than for 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 higher price, than product k.

The money's worth of a nominal, non-guaranteed annuity can be computed as:

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

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 short-term interest rate at time period j. The above formula is easily adjusted, as in Finkelstein and Poterba (2002), for the case of index-linked or escalating annuities, and for annuities that make payments to the annuitant's estate. In our calculations for 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. Note that in the absence of mortality differences in the population purchasing different types of products, or other differences in costs or profits across different products, the money's worth should be the same for different types of products.

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 (GAD). 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 1985, we use the GAD's 1985 mortality table; this table includes projections for future mortality rates for 65-year-olds in that year. In practice, these projections have turned out to be reasonable. For example, a 65 year old man in 1985 was projected to have a 7.8 percent mortality rate in 1998 (when he would be 78); in practice, in 1998, the mortality rate for 78 year old males was 7.5 percent. More generally, the ratio of actual mortality in 1998 to projected mortality in 1985 for men and women who were 65 and 75 in 1985 ranged from 0.96 to 1.04. Other studies, such as the Institute of Actuaries (1999a), more generally support the accuracy of historical projections of future mortality rates.

To discount the future payouts associated with an annuity product, we would ideally like to use a term structure of interest rates that correspond to the assets in the insurer's investment portfolio. At the end of our sample period, we know that roughly three quarters of our sample firm's annuity assets were held in nominal government bonds, with one quarter in corporate bonds. We therefore make two alternative assumptions about the interest rate. First, 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 addition to this term structure for riskless interest rates, we also construct an "imputed" term structure of interest rates for more-risky corporate bonds. There was very little issuance of new corporate bonds in the U.K. during the 1980s, so it is difficult to estimate the yields on newly-issued corporate bonds during this time period. This makes it difficult to construct a yield index for this time period, and we have not been able to find any data source that provides a consistent interest rate measure for U.K. corporate borrowers over the last two decades.

In 1993, however, Morgan Stanley Capital International began computing the yield on a "Eurosterling Credit Index." This corresponds to a portfolio of corporate bonds, roughly sixty percent issued by U.K. companies, all with a rating of at least BBB. We compute the average difference between the yield on the MSCI bond index, and that on U.K. government bonds, for six maturities along the term structure. We do this every month between 1993 and 1998, and we then average the differences to construct an average maturity-specific risk premium for corporate bonds. We then add this constant "corporate risk premium" to our daily yields for comparable-maturity U.K. government bonds for the whole 1981-1998 period, and thereby construct an estimated of the corporate bond yield that we can use for discounting. Mitchell et al. (1999) used a similar approach in discounting the payment streams for U.S. annuities. In practice, our estimates of the relative pricing of different features of the annuity contract are not sensitive to our choice regarding the term structure.

To explore how annuity prices are related to product characteristics, we estimate regression models that relate the effective price of the annuity to the characteristics of the annuity and the annuitant. The hedonic pricing equation, which we estimate by ordinary least squares, is:

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

X includes 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. As a result of the lower annual payments, the money's worth calculated using a common mortality table will be lower, and the effective 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 or 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 summary statistics on the distribution of the price variable in each of the markets, calculated using the two different term structures. As expected, effective prices are always higher when we use our estimate of the term structure for corporate interest rates, rather than government interest rates. As discussed above, the average effective prices that our sample firm charges in the compulsory market are close to those for the industry at large, but the effective prices for voluntary annuities appear comparatively low. The effective price is computed to be negative for roughly one quarter of the transactions in the voluntary market; this corresponds to money's worth values of greater than unity. These low – and ostensibly unprofitable – prices may explain the abnormally high volume the sample firm experienced in the voluntary market in the early years of the data, as well as its subsequent dramatic decline. This again points to caution in using the evidence from the firm's voluntary market to test for adverse selection in the market as a whole. In the compulsory market, by contrast, only about five percent of effective prices are computed to be negative. Negative effective prices may be generated by discrete price changes on the part of the firm. If nominal interest rates are falling, and the firm adjusts prices infrequently while we value annuity products using interest rates that apply to the date of purchase, it is possible for the money's worth of the annuity to exceed unity, and for the effective price to correspondingly be negative.

Table 6 reports the hedonic regression results, which are generally supportive of the pricing patterns predicted under asymmetric information.[9] We report separate results when price is estimated using the government and corporate borrowing rate term structures. 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 such 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 without such provisions. In results not reported here, we also found that ten-year guaranteed annuities in the compulsory market are priced significantly lower than five-year guaranteed products, which is consistent with the selection results in the compulsory market, by length of guarantee period, reported above.

The results for backloading are similarly supportive of asymmetric information models. 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 general pattern of a higher price for backloaded annuities, and a lower price for annuities that make payments to the estate, at our sample firm matches our theoretical predictions as well as average pricing differences across products at all firms described in Finkelstein and Poterba (2002). The correspondence between our firm-specific pricing patterns and the industry-wide pricing patterns provides further reassurance that our findings speak to an industry-wide adverse selection phenomenon, and are not just an artifact of some idiosyncrasy of our sample firm.

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, this coefficient is substantively unimportant, so there is little evidence of convexity in pricing. Indeed, a graph of the estimated price-payment schedule looks virtually linear in both the compulsory and the voluntary market.

Chiappori and Salanie (2000) and Chiappori (2000) note the difficulty of estimating a firm's pricing policy. Fixed costs and economies of scale and scope can introduce non-linearities, and such

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[9] Due to concerns about our firm's high sales volume in the voluntary market in 1984 and 1985, we re-estimated the voluntary pricing equation leaving out sales in those years. We found no evidence of sensitivity of the voluntary

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 firm prices annuities, within a given class (such as guarantee period, tilt, frequency of payment, gender and age) and in both markets, 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. The fixed policy fee (f) was £18 at the end of the sample period. This formula indicates the presence of bulk discounts for policies of less than £10,000 and it indicates a constant marginal price. Our estimates from the hedonic regression models suggest a very small bulk discount and essentially linear pricing with respect to increases in annual payments. The consistency between these results, and the actual pricing policy, provides a check on the basic estimation strategy that underlies our hedonic regressions. The constant marginal price also supports the assumption, common in the annuity literature, that such products are examples of non-exclusive contracts.

6. Conclusion and Discussion

We have used 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. We test for selection effects on multiple characteristics of annuity policies, and we find evidence of selection in both mortality rates and policy pricing. We nevertheless fail to find substantive evidence for selection on the dimension of the contract most commonly studied in other papers: the amount of payment if the insured event occurs. Our findings highlight the importance of recognizing the institutional details of actual insurance contracts when testing theoretical models of asymmetric information.

We find evidence of annuitant self-selection with respect to the time profile of annuity payouts, and with respect to whether the annuity may make any payments to the annuitant's estate. All else equal, annuitants who are longer lived select annuities with back-loaded payment streams. Similarly, annuitants

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estimates to this restriction.

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 both markets, the mortality difference between otherwise identical individuals who purchase backloaded and non-backloaded annuities is larger in magnitude than the mortality difference between male and female annuitants. We also find evidence that backloaded annuities are priced higher, and annuities with payments to the estate are priced lower, than other annuities. This is consistent with our findings that longer-lived annuitants buy backloaded policies, while the shorter-lived purchase estate protection.

Our findings on the differential mortality experience of annuitants who purchase different types of policies are consistent with individuals 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 (forthcoming), that suggest that individuals have informed, and plausible, views about their potential life expectancy, beyond the information that can be gleaned from their observable characteristics. Our results are not only consistent with individuals having private mortality information, but they also suggest that individuals use this information in making annuity purchase decisions.

While our results are consistent with the presence of adverse selection, a possible alternative explanation is that they 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, this could also generate the mortality patterns we have documented. 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 households are substantially modifying their behavior in response to the presence of annuity income.

We do not find substantive evidence of self-selection on the initial amount of the annuity payment, the contract dimension that is analogous to measures of the accident-induced payment that are used in other empirical papers on asymmetric information in insurance markets. Our finding is thus consistent with the evidence in 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 raise the interesting question of what determines whether or not selection occurs – and can be detected econometrically – on a feature of the insurance contract that satisfies the single crossing property. We regard this issue, as well as the broad question of what determines the information set that the insurance firm uses to set prices, as natural challenges for future work.

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TABLE 1:
PREDICTIONS OF ASYMMETRIC INFORMATION MODELS FOR ANNUITY MARKETS

ANNUITY FEATURE / POTENTIAL SCREENING DEVICE	MORTALITY PATTERN		PRICING RESPONSE	
	Mortality Difference	Coefficient in Hazard Model	Pricing Difference	Coefficient in Hedonic Price Equation
BACKLOADED ANNUITIES	Backloaded annuity buyers will be longer lived than level nominal annuity buyers	Negative	Backloaded annuities will have higher prices than level nominal 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 make such payments	Positive	Annuities that make payments to the estate will have lower prices than annuities that do not make such payments	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 ANNUITIES SOLD BY SAMPLE FIRM

	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.

Figure 1: Sample Firm vs. Industry, Compulsory Market

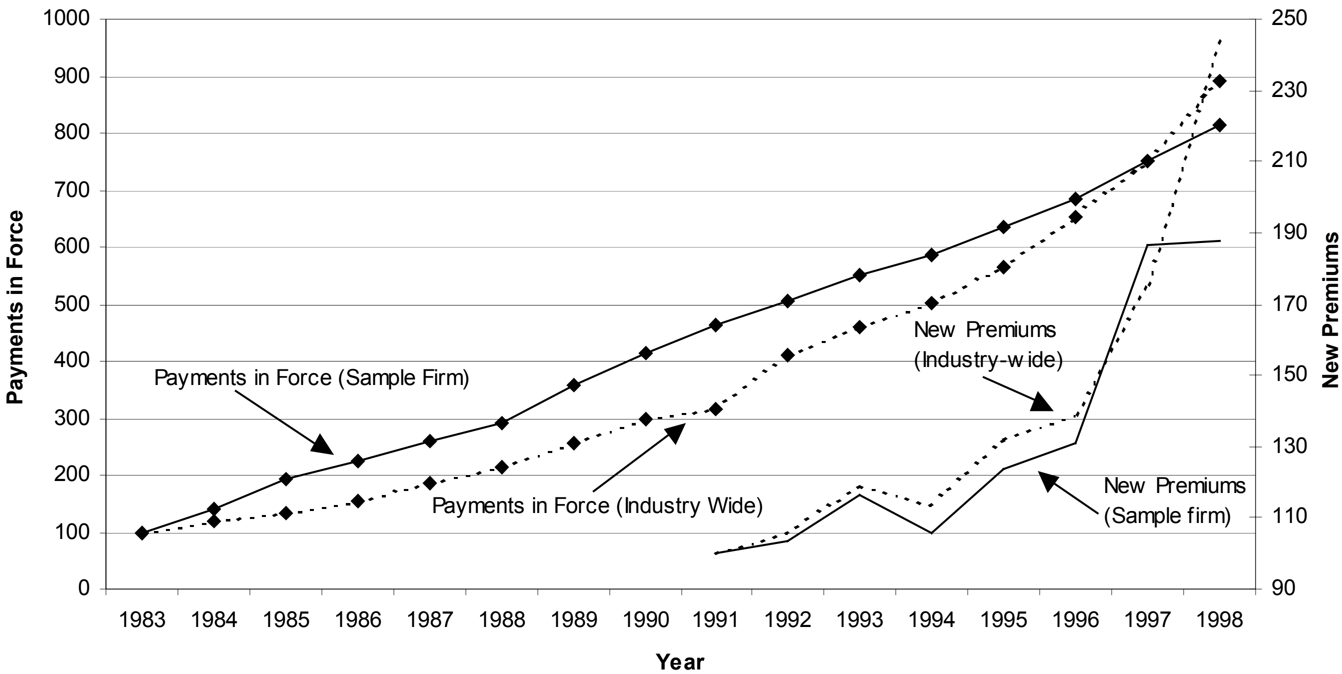

Figure 2: Sample Firm vs. Industry, Voluntary Market

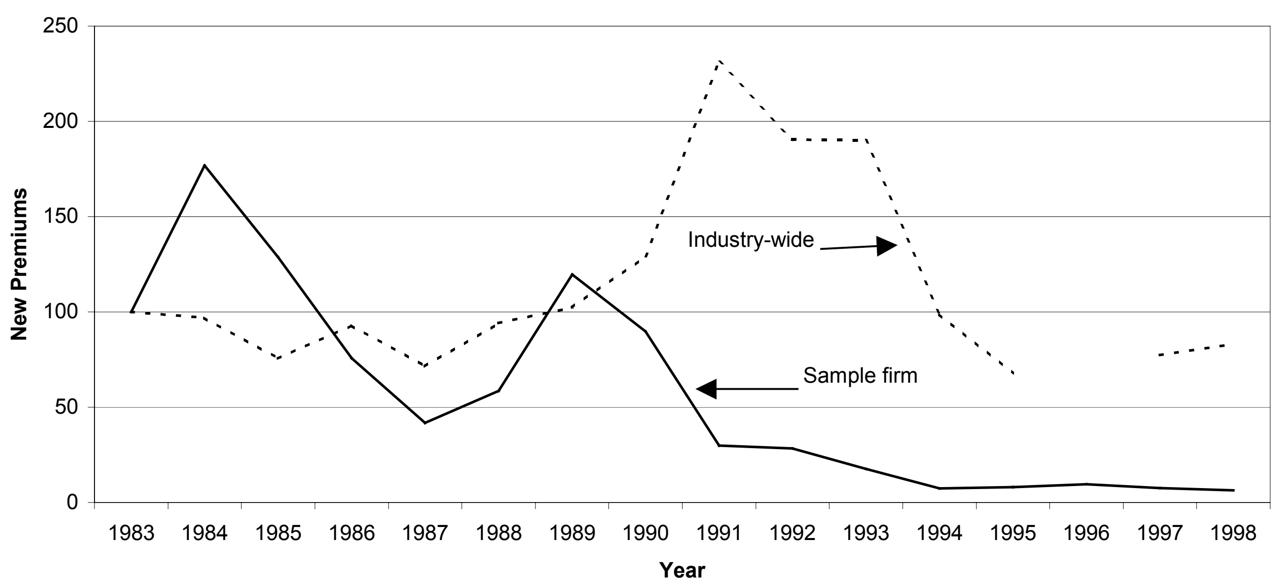

TABLE 3: SELECTION EFFECTS AND ANNUITY PRODUCT CHARACTERISTICS

EXPLANATORY VARIABLE	Estimates from Hazard Model of length of time lived after purchasing an annuity		Estimates from Linear Probability model of probability of dying within five years	
	COMPULSORY MARKET	VOLUNTARY MARKET	COMPULSORY MARKET	VOLUNTARY MARKET
INDEX-LINKED	-0.839***	-0.894**	-0.053***	-0.185***
	(0.217)	(0.358)	(0.019)	(0.050)
ESCALATING	-1.085***	-1.497***	-0.072***	-0.152***
	(0.113)	(0.253)	(0.010)	(0.030)
GUARANTEED	0.019	0.216***	0.007*	0.046***
	(0.029)	(0.060)	(0.004)	(0.016)
CAPITAL-		0.056		0.064***
PROTECTED	-------------	(0.051)	-------------	(0.016)
PAYMENT	-0.003***	0.001**	-0.0003***	0.0003***
(in £100s)	(0.0006)	(0.0004)	(0.0001)	(0.0001)
MALE	0.640***	0.252***	0.044***	0.044***
ANNUITANT	(0.039)	(0.051)	(0.005)	(0.014)
N	38,362	3,692	24,481	3,575
Number of deaths in sample	6,311	1,944	2,693	822

Note: First two columns report estimates from Han-Hausman discrete-time, semi-parametric proportional hazard models on the full sample. These are estimated using 17 annual discrete time intervals. Baseline hazard parameters are not reported. Third and fourth columns report estimates from a linear probability model of the probability of dying within five years of purchase; these models are estimates on the sample of individuals who purchased their annuity in 1993 or earlier, so that all observations are uncensored. All regressions include, in addition to the covariates shown above, indicator variables for five-year intervals for age at purchase, indicator variables for year of purchase, and indicator variables for the frequency of payments. Standard errors are in parentheses. The omitted category for the "backloaded" 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 percent levels, respectively.

TABLE 4: INTERPRETING SELECTION EFFECTS: PROBABILITY OF SURVIVING AT LEAST FIVE YEARS AFTER PURCHASING AN ANNUITY

	Compulsory Market Male, 61-65 years old, purchasing policy in 1998.	Voluntary Market Male, 61-65 year old, purchasing policy in 1998.	Voluntary Market Female, 76-80 years old, purchasing policy in 1984.
Baseline (nominal, non-guaranteed annuity paying mean initial annuity payment in the relevant market)	0.913	0.951	0.869
Index-linked annuity	0.962	0.980	0.945
Escalating Annuity	0.970	0.989	0.969
Guaranteed Annuity	0.911	0.940	0.840
Capital Protected Annuity	---------	0.949	0.862
Initial Annual Annuity Payment One Standard Deviation Above the Mean	0.918	0.949	0.862
Change in Annuitant's Gender	0.953	0.962	0.834

Note: Different rows reflect the five-year survival probability of an annuitant who has the baseline annuity except for the change noted in the first column. Estimates are based on coefficients and baseline hazard estimated from the hazard model in equation (3).

TABLE 5: SUMMARY STATISTICS ON EFFECTIVE ANNUITY PRICES

	Compulsory Market		Voluntary Market	
	Treasury Yield Curve	Corporate Yield Curve	Treasury Yield Curve	Corporate Yield Curve
5th percentile	-0.05	-0.01	-0.09	-0.07
25th percentile	0.04	0.08	-0.03	-0.02
Median	0.09	0.13	0.01	0.02
75th percentile	0.14	0.17	0.06	0.07
95th percentile	0.25	0.29	0.15	0.15
Mean	0.09	0.13	0.02	0.03

Note: Effective prices are defined as 1 – money's worth; see equation (5) for the formula for money's worth. We calculate effective prices under two different assumptions about discount rates, one using the riskless term structure for government debt, the other using an imputed term structure for riskier corporate bonds.

TABLE 6: HEDONIC MODEL OF ANNUITY PRICING: THE EFFECT OF PRODUCT CHARACTERISTICS

	COMPULSORY MARKET		VOLUNTARY MARKET	
	Annuity Prices Computed Using Treasury Yield Curve	Annuity Prices Computed Using Corporate Yield Curve	Annuity Prices Computed Using Treasury Yield Curve	Annuity Prices Computed Using Corporate Yield Curve
INDEX-LINKED	0.096*** (0.004)	0.104*** (0.004)	0.046*** (0.007)	0.060*** (0.006)
ESCALATING	0.004* (0.002)	0.019*** (0.002)	-0.032*** (0.005)	-0.016*** (0.004)
GUARANTEED	-0.014*** (0.0009)	-0.014*** (0.0009)	-0.037*** (0.002)	-0.036*** (0.002)
CAPITAL PROTECTED	----------------	----------------	-0.081*** (0.002)	-0.040*** (0.002)
PAYMENT (in £100s)	-0.002*** (0.00003)	-0.002*** (0.00003)	-0.0003*** (0.00003)	-0.0003*** (0.00003)
PAYMENT* PAYMENT (in £100s)	2.56e-06*** (9.24e-08)	2.45e-06*** (8.83e-08)	5.31e-07*** (8.78e-08)	5.04 e-07*** (7.67 e-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 as described in equation (6). We estimate equation (6) with price calculated under two different assumptions about the term structure, as discussed in the text. 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 percent levels, respectively.