

Adverse Selection in Insurance Markets: Policyholder Evidence from the U.K. Annuity Market

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We use a unique data set of annuities in the United Kingdom to test for adverse selection. We find systematic relationships between ex post mortality and annuity characteristics, such as the timing of payments and the possibility of payments to the annuitant's estate. These patterns are consistent with the presence of asymmetric information. However, we find no evidence of substantive mortality differences by annuity size. These results suggest that the absence of selection on one contract dimension does not preclude its presence on others. This highlights the importance of considering detailed features of insurance contracts when testing theoretical models of asymmetric information.

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 a con-

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sequence of asymmetric information. Yet the empirical evidence on the importance of asymmetric information in insurance markets is decidedly mixed. Several recent empirical studies have not rejected the null hypothesis of symmetric information in property-casualty, life, and health insurance markets. These studies include those by 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 suggests the importance of asymmetric information in health insurance markets, and Puelz and Snow (1994) and Cohen (2001) offer 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.

Most empirical research on insurance markets has tested similar 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 contract features. Our results, like those in several other studies, suggest little 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. This underscores 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 selection can be detected on some margins but not on others.

Annuity markets present an 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 et al. (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 insurance value of annuity products for households that face uncertain mortality risks, 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, for example, by Brugiavini (1993) and others.

This paper is divided into five sections. Section I describes the general operation of annuity markets, with particular reference to the United Kingdom, and summarizes how the theoretical predictions of asymmetric information models can be tested in annuity markets. Section II describes the data set that we have obtained from a large U.K. insurance company. Section III reports our findings on the relationship between mortality patterns and annuity product choice, using hazard models to relate annuitant mortality patterns to annuity product characteristics. Section IV investigates the pricing of different annuity products, using hedonic models to confirm that annuity pricing is consistent with our estimates of mortality differences across different annuity policies. Section V summarizes our findings and considers alternative interpretations of the results.

I. Background on Annuities and Testing for Asymmetric Information

A. Overview of the Annuity Market

An annuity is a contract that pays its beneficiary, the annuitant, a pre-specified amount for as long as he or she is alive. It thus insures the annuitant against the risk of outliving accumulated resources. From the insurer's standpoint, high-risk annuitants are those who are likely to live longer than their 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 markets in the United States and the United Kingdom has puzzled many researchers. Friedman and Warshawsky (1990) and Brown et al. (2001) offer several possible explanations, including bequest motives, the prevalence of annuitized public-sector social security programs and private defined-benefit pensions, and the potential need for buffer stock savings to pay for medical and long-term-care needs.

Demand for annuities may also be low 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 from the standpoint of typical individuals.

Several previous studies have reported indirect evidence of adverse selection in annuity markets, in contrast to the direct evidence that we present. The pricing of voluntary annuities in both the United States and the United Kingdom implies that, for a typical individual, the expected present discounted value of payouts is only 80–85 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 both nations suggest that life expectancy for a typical 65-year-old male voluntary annuitant is 20 percent longer than 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. This relationship between product choice and ex post risk experience is the central prediction of theoretical models of insurance markets with asymmetric information. Our data permit what is to our knowledge the first 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 life cycle consumers with plausible risk aversion and mortality uncertainty and no annuity income, purchasing an annuity may raise lifetime expected utility, even if the expected present discounted value of payouts from the annuity is no more than 75 percent of the purchase price.

The United Kingdom provides a particularly rich setting for studying adverse selection since there are *two* separate annuity markets. One is a compulsory annuity market in which individuals who have accumulated savings in tax-deferred retirement saving accounts are required to

¹ Murthi, Orszag, and Orszag (1999) and Finkelstein and Poterba (2002) 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.

annuitize a large portion of their accumulated balance. There is also a voluntary annuity market in which individuals with accumulated savings may purchase an annuity. Adverse selection is expected to operate differently in these two markets. In the voluntary market, low-risk individuals, those with high expected mortality, have the option of not buying at all. As a result, selection on the extensive margin, between annuitants and nonannuitants, should be larger in the voluntary market than in the compulsory market. 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. Because low-risk individuals can opt out of the voluntary market, however, the voluntary annuitant population will be more homogeneous 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.

B. Testing for Adverse Selection in the Annuity Market

A central shared prediction of many models of asymmetric information, summarized in Chiappori (2000) and Chiappori and Salanie (2000), is that when observationally identical individuals are offered a choice from the same menu of insurance contracts, higher-risk individuals will buy more insurance. The intuition is straightforward. 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. Of course, this prediction, and any empirical test based on it, applies *conditional* on the characteristics of the individual observed by the insurance company and used in setting insurance prices. Chiappori (2000) provides a survey of existing empirical studies that have implemented this test for asymmetric information.

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. Most previous empirical studies, such as Cawley and Philipson (1999) and Chiappori and Salanie (2000), have similarly limited their focus to whether individuals whose insurance will make a greater payment in the event of a claim exhibit higher risk *ex post*. In practice, however, most insurance contracts are multidimensional, with several different features that affect the effective quantity of insurance provided. Our data allow us to test for self-selection on multiple policy dimensions.

We examine selection along three features of annuity policies that affect the effective quantity of insurance provided. One is the initial

annual annuity payment. This is the analogue of the payment in the event of a claim, or “quantity” in most stylized theoretical models and in previous empirical studies. It is straightforward to see that the amount of insurance is increasing in the initial amount of annuity payment.

The second feature is the annuity’s degree of back-loading. A more back-loaded 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. 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 prespecified nominal rate in each year. Annuities escalate at a nominal rate of anywhere from 3 to 8.5 percent per year in our data. Whether they offer rising real payouts depends on the expected rate of inflation. There are also real annuities, which pay out a constant real amount in each year. Their payouts are indexed to the price level. The payments from real annuities and from escalating annuities are both “back-loaded” relative to those from nominal annuities. A back-loaded 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 back-loaded annuity pays out more than the flat annuity. Such an annuitant therefore expects to gain more, at a given price, from a back-loaded annuity than an annuitant with a shorter life expectancy.

The 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 15 years are present in our data sample, although in the compulsory market, regulations forbid the sale of policies with guarantee periods of more than 10 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. Payments to the estate decrease the effective amount of insurance in a given annuity contract. In the extreme, for example, a 50-year guaranteed annuity purchased by a 65-year-old male offers effectively no insurance. Its payments will almost surely be the same as those from a 50-year bond. Similarly, an annuity that pays out more in the event of an early death, either with a guarantee period or with capital protection, is more valuable to a short-lived than to a long-lived individual.

All three of these features thus satisfy the single-crossing property: at a given price, the marginal value of each annuity product feature varies

monotonically with risk type. Theoretical models of equilibrium with adverse selection therefore make clear predictions about the relative mortality patterns of individuals whose annuities differ along these features. Those who buy back-loaded annuities should be longer-lived, conditional on observables, than other annuitants. Similarly, those who buy annuities that make payments to the estate should be shorter-lived, and 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.

These selection patterns have implications for equilibrium pricing that we exploit in designing our second set of empirical tests. In particular, features of the annuity that are selected by high-risk types should be priced more highly than those purchased by low-risk types. Of course, if contracts are not exclusive, so that nothing prevents individuals from purchasing multiple insurance contracts, features selected by high-risk types can be priced higher only if 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 back-loaded and non-guaranteed annuities satisfy the nonreplicability condition. Buyers who want a back-loaded annuity cannot replicate such an annuity by buying several less expensive nominal annuities, and someone who wants a nonguaranteed annuity cannot create one by purchasing multiple (cheaper) 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, back-loaded 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-back-loaded 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.²

Our predictions with respect to pricing and mortality patterns in annuity markets with adverse selection would not emerge if information were symmetric.³ Consider the case of policy back-loading. With sym-

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: 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.

³ Recent research by Chiappori et al. (2002) suggests that in some models with *symmetric* information—in particular when the price of insurance is marked up above expected claims—it might be possible to generate these same pricing and mortality patterns. The discussion here assumes that prices are not marked up above expected claims.

metric information, a longer-lived annuitant has no incentive to buy an annuity with back-loaded 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 does not adjust to account for his mortality prospects.

II. 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 17-year period ending on December 31, 1998. The first year in our sample, 1981, was the first year in which the company sold both voluntary and compulsory annuities. At the end of the sample period, the firm was among the 10 largest sellers of new compulsory annuities in the United Kingdom.⁴ We restrict our attention 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. The mortality patterns of the single insured lives on each policy provide a straightforward measure of ex post risk type. Our sample includes 42,054 annuity policies.

Our data set includes almost everything that the insurance company knows about its annuitants. The only information that was suppressed to protect confidentiality was 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 annuitants. In particular, it does not collect any information on the wealth, income, education, occupation, or other indicators of socioeconomic status, even though such factors might be related to mortality risk. The information collection practices at the firm we study are typical for insurance companies selling annuities in the United Kingdom. Moreover, like other firms in the market, it varies the annuity price on the basis of only age

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 he dies, annuitants are unlikely to leave the sample before they die.

TABLE 1
OVERVIEW OF THE COMPULSORY AND VOLUNTARY ANNUITIES SOLD BY THE 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
Back-Loaded 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

NOTE.—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.

and gender, and not on the basis of the individual's geographic location.⁶

A fundamental issue in trying to infer marketwide phenomena such as adverse selection from data for a single firm concerns whether the firm is representative of the industry as a whole. Table 1 provides an overview of the characteristics of the compulsory and voluntary annuities sold by our sample firm. Our firm appears typical of the industry in terms of the relative magnitude of voluntary and compulsory sales, the differences in the average age and gender of compulsory compared to

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 socioeconomic status, as well as the use of much richer information in the pricing of life insurance contracts in the United Kingdom. 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 U.K. annuity company—Prudential—began offering compulsory annuities whose prices vary on the basis of the annuitant's health characteristics. Analyzing the determinants and consequences of such richer characteristic-based pricing in annuity markets may be a fruitful area for further work.

voluntary annuitants, and the product mix of annuities sold.⁷ In addition, in results not reported, we find that the age- and gender-specific survival probabilities for voluntary and compulsory annuitants in our firm match the industrywide survival patterns for these two groups of annuitants reported in Institute of Actuaries (1999*a*, 1999*b*). Using 1998 industrywide pricing data from Finkelstein and Poterba (2002), we also found that average prices for our sample firm's compulsory products in 1998 closely match the industrywide averages. Our sample size is too small to permit such comparisons in the voluntary market, where the firm sold only 10 annuities in 1998.

Trends in annuity sales for our sample firm mirror industrywide trends reported in the *Insurance Statistics Year Book* in the compulsory but not the voluntary market. In the former, our sample firm shows upward trends virtually identical to those of the industry as a whole in terms of new premiums issued each year and amount of annuity payments made each year. For example, both the industry as a whole and our sample firm experienced about a 7.5-fold increase in annuity payments between 1983 and 1997. This trend in part reflects the expansion in the late 1980s of the set of retirement savings plans that faced compulsory annuitization requirements. In the voluntary market, the sample firm experiences the same basic pattern as the industry of a general decline in new premiums and annual payments in the 1990s, although the exact timing is not the perfect match that it is in the compulsory market. Moreover, our firm experiences an abnormally high number of voluntary sales in 1984 and in 1985. Fortunately, our empirical findings on mortality and pricing in the voluntary market are not affected if we exclude sales in these two years. However, because about one-quarter 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.⁸ The compulsory market represents the quantitatively more important market, since it is roughly 10 times the size of the voluntary market both for our sample firm and for the industry.

III. Annuitant Mortality and Annuity Product Choice

A. A Hazard Model Framework for Studying Annuitant Mortality

We estimate mortality differences among different groups of annuitants using the discrete-time, semiparametric, proportional hazard model

⁷ For the relevant industrywide data, see, respectively, the *Insurance Statistics Year Book* (Association of British Insurers), Banks and Emerson (1999), and Murthi et al. (1999).

⁸ An earlier version of the paper (available on request) provides more detailed data comparing our sample firm with the industry at large.

used by Han and Hausman (1990) and Meyer (1990). Our duration measure is the length of time the annuitant lives after purchasing an annuity. We let $\lambda(t, \mathbf{x}_i, \boldsymbol{\beta}, \lambda_0)$ denote the hazard function, the probability that an annuitant with characteristics \mathbf{x}_i dies t periods after purchasing the annuity, conditional on living until t .

The proportional hazard model assumes that $\lambda(t, \mathbf{x}_i, \boldsymbol{\beta}, \lambda_0)$ can be decomposed into a baseline hazard $\lambda_0(t)$ and a "shift factor" $\phi(\mathbf{x}_i, \boldsymbol{\beta})$ as follows:

$$\lambda(t, \mathbf{x}_i, \boldsymbol{\beta}, \lambda_0) = \phi(\mathbf{x}_i, \boldsymbol{\beta})\lambda_0(t). \quad (1)$$

The baseline hazard, $\lambda_0(t)$, is the hazard when $\phi(\cdot) = 1$. The function $\phi(\cdot)$ represents the proportional shift in the hazard caused by the vector of explanatory variables \mathbf{x}_i with unknown coefficients $\boldsymbol{\beta}$. We restrict the effects of the explanatory variables (\mathbf{x}_i) to be duration-independent.

We adopt one of the common functional forms for $\phi(\cdot)$, $\phi(\mathbf{x}_i; \boldsymbol{\beta}) = \exp(\mathbf{x}_i'\boldsymbol{\beta})$. The proportional hazard model is then written as

$$\lambda(t, \mathbf{x}_i, \boldsymbol{\beta}, \lambda_0) = \exp(\mathbf{x}_i'\boldsymbol{\beta})\lambda_0(t). \quad (2)$$

We model the baseline hazard $\lambda_0(t)$ nonparametrically as a step function. This allows us to avoid imposing any restrictive functional form assumptions. We have 17 years of data and we allow for 17 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

$$\lambda(t_i; \mathbf{x}_i, \boldsymbol{\beta}, \delta) = 1 - \exp[\exp(\mathbf{x}_i'\boldsymbol{\beta})(\delta_t - \delta_{t+1})]. \quad (3)$$

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

$$\ln(L) = \sum_{i=1}^n (1 - c_i) \ln[\lambda(t_i; \mathbf{x}_i, \boldsymbol{\beta}, \alpha)] - \int_0^t \lambda(s; \mathbf{x}_i, \boldsymbol{\beta}, \alpha)ds, \quad (4)$$

where c_i is an indicator variable that equals one if individual i survives until the end of our sample period and zero otherwise. In our data set, 84 percent of the compulsory annuitants and 47 percent of the voluntary annuitants survived until the end of our sample.

We estimate hazard models for annuitant deaths as a function of all the known characteristics of the annuitants and their annuity policies. We estimate separate models for annuitants in the voluntary and compulsory markets. In all 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.

Our main covariates of interest are three annuity policy characteristics: the degree of back-loading, the presence of payments to the estate,

and the initial annual annuity payment. Under the null hypothesis that there is symmetric information in the annuity market, the coefficients on these variables will be zero. Our key empirical test focuses on whether these covariates have nonzero coefficients and whether their sign is that predicted by asymmetric information theory.

We include two indicator variables to capture the degree of annuity back-loading. 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 asymmetric information 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 mortality 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 relative amount of back-loading in an escalating and indexed annuity depends on the degree of escalation and the rate of expected inflation.

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 asymmetric information theory described above predicts that individuals who buy annuities with more payments to the estate will be shorter-lived (i.e., have a higher mortality 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 since there is no clear measure of which is relatively more attractive to someone with mortality that diverges from the population average.

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 asymmetric information theory described above predicts that individuals who will receive 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.

TABLE 2
SELECTION EFFECTS AND ANNUITY PRODUCT CHARACTERISTICS

EXPLANATORY VARIABLE	ESTIMATES FROM HAZARD MODEL OF MORTALITY AFTER PURCHASING AN ANNUITY		ESTIMATES FROM LINEAR PROBABILITY MODEL OF PROBABILITY OF DYING WITHIN FIVE YEARS	
	Compulsory Market (1)	Voluntary Market (2)	Compulsory Market (3)	Voluntary Market (4)
Index-linked	-.839*** (.217)	-.894** (.358)	-.053*** (.019)	-.185*** (.050)
Escalating	-1.085*** (.113)	-1.497*** (.253)	-.072*** (.010)	-.152*** (.030)
Guaranteed	.019 (.029)	.216*** (.060)	.007* (.004)	.046*** (.016)
Capital-protected056 (.051)064*** (.016)
Payment (£100s)	-.003*** (.0006)	.001** (.0004)	-.0003*** (.0001)	.0003*** (.0001)
Male Annuitant	.640*** (.039)	.252*** (.051)	.044*** (.005)	.044*** (.014)
Observations	38,362	3,692	24,481	3,575
Number of deaths in sample	6,311	1,944	2,693	822

NOTE.—Cols. 1 and 2 report estimates from Han-Hausman discrete-time, semiparametric proportional hazard models on the full sample. These are estimated using 17 annual discrete time intervals. Baseline hazard parameters are not reported. Cols. 3 and 4 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 “back-loaded” 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.

* Statistically significant at the 10 percent level.

** Statistically significant at the 5 percent level.

*** Statistically significant at the 1 percent level.

B. Basic Results on Annuity Choice and Mortality Patterns

Table 2 presents estimates of the hazard model in equation (3). Columns 1 and 2 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 columns 3 and 4 of table 2, show the same mortality patterns across products as the hazard models. Given the similarity of the findings, our discussion of the findings focuses on the hazard model specifications in columns 1 and 2. Finkelstein and Poterba (2000) describe the robustness of the findings in table 2 to a number of other alternative specifications.

In both the compulsory and the voluntary markets, there is strong evidence that individuals who buy more back-loaded annuities are longer-lived. The coefficients on indicator variables for index-linked and escalating annuities are negative and statistically significant at the 1 percent 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. Individuals who buy guaranteed annuities have higher hazards, and hence are shorter-lived, than observationally similar individuals who buy nonguaranteed, non-capital-protected annuities. This coefficient is statistically significantly different from zero. 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 nonguaranteed, 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 nonguaranteed annuities, we are unable to reject the null hypothesis of no difference at standard statistical confidence levels. However, in the compulsory market there is sufficient sample size to allow us to 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 10-year guaranteed annuities. The remainder, less than 0.5 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 nonguaranteed annuitants, annuitants with 10-year guarantee periods, the longest in the compulsory market, are significantly shorter-lived than annuitants with nonguaranteed 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- and 10-year guarantee periods are also statistically significantly different from each other. These results are consistent with models of adverse selection.⁹

Table 2 also provides evidence that in the compulsory market, but

⁹ Small sample sizes preclude us from testing similar predictions for selection by degree of back-loading or by amount of escalation for escalating annuities in the compulsory market, or for selection by length of guarantee period or amount of escalation in the voluntary market.

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 consistent with adverse selection. These results are broadly consistent with marketwide data on the relationship between the size of the annuity and the mortality of the annuitant. For example, the Institute of Actuaries (1999*a*, 1999*b*) reports that those who buy larger compulsory annuity policies tend to live longer than those who buy smaller policies, but that no such relationship is discernible in the voluntary market. The reason may be that voluntary annuitants are drawn to a substantial extent from the highest wealth strata of the population and that the variation in mortality rates by wealth within this group is limited.

The findings of statistically significant mortality differences associated with back-loaded and guaranteed annuities allow us to reject the null hypothesis of symmetric information. In rejecting the null, we reject the hypothesis that these annuity policy characteristics are uncorrelated with unobservable predictors of the individual's mortality. Indeed, our results suggest that there are unobserved aspects of the individual's mortality risk that are correlated with the individual's choice of annuity contract. Since indicator variables for various aspects of this choice are the explanatory variables in our hazard models, the correlation between these variables and the unobserved mortality heterogeneity makes it impossible to give a causal or structural interpretation to the coefficients on these covariates.

It may nevertheless be of interest to comment on the relative magnitude of different coefficients. These relative magnitudes indicate the degree of correlation between particular contract choices and the unobserved mortality heterogeneity rather than the causal impact of specific contract choices on subsequent mortality experience. The coefficients 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. For example, in both the voluntary and the compulsory markets, the coefficient estimates indicate that the mortality differences between back-loaded and non-back-loaded annuitants are larger than the mortality differences between male and female annuitants. Mortality differences between guaranteed and nonguaranteed annuitants in the voluntary market are only slightly smaller than mortality differences between male and female annuitants in the voluntary market.

In contrast, it should be emphasized that in both the voluntary and the compulsory annuity markets, the estimated mortality differences across annuitants with different amounts of initial annual payment are small both in absolute terms and compared to the magnitude of the effect of other annuity features on mortality. For example, in the com-

pulsory market, a one-standard-deviation increase in the amount of the initial annuity payment is associated with only a 5 percent decrease in the mortality hazard. The difference between being male and being female, by comparison, is associated with a 64 percent shift in the mortality hazard. In the compulsory market, our findings support selection on the annuity payment in the direction predicted by asymmetric information theory, but the coefficient estimate suggests that the mortality differences are not substantively important. In the voluntary market, the selection on the annuity payment has the opposite sign than that predicted by asymmetric information theory and again is substantively trivial.

These findings of little, if any, selection on the initial annuity payment are consistent with 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. The finding of little selection on the annuity payment is particularly surprising because if higher-wealth households are inclined to purchase larger annuities and if life expectancy is an increasing function of wealth, this alone should generate a negative correlation between the size of the annuity payment and the mortality hazard.

IV. 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.

A. *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 pay-

outs 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. The money's worth for an actuarially fair annuity is unity, and it has 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, 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, nonguaranteed annuity can be computed as

$$MW_{\text{NOM}} = \frac{\sum_{t=1}^T [(A \times S_t) / \prod_{j=1}^t (1 + i_j)]}{P}. \quad (5)$$

In this expression, A denotes the payment per period 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 . This 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 the annuity purchase.

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 annuitant in our data set. In each case, we use mortality tables from the year in which the annuity was purchased. For example, for a 65-year-old male who purchased an annuity in 1985, we use the department'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 (1999*a*), more generally support the accuracy of historical projections of future mortality rates.

To discount future annuity payouts, we would ideally like to use discount rates that correspond to the assets in the insurer's investment portfolio. At the end of our sample period, 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 discount rate assumptions. 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. This is difficult in the first part of our sample because there was very little issuance of new corporate bonds in the United Kingdom during the 1980s. 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 60 percent of which are issued by U.K. companies, all with a rating of at least BBB. For each month between 1993 and 1998, we compute the average difference between the yield on the Morgan Stanley bond index and that on U.K. government bonds for six maturities along the term structure. 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 1981–98 period. This provides an estimate 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.

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

$$\begin{aligned} \text{price}_i = & \alpha + \beta_1 \text{index-linked}_i + \beta_2 \text{escalating}_i + \beta_3 \text{guaranteed}_i \\ & + \beta_4 \text{capital-protected}_i + \beta_5 \text{payment}_i + \beta_6 \text{payment}_i^2 \\ & + \beta_7 \mathbf{X}_i + \epsilon_i \end{aligned} \quad (6)$$

where \mathbf{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

TABLE 3
SUMMARY STATISTICS ON EFFECTIVE ANNUITY PRICES

	COMPULSORY MARKET		VOLUNTARY MARKET	
	Treasury Yield Curve	Corporate Yield Curve	Treasury Yield Curve	Corporate Yield Curve
5th percentile	-.05	-.01	-.09	-.07
25th percentile	.04	.08	-.03	-.02
Median	.09	.13	.01	.02
75th percentile	.14	.17	.06	.07
95th percentile	.25	.29	.15	.15
Mean	.09	.13	.02	.03

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

a series of indicator variables for the frequency of the annuity payments. Recall that we measure price by $1 - MW$.

Equilibrium requires that the prices of various annuity product features be 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 ($\beta_6 > 0$). We can test the exclusivity of annuity contracts indirectly by studying the coefficients on the variables measuring the amount of the initial annuity payment.

B. Empirical Findings

Table 3 reports summary statistics on the distribution of the effective annuity price variable in both the voluntary and the compulsory 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

TABLE 4
 HEDONIC MODEL OF ANNUITY PRICING: THE EFFECT OF PRODUCT CHARACTERISTICS

TERM STRUCTURE	COMPULSORY MARKET (<i>N</i> = 38,362)		VOLUNTARY MARKET (<i>N</i> = 3,692)	
	Treasury	Corporate	Treasury	Corporate
Index-linked	.096*** (.004)	.104*** (.004)	.046*** (.007)	.060*** (.006)
Escalating	.004* (.002)	.019*** (.002)	-.032*** (.005)	-.016*** (.004)
Guaranteed	-.014*** (.0009)	-.014*** (.0009)	-.037*** (.002)	-.036*** (.002)
Capital-protected	-.081*** (.002)	-.040*** (.002)
Payment (£100s)	-.002*** (.00003)	-.002*** (.00003)	-.0003*** (.00003)	-.0003*** (.00003)
Payment squared (£10,000s)	2.56e-06*** (9.24e-08)	2.45e-06*** (8.83e-08)	5.31e-07*** (8.78e-08)	5.04e-07*** (7.67e-08)

NOTE.—Coefficient estimates are taken from linear regressions of one minus money's worth on product characteristics as described in eq. (6). We estimate money's worth 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.

* Statistically significant at the 10 percent level.
 ** Statistically significant at the 5 percent level.
 *** Statistically significant at the 1 percent level.

discussed above, the average effective prices that our sample firm charges in the compulsory market are close to those for the industry at large.

The effective price is 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 5 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 be correspondingly negative.

Table 4 reports the hedonic regression results, which are generally supportive of the pricing patterns predicted under asymmetric information. We report separate results when price is estimated using the government and corporate borrowing rate term structures. The esti-

mated 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 markets than annuities that do not make such payments. This is consistent with the hazard model results that suggest that annuitants who purchase annuities that make payments to the estate are shorter-lived than annuitants who purchase annuities without such provisions. In results not reported here, we also found that 10-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 back-loading are similarly supportive of asymmetric information models. Index-linked annuities are priced significantly higher than nominal annuities in both the compulsory and voluntary markets, reflecting the fact that the typical annuitant who purchases an index-linked annuity is longer-lived than the typical annuitant who purchases a nominal annuity. In the compulsory market, there is also evidence that escalating annuities have higher prices than nominal annuities.

The general pattern of a higher price for back-loaded 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 industrywide pricing patterns provides further reassurance that our findings speak to an industrywide adverse selection phenomenon and are not an idiosyncratic feature of our 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's (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 markets.

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

$$\frac{P \times A}{10,000} + \frac{(P - 10,000) \times f}{10,000},$$

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 nonexclusive contracts.

V. 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 on multiple characteristics of annuity policies, and we find evidence of selection in both mortality rates and policy pricing. Specifically, 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 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, the mortality difference between otherwise identical individuals who purchase back-loaded and non-back-loaded annuities is larger than the mortality difference between male and female annuitants. We also find evidence that back-loaded annuities are priced higher, and annuities with payments to the estate are priced lower, than other annuities. This is consistent with our finding that longer-lived annuitants buy back-loaded policies, whereas the shorter-lived purchase estate protection.

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. This finding is thus

consistent with the evidence in Cawley and Philipson (1999) and Chiapori 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 theoretical models of asymmetric information. They also raise the question of what determines whether selection occurs, and whether it can be detected, on a feature of the insurance contract that satisfies the single-crossing property.

Our findings of differential mortality experience for annuitants who purchase different types of policies are consistent with standard models of adverse selection in which individuals have private information about their risk type, and this private information influences their choice of insurance contract. Interpreted in this light, these findings are complementary to survey-based studies, such as Hamermesh (1985) and Hurd and McGarry (2002), 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 consistent not only with individuals' having private mortality information but also with individuals' using this information in making annuity purchase decisions.

It is important to note, however, that there are several other potential explanations for our findings. One alternative explanation emphasizes moral hazard rather than adverse selection. 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. In this case, our findings are still evidence of asymmetric information, but we interpret the causality of the relationship between contract choice and subsequent mortality differently.

It is notoriously difficult to distinguish empirically between adverse selection and moral hazard. However, 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, however, we suspect that its quantitative importance is small, especially in a developed nation such as the United Kingdom. Moreover, Banks and Emmerson (1999) report that among both voluntary and compulsory annuitants in the United Kingdom, 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.

A second possible interpretation is that rather than reflecting private information on the part of the annuitant, our findings are the outcome of a noncompetitive equilibrium with symmetric information. Recent theoretical work by Chiappori et al. (2002) suggests that imperfect competition can produce a correlation between the quantity of insurance and the ex post occurrence of risk that is observationally equivalent to what would be predicted by asymmetric information. We consider this an unlikely explanation for our findings, however. The insurance company we study uses only age and gender in pricing, so annuitants have substantial private information that might bear on expected longevity, including health history and socioeconomic status.

A third possibility is that individuals have different preferences as well as different risk types, and that neither are fully observed by insurance companies. If preference elements such as the discount rate, risk aversion, or desire to leave a bequest are correlated with both insurance demand and risk type, this could generate a correlation between policy choice and mortality risk. For example, 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. Anything that is correlated with mortality and is known by the individual but not by the insurance company, even if the individual does not recognize its effect on his mortality, operates just like asymmetric mortality information.

However, if such preference-based selection is the primary factor driving our findings, this might help reconcile apparent differences across insurance markets in the correlation between insurance coverage and risk occurrence. For example, in contrast to our findings in annuity markets, Cawley and Philipson (1999) find that in life insurance markets, where the insured are insuring against early death rather than long life in annuity markets, individuals who buy larger policies do not display above-average mortality risk. One potential unifying explanation for these findings is that more risk-averse individuals demand more of both types of mortality-related insurance, and more risk-averse individuals are also longer-lived. They are thus higher-risk from the perspective of the annuity contract and lower-risk from the perspective of the life insurance contract. Consistent with such preference-based selection, Finkelstein and McGarry (2003) find evidence in the long-term-care insurance market that more risk-averse individuals are both more likely to buy long-term-care insurance and less likely to consume long-term care. We regard a further investigation into the nature of preference-based selection as an important area for further work.

References

- Banks, James, and Carl Emmerson. 1999. *UK Annuitants*. Briefing Note no. 5. London: Inst. Fiscal Studies.
- Brown, Jeffrey R., Olivia S. Mitchell, and James M. Poterba. 2002. "Mortality Risk, Inflation Risk, and Annuity Products." In *Innovations for Financing Retirement*, edited by Olivia S. Mitchell et al. Philadelphia: Univ. Pennsylvania Press.
- Brown, Jeffrey R., Olivia S. Mitchell, James M. Poterba, and Mark J. Warshawsky. 2001. *The Role of Annuity Markets in Financing Retirement*. Cambridge, Mass.: MIT Press.
- Brugiavini, Agar. 1993. "Uncertainty Resolution and the Timing of Annuity Purchases." *J. Public Econ.* 50 (January): 31–62.
- Cardon, James H., and Igal Hendel. 2001. "Asymmetric Information in Health Insurance: Evidence from the National Medical Expenditure Survey." *Rand J. Econ.* 32 (Autumn): 408–27.
- Cawley, John, and Tomas J. Philipson. 1999. "An Empirical Examination of Information Barriers to Trade in Insurance." *A.E.R.* 89 (September): 827–46.
- Chiappori, Pierre-André. 2000. "Econometric Models of Insurance under Asymmetric Information." In *Handbook of Insurance*, edited by Georges Dionne. London: Kluwer.
- Chiappori, Pierre-André, Bruno Jullien, Bernard Salanie, and François Salanie. 2002. "Asymmetric Information in Insurance: General Testable Implications." Manuscript. Chicago: Univ. Chicago.
- Chiappori, Pierre-André, and Bernard Salanie. 2000. "Testing for Asymmetric Information in Insurance Markets." *J.P.E.* 108 (February): 56–78.
- Cohen, Alma. 2001. "Asymmetric Information and Learning in the Automobile Insurance Market." Manuscript. Cambridge, Mass.: Harvard Univ., Dept. Econ.
- Cutler, David M. 2002. "Health Care and the Public Sector." In *Handbook of Public Economics*, vol. 4, edited by Alan J. Auerbach and Martin Feldstein. Amsterdam: North-Holland.
- Finkelstein, Amy, and Kathleen McGarry. 2003. "Private Information and Its Effect on Market Equilibrium: New Evidence from Long-Term Care Insurance." Working Paper no. 9957 (September). Cambridge, Mass.: NBER.
- Finkelstein, Amy, and James M. Poterba. 2000. "Adverse Selection in Insurance Markets: Policyholder Evidence from the U.K. Annuity Market." Working Paper no. 8045 (December). Cambridge, Mass.: NBER.
- . 2002. "Selection Effects in the United Kingdom Individual Annuities Market." *Econ. J.* 112 (January): 28–50.
- Friedman, Benjamin M., and Mark J. Warshawsky. 1990. "The Cost of Annuities: Implications for Saving Behavior and Bequests." *Q.J.E.* 105 (February): 135–54.
- Hamermesh, Daniel S. 1985. "Expectations, Life Expectancy, and Economic Behavior." *Q.J.E.* 100 (May): 389–408.
- Han, Aaron, and Jerry A. Hausman. 1990. "Flexible Parametric Estimation of Duration and Competing Risk Models." *J. Appl. Econometrics* 5 (January–March): 1–28.
- Hurd, Michael D., and Kathleen McGarry. 2002. "The Predictive Validity of Subjective Probabilities of Survival." *Econ. J.* 112 (October): 966–85.
- Institute of Actuaries and Faculty of Actuaries. Continuous Mortality Investigation Committee. 1999a. *Continuous Mortality Investigation Reports*, no. 16. London: Inst. Actuaries.

- . 1999*b*. *Continuous Mortality Investigation Reports*, no. 17. London: Inst. Actuaries.
- Meyer, Bruce D. 1990. "Unemployment Insurance and Unemployment Spells." *Econometrica* 58 (July): 757–82.
- Mitchell, Olivia S., James M. Poterba, Mark J. Warshawsky, and Jeffrey R. Brown. 1999. "New Evidence on the Money's Worth of Individual Annuities." *A.E.R.* 89 (December): 1299–1318.
- Murthi, Mamta, J. Michael Orszag, and Peter Orszag. 1999. "The Charge Ratio on Individual Accounts: Lessons for the U.K. Experience." Working Paper no. 99–2. London: Univ. London, Birkbeck Coll.
- Philipson, Tomas J., and Gary S. Becker. 1998. "Old-Age Longevity and Mortality-Contingent Claims." *J.P.E.* 106 (June): 551–73.
- Puelz, Robert, and Arthur Snow. 1994. "Evidence on Adverse Selection: Equilibrium Signaling and Cross-Subsidization in the Insurance Market." *J.P.E.* 102 (April): 236–57.
- Rothschild, Michael, and Joseph Stiglitz. 1976. "Equilibrium in Competitive Insurance Markets: An Essay on the Economics of Imperfect Information." *Q.J.E.* 90 (November): 629–49.
- Yaari, Menahem E. 1965. "Uncertain Lifetime, Life Insurance, and the Theory of the Consumer." *Rev. Econ. Studies* 32 (April): 137–50.