Quality and Provider Choice: A Multinomial Logit–Least-Squares Model with Selectivity

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A Federal Trade Commission survey of contact lens wearers is used to estimate a multinomial logit–least-squares model of the joint determination of provider choice and quality of care in the contact lens industry. The effect of personal and industry characteristics on a consumer's choice among three types of providers—opticians, ophthalmologists, and optometrists—is estimated via multinomial logit. The regression model of the quality of care has two features that distinguish it from previous work in the area. First, it uses an outcome rather than a structural or process measure of quality. Quality is measured as an index of the presence of seven potentially pathological eye conditions caused by poorly fitted lenses. Second, the model controls for possible selection bias that may arise from the fact that the sample observations on quality are generated by consumers' nonrandom choices of providers. The multinomial logit estimates of provider choice indicate that professional regulations limiting the commercial practices of optometrists shift demand for contact lens services away from optometrists toward ophthalmologists. Further, consumers are more likely to have their lenses fitted by opticians in states that require the licensing of opticians. The regression analysis of variations in quality across provider types shows a strong positive selection bias in the estimate of the quality of care received by consumers of ophthalmologists' services. Failure to control for this selection bias results in an overestimate of the quality of care provided by ophthalmologists.

Quality of care is becoming an increasingly important issue in the market for health care services. For example, the change from retrospective cost-based reimbursement to prospective diagnosis-based reimbursement of hospitals under the Medicare program has resulted

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in complaints of lower-quality care for Medicare beneficiaries (Rover 1986). As a result of reduced tax subsidies for health insurance premiums and increased cost sharing in health insurance plans, consumers may be substituting lower-cost providers, such as midwives for obstetricians, or podiatrists and chiropractors for orthopedic surgeons, and "not much is actually known about the quality of care provided by these nonphysicians as compared to that of physicians" (Wyszewianski, Wheeler, and Donabedian 1982, 529).

Policymakers' abilities to address increasingly pressing issues of quality have been limited by two major factors. The first is the lack of data on quality; quality is difficult to define and even harder to measure. Donabedian (1980) distinguishes among three components of quality: the technical aspects of quality, the interpersonal aspects of quality, and the amenities of care. The technical aspects refer to how well medical science and knowledge are applied to the diagnosis and treatment of the medical problem. The interpersonal component of quality is defined in terms of the responsiveness, friendliness, and attentiveness of the health care provider in interacting with the patient. The amenities of care include the appeal and comfort of the health care facility.

Further, measures of quality of care fall into three categories: structure, process, and outcome (Donabedian 1980). Structure refers to the relatively fixed characteristics of the medical delivery system, such as the number, types, and qualifications of health care providers and facilities. Process measures reflect what is done to and for the patient—the application of medical procedures, drugs, and so forth. Outcome refers to the changes in the patient's current and future health status that can be attributed to antecedent medical care.

While there are three potential approaches to measuring quality, outcome measures are the most relevant for quality assessment. A recent report from the Office of Technology Assessment states that "patient outcomes are the most desirable benchmark against which to assess quality of care" (U.S. Congress 1985, 79). And Donabedian (1988) writes that "structural attributes, although of vital importance to system design, are rather blunt instruments in quality assessment" (p. 177). Further, the federal government plans to use outcome measures of quality in their study of the quality of care provided by the more than 300,000 physicians who treat Medicare patients. Dr. William Roper, administrator of the Health Care Financing Administration, said, "We plan to measure the performance of individual physicians by seeing how well their patients do" (*New York Times* 1988, 1).

Yet many empirical studies of quality rely on structural measures,

such as provider characteristics, to draw inferences about the quality of care. For example, Marquis (1985) measures quality as an attribute of provider specialty and practice setting. However, she qualifies her results by saying that quality is intended to mean "characteristics to which consumers attach value and does not necessarily imply technical quality" (p. 143). Goldman and Grossman (1978) measure quality as provider characteristics, such as number of years of experience, reputation of medical school alma mater, type of specialty, and membership in professional societies. Thus, their results depend on the assumption that quality is highly correlated with years of experience or membership in professional societies. Colle and Grossman (1978) estimate quality from the mean price of an office visit by provider type. Thus, their results depend on the assumption that quality and price are closely related.

The second issue complicating analyses of quality is of a statistical nature. Data on the quality of care observed by the researcher are generated not only by providers' preferences and abilities to produce quality but also by the individuals' preferences for quality and choice of provider. Consumers select a provider type (i.e., a general practitioner or a specialist in the medical care market; an ophthalmologist, optometrist, or optician in the eye care market; a psychiatrist, psychologist, or social worker in the mental health care market) as well as a specific provider. Therefore, quality and choice of provider are outcomes of the decisions of the consumer, that is, they are both endogenous.

However, empirical studies of quality in health care markets that do not measure quality by provider type treat provider choice as exogenous (Feldman and Begun 1978; Kwoka 1984; Haas-Wilson 1986, 1987). These studies potentially suffer from self-selection bias since observed differences in quality across providers may be due not only to the measured characteristics of the provider and the consumer but also to some unmeasured systematic differences between consumers choosing one type of provider over another. For example, the successful use of contact lenses depends not only on a proper fit by the ophthalmic supplier but also on the conscientiousness of the patient in the cleaning and sterilization of the lenses. If a researcher is unable to measure the patient's level of contact lens care and if the more conscientious patients are more likely to choose ophthalmologists over optometrists and opticians, then regression estimates of differences in the quality of care across provider types may overstate the quality of care offered by ophthalmologists. This has important implications for health policy. If this type of self-selection bias is present, then regulations that prevent opticians and optometrists from providing certain contact lens services

may not raise the overall level of the quality of these services. This is so because the characteristics of the population of purchasers of ophthalmologists' services will shift toward the characteristics of the average consumer.

In this article we estimate a model of the joint determination of provider choice and quality of care in the contact lens industry. Rather than using a structural measure of quality we have an outcome measure of the quality of the contact lens fittings provided by three types of providers—ophthalmologists, optometrists, and opticians. Specifically, quality is measured as an index of the contact lens wearers' eye health or the relative presence of seven potentially pathological eye conditions caused by poorly fitted contact lenses.

In our statistical model the observed levels of quality are generated, in part, by the level offered by each provider and, in part, by consumers' choices among these three types of providers. To correct for selectivity bias, we follow a method proposed by Lee (1982, 1983) that is ideally suited to models that have more than two choices. The method has clear computational advantages over the multinomial probit extension of the Heckman two-stage estimator and has extensive applications to health care issues.[1]

THE DATA

We use a data set constructed by the Federal Trade Commission (FTC) from a survey of contact lens wearers. In order to collect the contact lens data, the FTC mailed questionnaires to 31,219 households in 18 urban areas.[2] Respondents who indicated that they had been fitted with contact lenses within the past three years and that they still wore the lenses, were offered a modest sum to participate in the study. Between June 1979 and February 1980, the FTC examined 502 contact lens wearers and their lenses.

Each contact lens wearer underwent a biomicroscopic and keratometric examination by each of three examiners.

> The biomicroscope was used to examine the surface of the eye for a variety of potentially pathological conditions, including: epithelial and microcystic edema (intercellular accumulation of fluids which causes the cornea to swell); corneal staining (abrasions or lesions of the cornea); corneal neovascularization (impingement of blood vessels into the normally avascular cornea, which may cause part or all of the cornea to become opaque); corneal striae (ridges or furrows on the cornea); and

> injection ("bloodshot" eyes or eyelids). Each of the six conditions was graded on a 0-1-2-3-4 scale according to an illustrated grading manual given to each examiner. . . . The keratometer was used to take k-readings (measurements of the steepest and flattest curvature of the corneal surface) and to evaluate corneal distortion (irregularity in the curvatures of the cornea). (Federal Trade Commission 1983, 22-23)

The results from the three examiners were then transformed into a single score for each of the seven potentially pathological conditions. Fourteen individual final scores (seven for each eye) were calculated for each subject. These 14 final scores were then added together to create an unweighted quality index for each consumer. The scores recorded by the examiners were negatively related to eye health (i.e., a high score meant that the condition was present). In our study, we rescaled the score so that the summary quality index would be positively related to eye health. The rescaled index ranged from 1 to 23, in our sample, with a mean and standard deviation of 19.56 and 3.46, respectively. This index formed our outcome measure of the quality of care.

After February 1980, questionnaires were sent to the ophthalmic supplier named by each subject as the source of his or her contact lenses. The responses to the ophthalmic suppliers' questionnaire enabled the FTC to determine whether the subject had been fitted by an ophthalmologist, optometrist, or optician. (These data are described in more detail in Federal Trade Commission 1983).

ECONOMETRIC SPECIFICATION AND ESTIMATION

The economic model underlying our econometric specification is one of an implicit market for quality, which can be characterized by standard demand and supply curves:

$$Q^D = Q^D(\hat{p}, X^D)$$
$$Q^S = Q^S(\hat{p}, X^S)$$

where Q^D and Q^S are the demand for the supply of quality; $\hat{p}$ is the implicit price of a unit of quality; and X^D and X^S denote exogenous demand and supply variables, respectively. This framework was first applied to empirical models of the demand for medical care by Goldman and Grossman (1978) in their analysis of the demand for pediatric care. It has since served as the theoretical basis for much of the empiri-

cal work on quality of care (see, for examples, Marquis 1985; Feldman and Begun 1985).

In this model, quality and its implicit price are endogenously determined by market forces. Rather than estimating the structural supply and demand curves we estimate the model in its reduced form. That is, we estimate the effect of exogenous factors on the equilibrium levels of quality. Our regression model then consists of the following set of equations:

$$Q_{ij} = X_i\beta_j + \epsilon_{ij} \qquad \begin{matrix} i = 1, \ldots, N_j \\ j = 1, 2, 3 \end{matrix} \tag{1}$$

where

Q_{ij} = the quality of the services of the jth provider type received by individual i;
X_i = (X^D_i, X^S_i);
N_j = the number of individuals choosing provider type j;
β_j = a set of unknown parameters measuring the effects of changes in the variables contained in X_i on quality; and
ϵ_{ij} = an unobservable random error.

To model the consumer's choice of provider, let I_{ij} be a latent variable representing the benefits of the services of the jth provider type perceived by individual i. I_{ij} should be influenced by price, the perceived quality of the services, and exogenous factors. Here, too, we estimate our choice model in its reduced form:

$$I_{ij} = Z_i\alpha_j + \mu_{ij} \tag{2}$$

where

Z_i = a set of exogenous explanatory variables that includes variables that influence the consumer's perception of quality and price;
α_j = a set of unknown parameters; and
μ_{ij} = an unobservable random component.

A consumer purchases contact lenses from the provider whose services yield the greatest perceived benefits.

To estimate the model consistently we need to account for the fact that our observations on quality are not generated randomly but instead are generated by consumers' nonrandom choices of providers. For example, the quality of the services of provider type 1 is observed

only for those consumers who choose provider type 1, that is, only for consumers for which $I_{i1} > I_{i2}$ and $I_{i1} > I_{i3}$. Therefore, in our sample the mean quality of provider type 1's services is conditional on the consumer's selection of provider type 1:

$$E(Q_{i1}|I_{i1} > I_{i2} \text{ and } I_{i1} > I_{i3}) = X\beta_1 + E(\epsilon_{i1}|I_{i1} > I_{i2} \text{ and } I_{i1} > I_{i3}) \quad (3)$$

If the errors in the quality equation and the errors in the choice model are correlated, then the conditional mean of the regression error will differ from zero. Thus, a regression of Q_1 on X alone will lead to biased and inconsistent estimates of the parameter vector, β_1. Not accounting for the nonzero conditional mean of the error in the regression function is equivalent to omitting a relevant variable from the estimated model.

The most widely used method for obtaining consistent regression estimates in models with selectivity is a two-stage procedure developed by Heckman.[3] This approach involves, first, estimating the choice model to construct a variable that measures the mean of ϵ_{i1} conditional on the individual's estimated choice behavior (the second term in the bottom part of Equation 3). The second stage includes this variable as an additional regressor in the regression function. Assuming that the errors in the regression function and the errors in the choice model are normally distributed, the Heckman procedure calls for probit estimation of the choice model.

Heckman's procedure was originally designed for models where individuals face only two choices. In our model consumers are choosing from more than two types of providers. While, theoretically, Heckman's method can be extended to higher dimensional choice models, in practice the method is difficult to implement. The assumption of normality in errors of the choice model implies the use of the multinomial probit technique, which requires the evaluation of multiple integrals and thus imposes considerable computational costs.

To obtain consistent estimates of the quality equation, we use instead a modification of Heckman's two-step estimator suggested by Lee (1982, 1983). The principle underlying Lee's method is that a random variable from a nonnormal distribution can always be transformed into a standard normal random variable. Hence, one need not assume normality in the errors of the choice model. This procedure allows us to estimate the choice model via multinomial logit, a computationally simple procedure, and to construct the mean of the regres-

sion error conditional on the normal transformation of the estimated logit choice model.[4]

EMPIRICAL SPECIFICATION AND RESULTS

EMPIRICAL SPECIFICATION

We include in our logit and regression models exogenous demand variables such as income, search costs, and quality preferences, and exogenous supply factors such as input costs and the presence of regulations that may affect the number of opticians, optometrists, and ophthalmologists in the market and, hence, the degree of price and quality competition. We also control for some exogenous lens characteristics which, regardless of the skill of the provider, may affect the quality of the fit. Table 1 reports the means and standard deviations of these variables.

A consumer's income, education, age, sex, race, and previous experience with wearing contact lenses may directly or indirectly affect the consumer's choice of provider and demand for quality. Consumer characteristics may have indirect effects on provider choice and quality through their effects on search costs and quality preferences.

Individuals with higher earnings have higher opportunity costs of

Table 1: Description of Variables

Variable Description	*Mean*	*Standard Deviation*
Eye health index	19.56	3.46
Age of consumer	26.83	10.36
Dummy = 1 if consumer is female	0.76	0.45
Dummy = 1 for soft contact lenses	0.43	0.50
Index of commercial practice restrictions on optometrists	2.26	1.26
Dummy = 1 if state restricts advertising by optometrists	0.12	0.32
Time in hours between insertion of lenses and FTC exam	2.68	2.15
Dummy = 1 if state prohibits contact lens fitting by independent opticians	0.48	0.50
Dummy = 1 if state licenses opticians	0.52	0.50
Dummy = 1 if consumer has had a previous unsuccessful contact lens episode	0.26	0.44
Income of consumer	18,742.96	8,418.44
Dummy = 1 if consumer has only a high school degree	0.66	0.48
Dummy = 1 if consumer has at least a college degree	0.30	0.46
Dummy = 1 if consumer is white	0.95	0.21
Index of local hourly wage rates	1.11	0.10

time, and thus may be more likely to select providers who are more accessible geographically in order to minimize the time costs of care. Since there are approximately twice as many optometrists as ophthalmologists practicing in the United States (There were 12,619 active ophthalmologists and 21,855 active optometrists in the United States in 1979 (U.S. Dept. of Health and Human Services 1984), persons with higher incomes may select optometrists more frequently. Persons with more education are likely to be more efficient at obtaining and analyzing information about ophthalmologists, optometrists, and opticians. Thus, educated consumers with lower search costs may be more successful in selecting higher-quality providers of all types. Older consumers with a higher probability of eye disease may be more likely to choose ophthalmologists, since ophthalmologists are trained to diagnose and treat eye diseases. In 1979, the percent of all eye care visits that were to ophthalmologists for persons 65 years and over was 67 percent; for persons between 45 and 64 years, it was 52 percent, and for persons between 17 and 44 years, it was 33 percent (U.S. Dept. of Health and Human Services 1984).

Finally, consumers who report a previous unsuccessful experience with contact lenses may be more likely to choose an ophthalmologist, since ophthalmologists have the most formal training. Providers may also find it more difficult to fit lenses for these consumers. As the degree of difficulty in fitting contact lenses increases, the quality of the fitting may worsen.

Included as exogenous supply factors are input costs and state regulations on optometrists and opticians. In areas with higher costs of production, the supply of quality by all provider types may be lower. Regulations on optometrists' advertising prior to 1978 and regulations on the other commercial practices of optometrists, such as the use of trade names, the number and location of offices, and business affiliations, tend to decrease the supply of chain optical firms that employ optometrists (Haas-Wilson forthcoming) and to increase the prices of optometrists' services (Benham 1972, Feldman and Begun 1980, Kwoka 1984, Haas-Wilson 1986, 1987). Thus, consumers may be less likely to select optometrists in states with these restrictions.

The effect of regulations on quality is less certain. Proponents of the regulations argue that they increase quality. The regulations are necessary to prevent some optometrists from increasing their market shares by selling services at lower prices and substituting low-quality for high-quality care in ways not apparent to the consumer. In a similar vein, Feldman and Begun (1985) argue that by limiting price competition the regulations may make quality competition a relatively

more profitable means of attracting customers and may raise overall quality levels. Kwoka (1984), on the other hand, argues a potentially offsetting effect: in unregulated markets professionals may be able to increase the volume of sales, and higher volume may increase the incentive to improve professional skills. Quality levels may then be inversely related to the degree of regulations.

In states where opticians need a license to practice, the price of opticians' services may be higher since the licensure requirement is an entry barrier for opticians. Thus, consumers may be less likely to choose opticians. However, if consumers view licenses as a signal of higher quality, then they may be more likely to choose opticians in states that require optician licensure. And if the licensure requirement prevents unqualified opticians from practicing, then optician licensure may increase quality.

Before purchasing contact lenses a consumer must undergo two examinations—a refractive eye examination and a kerotometric or fitting examination. Opticians are prohibited from performing the refractive examination in all states. Some states also prohibit contact lens fittings by independent opticians—opticians practicing independently of ophthalmologists and optometrists. In these states the sale of contact lenses is effectively tied to the services of ophthalmologists and optometrists. Only consumers with contact lens prescriptions that include both refractive and fitting measures will be able to purchase their lenses from independent opticians. Thus, consumers will be less likely to receive their fitting exams from independent opticians; however, consumers may be more likely to receive their fitting exams from opticians employed by ophthalmologists or optometrists.

Included as exogenous lens factors—which, regardless of the skill of the provider, may affect the quality of fit—are the number of hours the contact lenses were worn on the day of the Federal Trade Commission's examination to determine fit quality, and whether the contact lenses are hard or soft.

Logit Estimates

Table 2 presents logit estimates of the choice model of Equation 2. A test of the joint significance of the specified variables suggests that the model has reasonable explanatory power. A likelihood ratio test where the null model constrains all but the constant terms to zero rejects the hypothesis that the specification explains none of the choice behavior.

Among the demand variables, we find that while most individually have statistically insignificant effects on provider choice, the con-

Table 2: Estimates of the Choice Model*

Variables	*Ophthalmologist*	*Optician*
Constant	-1.766	1.688
	(3.240)	(2.448)
Age of consumer	0.026	0.023‡
	(0.019)	(0.014)
Dummy = 1 if consumer is female	-0.342	0.481
	(0.482)	(0.358)
Dummy = 1 if consumer is white	-0.278	0.130
	(0.847)	(0.711)
Dummy = 1 if consumer has had a previous unsuccessful contact lens episode	-0.437	-0.913†
	(0.547)	(0.384)
Dummy = 1 if consumer has only a high school degree	0.089	0.214
	(1.158)	(0.782)
Dummy = 1 if consumer has at least a college degree	0.577	0.202
	(1.191)	(0.819)
Income of consumer (÷ 10,000)	0.312	0.083
	(0.264)	(0.176)
Time in hours between insertion of lenses and FTC exam	0.012	0.026
	(0.098)	(0.069)
Index of local hourly wage rates	-2.431	-4.143†
	(2.489)	(1.854)
Dummy = 1 for soft contact lenses	-0.240	-0.270
	(0.443)	(0.311)
Index of commercial practice restrictions on optometrists	0.477†	-0.008
	(0.190)	(0.141)
Dummy = 1 if state restricts advertising by optometrists	1.447†	0.556
	(0.723)	(0.572)
Dummy = 1 if state prohibits contact lens fitting by independent opticians	-0.184	-0.231
	(0.472)	(0.348)
Dummy = 1 if state licenses opticians	0.528	1.518†
	(0.469)	(0.336)
Log of the likelihood function: -225.937.		
Number choosing optometrists = 187.		
Number choosing ophthalmologists = 29.		
Number choosing opticians = 79.		

* The coefficients for optometrists are normalized to zero. Asymptotic standard errors are shown in parentheses.

† Statistically significant at the 5 percent level.

‡ Statistically significant at the 10 percent level.

sumer's prior experience with contact lenses has a statistically significant effect. Consumers who have had previous unsuccessful experiences with contact lenses are less likely to choose opticians. With respect to the supply-side variables, the logit results support the hypothesis that consumers use licenses as signals of quality. In states

Table 3: Simulated Probabilities of Selecting Alternative Providers

	Optometrist	*Ophthalmologist*	*Optician*
Index of commercial practice restrictions on optometrists			
0 (no restrictions)	71%	3%	26%
1	69	5	26
2	68	8	25
3	65	12	23
4	60	18	22
Advertising restrictions on optometrists			
0	69	7	24
1 (advertising prohibited)	49	22	29
Licensure of Opticians			
0	79	8	13
1 (license required)	52	8	40

that require the licensure of opticians, consumers are more likely to select opticians. Further, advertising and other commercial practice restrictions on optometrists have statistically significant effects on provider choice. The presence of these restrictions appears to shift demand away from optometrists toward ophthalmologists.

To illustrate the magnitude of these effects, Table 3 shows the consumer's probability of selecting each provider under different regulatory regimes. To isolate the effect of each regulation, our simulation sets each of the other variables equal to its sample mean. We see that the advertising and licensing restrictions have the largest effects on consumer choices. When advertising is prohibited, the probability of selecting an optometrist drops from 69 percent to 49 percent. The probability of choosing an optician is three times higher in states in which they are licensed.

Regression Estimates

The first column of Table 4 reports estimates of the quality equations using the statistical procedure described in the earlier section on econometric specification.[5] Statistical tests of the equality of coefficients across equations support the hypothesis that the coefficients on many of the characteristics of the individual (sex, age, previous contact lens experience, education, and race) and the coefficients on local hourly wages and type of lenses are identical across providers. This allows us to improve the efficiency of our estimates by pooling observations.

The results suggest that optometrists provide lower-quality care

Table 4: Estimates of the Quality Equations*

Variable Description	*Estimated Model with Self-Selection Correction*		*Estimated Model without Self-Selection Correction*	
Dummy = 1 if consumer is female	-0.107	(0.377)	-0.010	(0.441)
Age of consumer	-0.051†	(0.019)	-0.084†	(0.032)
Dummy = 1 if consumer has had a previous unsuccessful contact lens episode	0.740	(0.520)	0.904‡	(0.538)
Income of consumer (+ 10,000)	-0.038	(0.203)	-0.048	(0.227)
Dummy = 1 if consumer had only a high school degree	-0.287	(0.598)	-0.216	(0.755)
Dummy = 1 if consumer has at least a college degree	-0.750	(0.640)	-1.275	(0.832)
Dummy = 1 if consumer is white	-0.132	(1.014)	-0.699	(0.875)
Dummy = 1 for soft contact lenses	1.161†	(0.413)	1.511†	(0.428)
Index of local hourly wage rates	-0.500	(3.045)	2.485	(2.352)
Opticians				
Constant	18.585†	(2.598)	19.906†	(3.449)
Time in hours between insertion of lenses and FTC exam	-0.273†	(0.142)	-0.357†	(0.143)
Dummy = 1 if state prohibits contact lens fitting by independent opticians	1.327†	(0.592)	3.191†	(1.242)
Dummy = 1 if state restricts advertising by optometrists	-0.611	(1.087)	-0.995	(3.224)
Dummy = 1 if state licenses opticians	-0.650	(1.293)	-2.837‡	(1.517)
Index of commercial practice restrictions on optometrists	0.284	(0.257)	0.641	(0.479)
Self-selection correction	2.461	(1.780)	—	
Optometrists				
Constant	23.397†	(4.458)	20.737†	(3.526)
Time in hours between insertion of lenses and FTC exam	-0.053	(0.109)	-0.069	(0.104)
Dummy = 1 if state prohibits contact lens fitting by independent opticians	-1.188†	(0.442)	0.093	(0.175)
Dummy = 1 if state restricts advertising by optometrists	-0.100	(0.939)	-0.233	(0.962)
Dummy = 1 if state licenses opticians	0.853	(1.121)	0.093	(0.532)
Index of commercial practice restrictions on optometrists	-0.291	(0.199)	-0.371‡	(0.219)
Self-selection correction	-1.957	(2.822)	—	

Continued

Table 4: Continued

Variable Description	*Estimated Model with Self-Selection Correction*		*Estimated Model without Self-Selection Correction*	
Ophthalmologists				
Constant	9.098	(8.321)	23.837†	(3.830)
Time in hours between insertion of lenses and FTC exam	-0.617‡	(0.338)	-0.433‡	(0.260)
Dummy = 1 if state prohibits contact lens fitting by independent opticians	-1.107	(1.332)	-1.704	(1.242)
Dummy = 1 if state restricts advertising by optometrists	3.394	(2.302)	0.102	(1.158)
Dummy = 1 if state licenses opticians	0.405	(1.528)	1.122	(2.045)
Index of commercial practice restrictions on optometrists	0.792	(0.868)	-0.982	(0.867)
Self-selection correction	7.137†	(2.986)	–	
Adjusted R^2	0.134		0.124	
Total sample = 284.				
Number of opticians = 72.				
Number of ophthalmologists = 28.				
Number of optometrists = 184.				

* Asymptotic standard errors are in parentheses.
† Significant at the 5 percent level.
‡ Significant at the 10 percent level.

and opticians provide higher-quality care in states that prohibit the fitting of contact lenses by independent opticians. An earlier study that did not correct for selection bias and did not allow for differential regulatory effects across providers found that this prohibition had a statistically insignificant effect on quality (Haas-Wilson 1987). The negative effect on the quality of optometrists' services suggests that this regulation, by restricting entry, may reduce the pressure on optometrists to compete on the basis of quality.

The presence of advertising and other commercial practice restrictions on optometrists has a statistically insignificant effect on the quality of all providers' services. This result is consistent with an earlier study that found that commercial practice restrictions have a statistically insignificant effect on the quality of eye examinations and eyeglasses provided by optometrists (Haas-Wilson 1986).

Focusing on the selectivity variables, we see that selection bias is present in the equation for ophthalmologists. The coefficient on the selectivity variable in the quality equation for ophthalmologists is posi-

tive and significant. This coefficient captures the effects of the unmeasured characteristics of the consumer that influence the choice of provider and the quality of care received. Its positive sign indicates that, on average, consumers who select ophthalmologists experience fewer adverse side effects from fittings by ophthalmologists than would a randomly assigned person with the same measured characteristics. A plausible hypothesis consistent with this result is that individuals who select ophthalmologists tend to take better than average care of their eyes and of their lenses.

Among the constrained coefficients, age and type of lenses have statistically significant effects on quality. The positive sign on the dummy variable for lens type suggests that soft lenses lessen the health problems caused by poorly fitted lenses. The negative sign on age suggests that this variable primarily controls for exogenous health factors.

DISCUSSION

Farley in her 1986 synthesis and critique of economic theories about the market for physician services concludes that "much more attention needs to be given to empirical models of patients' decisions to seek care and choice of provider" (p. 332). In this article we analyzed the joint determination of provider choice and quality in the market for contact lens services. Our results show that provider choice is not exogenous to a model explaining quality variation and, therefore, that selection bias may be present in earlier empirical studies of quality of care.

Our quality estimates corrected for selectivity bias suggest substantially different results from those of regression estimates of quality that do not correct for this bias. A comparison of our corrected estimates with the uncorrected estimates, reported in the second column of Table 4, shows a difference in the constant term for ophthalmologists—9 in the corrected estimates and 24 in the uncorrected estimates. The latter estimate picks up the large nonzero conditional mean of the error in the equation for ophthalmologists. To the extent that this mean measures the unobservable attributes of consumers who select ophthalmologists, the ordinary least-squares (OLS) estimate of the quality index for a randomly selected consumer will largely overstate the true quality offered by ophthalmologists. For example, OLS estimates imply that an individual with the average characteristics of the consumers in our sample will receive roughly the same quality for contact lens fittings from each of the three provider types (an index value of

20). Estimates corrected for selection bias, however, predict a much lower level of quality provided by ophthalmologists (an index value of 7 for ophthalmologists).

This evidence has important implications for the contact lens industry, an industry characterized by regulations that limit the practices of nonphysicians. Proponents of the regulations restricting the commercial practices of optometrists argue that the regulations are necessary to prevent adverse health outcomes and to protect consumers from low-quality vision care (Federal Trade Commission 1983). Our results suggest, however, that such restrictions are failing to improve health outcomes in the contact lens industry and may even be lowering them. In our model of provider choice, we find that the commercial practice regulations imposed on optometrists shift demand away from optometrists toward ophthalmologists, the lower-quality providers of contact lens fittings. This, combined with the result that the commercial practice restrictions on optometrists have no direct effect on the quality of care in the industry, suggests that these restrictions may actually lower quality. We also find that the positive effect of the regulation restricting the fitting of contact lenses by independent opticians on the quality of opticians' services is offset by its negative effect on the quality of optometrists' services.[6]

Further, this article highlights a problem common to all health care markets, namely, that consumers make provider choices based on imperfect information. As Ginsberg and Hammons (1988) wrote, "Though consumers value technical quality highly they, generally, do not have the ability to evaluate it accurately" (p. 110). For example, state licensure of opticians has a statistically insignificant effect on quality in the contact lens industry. Consumers, however, appear to use licensure as a signal of quality, as licensure substantially increases the probability of having one's contact lenses fitted by an optician.

Several limitations to this analysis, however, must be pointed out. For one, our inferences are based on a small sample of ophthalmologists. Second, the data do not allow us to control for individual characteristics of the provider. Nevertheless, our findings indicate that the quality of care provided by nonphysicians in the contact lens industry is at least as good as the quality of physicians' services and that this holds in both regulated and unregulated markets. Further, our findings suggest that future evaluations of regulations imposed on health care providers should include estimates of the indirect effects of these regulations on quality. More specifically, future analysis should include estimates of the effect of the regulations on consumers' choice of provider.

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NOTES

1. See Maddala (1985) for a discussion of the sources of selectivity bias in health care markets. See Trost and Lee (1984) and Dowd, Feldman, Cassou, and Finch (1987) for other applications of the method used in this article.
2. Atlanta, GA; Boston, MA; Chicago, IL; Cincinnati, OH; Cleveland, OH; Detroit, MI; Houston, TX; Kansas City, MO; Los Angeles, CA; Minneapolis-St. Paul, MN; Nashville, TN; Phoenix, AZ; Pittsburgh, PA; Rochester, NY; St. Louis, MO; San Diego, CA; San Francisco, CA; and Winston-Salem/Greensboro, NC.
3. See Maddala (1983) for a discussion of the Heckman two-step estimator.
4. A technical appendix that contains a detailed description of our estimation procedures is available to interested readers on request.
5. Our regression estimates are robust to nonlinear specifications of the dependent variable, including *ln(QUALITY)* and a Box-Cox transformation, $QUALITY^{\lambda} - 1/\lambda$ where λ is estimated along with the other coefficients of the model using nonlinear least squares.
6. This result, however, is not robust to methodology. OLS estimates show that this restriction substantially raises the quality of opticians' services and has no statistically significant effect on the quality of optometrists' services.

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