STUDIES IN THE ECONOMICS OF THE PROFESSION OF OPTOMETRY

by

DOUGLAS COATE

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York.

1974

This manuscript has been read and accepted for the Graduate Faculty in Economics in satisfaction of the dissertation requirement for the degree of Doctor of Philosophy.

5/14/74
date

Melvin Reder
Chairman of Examining Committee

5/14/74
date

Melvin Reder
Executive Officer

Victor Fuchs

Michael Grossman

Supervisory Committee

The City University of New York

ACKNOWLEDGEMENTS

Dr. A.N. Haffner, Dean of the School of Optometry, State University of New York, deserves special mention for his contribution to this dissertation. He was literally available around the clock for consultation and encouragement. His national sample of optometrists forms the empirical foundation for much of the analysis in this dissertation.

It was Professor Victor Fuchs' suggestion that I originally undertake this research. He is to be acknowledged, not only for his help with the dissertation, but also for the time and effort he has put into my training as an economist. Over the last four years, the time and effort he has devoted to me has been substantial.

Professor Michael Grossman gave unlimited time and provided many valuable suggestions. It was particularly gratifying to receive his comments so soon after he had received my rough drafts.

Professor Melvin Reder is unrivaled as a reader of manuscripts. For two and one-half years, he provided countless suggestions to improve the research design, presentation, and interpretation of results. His suggestions were sound and it is unfortunate that all were not implemented, nor could they have been if another two and one-half years were spent on the dissertation. It is a tribute to Professor Reder that he can always convince you that your manuscript is something less than it could have been.

TABLE OF CONTENTS

LIST OF TABLES

INTRODUCTION

The plan of this dissertation is to provide an economic analysis of selected aspects of the profession of optometry. There are four major areas of study. These are: the determinants of the demand for an optometric education; the specification and estimation of a market model for optometric services; an examination of the causes of variation in the incomes of optometrists from their professional practices; and a production function analysis of the employment of assisting manpower in optometry. These topics were selected because their investigation should be of interest to most health economists, rather than just those with a specialized interest in eye care.

Chapter I, a historical sketch of the evolution of the profession of optometry, is introductory in nature and should be read before the remaining chapters of the dissertation. Chapters III and IV should be read in sequence because the income generating function estimated in chapter IV is derived from the market model of chapter III. Chapters II and V may be read out of sequence. Despite the fact that the dissertation is a collection of separate studies, the order of their presentation is a natural one. From the history of the profession, we move to the discussion of the choice of optometry as a profession; then to the analysis of the market for optometric services and of the causes of variation in optometric incomes; and finally we consider how efficiently optometric services are produced, with emphasis on the optimal employment of assisting manpower.

The Practice of Optometry - An Overview

Optometry is a relatively small health profession. The mean gross

income of the 16,000 self-employed optometrists in the United States from their professional practices is approximately 50 thousand dollars, implying that upwards of 800 million dollars are spent annually on optometric services.[1] These figures are small when compared to the 255,000 physicians providing patient care and to the 13.6 billion dollars spent on physician services.[2]

The primary health services provided by optometrists are the refraction of the eye and the prescription and provision of lenses to correct refractive error. Besides fitting, the optometrist may also adjust and repair eyeglasses.

Most optometrists, like physicians, are engaged in solo practices. Only about 12 percent of optometrists are in partnerships or group practices as compared to about 20 percent of physicians in partnerships or group practices.[3] Optometrists who are allied in group practices receive higher incomes than solo practitioners. The pattern is the same for physicians (see Table 1).

There are few specialists in the profession of optometry. Only about 3.5 percent of optometrists specialized in contact lenses, vision training, industrial vision or other fields.[4] Most optometrists are general practitioners, concentrating primarily on examining and dispensing. Forty-four percent of the surveyed optometrists in the Haffner sample indicated that general practice plus some contact lens work best described the practice in which they were engaged, while an additional 38 percent indicated general practice plus some contact lens work and some vision training as their type of practice.[5] There is no difference in the formal education a specialist or a general practitioner receives. An optometrist becomes a specialist by emphasizing a specific field of optometry in his practice, such as the fitting and dispensing of contact lenses.

TABLE 1

INCOMES OF PHYSICIANS AND OPTOMETRISTS
BY TYPE OF PRACTICE

	Earnings per MD* before taxes (1969)	
	Gross	Net
Solo	$61,640	$38,470
2 Partners	75,540	43,370
3 Partners	72,690	47,140

	Earnings per Optometrist before taxes (1969)	
	Gross	Net
Solo	$45,233	$20,864
Partnership or group	58,024	24,538

* Self-employed M.D's less than age 65.

Physician Source: Arthur Owens, "Solo vs. Partnership : A New Economic Comparison," Medical Economics, March 15, 1971, p.86.

Optometric Source: Fred Chipman, "AOA 1969 Economic Survey - Part IV," Journal of the American Optometric Association, V.41, #6, 6/70, p.552.

There are two other eye professions involved in the delivery of eye care services in the United States. The ophthalmologist diagnoses eye disease, prescribes medical treatment and performs surgical operations, and prescribes eye glasses to correct refractive error. The primary role of the optician is the fitting and dispensing of eye glasses according to prescription. There are approximately 8,600 active ophthalmologists and about 11,000 active opticians in the United States.[6]

FOOTNOTES TO INTRODUCTION

1. In 1968, there were 18,427 optometrists in active practice. Self-employed optometrists totaled 15,724. (National Center for Health Statistics, Optometrists Employed in Health Services, United States, 1968, Dept. of HEW publication No. (HSM) 73-1803, Vital Health Statistics - Series 14, #8). In 1969, the mean annual income of practicing optometrists was 46 thousand dollars. (Fred Chipman, "AOA 1969 Economic Survey, Part IV," Journal of the American Optometric Association, V. 41, #6, June 1970,p.551).

2. Statistical Abstract of the United States - 1972, U.S. Dept.of Commerce, p.66-68. The physician figures are for 1970.

3. Group practice figures for optometry from "A Survey of Optometrists," Journal of the American Optometric Association, V.40, #12, Dec.1969, p.1195. Group practice figures for physicians from Paul M. Ellwood, "Impact of National Health Insurance Plans on Providers and Delivery Systems," in National Health Insurance Conference Proceedings, Robt. D. Eilers and Sue S. Moyerman, Editors. Richard D. Irwin, 1971,p.142. Ellwood cites the fast growth of medical group practices and predicts that 30% of all physicians will be in group practices by the end of 1973.

4. "A Survey of Optometrists," op.cit., p.1194.

5. Alden N. Haffner, A National Study of Assisting Manpower in Optometry, U.S. Dept. of Labor Contract DL 81-34-70-11, August 1971. For a description of this data set, see appendix B.

6. National Center for Health Statistics, Ophthalmology Manpower : Characteristics of Clinical Practice, United States - 1968, Vital Health Statistics, Series 14, #7, March 1973. And Opticians Employed in Health Services, United States - 1969, Vital Health Statistics, Series 14, #3, June 1972, p.3.

SUMMARY

In chapter one, the evolution of the profession of optometry is traced. Optometry developed from opticianry when some opticians, despite opposition from the medical profession, began to provide eye refractions for a fee in addition to their traditional output of corrective lenses.

In chapter two, the education requirements and professional training of optometrists are discussed. The determinants of the demand for an optometric education are examined by specifying and estimating the demand relationship. The first difference regression results showed that the important determinants of the demand for an optometric education are the level of income earned by practicing optometrists and medical school admission requirements. The higher optometric incomes and the lower the medical school acceptance rates, the greater the demand for a professional education in optometry.

A market model for optometric services is specified and estimated in chapter III. The price and income effects on the demand for optometric services are difficult to determine because of multicollinearity. However, there is some evidence that both the price and income elasticities exceed those that have been computed for physician services. The demand for optometric services is not significantly related to the education level of the potential patient population and is negatively associated with the percent of the population in professional or technical occupations. Apparently, the more educated and the occupational elite prefer to receive their vision care from physicians. The demand for optometric services may be as much as 10 percent higher in those states where the advertising of optometric services

is not restricted. This is not an unexpected result; advertising should lower search costs and help optometrists attract patients from ophthalmologists.

On the supply side, optometrists were found to be quite sensitive to price when making their location decision. In addition to being attracted by higher output prices, optometrists are also drawn to areas that offer those environmental advantages which are positively associated with median family income. States with more restrictive licensing requirements were found to have 14 percent fewer optometrists per 100,000 population, holding other variables equal, than those states with less restrictive licensing arrangements.

The causes of the variation in income that optometrists receive from their professional practices are studied in chapter IV. Human capital theory provides the point of departure for the specification of the income generating function. The regression results show the log income-experience profiles of optometrists to be flatter than expected for a class of individuals with such heavy investments in human capital. Human capital investments in interstate mobility by optometrists, as measured by number of licenses held, pay off in terms of higher optometric income according to the estimated income generating models. Class standing in optometry school is also positively associated with net income from practice. Female and non-white optometrists receive lower net incomes than their male and white counterparts, controlling for ability, commitment to practice, years of experience and other variables. The existence of customer discrimination against female and non-white optometrists may be a partial explanation of why these groups are under-represented in the profession of optometry. Jewish optometrists were found to have slightly higher net incomes from practice, although hours worked

could not be controlled for.

The regression results show that the per capita number of ophthalmologists located in the community of practice of the optometrist had a more adverse effect on the income of the optometrist than did the per capita number of competing optometrists. One explanation of this result is that many people prefer to receive their vision care from a physician, rather than an optometrist, if they have the opportunity. The education level of the place of practice was negatively related to the income of optometrist. Medium family income was positively associated with income from practice. Optometrists practicing in states where the development of commercial, retail-type practices are discouraged and where advertising is restricted received annual net incomes about five percent lower than those optometrists practicing in more laissez faire states.

In chapter five, production functions for optometric services are specified and estimated. Analysis of the first order conditions of both the Cobb-Douglas and Reinhardt models indicates that the average optometrist could increase the efficiency of his practice by expanding his employment of assisting manpower. The profit maximizing wage bills are also calculated and show that the average optometrist could profitably employ about twice the number of aides he presently does. However, these results may be misleading. Optometrists may not be able to sell all the services they desire at the going market price. It may be optimal for optometrists to place a low value on their own time because many have some idle hours that must be spent waiting for patients, most of which are non-appointment.

CHAPTER I

THE HISTORY OF OPTOMETRY

A historical sketch of the evolution of the profession of optometry properly begins with the invention of eye glasses about 1300. Magnifying lenses were used to start fires at least 2000 years before this, and undoubtedly were used as vision aids long before 1300, but there is no evidence that these convex lenses were framed and worn as eye glasses until about 1300.

The demand for a procedure or a device to correct blurred vision at close range was probably as old as man himself, but no where was myopia or presbyopia more bothersome before 1300 than in the churches and monasteries, where the majority of reading and writing was done. It is not surprising then that the individual who invented spectacles should have close ties to the church. It is not certain who the real inventor of eye glasses was, but historians have narrowed the field of possible inventors to three: the English monk, Roger Bacon, the Italian Brother, Alessandro della Spina; or the Italian, Salvino d'Armati.

The invention of movable type followed the invention of spectacles by less that 200 years and the combination of both enabled the spread of the printed word from the churches and monastaries to the public at large. Of course without eye glasses the demand for the printed word would not have been as great, since many, particularly those past middle age, would have been unable to read it without great effort. Medical men looked unfavorably on the invention of spectacles. Buy de Chauliac, a French eye specialist who practiced in the 1300's, wrote that spectacles could be used, but only if the careful use of his eye lotions proved unsuccessful

in correcting the vision defect. Bartish, who practiced in the latter half of the 16th century and is often considered the father of modern ophthalmology because of his writings on the eye and his accomplishments in cataract surgery, taught that eye powers and eye lotions should be used rather than eye glasses to help patients see better. Bartish claimed to have knowledge of cases where the use of spectacles resulted in the destruction of the eye.[1]

The discouragement of the use of spectacles by medical eye specialists continued through the 1800's. Weller, in a standard test in 1832, wrote that concave lenses deformed the eye.[2] Wood, in the American Encyclopedia of Ophthalmology of 1919, wrote that ophthalmologists are "opposed to simple refracting by a qualified optometrists and still refuse to do the work themselves."[3]

The real explanation for the historical opposition to eye glasses expressed by medical men is undoubtedly an economic one. Initially, medical men discouraged the use of eye glasses because their use meant the substitution of a non-medical service for their powders and lotions. By 1900, most ophthalmologists had given up the use of powders and lotions to correct refractive error, but still did not encourage the use of eye glasses.

Advances in optics and lens technology occurred outside the scope of medicine until 1864. In 1784, Benjamin Franklin invented bifocals and in 1827, a British astronomer, Airy, invented cylindrical lenses to overcome the visual problems resulting from astigmatism.

In 1864, a physician, Frans Cornelis Donders published a major work which created scientific clinical refraction.[4] Donders recognized the value of spectacles and made their prescription a scientific procedure. Eyeglasses could now be fitted to the individual and bifocals or cylindrical

lenses or different lenses for each eye could be prescribed,if necessary. Despite this knowledge, there was little scientific refraction of the eye performed until the 1900's. During the latter half of the 18th century, an eye physician who believed in eyeglasses would usually refer a patient who needed them to the shop of an optician, where the patient would try on glasses until he found the pair which he liked best. Some opticians would perform eye examinations for their customers.

The development of the profession of optometry in the United States in the 1890's was important to the eventual widespread use of scientific clinical refraction in the prescribing of eyeglasses. Charles Prentice is considered to be the founding father of optometry in the United States. In 1892, Prentice was practicing opticianry in New York City. Unable to earn what he considered a sufficient income by just dispensing glasses to customers referred to him by eye physicians, Prentice administered vision tests for an additional fee. Prentice's practice of administering an eye examination for a separate fee came to the attention of Dr. D.B.St. John Roosa, who accused Prentice of charging a fee for a service relative to the practice of medicine. Roosa asked the New York County Medical Society to exclude any member who sent patients to an optician for an eye examination.

Prentice felt that the threat from medicine made it imperative for opticians to organize. Accordingly, the Optical Society of the State of New York was founded in 1896, with Prentice as the first president. However, at the first meeting of the association, a statement by Dr. Roosa was read which warned that any optician who joined the organization would be punished and that Prentice was to be jailed for his unethical medical practices. Following the reading of Roosa's statement, the purely dispensing opticians

in attendance left the meeting and the new organization was to consist only of those opticians who wanted to assure themselves the right of administering eye examinations for a fee.

Prentice had to defend his organization and the right of opticians to administer eye examinations for a fee before the Committee on Public Health in Washington in 1896. His argument was that spectacle makers and/or opticians had been responsible for most all the advances in spectacles and refraction from their invention to Donder's work in 1864. Additionally, he argued that most refractions had historically been performed by opticians since the recognition and treatment of eye disease had given and would continue to give the eye physician little time for optics.

The American Association of Opticians was founded in 1898 and soon became dominated by refracting opticians. By 1900, the association consisted entirely of refracting opticians or optometrists, and the name of the organization was soon changed to the American Optometric Association.

The scope of optometry was defined by law in all states by 1924 and was inclusive of the right to administer eye examinations for a fee. In some states, organized medicine attempted to control the new profession. A law was passed in Pennsylvania in 1913, for example, which gave the medical examining board control over any profession which the board felt to be a branch of medicine. The law was later overturned by the courts.

FOOTNOTES TO CHAPTER I

1. The material for this historical sketch was taken from the following sources unless otherwise noted.
Monroe J. Hirsh and Ralph E. Wick, The Optometric Profession, Chilton Books, 1968, p.45-148
Encyclopedia Britanica, Vol.9, W. Benton, 1967, p.14-15.

2. Arnold Sorsby, ed., Modern Ophthalmology, Butterworth Inc.,1963.

3. Casey A. Wood in the American Encyclopedia of Ophthalmology, Cleveland Press, V.12, p.9102.

4. F.C. Donders, On the Anomalies of Accommodation and Refraction of the Eye,translated by W.D. Moore, The New Sydenham Society, 1864.

CHAPTER II

THE DEMAND FOR AN OPTOMETRIC EDUCATION

In order to practice optometry, an individual must satisfactorily complete the curriculum of an optometry school and pass a licensing examination in the state in which he chooses to practice. At least two years of undergraduate schooling are required before an individual can be considered for admission to an optometry school. However, a significant number of optometrists presently practicing have completed more than two undergraduate years at a college or university (see Table 1).

The length of the professional curriculum in each of the optometry schools in the United States today is four years. It was not until the mid 1960's that all optometry schools had extended their curriculums to four years. As table 1 shows, most optometrists presently in practice have had a professional curriculum of three years.

Of the twelve optometry schools, six are university affiliated and the remaining six are independent professional schools. There appears to be a reluctance by organized optometry to affiliate all their professional schools with universities because of a fear that organized medicine may gain too much influence in determining the scope of optometric education.[1]

There has been a substantial variation in the number of graduates from optometry schools since 1950. Table 2 shows the total number of students, number of first years students and number of graduates from optometry schools in the United States for the academic years 1950-51, 1960-61, and 1969-70. As is evident from the table, the number of optometry students declined substantially during the 1950's and increased substantially in the 1960's. For the most part, these changes were not due to influences

TABLE 1

THE EDUCATION OF PRACTICING OPTOMETRISTS IN 1970

Length of Undergraduate Education

One Year	9.5%
Two Years	39.2
Three Years	21.0
Four Years	30.3

Length of Professional Curriculum

Two Years	11.9%
Three Years	50.1
Four Years	37.1

SOURCE: A.N. Haffner and J. Sherman, A National Study of Assisting Manpower in Optometry, U.S. Dept. of Labor, DL.81-34-70-11-1, August, 1971.

TABLE 2

SUMMARY STATISTICS FOR OPTOMETRY SCHOOLS
IN THE UNITED STATES, 1950-1970

Year	No. of Schools	No. of Students	No. of Graduates	No. of 1st Year Students
1950-1	10	2435	961	570*
1960-1	10	1113	321	412
1969-70	11	2443	444	786

* Estimated by author. The first year for which figures on the number of first year students could be found was 1952-53. In this academic year there were 552 first year students.

SOURCE: Pennel, Maryland and Delong, Marril, "Optometric Education and Manpower," Journal of the American Optometric Association, V.41, #11, 11/70, p.946, and unpublished data from the American Optometric Association.

on the supply side. The fall off in the number of optometry students in the 1950's, for example, did not result from a decrease in the number of available seats in optometry schools. Rather, the fall off resulted from a leftward shift in demand for the available seats.[2] With the supply of available seats approximately fixed during the 1950's and 1960's, we must look to the demand side for an explanation of the variation in the number of optometric students.

The Demand for Optometric Education

It is not difficult to catalogue those variables which we might expect to influence the demand for optometric education. Certainly price (i.e. tuition and other expenses), opportunity cost and expected future income from practice should be important explanatory variables in the demand relationship. Frank Sloan, in his investigation of the demand for medical education, included these variables in his estimated demand equations as well as a measure of the pool of potential applicants to medical schools and the applicant acceptance rate of the previous year.[3] Sloan used a time series data base consisting of yearly observations from 1934 to 1966 to estimate his demand models. Sloan found the number of applicants to medical schools, his dependent variable, to be quite sensitive to his price or direct educational cost variable (specified as tuition and fees minus average stipend). He concluded that a dollar reduction in price would be generated from 6 to 35 additional applicants. Lagged physician income was also generally significant at the 5% level in Sloan's estimated demand equations. His results showed that a dollar increase in lagged physician income would increase the number of applicants by .3 to 1.3. Starting business salaries, one of Sloan's measures of opportunity cost for the medical student, was not generally significant in his estimated

models. The growth in biologist's income, another measure of opportunity cost, was statistically significant with the expected negative sign. However, the biologists income level variable was not statistically significant.

Unfortunately, our area of interest, the demand for optometric education, is not as easy to investigate as is the demand for medical education because the available data is more limited. There is initially the problem of how to measure demand. Sloan used the number of applicants to medical schools as his measure, but there has been no similar statistic collected and published by optometry schools. Additionally, data on the earnings of optometrists were not collected regularly throughout the 1950's and 1960's. Nevertheless, it is possible for us to develop a simple model of the demand for optometric education within the constraints of the available data.

The Model

In our model we hypothesize that the demand for optometric education is determined by price, expected future income from practice, opportunity cost, the ease of obtaining license to practice, the pool of potential applicants, and barriers to entry into medicine. A discussion of the variables and their sources follows. Our model will be estimated over the twenty years, 1951-1970.

The Demand Variable : The Number of First Year Students

We will measure the demand for optometric education by the number of first year students. This measure would appear to raise all sorts of problems at first glance. Obviously if excess demand has existed in the market for optometric education, then we are underestimating demand and using a proxy for it that is determined by the number of available slots

in optometry schools. This would certainly be a problem if we were using the number of first year students as a dependent variable in estimating the demand for medical education. But the market for optometric education has more likely been characterized by excess supply rather than excess demand during a good portion of the period that we are examining.[4] For example, not until the academic year 1965-66, did the number of first year students in optometry schools reach the 1951-52 level. Throughout the 1950's, optometry schools were confronted with a declining interest in their programs. Hence, our measure of demand is not as weak as it may have first appeared. The number of first year students in optometry schools was obtained from unpublished data from the American Optometric Association or from Pennell and Delong's article on optometric education and manpower.[5]

Price

We will consider opportunity costs separate from direct education costs and our price variable will include only the latter. Because of the data limitations we must limit our direct education costs to the difference between average yearly tuition charges and average scholarship funds per student. Although other education costs such as incidental fees and books and supplies are not insignificant, tuition is undoubtedly the price component to which students are most sensitive. Average yearly tuition charges and average scholarship funds per student were determined from data supplied by those optometry schools who responded to a letter requesting such information. The responding schools were the Los Angeles College of Optometry, Illinois College of Optometry, Massachusetts College of Optometry and Pennsylvania College of Optometry. All of the above schools provided their yearly tuition charges for the two decades in question, but only the Los Angeles and Massachusetts schools provided scholarship

information. Their data shows scholarship support to be negligible until 1967-68, when grants averaged $124 per student at the two schools. By way of comparison, scholarship support totaled $191 per medical student in 1966.[6]

Opportunity Costs

The biggest cost incurred by those who attend optometry school is the earnings they forego by passing up employment opportunities. Certainly the job possibilities are many for a student with two, three, four or more years of college who is weighing the decision of whether to attend optometry school or not. To control for this deterrent to optometry school attendance we enter starting business monthly salaries for college graduates into our regression models. Of course, we are not making the claim that this measure of opportunity cost is complete, but business careers do attract many students and fluctuations in starting business salaries coincide to at least some extent with fluctuations in the economy and hence with prospects in non-business careers. The source for starting business salaries is Frank Endicott's, Trends In Employment of College and University Graduates in Business and Industry, published each year by Northwestern University.

Expected Future Income From Practice

Obviously, a prospective optometry student is interested in how an investment in optometric education would pay off in terms of future income. One of the best indicators of what the future income of optometrists is likely to be is the present yearly income of optometrists and this variable is included in the regression models. There were four surveys of optometrists that yielded income figures between 1950 and 1969 that were used as data sources.[7] The income figures for those years not covered by the surveys

were estimated by interpolating.

Ease of Obtaining License to Practice

The expected return from an optometric education is partly determined by the ease of a gaining license to practice optometry. The value of an optometric education would be greatly diminished, to say the least, if a graduate from optometry school was unable to gain a license to practice. One indication of the ease graduates from optometric schools have in gaining their license is the passing rates on the national board examinations in optometry. The national boards are accepted in many states as fulfilling the requirements of the written portion of the state licensing examination. In these states, the applicant for license who has passed the national boards must pass only the clinical portion of the state licensing examination to gain his license to practice. Twenty states in 1970 did not accept the national boards as fulfilling the written portion of their state licensing examination.[8] Only 17 percent of optometrists presently practicing have been licensed by the National Board.[9]

There are two problems with using passing rates on the national boards as a measure of the ease of gaining a license to practice optometry. First, the significant number of states that do not accept the national boards diminishes their importance, particularly for those optometry graduates who plan to practice in these states. Second, the variation in the passing rates of those who have taken the national boards has not been that great. The coefficients of variation for the passing rates for Part I and Part II of the national board examinations presented in Table III are .05 and .06 respectively. Of course an average of the passing rates for individual state licensing examinations would be a variable of greater value, but this data is not available. The passing rates for both Parts I and

TABLE 3

NATIONAL BOARD EXAMINATION RESULTS,
1952 - 1971

Summary by Year

Year	Part I	% Pass	Part II	% Pass	Subtotal	2nd Year	% Pass	Total
1952	151		Not given					
1953	220		180					
1954	140	85.0	159	77.4				
1955	82	82.9	95	82.0	112			
1956	136	80.1	126	74.6	148			
1957	174	85.1	137	83.2	189			
1958	228	70.2	169	63.5	277			
1959	184	72.8	140	71.4	251			
1960	141	80.1	147	81.6	225			
1961	189	83.6	143	82.5	256			
1962	212	72.2	189	72.0	312			
1963	254	78.0	218	76.2	364			
1964	250	76.0	176	78.4	371			
1965	285	76.5	241	78.4	432			
1966	347	80.9	251	79.8	503			
1967	440	76.6	337	77.2	647			
1968	388	80.9	360	79.2	637			
1969	408	81.7	341	80.7	659			
1970	460	81.1	349	80.5	747	167	76.0	914
1971	513	85.0	429	82.1	942	235	80.0	1177

SOURCE: Proceedings of the 52nd Annual Meeting, 1971, International Association of Boards of Examiners in Optometry, Inc., Wallace, N.C., p.29-30.

II of the national board licensing examination are entered into the specified demand equation.

Pool of Potential Optometry Students

To qualify for admission to optometry school during the 1950's and 1960's, an applicant must have completed at least two years of undergraduate schooling. Many optometry students, however, complete three or four years of undergraduate schooling and some have completed one or more years of non-optometric graduate education (see Table 1, p.). The best measure of this pool is probably the lagged value of the number of college students in their second, third, or fourth years. However, this data is not readily available on a national basis, and the measure chosen in its place is the yearly number of bachelor degrees conferred by U.S. colleges and universities.[10]

Barriers to Entry Into Medicine

Casual empiricism, rumors and hearsay have long indicated that many dentists and optometrists are actually frustrated physicians. For one reason or another, the story goes, many optometrists and dentists are practicing in a profession that was their second choice after medicine during their college years. Perhaps medical schools were too expensive or their entrance requirements too stringent for these individuals, so they settled for dentistry or optometry. If this line of conjecture is true, we should find that interest in an optometric education increases as entry into medical schools becomes more difficult. To test this hypothesis, we enter the percentage of applicants accepted to medical schools in our demand models.[11]

Our final demand model to estimated over the years 1951 to 1970 is $F = F(t, Oy, By, NBI, NBII, Pool, Med, Trend)$ where

F = number of first year students

t = average yearly tuition charges minus average scholarship funds per student

Oy = mean income of optometrists from their professional practices

By = starting business salaries of college graduates

NBI = percent passing part I of national board examinations in optometry

NBII = percent passing part II of national board examinations in optometry

Med = percent of applicants accepted to medical schools

Pool = number of bachelor degrees conferred

Trend = trend variable

All variables in money terms have been deflated by the CPI, 1967 = 100.

Regression Results

Estimation of the demand models with the variables in their original form yielded Durbin-Watson statistics between 1.0 and 1.5, which did not make it possible to reject the hypothesis of positively autocorrelated disturbances. The problem that autocorrelation presents is not bias in the OLS estimates of the regression coefficients. Rather the variances of the estimators become relatively inefficient. Hence, the unbiased estimates can differ substantially from their true values. Despite the fact that the variances of the regression coefficients yielded by OLS estimation are relatively inefficient (compared to those resulting from generalized least squares estimation), they actually underestimate the true variability of the OLS estimators. Thus, the OLS regression coefficients appear to be more reliable or of greater statistical significance than is actually the case.

The solution to the auto-correlation problem most often applied is the first difference approach.[12] First difference estimates of the

TABLE 4

THE DEMAND FOR AN OPTOMETRIC EDUCATION
1951-1970: FIRST DIFFERENCE ESTIMATES

	R^2	△Price	△ Income of Optometrists	△Opportunity Cost	△ Med. School Accept. Rate (Percent)	Percent Passing National Boards △Part I	△Part II	△Pool of potential applicants	Durbin Watson
I	.58		.07 (2.5)		-7.51 (-3.2)				2.51
II	.59	.17 (.4)	.07 (2.4)		-7.96 (-3.0)				2.52
III	.58		.07 (2.4)	.001 (.01)	-7.51 (-3.1)				2.48
IV	.59	.23 (.5)	.07 (2.3)	-.28 (-.2)	-8.00 (-2.9)				2.31
V	.59		.07 (2.5)		-9.31 (-2.8)			-.25 (-.7)	2.56
VI	.59		.07 (2.4)		-7.46 (-2.9)	.001 (.42)	-.05 (-.19)		2.54

All variables expressed in money terms have been deflated by the CPI, 1967=100.

t statistics in parentheses

N = 19

demand model are presented in Table IV. These estimates do not differ substantially from the ordinary least squares estimates, although the Durbin-Watson statistics are now greater than two. The only two statistically significant variables are optometrist's income and the medical school acceptance rate.

The variable, percent of applicants accepted to medical schools, was significant at the 1% level in each of the estimated regressions. The results indicate that a one percentage point increase in the medical school acceptance rate reduced the number of first year optometry students by 8 to 9 during the 1950's and 1960's. The hypothesis that the first career choice of some optometrists was medicine, but that strict admission requirements prevented their entry into medical school, is substantiated.

The income of optometrists played an important role in attracting students to optometry schools. A ten dollar increase in optometrists' income increased the number of first year students by .7. The elasticity computed at the means is 1.6, which is in the upper range of elasticities implicit in Sloan's results for his physician income variables.

The price variable is never significantly different from zero in the estimated demand models. The low price elasticity is not consistent with Sloan's results. Slaon's price elasticities, computed at the mean values, ranged between .6 and 3.0, depending on his model specification. Sloan argues that many students are quite sensitive to the size of tuition charges because of the poor access these students have to sources of external funds. His finding of a rather high price elasticity supports this conclusion. One could argue however, that students should not be all that sensitive to the size of tuition charges since they only represent a small portion of the costs of education, the major portion being opportunity

costs. This argument assumes a better functioning capital market than Sloan is willing to.

Starting business salaries, our measure of opportunity cost, is not significant in the regression models. This result is surprising since the opportunity costs incurred as a result of attending optometry school would be a crucial determinant of the rate of return to an optometric education. One explanation of the statistical insignificance of the variable is that starting business salaries do not reflect the opportunity cost of optometry school attendance.

The percent passing either the first or second part of the national boards was insignificant in the estimated models. We discussed above the shortcomings of these variables as a measure of the ease in gaining a license to practice and should not be surprised by this result.

We can get an indication of the validity of our model by comparing its predictions against the actual changes that occurred in the number of first year students during the 1950's and 1960's. The number of first year students fluctuated from around 600 in 1950-51 to about 400 in 1960-61 and back up to over 700 in 1968-69. The estimation of our model yielded two significant variables, the acceptance rate for medical school applicants and the income of optometrists. The medical school acceptance rate was 33% in 1950-51 and 60% in 1960-61. Our regression results indicate that this variation should have reduced the number of first year students by about 216. The income of optometrists increased by about $4000 during this period. The product of 4000 and .07, the income coefficient, is 28. Hence, the net effect of the variation in these two variables, as predicted

by our model, would have been to reduce the number of first year optometry students by 188. This is very near the actual change that occurred. The same analysis was applied to the upward swing in the number of first year students during the 1960's. The two significant explanatory variables again had good predictive power.

FOOTNOTES TO CHAPTER II

1. Monroe J. Hirsh and Ralph E. Wick, The Optometric Profession, Chilton Books, 1968, p.292.

2. This information was provided in personal interview by Dr.A.N. Haffner, Dean, School of Optometry, State University of New York, and Executive Director, Optometric Center of New York.

3. Frank Sloan, "The Demand for Higher Education:the case of Medical School Applicants", The Journal of Human Resources, VI, #4, Fall, 1971.

4. By "excess supply" we mean there were unfilled slots in optometry schools at the going price for an optometric education.

5. Maryland Pennel and Merril Delong, "Optometric Education and Manpower", JAOA, V41, #11, 11/70, p.946, and unpublished data from the American Optometric Association.

6. Sloan, op.cit., p.471.

7. The sources of the income figures for optometrists are:
H.W. Hofstetter, "A Re-Evaluation of the 1951 Optometric Income Data", Journal of American Optometric Association, Vol.26, #5, 12/54, p.263-264.
1958 National Economic Survey, American Optometric Association, St. Louis, 1959.
"1964 National Economic Survey", Journal of American Optometric Association, April 1966, p.365.
Fred Chipman, "AOA 1969 Economic Survey - Part I", Journal of American Optometric Association, Vol.40, #12, 12/69, p.1197.

8. According to unpublished data provided by the Optometric Center of New York.

9. Haffner, p.26.

10. This data was collected from annual editions of Earned Degrees Conferred, U.S. Office of Education.

11. This data was collected from the Journal of the American Medical Association, educational issues, published annually.

12. R. Stone, for example, used first difference estimation extensively in The Measurement of Consumer's Expenditure and Behavior in the United Kingdom, 1920-1938, Vol.I,1954. First differences is the simplified case of generalized differences. To use the generalized difference technique

one hypothesizes that the error terms are related so that

$$U_t = P\,U_{t-1} + V_t$$

$$E(V_t) = 0$$

$$E(V_t\,V_{t+j}) = \sigma_v^2 \qquad j = 0$$

$$= 0 \qquad j \neq 0$$

If we assume a simple linear model at time t of

(1) $Y_t = a + B\,x_t + U_t$

then the same structural relationship should hold in period t - 1

(2) $Y_{t-1} = a + B\,x_{t-1} + U_{t-1}$

Multiplying each side of this expression by P and then subtracting it from (1) yields

$$Y_t - P\,Y_{t-1} = a(1-P) + B\,(X_t - PX_{t-1}) + u_t - P\,u_{t-1}$$

$$= a\,(1-P) + B\,(X_t - PX_{t-1}) + V_t$$

One can use ordinary least squares to estimate this relationship given knowledge of P and our previously stated conditions on V_t. Without knowledge of P, the first difference approach is often used, that is, P is assumed to equal 1. This assumption presents problems, however, because if P=1 the error term would explode as t gets large and the relationship between Y and X would be difficult to determine. If P=1,

$$u_t = u_{t-1} + V_t$$

$$= u_{t-2} + V_{t-1} + V_t$$

$$= u_1 + V_2 \ldots V_{t-1} + V_t$$

$$\text{Var}(u_t) = \sigma_{u_1}^2 + t\,\sigma_v^2$$

The fail safe provision of rather questionable logic that is employed to overcome the problem of exploding variance is that P is actually less than one and the assumption that P=1 is only an approximation which enables the investigator to use the first difference technique.

Without knowledge of P, there are few options other than first differences. One can estimate P by using the residuals resulting from the OLS estimate of the original structural relationship. But the coefficient obtained by estimating the relationship

$$u_t = P u_{t-1} + W$$

will be a biased estimate of P because the OLS residuals will differ substantially from the true residuals because of the problem of auto-correlation.

This discussion has been abstracted from the analysis of the auto-correlation problem in R.J. Wonnacott and T.H. Wonnacott, Econometrics, John Wiley & Sons, 1970.

CHAPTER III

THE MARKET FOR OPTOMETRIC SERVICES IN THE UNITED STATES

In this chapter we specify and estimate a market model for optometric services. It is only within the context of such a model that many of the more interesting questions relating to the practice of optometry can be properly approached.

Although there have been no previous attempts to estimate market models for optometric services, there is some medical economics literature on the physician location decision and on the market for physician services. The interest in the physician location decision and the market for physician services grew out of the concern over the uneven distribution of physicians in the United States. It would be appropriate here to examine this concern and review the relevant literature.

The disparity in physician-population ratios, particularly between urban and rural areas, has led many health economists to the conclusion that a maldistribution of physicians exists.[1] In 1971, for example, the mean number of physicians per 100,000 population in rural states was 93.5, as compared to 125.8 in urban states (see Table 1). The relative scarcity of physicians in rural areas is magnified when it is considered that rural physicians are few not only on a per capita basis but also spacially. Rural physicians also tend to be older and hence may be less productive.[2]

TABLE I

PHYSICIANS IN PATIENT CARE PER 100,000 POPULATION IN URBAN AND RURAL STATES,1971

Urban States*		Rural States*	
Massachusetts	171	Maine	98
Rhode Island	142	New Hampshire	116
Connecticut	163	Vermont	145
New York	198	Iowa	91
New Jersey	128	N.Dakota	85
Pennsylvania	132	S.Dakota	73
Ohio	117	Nebraska	99
Illinois	122	Kansas	103
Michigan	111	W. Virginia	95
Wisconsin	109	N. Carolina	94
Minnesota	129	S. Carolina	85
Indiana	90	Georgia	96
Delaware	121	Kentucky	91
Maryland	157	Tennesse	104
Washington,D.C.	344	Alabama	80
Virginia	110	Mississippi	75
Florida	122	Arkansas	82
Texas	105	Louisiana	107
Colorado	148	Oklahoma	88
Arizona	123	Montana	98
Utah	122	Idaho	86
Nevada	100	Wyoming	89
Washington	127	New Mexico	101
Oregon	124	Alaska	80
California	166		
Hawaii	137	Mean** = 93.5	
Missouri	111		
Mean** = 125.8			

---

* States which fall into urban category have 55% or more of their population in metropolitan areas.

** State observations weighted by 1970 populations.

SOURCE: Distribution of Physicians in the U.S., 1971, Center for Health Services, Research and Development, AMA, Chicago, 1973.

Rural areas are not the only places where physicians are relatively scarce. Physicians have also shown a reluctance to practice in urban ghettos.[3]

This "maldistribution" of physician services is similar to the distribution of many other goods and services in the United States. The heightened concerned that exists over the uneven distribution of physician services results from the fact that consumption of medical services is considered more necessary than the consumption of most other goods and services. There have been several attempts to identify the determinants of physician location by estimating models of the demand and supply of physician services.

Benham, Maurizi and Reder analyzed the migration and location patterns of physicians and dentists between 1930 and 1960 and concluded that physicians and dentists have migrated in response to the demand for their services.[4] Their cross section regression results showed that these health professionals were particularly sensitive to population, and secondarily, per capita income, when making the choice of the state in which to establish their practices.

Fuchs and Kramer brought the demand and supply sides together by estimating a multi-equation model of the market for physician services, across states, using 1966 data.[5] They concluded that the physicians average fee, the hospital bed supply, per capita income and the presence of medical schools were the primary determinants of physician location.

On the demand side, per capita income, the price of physician services, health insurance coverage, the per capita number of physicians and the number of hospital beds were important in explaining the utilization of physician services.

Fuchs and Kramer could find no evidence to support the notion that the residents of those states where the consumption of physician services is relatively low are in poorer health as a result. However, their measures of health - the unadjusted death rate and the infant mortality rate - were admittedly crude.

The distribution of optometrists in the United States between urban and rural areas is more uniform than is the case for physicians. In table 2, states are classified as urban or rural, and the number of optometrists, ophthalmologists and opticians per 100,000 population are presented. There are 9.7 active optometrists per 100,00 population in urban states as compared to 9.1 in rural states.[6] A much larger disparity exists in ophthalmology manpower between urban and rural states. There are 4.8 active ophthalmologists per 100,000 population in urban states and 3.6 per 100,000 in rural states. This is not a surprising discrepancy given the research summarized above which indicated physicians prefer to locate near medical schools and hospitals, as well as in high per capita income areas. All of these influences would attract the physician to the urban area. Opticians are also concentrated in urban states, with 7.0 active practitioners per 100,000 population, as compared to 4.2 per 100,000 in rural states.

The distribution of optometrists becomes uneven, however, when the United States is considered by geographic region (see Table 3). The southern region contains only 6.8 optometrists per 100,000 population

TABLE 2

EYE MANPOWER PER 100,000 POPULATION
IN URBAN AND RURAL STATES,1968

Rural States*	Optometrists per 100,000	Ophthalmologists per 100,000	Opticians per 100,000
Maine	12.0	4.0	1.0
New Hampshire	10.0	3.9	4.2
Vermont	8.9	4.6	1.8
Iowa	12.1	3.7	6.1
N. Dakota	11.8	3.3	3.3
S. Dakota	14.2	3.3	5.7
Nebraska	10.8	3.8	7.9
Kansas	10.1	3.4	4.3
W. Virginia	8.1	3.5	3.4
N. Carolina	6.4	3.5	3.2
S. Carolina	6.0	2.8	2.2
Georgia	5.9	3.2	5.6
Kentucky	7.2	3.0	5.0
Tennesse	7.6	3.3	4.2
Alabama	5.2	2.5	4.7
Mississippi	5.2	2.7	2.7
Arkansas	7.7	2.1	1.7
Louisiana	6.1	4.2	4.1
Oklahoma	9.9	3.9	5.1
Montana	12.9	5.7	7.7
Idaho	12.2	4.8	2.9
Wyoming	12.9	5.0	2.5
New Mexico	7.3	4.6	4.9
Alaska	7.0	2.1	5.6
Means**	9.1	3.6	4.2

TABLE 2 - Continued

Urban States*	Optometrists per 100,000	Ophthalmologists per 100,000	Opticians per 100,000
Massachusetts	13.3	5.2	8.7
Rhode Island	15.0	3.6	7.5
Connecticut	8.8	5.2	6.7
New York	8.8	5.6	7.4
New Jersey	9.6	4.4	4.8
Pennsylvania	9.8	5.0	5.9
Ohio	8.9	3.7	5.3
Illinois	14.8	3.9	3.9
Michigan	8.2	3.9	4.2
Wisconsin	10.2	4.0	5.6
Minnesota	9.7	4.0	7.7
Indiana	10.1	3.5	4.1
Delaware	6.7	4.0	9.0
Maryland	4.8	4.5	8.5
Washington D.C.	9.0	10.3	17.6
Virginia	6.2	3.7	5.7
Florida	8.1	4.9	6.9
Texas	7.0	3.7	6.1
Colorado	9.4	6.1	12.5
Arizona	10.9	7.8	6.5
Utah	7.2	4.6	11.3
Nevada	8.2	3.6	5,1
Washington	11.9	5.0	5.4
Oregon	13.7	5.5	5.2
California	11.9	5.7	3.8
Hawaii	8.9	4.2	7.5
Missouri	9.5	4.2	6.0
Means**	9.7	4.8	7.0

* All states that fall into the urban category have 55% or more of their population in urban areas.

** State observations weighted by population.

TABLE 2 - Continued

SOURCE: Optometrists Employed in Health Services, United States,1968, Dept. of Health, Education and Welfare publication # (HSM) 73-1803, Vital Health Statistics - Series 14, #8.

Opticians Employed in Health Services,United States, 1969, Dept. of Health, Education and Welfare publication # (HSM) 72-1052, Vital Health Statistics - Series 14, #3, p.8-9.

Ophthalmology Manpower : Characteristics of Clinical Practice, United States, 1968, Dept. of Health, Education and Welfare publication # (HSM) 73-1802, Vital Health Statistics - Series 14, #7.

TABLE 3

DISTRIBUTION OF ACTIVE EYE PROFESSIONALS
BY GEOGRAPHIC REGION, 1968

	Optometrists per 100,000 population	Ophthalmologists per 100,000 population	Opticians per 100,000 population
Northeast	9.9	5.1	6.5
North Central	10.6	3.8	5.0
South	6.8	3.7	5.2
West	11.2	5.4	4.9

SOURCE: Optometrists Employed in Health Services, United States, 1968, Dept. of Health, Education and Welfare publication # (HSM) 73-1803, Vital Health Statistics - Series 14, #8.

Opticians Employed in Health Services, United States, 1969, Dept. of Health, Education and Welfare publication # (HSM) 72-1052, Vital Health Statistics - Series 14, #3, p.8-9.

Ophthalmology Manpower : Characteristics of Clinical Practice, United States, 1968, Dept. of Health, Education and Welfare publication # (HSM) 73-1802, Vital Health Statistics - Series 14, #7.

as compared to around 10 optometrists per 100,000 in the rest of the country. Ophthalmologists are also under-represented in the South. The inter-region differences in optometric manpower are reflected in the differences in the quantity of optometric services consumed by region (see Table 4). In the southern states only 7.9 visual examinations per 100 population were supplied by optometrists in the mid 1960's. The comparative figure for the other regions of the United States all exceeded 10. These related issues -- the distribution of eye care manpower and the variation in the consumption of optometric services by states -- are two of the areas that the estimation and specification of a multi-equation model of the market for optometric services enable us to investigate. Within the context of the model we are able to examine a broad range of hypothesis that will be of interest to observers of the delivery of eye care in the United States and to health economists.

Specification of the model

Our model consists of three equations and one identity that incorporate four endogenous variables. The first of the three equations is a demand equation for optometric services. The final two equations describe the supply of optometric services and consist of a location equation and workload equation. The model is specified below. It is very similar to the model estimated for physician services by Fuchs and Kramer.[7]

(1) $\hat{Q}_d = Q_d\ (\hat{P},\ Y,\ Age,\ NW,\ Ed,\ WC,\ Prof,\ Clerk,\ Oph,\ Opti,\ Norst)$

(2) $\hat{Opto} = Opto\ (\hat{P},\ \hat{Work},\ License,\ Y,\ School)$

(3) $\hat{Work} = Work\ (\hat{P})$

(4) $Q_d \equiv Opto \cdot Work$

Q_d, P, Opto, Work-endogenous variables.

Q_d = quantity of optometric services demanded per 100,000 population

TABLE 4

VISUAL EXAMINATIONS SUPPLIED BY OPTOMETRISTS
PER 100 POPULATION, BY REGION
AND STATE*

Northeast	
Maine	14.8
Massachusetts	11.8
Connecticut	9.2
New York	11.2
New Jersey	8.3
Pennsylvania	10.1
Mean**	10.5

South	
Maryland	6.4
Virginia	7.7
W. Virginia	8.8
N. Carolina	7.0
S. Carolina	5.7
Georgia	6.9
Florida	7.8
Kentucky	8.7
Louisiana	6.3
Tennessee	9.7
Arkansas	7.3
Oklahoma	9.2
Texas	9.2
Mean**	7.9

North Central	
Ohio	9.1
Indiana	10.2
Illinois	15.3
Michigan	9.6
Wisconsin	10.7
Minnesota	9.8
Iowa	13.1
Missouri	9.6
Nebraska	9.6
Kansas	12.3
Mean**	11.1

West	
Washington	10.6
Oregon	9.5
California	10.3
Mean**	10.3

TABLE 4 - Continued

* The number of visual examinations provided per 100 population was computed by multiplying the annual average number of visual examinations provided per optometrist in each state by the number of practicing optometrists per 100 population. The annual average number of visual examinations provided per optometrist was determined by averaging by states the annual number of visual examinations performed by those optometrists who responded to the American Optometric Association's survey of optometrists, 1964. The smaller populated states in which less than forty optometrists responded to the AOA survey were excluded from the table. Thirty-two states had forty or more respondents. The number of active optometrists per 100 population, by state, was obtained from the 1968 national vision and eye care manpower survey, National Center for Health Statistics. The AOA survey data is described in Appendix A. The sources for the national vision and eye care manpower survey are listed in table 2.

** State observations weighted by population.

P = price

Y = Median Family Income

Age = percent of the population 65 + over

NW = percent of the population non-white

Ed = percent of the population with 1-3 years of college

WC = percent of employed in white collar occupations

Prof = percent of the employed in professional, technical or kindred occupations

Clerk = percent of the employed in clerical occupations

Oph = ophthalmologists per 100,000 population

Opti = opticians per 100,000 population

Norst = advertising restriction dummy,
1 = No state restrictions on advertising

Opto = optometrists per 100,000 population

Work = average annual number of visual exams performed by optometrists

License = National board licensing dummy
1 = national boards not accepted

School = Number of graduating optometrists from optometry schools

The model will be estimated across 32 states, using primarily 1968 data. Unfortunately, date limitations necessitate the combining of sources from several different years. The different data sources and the selection process of those states which serve as our units of observation are described below as the model is discussed in detail.

Quantity of Optometric Services Demanded Per Capita

Our quantity measure of the per capita consumption of optometric services by state is computed by multiplying the annual average number of visual examinations provided per optometrist in each state by the number of practicing optometrists per 100,000 population. The annual average

number of visual examinations provided per optometrist was determined by averaging by states the annual number of visual examinations performed by those optometrists who responded to the American Optometric Association's survey of optometrists, 1964.[8] The smaller populated states in which less than forty optometrists responded to the AOA survey were excluded from the cross section. Thirty-two states had forty or more respondents. The number of active optometrists per 100,000 population, by state, was obtained from the 1968 national vision and eye care manpower survey, National Center for Health Statistics.[9]

There are then two sources of potential bias in the quantity measure. First, we are representing the output of an optometrist's practice by the number of visual examinations performed. Since the output of an optometric practice is generally a joint product consisting of visual examinations and corrective lenses, we must make the not unreasonable assumption that each optometrist provides nearly the same proportion of eye glasses to visual examinations and that differences in this proportion are random throughout our cross section of optometrists. The other problem with our quantity measure results from the fact we must use 1964 data in conjunction with 1968 data to determine the per capita quantity of services provided. A bias in our quantity measure is introduced if changes occured in the average number of visual examinations performed by optometrists, by state, between 1964 and 1968. There is no way to determine the extent of such changes.

A well-specified demand equation would include price of the product, the income of potential consumers, the prices of substitutes and complements and taste variables. Our demand equation falls somewhat short of this ideal. The price variable is derived from the 1964 AOA survey of optometrists.

The price of optometric services in any state is determined by computing the average gross annual income per visual examination of the responding optometrists, weighted by the number of examinations performed.

We cannot include the price of the competing eye care services offered by ophthalmologists and opticians because the data is not available. However, we can include the number of these competing eye professionals per 100,000 population in the demand equation in the hopes of gaining some idea of the substitutability of the services of the different eye professions. It may be true that the greater the number of opthalmologists and opticians per 100,000 population in a state, the lower the price of their services, particularly with the socioeconomic variables held constant that are included in the demand equation for optometric services. The number of opticians per 100,000 population and the number of ophthalmologists per 100,000 population must be assumed exogenous in the model. These variables should rightfully be considered endogenous and our simple market model for optometric services should ideally be expanded to include separate supply and demand equations for the services of opticians and ophthalmologists. Unfortunately, this more complete model cannot be specified because price and quantity data for the other eye professions are not available. The number of ophthalmologists and opticians per 100,000 population were obtained from the 1968 national vision and eye care manpower survey, National Center of Health Statistics.[10]

A dummy variable is included in the demand equation which takes on a value of one for those states that did not restrict the advertising of optometric services. The advertising of optometric services should reduce the cost of these services to consumers. Search costs are obviously reduced

by advertising. Advertising can provide the price and terms of sale as well as information on the suppliers identity, location and reliability. Lee Benham has shown that advertising also lowers the price paid by consumers for eyeglasses because it stimulates price competition among sellers.[11] Holding price constant, the effect of the right to advertise should be to shift the demand curve for optometric services to the right because it lowers the information costs faced by consumers and may also enable optometrists to more effectively compete with ophthalmologists for patients seeking corrective lenses. Ophthalmologists, like all physicians, cannot advertise as a condition of license.

Those states not restricting advertising were determined from Lee Benham's classification of states in accordance with the restrictions placed on the advertising of eyeglasses. Benham constructed the series by examining state laws, by interviewing optometrists and members of state optometry boards, and by searching newspapers for eyeglass advertisements.

Several socioeconomic variables have been specified in the demand equation. The age distribution variable, percent of the population 65 and over, was included in the demand relation because the need for, and utilization of, corrective lenses increases dramatically with age. Table 5 presents the visual acuity of adults by age for uncorrected distance and near vision in the United States. As is evident from the table, near vision deteriorates quite rapidly after the age of 34, with 90% of adults having visual acuity of less than 14/14 between the ages of 45 and 54. The same pattern holds for distance vision, although the rate of deterioration is not as great. With this background, it is not surprising to find that the utilization of corrective lenses increases markedly with age, with

TABLE 5

VISUAL ACUITY OF ADULTS,
UNITED STATES,1960-62

DISTANCE VISION

% Distribution

Age	Less than 20/20	Less than 20/30
18-24	25%	16%
25-34	22%	13%
35-44	23%	13%
45-54	55%	33%
55-64	79%	58%
65-74	94%	74%
75-79	98%	86%

NEAR VISION

Age	Less than 14/14	Less than 14/21
18-24	17%	8%
25-34	17%	10%
35-44	32%	18%
45-54	90%	79%
55-64	99%	96%
65-74		
75-79		

SOURCE: Binocular Visual Acuity of Adults, U.S. 1960-62, National Center for Health Statistics, Series 11, #3.

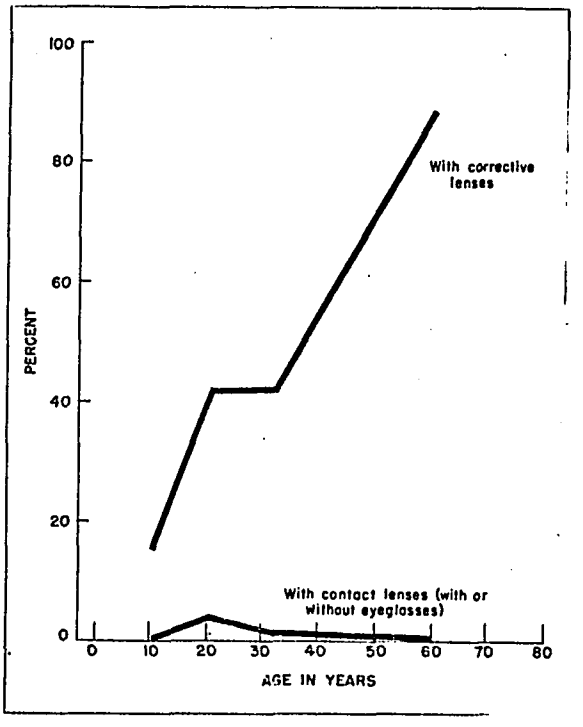
about 90% of adults having eyeglasses by the age of 60 (see Table 6). Consequently, we would expect that the older the population the optometrist serves, the greater should be the demand for his services.

The race variable, percent non-white, is included as an independent variable because of the evidence of White-Negro differences in uncorrected visual acuity. Table 7 presents this evidence which is strongest in the comparison of the percentage of white and Negro males with visual acuity of 20/30 or better. For example, at the age of 50, about 90% of Negro males had uncorrected distance vision of 20/30 or better as compared to less than 75% of the white male population of the same age. White-Negro differences become most pronounced when we consider individuals with poor distance vision. Table 8 shows the percent of the white and Negro populations with uncorrected distance visual acuity of 20/100 or less, by age for men and women. At every age level, a greater percentage of whites than Negroes have uncorrected distance vision of 20/100 or less. To test whether differences in racial composition actually translate into differences in the demand for optometric services, the percent of the population that is non-white is entered into the demand equation.

Table 9 shows the percent of the population with corrective lenses by family income and education, age adjusted, for July 1965 to June 1966. It is clear that the utilization of corrective lenses increases with family income and education, but it is not evident from the table whether the income effect results from the higher educational levels associated with higher income individuals, or whether the educational effect results from a positive income elasticity for corrective lenses. To go a step further, it is not even clear that higher incomes and/or educational levels of the family directly cause increased utilization of eyeglasses, since income and

TABLE 6

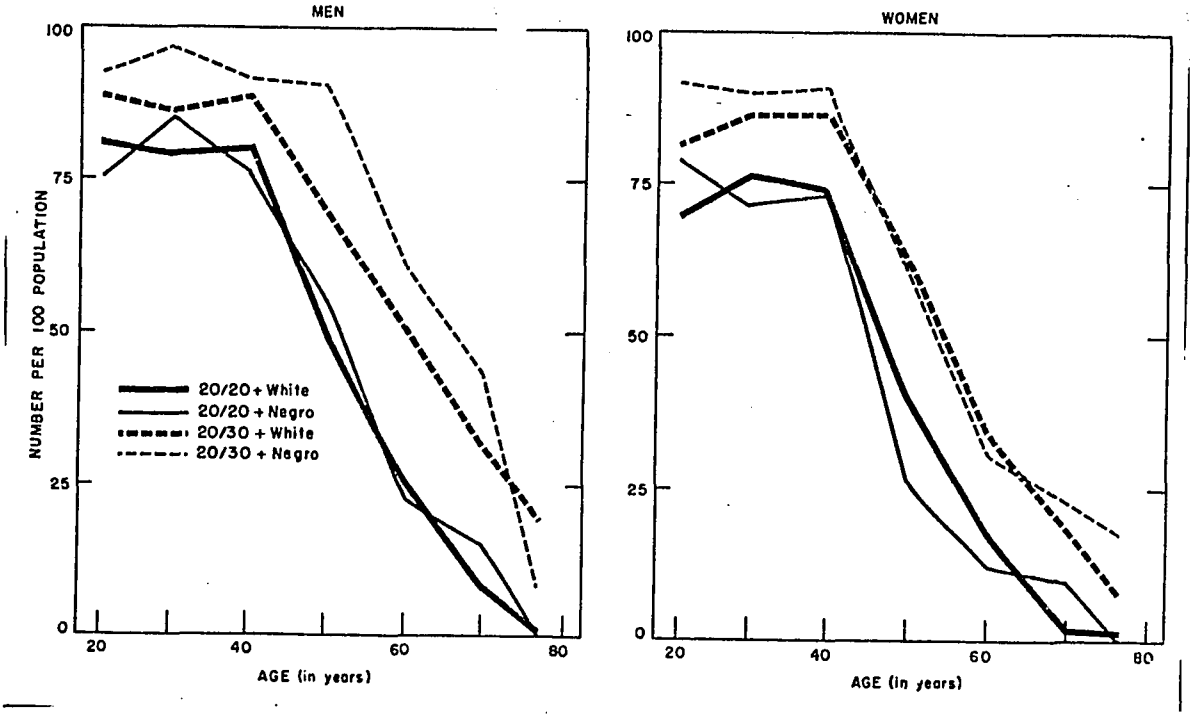
PERCENT OF U.S. POPULATION WITH EYEGLASSES AND CONTACT LENSES, BY AGE, 1965-66



SOURCE: Characteristics of Persons with Corrective Lenses, 1965-66, National Center for Health Statistics, Series 10, #53.

TABLE 7

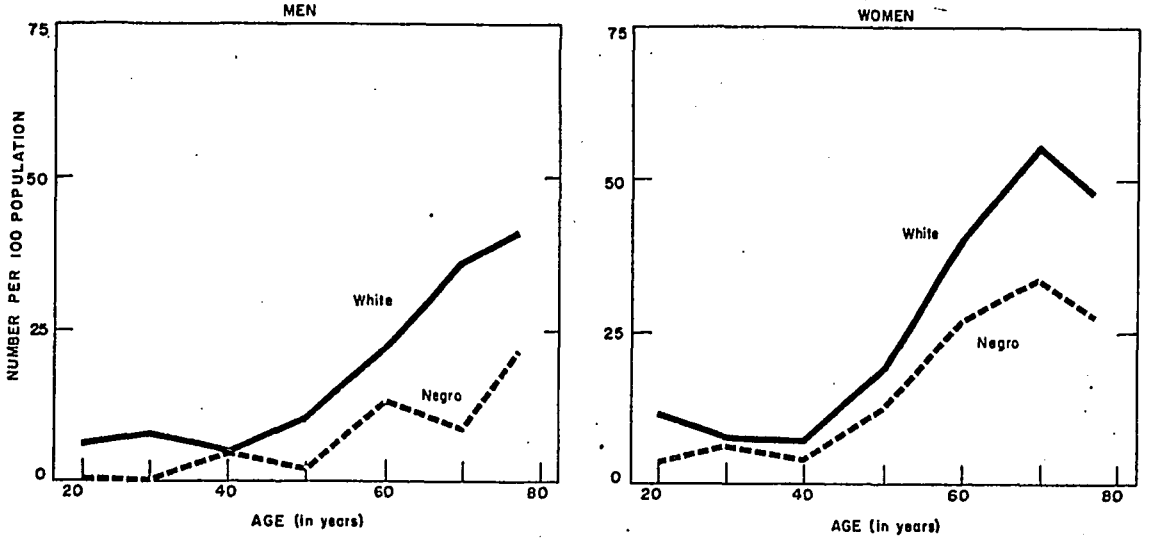
NUMBER OF ADULTS PER 100 POPULATION WITH UNCORRECTED DISTANCE VISUAL ACUITY OF 20/20 OR BETTER AND 20/30 OR BETTER, BY AGE FOR WHITE AND NEGRO MEN AND WOMEN, U.S., 1960-62



SOURCE: Binocular Visual Acuity of Adults, U.S. 1960-62, National Center for Health Statistics, Series 11, #3.

TABLE 8

NUMBER OF ADULTS PER 100 POPULATION WITH UNCORRECTED DISTANCE VISUAL ACUITY OF 20/100 OR LESS, BY AGE FOR WHITE AND NEGRO MEN AND WOMEN, U.S.,1960-62



SOURCE: Binocular Visual Acuity of Adults, U.S. 1960-62, National Center for Health Statistics, Series 11, #3.

TABLE 9

PERCENT OF U.S. POPULATION WITH CORRECTIVE LENSES, AGE ADJUSTED, BY FAMILY INCOME AND EDUCATION, 1965-66

	Unadjusted	Adjusted
Family Income:		
Under $5,000	49.7	43.8
$5,000+	46.7	50.1
Education of head of family:		
12 years or less	47.2	46.3
13-years	51.1	54.4

SOURCE: Characteristics of Persons with Corrective Lenses, 1965-66, National Center for Health Statistics, Series 10, #53.

education are correlated with a third factor, occupation, which may be the important causal variable. White collar workers, for example, are more likely to utilize corrective lenses than blue collar workers, service workers or farm workers (see Table 10). Inter-occupational differences are most evident at younger ages. For the age category, 25-44 years, the data in Table 10 show that 52.5 percent of white collar workers use corrective lenses as compared to only 29.6% of blue collar workers, 36.8% of service workers and 25.7% of farm workers. Education and income levels are, of course, higher in the white collar group. Table 11 presents years of schooling completed by sex and race for major occupation groups and clearly demonstrates higher educational levels are associated with white collar employment. Table 12 shows the association between higher median money income and white collar employment. Even within the white collar category there exists substantial variation in the use of corrective lenses (see Table 10). About 56% of professional and clerical workers in the age category of 25-44 have eyeglasses as compared to only about 45% of managers and sales workers. These inter and intra-occupational differences show that workers in occupations that require relatively more reading and writing are more likely to have corrective lenses.

To separate out the effects of income, occupation, and education on the demand for optometric services we enter into the demand equation the variables; per capita income; percent of the population with 1-3 years of college; and three measures of occupational distribution - percent of the employed holding white collar jobs, percent of the employed holding professional, technical or kindred jobs, and percent of the employed holding

TABLE 10

PERCENT DISTRIBUTION OF PERSONS 17 YEARS OF AGE AND OVER IN THE LABOR FORCE WITH OR WITHOUT CORRECTIVE LENSES, BY TYPE OF LENS ACCORDING TO OCCUPATION AND AGE: UNITED STATES, JULY 1965-JUNE 1966

Occupation and age	Persons 17 years and over[1]	No corrective lenses	With corrective lenses		
			Total	Eye-glasses only	Contact lenses with or without eyeglasses
All occupations[2]	Percent distribution				
All ages, 17 years and over	100.0	41.1	58.9	57.5	1.4
17-24 years	100.0	59.2	40.7	37.1	3.6
25-44 years	100.0	59.1	40.9	39.6	1.3
45 years and over	100.0	13.8	86.2	85.8	0.4
White-collar workers					
All ages, 17 years and over	100.0	31.8	68.1	65.7	2.4
17-24 years	100.0	46.2	53.7	47.2	6.5
25-44 years	100.0	47.5	52.5	50.2	2.3
45 years and over	100.0	8.1	91.9	91.2	0.7
Professional					
All ages, 17 years and over	100.0	30.8	69.2	66.0	3.1
17-24 years	100.0	42.7	57.1	49.0	8.1
25-44 years	100.0	43.1	56.9	53.8	3.1
45 years and over	100.0	7.3	92.6	91.8	*
Managers					
All ages, 17 years and over	100.0	30.7	69.2	68.1	1.1
17-24 years	100.0	59.1	40.7	37.3	*
25-44 years	100.0	55.4	44.6	43.5	*
45 years and over	100.0	9.0	91.0	90.1	*
Clerical					
All ages, 17 years and over	100.0	32.5	67.4	64.6	2.8
17-24 years	100.0	44.3	55.6	49.3	6.3
25-44 years	100.0	43.8	56.1	53.8	2.3
45 years and over	100.0	8.1	91.8	91.5	*

TABLE 10 - Continued

Occupation and age	Persons 17 years and over[1]	No corrective lenses	With corrective lenses		
			Total	Eye-glasses only	Contact lenses with or without eyeglasses
Sales	Percent distribution				
All ages, 17 years and over	100.0	34.0	66.0	64.0	1.9
17-24 years	100.0	54.7	45.2	40.0	
25-44 years	100.0	55.1	44.7	42.9	
45 years and over	100.0	7.6	92.4	91.8	
Blue-collar workers					
All ages, 17 years and over	100.0	51.1	48.8	48.4	0.
17-24 years	100.0	71.7	28.0	27.3	
25-44 years	100.0	70.3	29.6	29.1	0.
45 years and over	100.0	18.6	81.4	81.2	
Service workers					
All ages, 17 years and over	100.0	40.7	59.2	58.3	1.
17-24 years	100.0	60.7	39.1	35.9	3.
25-44 years	100.0	63.0	36.8	36.3	
45 years and over	100.0	13.7	86.3	86.1	
Farm workers					
All ages, 17 years and over	100.0	48.6	51.4	51.2	
17-24 years	100.0	79.2	20.8	20.8	
25-44 years	100.0	74.3	25.7	25.4	
45 years and over	100.0	25.8	74.2	73.9	

SOURCE: Characteristics of Persons with Corrective Lenses, 1965-66, National Center for Health Statistics, Series 10, #53.

TABLE 11

EDUCATION LEVELS OF MAJOR OCCUPATION GROUPS, U.S., 1971

	Percent with four years of High School or more	
	White Males	Negro & Other Males
White Collar	86%	80%
Blue Collar	53%	37%
Service Workers	55%	38%
Farm	42%	12%

SOURCE: Special Labor Force Report, U.S. Bureau of Labor Statistics, reprinted in Statistical Abstract of the United States, 1972, p. 114.

TABLE 12

MEDIAN EARNINGS OF CIVILIANS, BY SEX AND BY OCCUPATION OF LONGEST JOB : 1970

$000

	Male	Female
White Collar:		
Professional, Technical & Kindred Workers	10.9	5.8
Managers, Not Farm	10.7	4.8
Sales Workers	7.3	1.4
Clerical & Kindred Workers	7.2	3.9
Service Workers	4.1	1.5
Farm Workers	.7	.4
Blue Collar:		
Craftsmen and Kindred Workers	8.4	3.4
Operative and Kindred Workers	6.4	3.2
Laborers, Not Farm & Mine	2.8	2.1

SOURCE: Current Population Reports, p.60, No.33, 41, 53, 80 and unpublished data; collected in Statistical Abstract of the U.S., 1972, p. 237.

clerical jobs. The latter two variables are, of course, categories within the white collar group.

Even if those with higher incomes and education (holding occupation constant) had a high propensity to use corrective lenses, it is not clear, a priori, that the partial effects of income and education on the demand for optometric services would be positive. This is because the higher the income and education of an individual, the more likely he is to use the services of an ophthalmologist instead of an optometrist to obtain his corrective lenses. Table 13 shows that 25 percent of those individuals with family income under $5000 who had an eye examination and purchased eyeglasses during the two years preceding July 1965 to June 1966 used an ophthalmologist as a source of their optical prescription, while the same figure for those with family income of $5000 and over was 36%. Similarly, 28% of those individuals whose family head had 12 years of schooling or less used an ophthalmologist as the source of their optical prescription while the comparable figure was 48% for those individuals whose family head had 13 years of schooling and over.

All of the socioeconomic variables were collected from the 1970 census.

The Supply of Optometric Services

On the supply side, we have divided the quantity of optometric services into a location equation and an average workload equation.

The Location of Optometrists

Two indicators of the potential profit from establishing a practice in a particular location, the price of optometric services and the average workload per optometrist, are included in the location equation. Optometrists should be attracted to locations that feature both high workloads and high

TABLE 13

SOURCE OF OPTICAL PRESCRIPTION, PERSONS 3 YEARS AND OVER, WHO WERE EXAMINED FOR CORRECTIVE LENSES IN PAST TWO YEARS, U.S. JULY 1965 - JUNE 1966

Characteristic	Persons examined for corrective lenses in past 2 years	Source of optical prescription in past 2 years					
		Eyeglasses only			Contact lenses with or without eyeglasses		
		Ophthalmologist	Optometrist	Other[1]	Ophthalmologist	Optometrist	Other[1]
Family income							
Under $5,000	100.0	25.2	60.4	12.4	0.7	1.0	*
$5,000 and over	100.0	35.7	53.7	7.9	1.2	1.4	0.2
Education of head of family							
12 years or less	100.0	27.7	60.2	10.6	0.5	0.9	0.1
13 years and over	100.0	47.6	41.5	5.7	2.5	2.3	0.5

SOURCE: Characteristics of Persons with Corrective Lenses, 1965-66, National Center for Health Statistics, Series 10, #53.

prices, although optometrists might avoid high workload areas if they feel an obligation to provide eye care to all those who come to their door and also feel strongly about setting aside an adequate amount of time for leisure activities.[12]

The per capita income variable in the location equation must be interpreted as a proxy for the cultural, educational and other non-natural environmental advantages that a state offers which are correlated with per capita income.

The number of graduating students in optometry schools is entered into the equation to test whether graduating optometrists have a propensity to remain in the state where they receive their professional education. This result is expected because optometry schools would seem more likely to draw entering students from their own states because of the lower cost home state students would face in terms of shorter distances to travel, and in some cases, lower tuition costs and the chance to live inexpensively at home. The source for the number of graduates from individual optometry schools is Pennell and Delong.[13]

To serve as a proxy for the stringency of state licensing requirements, we include a national board dummy variable, which takes on a value of one for those states which did not accept the national boards examination in 1968 and a value of zero otherwise. The national board examination was accepted in lieu of the written portion of the state licensing examination in 26 states in 1968.[14] The failing rates on individual state licensing examinations would be the more appropriate barrier to entry variable, but such data is not available. Implicit in our use of the national board dummy is the assumption that those states which do not accept the national board examinations also have the most stringent licensing requirements. Although

state licensing requirements are established for the expressed purpose of ensuring that high standards of optometric care are practiced, economists have argued that licensing is used by members of a profession in order to limit the number of practitioners or to earn rents.[15] It is interesting to note that in most cases it is the professions that have demanded that their members be licensed. Consumers, who supposedly need to be protected from malpractice, have been less concerned about professional licensure.

There is evidence that the licensing arrangements of some professions have been used to restrict labor mobility between states. Holen found that interstate mobility in law and dentistry was low relative to medicine because of the "structure of licensing arrangements...(and) because of the exclusionary practices of various state licensing boards."[16] Holen found that those states in which lawyers or dentists enjoyed high incomes also tended to have high failure rates among candidates for license. Holen concluded that for the medical profession, where restrictions on interstate mobility are small because of reciprocity agreements and the use of national boards, the relationship between physician incomes and failure rates of candidates for license was generally independent.

Optometric Workloads

Price is included in the workload equation and we expect optometrists to take on higher workloads, the higher their per unit reward for doing so, unless their supply curves are backward bending and the average optometrist operates on that portion that is negatively sloped.

REGRESSION RESULTS

The Demand for Optometric Services

The estimated demand equations are presented in Table 14. In regressions 1 and 2 the white collar variables do not appear. These regressions results are sufficient if we are willing to assume that variation in the use of corrective lenses by occupation results solely from the differences in income and education levels associated with different occupations. For the moment we will operate under this assumption. One indication that there may be no pure occupation effect is that the explanatory power of the demand model is not increased when the white collar variables are added to the independent variables of regressions 1 and 2.

The income elasticity explicit in these regressions varies between .7 and .8. This range is high relative to the income elasticities of demand estimated for physician services. The highest income elasticity in what Fuchs and Kramer call their more successful demand equations for physician services is .20.[17] Other estimated demand elasticities for physicians range from .01 to .62.[18] However, the relatively high income elasticities of demand for optometric services that we have estimated should not be discounted. A good portion of optometric services, such as tinted glasses, more expensive, stylish frames and extra glasses, would seem to fall into the "luxury" category.

Price is negatively associated with quantity demanded in regressions 1 and 2, although significant at only the 50 percent level when the advertising dummy is entered into the demand model. The price coefficients range from -.29 to -.52. The elasticity of -.52 in regression 1, which is

TABLE 14

THE DEMAND FOR OPTOMETRIC SERVICES*

Second Stage of Two Stage Least Squares

	Percent Non-White	Percent 65 and Over	Median Family Income	Ophthalmologists per 100,000 Population	Opticians per 100,000 Population	Price	Education	White Collar	Professional, Technical	Clerk	Advertise 1=Yes 0=No	Constant	$\bar{R}^2$
1.	-.12 (-3.6)	.50 (2.9)	.72 (2.9)		-.22 (-3.5)	-.52 (-1.6)	.11 (.6)					8.6 (9.8)	.63
2.	-.11 (-3.0)	.55 (2.9)	.79 (3.0)	.06 (.3)	-.22 (-3.4)	-.29 (-.7)	.02 (.08)				.07 (1.0)	8.5 (9.4)	.63
3.	-.12 (-3.3)	.43 (2.1)	.90 (2.9)	.12 (.57)	-1.9 (-2.8)	-.46 (-1.1)	.17 (.74)		-.55 (-1.5)		.05 (.06)	9.81 (8.5)	.67
4.	-.16 (-3.4)	.21 (1.0)	.32 (.6)	-.05 (-.2)	-.27 (-2.6)	.06 (.1)	-.50 (-.2)		-.91 (-2.0)	1.59 (1.3)		8.01 (4.3)	.61
5.	-.14 (-2.8)	.37 (1.6)	-.004 (-.71)		-.29 (-2.9)	.50 (1.1)		-2.6 (-2.4)		3.01 (2.3)	.08 (1.1)		.52
6.	-.14 (-2.6)	.37 (1.5)	-.004 (-.77)	.02 (.06)	-.29 (-2.91)	.49 (1.0)		-2.6 (2.4)		2.99 (2.2)	.09 (1.1)		
7.	-.13 (-2.6)	.39 (1.8)			-.27 (-2.4)	.34 (.4)	.10 (.5)	-2.71 (-2.5)		3.11 (1.9)	.08 (.9)		.58

* All variables in natural logs except advertising dummy

t statistics in parentheses

N = 32

significant at the 10 percent confidence level, is high relative to those estimated for physician services. None of the price elasticities estimated by Fuchs and Kramer, for example, exceeded -.36.[19] This discrepancy is not unexpected. The price elasticity for optometric services should exceed that for physician services because there are more available substitutes for optometric services than for physician services. Both ophthalmologists and opticians offer services that can be substituted for optometric services. The availability of these substitute services is not completely controlled for in the demand models. Although the number of ophthalmologists and opticians are included in the regressions, the workloads of these practitioners remain free to vary.

It is also reasonable to assume that the substitute activity of "doing without" is a more attractive alternative in the case of optometric services. It is probably easier for most individuals to postpone or do without the purchase of a new pair of glasses or an eye examination than it would be for them to postpone the typical physician visit.

When the white collar occupation variables are entered into the demand equation, the interpretation of the price and income variables becomes strained. These regression results cannot be ignored, however, because it is possible that a white collar effect exists, even with income and education constant, because white collar occupations demand more reading and writing than other occupations. The income variable becomes statistically insignificant when included with the white collar and clerk variables (see regressions 4-7). Because of the correlation between the variables, it is impossible to determine their separate effects. (The simple correlation of median family income with percent of the employed

in clerical occupations and with percent of the employed in white collar occupations is .89 and .82, respectively).

The near zero income coefficients of regressions 4-7 are probably downward biased, with some of the income effect being captured by the occupation variables. The income coefficients of .7 and .8 in regressions 1 and 2 are more consistent with our a priori expectations. However, a near zero income elasticity of demand for optometric services is not an impossibility. The income elasticity would be low if the tendency to utilize the services of ophthalmologists and opticians rather than optometrists to secure optical prescriptions and corrective lenses increased markedly with income.

A problem with the interpretation of the regression results in this fashion is the inclusion of the number of ophthalmologists and opticians in the regression equation. One might question how the demand for the services of ophthalmologists and opticians could increase with income when their numbers are controlled for in the regression equations. There are two responses to this objection. First, although the number of ophthalmologists and opticians are held constant, their workloads are not. These practitioners could increase their workloads in response to rightward shifts in the demand curve for their services. Second, if we re-specify the demand equation to allow the number of ophthalmologists to vary, the results with respect to the income variable is unchanged (see regressions 5, 7).

The price coefficient is also sensitive to the inclusion of the white collar occupation variables in the demand model. The association between price and quantity demanded changes from negative to positive when the clerk and white collar variables are added. As discussed above, the price elasticity

of -.5 in regression 1 is in the range of values that we anticipated. Nevertheless, the zero or even positive price elasticity estimates are not necessarily inconsistent with our expectations or with demand theory. Our empirical price elasticity estimates may be biased in a positive direction if there exists variations in the quality of services provided per visual examination. Given a preference for quality care by consumers and a positive association between price and quality, estimated demand equations that fail to control for quality could yield zero or positive price coefficients.

The coefficients and t values of the white collar occupation variables are stable enough in the regression models for us to offer some hypotheses concerning the effects of occupation on the demand for optometric services. These interpretations, like those for the income and price variables, must be tentative because of the multicollinearity problem. The percent of the employed in white collar occupations is negatively related to the demand for optometric services. This is a surprising result given that white collar workers utilize corrective lenses to a much greater extent than is the case for those in other occupations. However, an explanation for this finding follows from the regression results. The variable, percent of the employed in the elite white collar category, professional, technical and kindred workers, also has a negative association with the demand for optometric services. In contrast, the variable, percent of the employed in clerical occupations, the lowest rung on the white collar ladder, is positively associated with the demand for optometric services. Although the clerical coefficient is not stable, ranging from 1.6 to 3.1 it is generally significant. It appears as if there are taste differences

within the white collar category for optometric services. The more elite members, the professional and technical workers, prefer on the whole to receive their vision care from ophthalmologists. The non-elite white collar members of the clerical category are content to receive their vision care from optometrists. These conclusions also hold when the number of ophthalmologists is allowed to vary.

The coefficients and statistical significance of the race and age variables remain fairly stable in all the estimated models. The positive association between the demand for optometric services and the percent of the population 65 and over is an expected result considering the increased utilization of corrective lenses with age. The age elasticity ranged from .21 to .43 in the double log formulations. The t coefficients are fairly high although in model 4, statistical significance drops to around the 30 percent level.

The race variable, percent non-white, has an adverse effect on the demand for optometric services. The negative association can be explained in part by the stronger vision possessed by Negroes. Perhaps a more important explanation however, is the higher price of securing optometric services that Negroes probably confront because of higher transportation and search costs. Many Negroes live in urban ghettos or rural areas in the south where optometric care is relatively scarce.

The advertising dummy is never significant at confidence levels above 25 percent and the t-values fall below one when the white collar variables appear in the estimated demand equations. The dummy coefficients range between .05 and .09. There is some evidence in these results that

the demand for optometric services is higher in those states where advertising is not restricted. If so, then advertising significantly lowers search costs or effectively serves to help optometrists attract patients from ophthalmologists. We further examine this question in the next chapter.

The education coefficient is not significantly different from zero in any of the estimated demand models in which it appears. This result lends support to the hypothesis that the tendancy to utilize the services of ophthalmologists and opticians rather than optometrists to secure optical prescriptions and corrective lenses increases with education. This conclusion follows only if we accept the assumption that the taste for corrective lenses increases with education. This assumption seems reasonable; the more educated probably place a greater emphasis on good health and probably have a greater interest in reading, an activity that requires the use of corrective lenses in most cases by middle age.

The regression results show that the number of opticians per 100,000 population offer competing services to those of the optician and adversely effect the demand for optometric services. The ophthalmology variable is not significantly related to the demand for optometric services. One interpretation of these results is that the services provided by opticians are more competitive with the services provided by optometrists than are the services of the ophthalmologists. In other words, the dispensing portion of the optometrist's practice is the major component of the services he offers and the provision of visual examinations is secondary. Even if this is true, it does not provide an explanation of why the ophthalmologist variable should be statistically insignificant. Many ophthalmologists are

involved in the dispensing of corrective lenses. About 22% of practicing ophthalmologists employ opticians or optical fitters.[20] The optician and ophthalmologist variables are correlated (r = .49), but even with the optician variable excluded from the demand equation, the ophthalmology variable still does approach significance. In the next chapter we specify and estimate an income generating function for optometric services that will enable us to further examine the role of ophthalmologists in the market for optometric services.

The Location of Optometrists

The regression results for the location equation are presented in Table 15. Not surprisingly, the national board dummy indicates that state licensing examinations are an effective means of restricting entry, given our assumption that states which do not accept the national boards in optometry also have more stringent licensing requirements. The dummy coefficient indicates that states with more restrictive licensing requirements have 14-17 percent fewer optometrists per 100,000 population, holding other variables equal, than those states with less restrictive licensing arrangements.[21]

Optometrists are quite sensitive to price in making their location decision. The price coefficient ranges from 1 to 1.1, implying that an instate increase in price of three dollars, or 10%, would attract approximately 10% more optometrists to the state, other things equal. This price elasticity is about two times the price elasticity for the per capita supply of physicians reported by Fuchs and Kramer. Optometrists may be more sensitive to interstate variations in price because they are

TABLE 15

THE LOCATION OF OPTOMETRISTS*-SECOND STAGE OF TWO STAGE LEAST SQUARES

	National Board Dummy 1 = No Accept	Medium Family Income	Price	Average Workload	Graduation Optometry Students	Gross Income of Optometrists	Constant	$\bar{R}^2$
1.	-.14 (-1.7)	.73 (2.1)	1.08 (2.1)	.19 (.1)	.002 (1.1)		5.3 (3.3)	.28
2.	-.14 (-1.7)	.77 (2.7)	1.11 (3.0)		.002 (1.2)		5.1 (3.9)	.28
3.	-.17 (-1.9)	.77 (2.3)			.002 (1.7)	.61 (.8)	-.90 (-.3)	.16

* All variables in logs except graduating optometry students and national board dummy

t statistics in parentheses

N = 32

more likely to migrate than physicians. The conclusion that optometrists are more likely to migrate (inter-state) than physicians is based on the presumption that migration in both these professions is undertaken predominately by recent graduates of the professional schools. The established practices of older practitioners should make them reluctant to migrate. Recent graduates of optometry schools should be more prone to migrate than their physician counterparts because of the much smaller number of optometry schools. There existed only 10 optometry schools in 1968, while medical schools were located in nearly every state.

Optometrists are also attracted to high per capita income states, holding price and average workload constant, indicating that environmental factors which are correlated with per capita income play a significant role in their location decision.

The workload variable, average number of annual visual examinations performed per optometrist, is positively associated with optometrists per capita but not statistically significant. There is no evidence then that optometrists shun high workload areas to avoid overwork; rather they may be attracted to them.

Gross optometric income, the product of price and average workload, is entered into model 3. The model loses predictive power when the highly significant price variable is replaced by income. The gross income variable is significant at only the 40 percent level. Apparently, the insignificant workload variable serves to temper the effect of gross income.

The schooling variable, number of graduating students from optometry schools in 1967, is statistically significant at the 10 percent level in regression one and at the 15 percent level in regression two. The results demonstrate that optometrists have at least a slight propensity to remain in the state where they receive their professional education. The elasticity

of the number of optometrists per 100,000 with respect to the number of graduating optometrists inherent in the regression results is very small, approximately .03. A small elasticity is to be expected because only nine states have optometry schools in the United States, so a significant amount of outmigration must take place by optometrists from the state where they receive their professional training, or optometrists would be much less evenly distributed around the country than they presently are. The elasticity must also be small because the total number of graduates from optometry schools in any one year is small in relation to the stock of practicing optometrists.

Optometric Workloads

The simple regression of the log of average workloads on the log of price yields:

$$\log \text{average workload} = \underset{(7.7)}{4.4} \quad \underset{(-4.5)}{-.74\ \text{Price}} \qquad \bar{R}^2 = .52$$

The obvious explanation of the negative price coefficient is that optometrists are on the backward bending portion of a labor supply curve. If this is true, the coefficient shows that an instate price increase of 10 percent would reduce the average workloads of optometrists by about 7%. The supply of optometric services within the state would not be reduced, however. The regression results for the location equation indicate that the per capita number of optometrists would increase by approximately 10 percent as a result of a 10 percent price increase. The net effect, then, of the price increase would be to increase the per capita quantity of optometric services supplied by about 3 percent.

There is another possible explanation for the negative price coefficient.

The negative coefficient could result from variation in the quality of services provided per visual examination and from a positive correlation between price and quality. By providing more thorough visual examinations and by otherwise spending more time with their patients, quality conscious optometrists would be able to supply less exams annually but may find it profitable to do so if consumers are willing to pay sufficiently high prices in return.

FOOTNOTES TO CHAPTER III

1. See particularly, Rashi Fein, The Doctor Shortage, The Brookings Institute, Washington D.C. 1967, p.71-79.

2. See Fein, p.74-75. Fein argues that many rural physicians are of the age where increases in productivity resulting from longer periods of experience are probably offset by lighter workloads brought on by the increased need for leisure time.

3. Data on the distribution of physicians within urban areas are hard to come by. The fact that physicians avoid practice in urban ghettos is referred to by Fuchs and Kramer (see note 5 for citation).
Fred Goldman studied the market for physician services in the ghetto community of Mott Haven in the South Bronx and in the white middle class health district of Westchester, also in the Bronx. He reported the number of physicians per 100,000 population to be 90.5 in the Westchester health district and 41.0 in Mott Haven. See Fred Goldman's Ph.D. dissertation, Dept. of Economics, Graduate Center, City University of New York: in progress.

4. L. Benham, A. Maurizi, and M.W. Reder, "Migration, Location, and Remuneration of Medical Personnel : Physicians and Dentists," Review of Economics & Statistics, 50 : 332-347, August 1966.

5. Victor Fuchs and Marcia Kramer, The Determinants of the Expenditures for Physician Services in the United States, 1948-68, National Bureau of Economic Research, occasional paper 117, 1973.

6. All states that fall into the urban category have 55% or more of their population in metropolitan areas. When states were reclassified so the urban category included those states with 70% or more of their population in metropolitan areas, the number of optometrists per 100,000 in rural states increased to 10.2, while the urban figure dropped to 9.5.

7. Fuchs and Kramer, op.cit.

8. For a description of the data, see appendix B.

9. Optometrists Employed in Health Services, United States, 1968, Dept. of Health, Education and Welfare publication #(HSM), 73-1803, Vital Health Statistics - Series 14, #8.

10. Opticians Employed in Health Services, United States, 1969, Dept. of HEW publication #(HSM) 72-1052, Vital Health Statistics - Series 14, #3, p.8-9.
Ophthalmology Manpower : Characteristics of Clinical Practice, United States, 1968, Dept. of HEW publication #(HSM) 73-1802, Vital Health Statistics - Series 14, #7.

11. Lee Benham, "The Effect of Advertising on the Price of Eyeglasses," Journal of Law and Economics, October 1972, p.337-353.

12. In some of the estimated models, average gross income from practice, or the product of price and average workload is an explanatory variable. This variable is entered because potential income may be a more significant consideration in the location decision than the separate influences of price and average workload.

13. M.Y. Pennel and M.B. Delong, "Optometric Education and Manpower," Journal of the American Optometric Association, Vol.41, #1, November 1970.

14. This information was collected from unpublished data of the Optometric Center of New York.

15. Rents are earned by the incumbent members of a profession if they can impose higher entry costs on new members. For a discussion of this and related issues, see:
Thomas Moore, "The Purpose of Licensing," Journal of Law and Economics, October 1961.
Simon Rottenberg, "The Economics of Occupational Licensing," in H. Greg Lewis, ed., Aspects of Labor Economics, NBER, 1962.
Arlene S. Holen, "The Effects of Professional Licensing Arrangements on Interstate Labor Mobility and Resource Allocation," Journal of Political Economy, 73, October 1965.
Alan Monhiet, "The Economics of Licensing in the Health Professions," Ph.D. Dissertation, City University of New York: in progress.

16. Holen, op.cit.

17. Fuchs & Kramer, op.cit.

18. Ibid.

19. Ibid.

20. Ophthalmology Manpower, ..., op.cit.

21. Licensing boards for physicians and dentists in Florida and California have the reputation of enforcing very strict entry requirements (see Benham, et.al., p.337-8). To test whether entry into these states is also difficult for the optometrist, the location equation was twice re-estimated. In the first model presented the observations on Florida and California are excluded. In the second model, all observations on difficult-to-enter states (or those states not accepting the national boards) were deleted except for Florida and California.

(1) $\text{Log OPto} = \underset{(3.7)}{5.69} + \underset{(2.9)}{1.3}\ \log \hat{P} + \underset{(-1.1)}{-.11}\ \text{License} + \underset{(2.8)}{.85}\ \log Y + \underset{(1.3)}{.002}\ \text{Student}$

$\bar{R}^2 = .27$

t statistics in parentheses
N = 30

(2) $\text{Log OPto} = \underset{(1.5)}{2.9} + \underset{(.9)}{.49}\ \log \hat{P} + \underset{(-.9)}{-.18}\ \text{License} + \underset{(2.0)}{.81}\ \log Y + \underset{(.6)}{.001}\ \text{Student}$

$\bar{R}^2 = .26$

t statistics in parentheses
N = 15

California and Florida appear to have more stringent licensing requirements than the other states that do not accept national boards. The licensing coefficient is -.18 in model (2), as compared to -.11 in model (1). However, the t values of both coefficients are low, approximately -1, and the Chow test of equality between the two licensing coefficients showed the coefficients to be not significantly different.

CHAPTER IV

THE DISTRIBUTION OF OPTOMETRIC INCOME

In this chapter we analyze the causes of the variation in income that optometrists receive from their professional practices. To put this another way, our concern is with the question: Why do some optometrists earn more than others? Although there have been few, if any, attempts in the past to explain intra-occupational income distributions, we need not be at a loss for a point of departure. The human capital theory of income distribution, originally devised as an explanation of the variation in labor incomes, has many interesting implications for our analysis of the distribution of optometric incomes.

The Human Capital Theory of Income Distribution

The primary determinant of labor incomes, according to human capital theory, is individual investment behavior. Variation in labor incomes results from the fact that individuals choose to undertake different amounts of training, or choose different stocks of human capital. Those who choose more schooling put off their earnings until later in their lives and this, according to Mincer, is the basic cause of differentials in labor earnings.[1] Besides schooling, individuals add to their stock of human capital by accumulating work experience and undertaking other forms of post school investment.

Empirical work in income distribution that is modeled on human capital theory centers around the estimation of the following equation:

$$Y = \alpha + b_1 S + b_2 E + b_3 E^2 + u$$

where S is number of years of schooling and E is the number of years of work

experience. The coefficient b_1 can be interpreted as the internal rate of return on schooling. The coefficients b_2 and b_3 are partly determined by the internal rate of return on post school investments. The E^2 term is included because of the non-linear relationship between experience and log earnings. For an overview of human capital theory and of the empirical work it has encouraged, see Mincer's survey article.[2]

Specification of Income Generating Functions for Optometric Income

To begin our examination of the determinants of the income of optometrists from their professional practices, we shall borrow considerably from human capital theory. However, human capital theory cannot provide a complete explanation of the variation in the incomes of optometrists. There are other explanatory factors, particularly on the demand side, which are also of importance. In fact, it will be best to think of the income generating function that we will eventually specify as a reduced form equation which falls out of a market model for optometric services that would be similar to the model estimated in the preceding chapter.

All variables we shall discuss below will appear in our estimated income generating functions. Our primary data source is the 1970 Haffner survey of optometrists, with supplementary information from the 1970 census. Variables not included in the Haffner survey and collected from census data are identified. For a description of the Haffner survey, see Appendix B. We shall start the discussion by considering the optometrist's investment in schooling.

Years of Professional Schooling

The length of the professional curriculum in each of the 12 optometry

schools in the U.S. today is four years. However, it was not until the mid 1960's that all optometry schools had extended their curriculum to four years, and many optometrists presently practicing have had a professional curriculum of two or three years (see Chapter II, Table 1, p.17). The extension of the curriculum was necessary, according to the administrators of optometry schools, because optometry had become a more complex science and optometrists, therefore, required more complete and rigorous training. This is not, however, the only possible motive. Many economists would argue that the length of optometry schooling may have been increased so as to discourage entry into the profession.

Our empirical results will give some insight into which of these motives might have been more dominant. By entering years of professional schooling into our income generating functions we can estimate the return associated with additional years of professional schooling. If consumers of optometric services have not recognized the value of increased technical training for optometrists by offering higher rewards to those optometrists with more extensive training, then we must be suspicious of the idea that this training is in some sense necessary and consider the possibility of extra years of training as a barrier to entry. It should be noted that years of professional schooling differ by age or experience of the optometrist. Table 1 presents a cross tabulation of length of professional curriculum by years of practice as an optometrist. There is variation in years of professional schooling, even for those optometrists with only 1 - 5 years of experience. Sixty-five percent of these optometrists had three year curriculums, 34 percent had four year, and one percent had two years. Years of professional schooling differs by experience as a

TABLE 1

LENGTH OF OPTOMETRY SCHOOL CURRICULUM
BY YEARS OF PRACTICE, HAFFNER
SAMPLE OF OPTOMETRISTS,1970

Years of Experience	Length of Curriculum (Percent of Row)			
	2	3	4	N
1-4		65%	35	277
5-9		75	25	178
10-14	2	68	30	238
15-19	4	50	45	351
20-24	17	28	55	425
25-29	17	26	57	118
30-34	32	44	24	112
35-39	55	32	12	68
40-44	66	27	7	41
45-49	65	30	4	23
50 +	100			5

SOURCE: A.N. Haffner, A National Study of Assisting Manpower in Optometry, Dept. of Labor Contract 81-34-70-11, 1971.

practicing optometrist because the lengthening of the optometry school curriculums did not occur uniformly across optometry schools. As a result, length of professional training is not determined by the age of the optometrist, and with experience held constant there still exists variation in years of professional schooling.

Years of Undergraduate Schooling

To be eligible for admission to optometry school, an applicant must have completed at least two years of undergraduate school. However, a large number of optometrists presently practicing have completed more than two undergraduate years (see Chapter II, Table 1, p. 17). Human capital theory would predict that there should be positive returns to the investment in the extra years of undergraduate schooling. To control for the effect of investment in undergraduate schooling on the income of optometrists from their professional practices, we include the number of years of undergraduate schooling as an independent variable in our income generating functions. The likely explanation of why the extra years of undergraduate schooling are undertaken by many optometrists is that career decisions are not made by these individuals until late in their college life. Of course, the argument could be made that these years of schooling were in no sense extra, but required to gain entry into the profession in the sense they were necessary to overcome other deficiencies in the applicants background, such as poor grades. This assertion is probably not correct. The correlation between class standing in optometry school and length of undergraduate school is positive,[3] indicating that those with extra years of undergraduate

schooling do not lack ability relative to those optometrists with the minimum two years of college training.

Years of Experience

Years of experience is an important determinant of labor incomes, according to human capital theorists, because it serves as a proxy for post-school investment in human capital. It is clear that the number of years an optometrist has been in practice should be an important determinant of his income. An optometrist's income should increase in his early years as he builds his practice and decline in his later years as he approaches retirement. A human capital explanation is relevant to this expected parabolic earnings - experience profile: in the early years optometrists should profit from their on the job experience by learning how to operate more efficienty and how to increase their patient loads: in later years deteriorating health stocks mean lower earnings and an increase in required leisure time. However, the human capital explanation is not complete, for if we were to consider a hypothetical optometrist who in no way adds to his stock of human capital during his early years of experience, we would still expect to find these early years characterized by increased earnings. This increase in earnings would be due to an increased patient load resulting from patient referrals, knowledge spreading through the community concerning the practice, etc.

We shall examine the earnings-experience profile of optometrists by including experience and experience squared in our income generating functions.

Number of States Licenses

An optometrist's inter-state mobility is hindered by state licensing

requirements. Those optometrists who have successfully passed the national board exams are exempt from the requirement of the written examination in some states, although 20 states in 1970 still did not accept national board scores as meeting the requirement of the written exam. An optometrist who is attracted to another state, perhaps because of the possibility of earning higher income, must then undertake an additional investment in his human capital in the form of at least preparing for the clinical examination if not for the written examination as well. Similarly, an optometrist who has passed the national boards has undertaken an investment in human capital that insures him more of an opportunity for interstate mobility than if he had not. Sixty-five percent of all optometrists in practice in 1970 were licensed to practice in only one state (see Table 2). Only 17 percent of practicing optometrists in 1970 were licensed by the national board,[4] but this rather low figure can be explained in part by the fact that the examination has only been administered since 1952. Table 3 shows the relationship between national board licensure and years of experience. Clearly less experienced or younger optometrists are more likely to be licensed by the national board.

We would expect that investment in inter-state mobility would be rewarded by higher income, and we shall test this hypothesis by entering the number of states licensed and a 0-1 dummy, where 1 indicates those optometrists licensed by the national board, as variables in our income generating functions.

Class Standing in Optometry School

Criticism has been leveled at many estimated income generating functions modeled on human capital theory because they have failed to

TABLE 2

NUMBER OF STATE LICENSES HELD, HAFFNER SAMPLE OF OPTOMETRISTS, 1970

One State	65%
Two States	26
Three States	8
Four States or more	1

TABLE 3

NATIONAL BOARD LICENSE BY YEARS OF PRACTICE,
HAFFNER SAMPLE OF OPTOMETRISTS, 1970

Years of Experience	National Board License (Percent of row)		
	Yes	No	N
1-4	48%	52	265
5-9	40	60	176
10-14	24	76	232
15-19	9	91	334
20-24	3	97	408
25-29	3	97	114
30-34		100	106
35-39	5	90	65
40-44	14	87	37
45-49	5	95	20
50 +		100	4

control for ability. It has been alleged, for example, that the high rate of return to a college education found by many investigators in part results from the fact that individuals with more intelligence or ability are more likely to go to college. The rate of return is biased upward because it captures returns to ability as well as to the extra years of schooling. Welch, in his summary of the literature on the relationships between income, schooling and ability, concludes that "biases in estimated rates of return to investments in schooling have probably been less than 10% due to a failure to correct for initial ability."[5] Our interest in ability results not only from the fact that we wish the other coefficients in our income generating functions to be unbiased, but also from a curiosity about the returns to ability itself for an optometrist engaged in practice. Welch reports that past research indicates a one standard deviation increase in ability will increase earnings by less than 5%.[6]

Unfortunately, ability measures are not usually collected in most surveys, one reason being that most individuals do not know what their ability is as, say, measured by IQ scores. However, one measure we do have at our disposal for optometrists is their class standing in optometry school. Class standing in optometry school is only partially determined by ability; study habits and a capability to deal with institutions and the present form of delivery of educational services may be even more important. It is undoubtedly true that the returns to high standing in optometry school are greater than returns to a high endowment of raw ability, since high class standing also represents the socialization and discipline aspects that may be more important than raw ability in developing an optometric practice.

Class standing is included as an independent variable in our income generating functions.

Race and Sex of the Optometrist

Optometry is a profession practiced almost exclusively by white males (see Table 4). The lack of non-white and female optometrists results either from discrimination by optometry schools against female and non-white applicants or from a reluctance on the part of non-whites and females to enter the optometric profession. If customer discrimination against women and non-white practitioners exists, then these individuals should have a greater reluctance to enter optometry schools than white males. The race (white, non-white) and sex of the practitioner is entered into the estimated models by the use of dummy variables. It will be interesting to see whether female or non-white optometrists receive lower incomes from their practices than males or whites, holding ability, experience and other variables constant.

Full or Part Time Practice

An optometrist's commitment to his professional practice in terms of the time he devotes to it is an important variable to control for in the income generating function. Failure to control for commitment to practice could make it difficult to interpret other variables in the regression equation. For example, if female optometrists devote less time to their practices on an annual basis than their male counterparts, human capital theory would predict smaller annual earnings for female optometrists, even with years of practice controlled for, because their accumulated work force experience would be less. Victor Fuchs has found that a substantial portion of the differential in male-female hourly

TABLE 4

RACE AND SEX OF OPTOMETRISTS,
HAFFNER SAMPLE OF OPTOMETRISTS,1970

SEX	
Male	97%
Female	3

RACE	
American Indian	.2%
Black American	.6%
Mexican American	.2%
Oriental American	1.2%
Puerto Rican	-
White American	97%
Other	.5%

earnings can be explained by the fact that females are less committed to the labor force than males.[7] Given the possibility that female optometrists may be less devoted to their practices than male optometrists, it would be difficult to establish whether female optometrists are discriminated against by potential patients, unless commitment to practice was controlled for.

One measure available in the Haffner survey of the annual amount of time devoted to professional practice is whether the optometrist practices on a full or part-time basis. This dummy variable is entered into the income generating function and takes on a value of one for part time practices and a value of zero otherwise. Only four percent of the responding optometrists in the Haffner survey called their practice part time.[8]

Religion

A religion dummy (1=Jew, 0=Non-Jew) is included in the estimated model of optometrist's annual earnings. There appears to be an astonishingly high number of Jewish optometrists relative to their representation in the U.S. population as a whole. Table 5 shows that 24 percent of the respondents in the Haffner survey were members of the Jewish faith. About three percent of the U.S. population is Jewish. Jews may be attracted to optometry in disproportionate numbers because of a high propensity to seek professional careers. We have already shown that many optometrists, at least at one stage in their lives had a strong interest in a career in medicine.[9] Another possible explanation of why there is a large number of Jewish optometrists is that Jews may be better practitioners

TABLE 5

RELIGIOUS DENOMINATION OF OPTOMETRISTS,
HAFFNER SAMPLE OF OPTOMETRISTS,1970

Roman Catholic	17%
Protestant	55
Jewish	24
Other	3

of optometry than non-Jews, and as a result receive higher incomes from practicing optometry. This would make the rate of return from practicing optometry higher for Jews than non-Jews; and the result should be a disproportionate number of Jews attracted to optometry if rates of return for Jews and non-Jews are similar in other occupations. If Jews do have traits that make them better optometrists, however, it is hard to imagine how these same traits would not similarly reward them in many other professions.

The Number of Competing Eye Professionals

Besides the optometrist's stock of human capital, there are other influences which we would expect to affect his income. Certainly a relatively high per capita number of competing eye professionals practicing in the same community should adversely affect an optometrist's income. Both ophthalmologists and opticians offer services that directly compete with those of the optometrist. Obviously other optometrists in the community also offer competing services. To examine the extent to which the per capita number of competing eye professionals in the same community adversely effects an optometrists' income, we include in our income generating functions the number of physicians in the optometrist's community who supply eye examinations as well as the number of optometrists, both weighted by 1/(population of the community). The number of opticians could not be included because the data is not available.

The number of optometrists and ophthalmologists by place of residence was obtained from the 1970 Blue Book of Optometry and from the 1970 Red Book of Ophthalmology and Otolaryngology.[10] There were two problems encountered in collecting the data. Both books include retired practitioners

in their listings so our figures overestimate active practitioners. Additionally, there are still many EENT (eye, ears, nose and throat) men or ENT (eye, nose, throat) men who practice ophthalmology. These physicians were included in our count of ophthalmologists.

The socioeconomic characteristics of the community in which the optometrist practices should also play a role in determining the optometrist's income. This is because there are differences in visual acquity by age and race, and because there are differences in the utilization of corrective lenses by age, race, income and education. These differences have been described in chapter III. The vollowing variables are entered into the income generating function to control for these demand side influences: percent of the population 65 years of age and over, median family income, percent non-white, and percent of the population 25 and over who have completed high school. These variables are specific to the optometrist's place of practice and were collected from the 1970 census.

Professional Restrictions on the Practice of Optometry

There are severe restrictions on the practice of optometry in many states as a condition of license. As discussed in chapter III, many states restrict the advertising of optometric services. Lee Benham has been carefully examining the effects of professional restrictions on the prices paid for eyeglasses and on the frequency with which individuals purchase eyeglasses.[11] This work is presently in progress and is an outgrowth of his previous research on the effect of advertising restrictions on the price paid for eyeglasses in 1963.[12] In his present work, Benham classifies states into restrictive, non-restrictive, and other categories for the

year, 1970. In general, non-restrictive states are those which do not restrict advertising and allow the employment of optometrists by corporations. Some states do not allow optometrists to be employed by corporations in order to discourage the development of "commercial", or high volume department store type optometric practices. Benham classified states on the basis of information supplied by representatives of five large commercial firms.

The question of interest to us is the effect of the restrictions on the practice of optometry on the incomes of optometrists. We have shown in chapter III, for example, that advertising by optometrists may shift the demand curve for their services to the right. Holding price constant, the effect of the rightward shift would be to increase the revenues to optometrists. However, Lee Benham has shown that advertising results in more competitive (i.e., lower) prices. It is not clear, then, that a more laissez faire atmosphere will necessarily result in higher net incomes for optometrists. Higher volumes may be offset by lower, more competitive prices and the increased cost of conducting an optometric practice brought on by advertising expenditures. Since professional restrictions on the practice of optometry have increased over time, optometrists apparently feel it is in their own interest to mold their profession along the lines of physician practices and to discourage the larger commercial establishments which resemble retail outlets.[13] We can investigate whether it is in the interest of optometrists, as measured by net income from practice, to increase the restrictions on information that can be disseminated to the public and to discourage the development of commercial firms. To do so, we enter two dummy variables into the income generating function which take on a value of

one for Benham's "restrictive" and "other" states, respectively.[14]

Region of Practice and Population of Community of Practice

Because wages and prices tend to be higher in larger cities and outside the South, a region dummy (South - Non-south) and the population of place of practice are entered into the model of optometric earnings.

The Model Summarized

To summarize this lengthy discussion of the specification of an optometric income generating function, we list the explanatory variables below. Our dependent variable is the natural log of net income from professional practice in 1970.

Explanatory Variables

years of professional schooling
years of undergraduate schooling
years of experience
experience squared
number of states licensed
national board dummy
class standing in optometry school
full or part time practice dummy
religion dummy (Jew -- non-Jew)
sex dummy
race dummy (White -- non-White)
per capita number of ophthalmologists
per capita number of optometrists
percent of community's population 65 years of age or older
percent non-White of community's population
median family income of the community
percent of community's population 25 and over with at least a high school education
population of community
restrictive dummy
other dummy
region dummy (South -- non-South)

REGRESSION RESULTS

The regression results are presented in Table 6. The region dummy

TAB

REGRESSION RESULTS
OPTOMETRIC EARN

	R^2	Intercept	EXP	EXPSQ	Part time Dummy 1=Part time	Class Standing	Undergraduate Schooling	Professional Schooling in years	Restriction Dummy	
1.	.21	9.4	.07 (19.5)	-.001 (-17.3)	-.23 (-4.7)	-.03 (-2.6)	-.01 (-1.0)			
2.	.21	9.4	.07 (19.6)	-.001 (-17.4)	-.23 (-4.6)	-.03 (-2.5)	-.01 (-.8)		-.06 (-2.2)	(
3.	.21	9.4	.07 (19.8)	-.001 (-17.2)	-.23 (-4.5)	-.03 (-2.4)		-.03 (-1.5)	-.06 (-2.4)	
4.	.20	9.4	.07 (18.6)	-.001 (-16.9)	-.23 (-4.6)	-.03 (-2.5)			-.05 (-2.1)	
5.	.22	9.3	.07 (19.6)	-.001 (-17.4)	-.22 (-4.5)	-.02 (-2.0)			-.04 (-1.6)	
6.	.22	9.3	.07 (19.5)	-.001 (-17.2)	-.22 (-4.4)	-.02 (-2.0)			-.04 (-1.6)	
7.	.01	10.0								
8.	.22	9.3	.07 (19.4)	-.001 (-17.2)	-.22 (-4.4)	-.02 (-2.0)			-.04 (-1.5)	

t statistics in parentheses

TABLE 6

SULTS FOR MODEL OF NET
C EARNINGS, 1970

ric- y	Other Dummy	States Licen- sed	Dummy National Boards 1=Yes	Religion Dummy 1=Jew	Sex Dummy 1=Fe- male	Race Dummy 1=White	Ophthal- mologist per capita	Opto- metrist per capita	Percent with H.S. education	Median Family Income
5 2)	-.01 (-.5)									
5 4)										
5 1)			-.01 (-.30)							
4 6)		.03 (1.8)		.01 (3.1)	-.06 (-1.2)	.004 (1.3)				
4 6)		.03 (1.9)		.01 (3.2)	-.06 (-1.1)	.004 (1.3)	-.20 (1.6)	-.01 (-.3)		
									-.005 (-3.9)	.01 (2.1)
4 5)		.03 (2.0)		.01 (2.9)	-.06 (-1.1)	.004 (1.3)	-.23 (-1.7)		-.002 (-1.3)	.01 (.8)

and population of place of practice variables were statistically insignificant when included in the income generating function. These results are not presented. If productive inputs for optometric practices are lower priced in the South and in smaller populated areas, the price of output is lower by the same proportion and net incomes are not significantly different in these areas.

Years of Professional Schooling

The number of years of professional training received by practicing optometrists was statistically insignificant when included in the estimated income generating models (see Model 3.). The implication of the finding is that even if those optometrists with longer periods of professional training are in some sense better optometrists, holding experience and other variable constant, consumers of optometric services fail to recognize this and do not discriminate in favor of the better qualified practitioners. Assuming still that the longer trained optometrists are superior practitioners, the reluctance of consumers to discriminate in their favor can be explained either by irrationality on the part of the consumer or by an inability to judge the standards of care they receive. Neither possibility seems likely; the first requires no comment and the second explanation, which might be relevant if we were discussing the delivery of medical services, is probably not relevant to most optometric services. Individuals who have been fitted for and supplied with eyeglasses by an optometrist can judge the quality of care they receive to a great extent by putting on the eyeglasses and looking through them. It could be argued in rebuttal that consumers may be ignorant of what a proper eye examination entails. They may be able to judge the quality of the refraction,

but not whether they have been properly checked for any developing eye diseases or other vision problems. Hence, higher quality eye examinations may be given by these optometrists with longer periods of training, but they go unnoticed by consumers of optometric services who are concerned primarily with the proper correction of refractive error. This argument is not persuasive, for if the patients of optometrists are concerned almost solely with the correction of refractive error, then the quality of the refraction and of the corrective lenses must be the primary determinant of the quality of optometric services.

We conclude then that it is not likely that the longer trained optometrists are providing better quality care. Why then were the professional curriculums of optometry schools lengthened? One motivation we discussed above was the possible desire to limit entry into optometry. Another likely explanation would seem to be the desire by optometrists to be recognized as a full fledged health profession with a lengthy and vigorous program of professional training. Optometrists would like to have the status of the physician, if not for its own sake, then to help them compete with ophthalmologists in the provision of eye care services.

Number of Years of Undergraduate Schooling

The number of years of undergraduate schooling appears in regressions 1 and 2. This variable is insignificant at conventional levels of confidence, but the t coefficients are large enough (in absolute value) to make one wonder about a possible explanation for the negative

coefficients. We previously discussed the notion that extra years of undergraduate education beyond the required two might be undertaken to overcome deficiences in an applicant's background, such as poor grades. This hypothesis would appear to be substantiated by the negative relationship between the natural log of net optometric earnings and years of undergraduate schooling. Those optometric students who required extra years of optometry school to overcome say, poor college grades, have lower incomes, other things equal, because they have less ability. But using length of undergraduate education as a proxy for lack of ability seems questionable. The correlation between length of undergraduate education and class standing in optometry school, as reported above, is .08. Furthermore, we control for ability as measured by class standing in optometry school in the regressions in which we enter years of undergraduate schooling and still get the negative relationship.

With ability and other variables held constant, it is difficult to rationalize how attending optometry school for an extra year or two could result in lower net income from professional practice. It seems best to interpret the coefficient on years of undergraduate schooling as not significantly different from zero. The human capital gained from extra years of undergraduate schooling beyond the required two does not yield returns in terms of optometric income.

Experience

In general, those individuals who invest more in their stock of human capital should have steeper log earnings-experience profiles that peak after fewer years of experience as compared to those that do not invest as much. This is because an individual's stock of

human capital is acquired, for the most part, early in life, much of it before work during the school years, and the rest primarily in the early stages of working life. Investment in human capital declines over time because the expected marginal benefits decrease as time goes on since the number of working years diminishes in which the returns from the investment can be realized. Additionally, the marginal cost of making a given investment in human capital usually increases as time goes on because the opportunity cost of time increases. Those individuals who invest more in their stock of human capital generally have a shorter span of working life in which to garner their returns, so necessarily their returns (income) must peak faster and at a higher level than is true for those individuals who do not invest as much.

The coefficients of experience and experience squared from Table 6 imply peak earnings for optometrists after 35 years of experience. Mincer's regression results, for non-farm males less than 65 years of age in the 1/1000 sample of the 1960 census, show peak earnings after about 31 years experience. As an example, consider Mincer's regression P(I).[15]

$$\begin{aligned} \text{LN INCOME} = {} & 6.20 + \underset{(72)}{.11}\ \text{Schooling} + \underset{(75)}{.081}\ \text{Experience} \\ & - \underset{(-56)}{.0013}\ \text{Experience}^2 \qquad R^2 = .29 \\ & \qquad\qquad\qquad\qquad\qquad\qquad \text{(t statistics in parentheses)} \end{aligned}$$

Since the average male has made smaller investments in human capital than optometrists have, it is surprising to find that male earnings peak earlier. In further comparing Mincer's regression results with ours it can be seen that the log annual earnings-experience profiles

are about equally steep. This is also an unexpected result. The implication is that the earnings of optometrists in their initial working year must be at a much higher level than is true for the non-farm male under sixty five. A comparison of the intercept term is important in this determination, and as can be seen from the regression results, the intercept term in the income generating functions for optometrists runs about 9.4 as compared to 6.20 in the Mincer specification.[16]

Number of States Licensed to Practice

The number of states in which the optometrist is licensed to practice is positively associated with net income from practice. It appears then that an investment in interstate mobility does pay off in terms of higher optometric income. The size of the coefficients indicate that annual net income increases by three percent when an optometrist gains licensure in an additional state.

The national board dummy was insignificant when included in the estimated model with number of states licensed. This is to be expected since the number of states licensed would be the causal variable through which the national board dummy operates to effect income. However the national board dummy is also insignificant when included without the license number variable. Apparently by 1970 not many optometrists had effectively used the national boards to gain higher net incomes through inter-state mobility.

Class Standing.

Class standing in optometry school was included in the estimated

models in order to control for ability, although we recognize that the correlation between class standing and self discipline must also be strong, perhaps even stronger than the correlation between raw ability and class standing. The variable is significant at the one percent level in all the estimated models and takes on a negative sign because higher values of the variable indicate lower class standing. The tabulated responses to the class standing question in the Haffner survey are interesting and shown in Table 7. It seems that either Haffner's attempt at a random sample of optometrists failed, or that nearly all optometrists near the bottom of their class cannot pass state licensing examinations, or that optometrists exaggerate their performance in optometry school like fishermen exaggerate the size of their catch. I would expect the latter explanation is the one nearest the truth. Since almost all respondents insisted that they were in the middle of their class or higher, we effectively have only three ranking categories. Hopefully, all optometrists upped their class standing by some constant proportion so that the variable we are left with still represents a relative ranking.

Assuming it does, the regression results show that an optometrist who was one rank above another in class standing receives an annual income two to four percent higher, other things equal. We conclude there are significant returns to raw ability and self discipline (and whatever else high class standing represents) in the development of an optometric practice. The standard deviation of class standing is .93. Hence a one standard deviation increase in class standing results in an increase in net optometric income of less than 4%.

TABLE 7

CLASS STANDING OF OPTOMETRISTS,
HAFFNER SURVEY OF OPTOMETRISTS, 1970

Top quarter	42.96
Above average but not top quarter	23.82
Average	26.91
Below average but not bottom quarter	2.21
Bottom quarter	1.09

Since the returns to ability are probably even less than the returns to class standing, our results are well within Welch's conclusion that a one standard deviation in ability will increase earnings by less than five percent.

Full or Part-Time Practice

The full or part-time practice dummy is highly significant in all the regression equations. The results show that part time optometrists receive annual incomes about 25 percent lower than full time optometrists.

Race and Sex of the Optometrist

The coefficients of the race and sex dummies are consistent with the notion that those consumers seeking optometric services discriminate against non-white and female optometrists. The t values for both variables indicate statistical significance at approximately the 20 percent level of confidence. Female optometrists receive six percent less annual income than male optometrists, holding commitment to practice (in the sense of full or part time) ability (as measured by class standing), the actual number of years of experience as a practicing optometrist, and other variables constant. This figure is not inconsistent with some of the past findings on male-female differentials in earnings. Victor Fuchs found that single, never married women, who presumably have a commitment to the labor force similar to males, received only about 90% of the hourly earnings of males in 1959, adjusting for color, schooling, age, city size, class of work and lengths of trip to work.[17] Fuchs' data base was the 1/1000 sample of the 1960 census, so most of the females Fuchs analyzed were salaried. Our sample, however,

consists of predominately independent professionals. Fuchs then was analyzing primarily employer discrimination while we are analyzing customer discrimination. Fuchs tended to discount employer discrimination, one reason being that women did not appear to seek refuge from employer discrimination by choosing self-employed careers. Our results show that one reason women may not choose self employment is because customer discrimination may be as bad as employer discrimination.

The regression results for the race dummy indicate that white optometrists receive net income about one-half percent higher than their non-white counterparts, controlling for other variables. It would appear that customer discrimination also exists against non-white optometrists, but at a level substantially less than that experienced by females.

To summarize, it appears that the existance of customer discrimination, particularly against females, is a partial explanation of why women and non-whites are under represented in the profession of optometry.

Religion

The Jew -non-Jew dummy variable is statistically significant at the one percent level in the regressions in which it is included in Table 6 and positively associated with net income. Some characteristic of Jewish optometric practices, whether it be the provision of higher quality care, the working of longer hours, or superior management techinques has resulted in higher net incomes. It would appear that by controlling for ability (class standing) we also control to some extent

for the aforementioned factors except for the working of longer days or more weeks per year. This may be the reason for the higher net income that accrues to Jewish optometrists.

The size of the coefficient indicates that Jews receive about one percent higher net incomes than non-Jews, other things equal. This does not seem to be a significant enough difference to account for the disproportionate number of Jews who practice optometry. This fact would seem better explained by the notion that Jews have a higher propensity to seek professional careers.

Competing Eye Professionals

The regression results with respect to the number of competing eye professionals are interesting. The per capita number of ophthalmologists in the community in which an optometrist practices appear to have a more detrimental effect on the income of an optometrist than the per capita number of competing optometrists. In fact, the per capita number of optometrists is insignificant in the estimated models in which the variable appears, while the per capita number of ophthalmologists is negatively related to optometric income and significant at the ten percent level.

In the estimated demand models of chapter III, the ophthalmology variable was not significantly related to the demand for optometric services. Since this result was unexpected, we suspended our conclusion with regard to the effect of the per capita number of competing ophthalmologists on the demand for optometric services. We have now found that a negative relationship exists between the per capita number of ophthalmologists and

optometric income. This result implies what we have consistently hypothesized; namely, that the optometrists and the ophthalmologist offer competing services. Because the number of observations is much larger, and because we have aggregated only over community of practice rather than state of practice, the empirical findings in this chapter should be considered more reliable than those in chapter III. The insignificant competing optometrist variable implies that in 1970 optometrists were in equilibrium with respect to the location of each other. In other words, the average optometrist could not gain higher income by moving to another community to practice. A problem with this interpretation is that it appears contradictory to our previous discussion of the competing ophthalmologist variable. If optometrists are in equilibrium with respect to the location of each other, then why are they not also in equilibrium with respect to the location of ophthalmologists?

One explanation of this apparent contradiction is that optometrists in 1970 were in the process of adjusting to the location of ophthalmologists, and were not yet in equilibrium. There is some additional empirical support for this hypothesis, although it is primarily circumstantial. We have already discussed the fact that ophthalmologists, and physicians in general, locate primarily in urban areas (see chapter III, Table 2). We have shown that optometrists are approximately evenly distributed between urban and rural states, and in fact are actually over-represented in rural states, if a rural state is defined as having less than 30 percent of its population in metropolitan areas (see chapter III, Table 2 and footnote 7). It is our hypothesis that optometry is a profession that is being practiced less in

urban areas overtime and more in suburban and rural areas. The reason for this is that the number of ophthalmologists has been increasing fairly rapidly over time and we assume these practitioners are continuing to locate primarily in urban areas in order to be near hospitals and urban amenities.[19] If so, those optometrists remaining in urban areas may be losing patients over time to the growing stock of ophthalmologists. Optometrists practicing in urban areas do not adjust instantaneously to the growing competition from ophthalmologists because of the locked-in effect of established practices and because of the start-up costs involved in building a new practice.

Socio-economic Characteristics of Place of Practice

The socio-economic characteristics of the community in which the optometrist practices did not play a prominate role in explaining the variation in optometric incomes. The per cent of the community over sixty five and percent non-white were insignificant when included in the income generating functions. These results are not presented. Apparently the variable, percent non-white, was statistically insignificant because racial differences in the utilization of optometric services are captured in the income or education variables and no pure racial effect exists.

It is surprising that the percent of the population over sixty-five of the community in which the optometrist practices did not turn up as a significant explanatory variable in the income generating function. The utilization of corrective lenses increases markedly with age, and we discovered in Chapter III that the demand for optometric services is positively related to the percent of the population sixty-five and over. The net income of a firm should rise with an increase in the demand for its output. The age variable result here is inconsistent with the age result in Chapter III. It is possible, although not likely, that the result in Chapter III is a statistical artifact. As individuals get older, they may prefer to receive their visual examinations from ophthalmologists because of a fear of eye diseases or other vision problems which they feel ophthalmologists are better qualified to handle. This may be particularly true for those individuals over sixty-five years of age and this is our

measure of the age of the population of a community. Medicare may also influence the choice of an eye professional by senior citizens. Although eye refractions for the expressed purpose of obtaining eye glasses are not covered under the medicare program, physician services for the most part are. It is not too difficult to imagine a senior citizen obtaining an eye examination from an ophthalmologist that included an eye refraction under the guise of diagnosing a potential eye disorder.[18]

The level of education of the community in which the optometrist practices seems to play an interesting role in determining optometric incomes. In regression number 7 the percentage of the community with a high school education is seen to be inversely related to optometric income, holding median family income constant. In regression 8, the inverse relationship holds but the t value has fallen from -3.9 in regression 7 to -1.3. The fall in t ratios is to be expected with the inclusion of so many more explanatory variables in regression 9. The education coefficient in regression 8 is still significant at the 20 percent level. So although more educated people are more likely to own corrective lenses, when income and other variables are held constant, the pure education effect on the income of optometrists is negative. Apparently, as education increases, other variables constant, an individual becomes more likely to receive his vision care from an ophthalmologist. This hypothesis is consistent with the regression results of Chapter III, which showed the demand for optometric services to be insignificantly related to the education levels of potential patients.

The median family income of the community in which the optometrist practices is positively associated with the net income of optometrists.

The income coefficients imply that a 10 percent increase in median family income in 1970 would have raised the net income of optometrists by about one percent, or 200 dollars.[20] The income elasticity of demand cannot be constructed from these figures because we are estimating a reduced form that includes both demand and supply side components. If increases in net income translate proportionally to increases in output, these results do indicate a reduced form income elasticity of .1. This elasticity must necessarily be less than the income elasticity of demand unless the supply curve is perfectly elastic. The income elasticities of demand computed in Chapter III were as high as .8.

Professional Control of Practice

Two dummy variables were specified in the income generating model to measure the effects of restrictions on the practice of optometry as a condition of license. The restriction dummy took on a value of one for those states which had the strictest sanctions against advertising and also discouraged the development of commercial practices. The other dummy represented those states in the middle ground between the restrictive and more laissez faire states.

The results of regression 2 show that optometrists practicing in restrictive states have net incomes six percent lower than those optometrists practicing in non-restrictive states. The coefficient of the restrictive dummy remains fairly stable in all the regression in which it appears. The net incomes of optometrists practicing in other states may be slightly lower than those of optometrists in non-restrictive states. The other dummy is negatively related to optometric net income, but statistically insignificant.

These results imply that it is not in the interest of optometrists, as measured by net income, to restrict the information that can be disseminated to the public or to curtail more commercial, less professional type practices. It is probably safe to conclude that the reason for this is that advertising gives optometrists a marketing advantage that ophthalmologists do not enjoy. As a result, optometrists have a larger market share where they are allowed to advertise than where they cannot. It would not seem in the interest of optometry to lobby for legislation that would take away this advantage.

FOOTNOTES TO CHAPTER IV

1. Jacob Mincer, "The Distribution of Labor Incomes: A Survey with Special Reference to the Human Capital Approach," JEL, March 1970, V.VIII, #1, p.7.

2. Ibid, p. 1-27.

3. The simple correlation between schooling and class standing in optometry school across the Haffner sample is .08.

4. A.N. Haffner and J. Sherman, A National Study of Assisting Manpower in Optometry, U.S. Department of Labor, DL 81-34-70-11-1, August, 1971, p.26.

5. Finis Welch, "Relationships Between Income and Schooling," Unpublished monograph, p.10.

6. Ibid, p. 13.

7. Victor Fuchs, "Differences in Hourly Earnings Between Men and Women," Monthly Labor Review, 94, May 1971.

8. Haffner, op. cit., p.24.

9. See Chapter II.

10. Both are published by the Professional Press, Chicago.

11. Lee Benham, "Price Structure and Professional Control of Information," Monograph, 1973.

12. This research was discussed and cited in Chapter III.

13. Lee Benham reports that restrictions on advertising increased across states between 1963 and 1970 (Benham, op.cit.).

14. The "other" states are: Arizona, Florida, Georgia, Indiana, Iowa, Kansas, Kentucky, Maine, Massachusetts, New Hampshire, New Jersey, New Mexico, Oregon, Washington and Wisconsin. The "restrictive" states are: Arkansas, California, Connecticut, Idaho, Louisiana, Montana, North Carolina, North Dakota, Oklahoma, South Carolina, and Tennessee.

15. Jacob Mincer, "Schooling, Age, and Earnings" in Human Capital and Personal Income Distribution, NBER (in progress).

16. Part of the difference in the intercept term can be explained by the fact that we are comparing 1959 earnings in the Mincer regressions with the 1970 earnings of optometrists. The value of the intercept term is not annual earnings in the first year of experience since the other terms in the regression equations must be considered. However, the intercept term dominates predicted first year earnings in Mincer's and our regressions.

17. Fuchs, op.cit.

18. This line of conjecture is possible only if we assume that ophthalmologists vary their workloads in response to changes in the demand for their services. This assumption is necessary because the number of ophthalmologists is held constant in the regression equations.

19. The figures in the table below imply that the number of ophthalmologists has been increasing at a substantial rate since 1956. Filled residencies in ophthalmology increased approximately 280 percent between 1956 and 1970. Filled residencies in all specialities increased about 200 percent during the same period. These figures were compiled from various issues of the Journal of the American Medical Association.

	Residencies offered in ophthalmology	Percentage filled of residencies offered in ophthalmology	Percentage filled of residencies offered - all specialities	Residencies offered - all specialities
1956	565	87%	79%	23,012
1964	1093	95	80	38,373
1966	1179	96	82	38,895
1970	1385	98	85	46,005

20. Median family income in the United States in 1970 was almost 10,000 dollars. The average 1970 net income of the optometrists in the Haffner survey was 21,400 dollars.

CHAPTER V

AN ECONOMIC ANALYSIS OF THE EMPLOYMENT OF ASSISTING MANPOWER IN OPTOMETRY

The concern by some observers over the alleged shortage of physicians has led to a rapidly expanding, if not yet substantial, health economics literature on the potential of substituting para-professional medical manpower for physicians in the production of physician services. Some investigators have found a substantial opportunity for physicians to increase their productivity by expanding the number of aides they employ.

Reinhardt concluded from his estimated production function for physician services that the average American physician could employ profitably twice the number of assistants as he presently utilizes and by so doing, increase his hourly rate of output by 25 percent.[1] Smith, Miller, and Golladay studied physician practices and used activity analysis to conclude that the efficient use of physician assistants would increase physician productivity by 49 to 74 percent.[2]

Not all investigators agree that an expansion of medical services could best be realized by increasing the number of employed aides. Feldstein found that the use of more para-medical personnel and other inputs relative to the quantity of physician input would result in an <u>increase</u> in the price of physician services. He speculates that physician practices, as currently organized, may not enable the efficient use of para-medical personnel and equipment.[3] In a separate piece of research, Feldstein concluded that in British hospitals "too much is being spent on nurses, catering and other supplies and not enough on doctors, drugs and dressings."[4]

Feldstein recommended that the number of doctors in British hospitals be increased relative to other inputs. Boaz, in her production analysis of 19 family planning clinics, found that the clinics should expand their employment of physicians for "the high fee charged by the physician is more than offset by his high marginal productivity compared to other personnel."[5]

There is not as much conflict in these findings as might first appear. Reinhardt and Smith, et. al., analyzed micro samples of physicians in private practice to reach their conclusions that auxillary personnel were underutilized in the production of physician services, while Feldstein's and Boaz's examination of hospitals and clinics showed physicians to be underutilized relative to other inputs. The results, then, appear to be sensitive to the setting in which health services are delivered. It may be true that physicians in private practice consistently employ less than the optimum number of aides because they place too small a value on their own time, or because they fear compromising the quality of care their patients receive. On the other hand in more institutional settings, such as clinics and hospitals, administrators may attempt to carry the substitution of capital and paramedical inputs too far because of a fear of overstocking expensive physician time. Additionally, hospital or clinic administrators may not be as quality conscious as physicians in private practice because competition for patients may not be as severe.

In this chapter we consider the potential of substituting optometric aides for optometrists in the production of optometric services. Optometrists in private practice, like physicians, combine inputs of their own time, the time of aides, capital and other inputs to produce health services.

It will be interesting to discover whether optometrists in private practice appear to be underestimating the potential of substituting the input of aides for their own input in the production of health services.

Optometric Aides

Sixty-six percent of practicing optometrists in 1970 employed aides who performed duties beyond secretarial work.[6] Only 1 percent of the employed aides received any college training to become an optometric assistant.[7] Most (90 percent) were trained on the job.[8] The duties of optometric aides are primarily administrative and housekeeping, although many aides assist the optometrist in the formal provision of eye care by helping in spectacle assembly and repair, in frame styling and selection, in visual training, in the measuring of visual acquity, and in the fitting of contact lenses.[9]

Method of Analysis

To analyze the potential of substituting the input of optometric aides for the input of the optometrist in the production of optometric services, we shall estimate production functions for optometric services. We rely exclusively on ordinary least squares to estimate the production relationship. The resulting estimates are biased unless we are willing to assume that inputs and outputs are not simultaneously determined. This assumption would be justified, for example, if optometrists choose current inputs on the basis of anticipated output, rather than current output.

Even if inputs and outputs are simultaneously determined in optometric practices, the resulting estimation bias may not be large.

If optometrists are confronted with substantially different product and input prices or differ greatly in their ability or willingness to maximize profits, the simultaneity bias is reduced.[10] Reinhardt argues that these conditions were met for his sample of physicians.

He reasoned that the price for one of the inputs in his production function for physician services, physician time, must necessarily vary a great deal among physicians because it is a shadow price and depends on how the physician values his own time. Reinhardt also noted that his cross section sample of physicians indicated there were substantial differences in the prices physicians received for their services and in the wage rates of auxiliary personnel. He attached greatest importance to what he assumed to be a difference in the ability of physicians to profit maximize. He argues that physicians differ substantially in their "ability (or willingness) to attain profit maximizing levels of factor inputs,"[11] if not so much in their ability to use inputs to produce physician services. The reason for Reinhardt's concern with the problem of simultaneous equation bias is that he estimates his production function for physician services by using ordinary least squares. Reinhardt lacked adequate instruments from which two stage estimates could be derived. Reinhardt did attempt to estimate a simultaneous system but termed the first stage estimates "extremely poor" and the second stage estimates "implausible."[12]

We also are confronted with the simultaneity question in the single equation ordinary least square estimates that we perform below. Unfortunately, we also lack adequate instruments from which two stage estimates could be derived. Nevertheless, we would appear to be on as

solid a footing as Reinhardt in minimizing the sumultaneity bias. For we are dealing with a national sample of optometrists in private practice while einhardt analyzed a national sample of physicians in private practice. A production function was estimated using Irving Hoch's indirect least squares technique which is designed to take account of the fact that inputs in a Cobb-Douglas production function are endogenously determined. The resulting estimates were not plausible; three of the coefficients were negative.

Cobb-Douglas Functional Form

We shall begin by specifying the production of optometric services as Cobb-Douglas. That is, $Q_i = A \prod_j X_{ji}^{\alpha_j} U_i$, where Q_i is the output of the ith optometric practice that results from combining the inputs, X_j. This specification implicitly assumes that substitution among all inputs can occur and that output is zero if any input is not used in the production process (i.e., if the value of any input is zero.) Our use of the Cobb-Douglas production function is in violation of this latter assumption because one of our factors of production will be optometric aides and certainly it is possible for an optometric practice to have a positive rate of output without the use of optometric aides. Below we will specify a production function that is consistent with positive rates of output occuring when some inputs need not be used in the production process.

Source of Data

We do face several constraints in the estimation of a production function for optometric services that are inherent in the available data. Our data base is the 1964 National Survey of Optometrists conducted by

the American Optometric Association. The primary problem with the date solicited in the survey is that the quantity of inputs used in the optometric practice was expressed in value terms instead of physical terms. As a result, we must measure inputs in our production relationship in value terms. This introduces a source of bias, the size of which depends on how much variation exists in the factor prices that optometrists face. Measuring inputs in value terms is, however, a common practice in the estimation of production functions.[13] One advantage of measuring inputs in value terms is that the labor input has a built in quality adjustment to the extent that more productive workers receive higher wage payments. If labor was measured in physical units, more productive workers could not be more heavily weighted than the less productive. For a more thorough description of the data, see appendix A .

Measuring Output

Measuring the output of a physician, a clinic, or a hospital has been one of the most difficult problems confronting health economists. In Reinhardt's analysis of the production of physician services, he used three different measures of output: patient billings, patient visits, and office visits. As he admits, these measures are far from ideal but were the only measures he had available. The problem with using visits as an output measure is the rather substantial variation that must exist in the quantity of services provided per visit. Patient billings would seem to take account of some of this variation in physician services per visit, but this measure can introduce bias depending upon the variation in fees charged by physicians for similar services. Reinhardt feels this variation may be quite substantial.[14a]

One advantage we have in our analysis of the production of optometric services is (probably) a better measure of output than health economists have had at their disposal in the past. Our measure of output will be the number of refractions or vision examinations performed by the optometrist in 1964. Since the output of an optometric practice is generally a joint product, consisting of a visual examination and corrective lenses, we must assume that each optometrist provides nearly the same proportion of eyeglasses to visual examinations in the year and that differences in this proportion are random throughout our cross-section of optometrists. It would seem fair to conclude that there is much less variation in the quantity and quality of services provided by optometrists per refraction than is true for the case of patient visits to a physician.

Measuring Inputs

As mentioned earlier, most of the input data in our survey of optometrists was collected in value terms. The data include: the dollar amount of annual wages paid to assistants, the dollar amount of annual rent for office space, and the dollar value of capital stock in the office. These variables are included as inputs in the production relation with one slight adjustment. The capital variable is multiplied by .10 to approximate depreciation of the capital stock. An additional input, the number of hours worked per week by the optometrist was also collected in the survey. This variable, multiplied by 49.5 to approximate hours worked per year, is also included as an input in the production function.

The Estimated Cobb-Douglas Production Function

The ordinary least squares estimation of the Cobb-Douglas production relationship is complicated by the presence of zero observations for the wage bill. Seventeen percent of the surveyed optometrists did not employ auxiliary personnel. The most often used solution to the problem of taking the log of a zero observation is to assign an arbitrarily small number to take the place of the zero. Often this number is one so that the log of the observation becomes zero. If the non-zero observations are a sufficient distance from zero, this approach is usually accepted without complaint. However, the regression results can be quite sensitive to the value of the arbitrarily assigned number. This is because the slope of a logrithmic function represents a percentage change, or, over time, a compound growth rate. The percentage changes implied in the observations on an independent variable would be quite sensitive to whether zero values are assigned the number 1,or say, the number 10, even if the non-zero observations are large. For example, 10,000 is 10,000 percent larger than 1, and only 1000 percent larger than 10.

Because of the probable sensitivity of the regression results to the value of the number assignment to take the place of the zero observations for the wage bill, several small numbers (E_i) were assigned and different regressions were estimated for each. These numbers were 1, 10, and 100. The E_i are some distance from the non-zero observations (the mean wage bill of those optometrists in the sample that employed assisting manpower was $4353).[14b] The regression results are presented in Table 1. Again, the model was estimated over a cross-section of optometric

TABLE 1

FULL SAMPLE COBB-DOUGLAS
REGRESSION RESULTS

	Intercept	LN Depreciation	LN Hours	LN Wage	LN Rent	Group Dummy	R^2
E=1	2.481	.139 (9.0)	.382 (10.5)	.034 (15.2)	.036 (2.3)	-.046 (-1.6)	.12
E=10	2.448	.133 (8.6)	.382 (10.5)	.050 (15.8)	.032 (2.0)	-.050 (-1.7)	.13
E=100	2.328	.120 (7.7)	.380 (10.5)	.088 (17.1)	.021 (1.4)	-.059 (-2.0)	.13

t statistics in parentheses

N = 4700

practices in the United States in 1964. The total number of observations was 4700. We can use the regression results to examine the optimal employment of factor inputs in the production of optometric services. First, however, we must derive the first order conditions explicit in the formulation of the production function.

Constrained output maximization of our Cobb-Douglas production function yields slightly different results than is the case for a conventional Cobb-Douglas production function because some of our inputs are measured in value terms (wages, capital, rent), and others in physical terms (optometrist's hours). The Lagrangian relevant to our production function is:

$$Z = A W^{\alpha_w} D^{\alpha_d} H^{\alpha_h} R^{\alpha_r} e^{\gamma DG} + (C^o - W - K - R - \mu H)$$

where W = wage bill
D = capital flow in dollars
H = optometrist's hours
R = rent bill
DG = group practice dummy
μ = shadow price inputed to own hours by the optometrist

The first order conditions for any two inputs measured in value terms are (say, for wages and capital)

$$\frac{\partial Z}{\partial W} = \alpha_w \frac{Q}{W} - \lambda = 0 \; ; \; \frac{\partial Z}{\partial D} = \alpha_D \frac{Q}{D} - \lambda = 0 ,$$

where Q represents the specified production function.

Or, the two inputs should be combined in that proportion where

$$\frac{\alpha_w}{\alpha_D} = \frac{W}{D} .$$

The first order condition for optometrist's hours, the input measured in physical terms, is

$$\frac{\partial Z}{\partial H} = \alpha_H \frac{Q}{H} - \lambda \mu = 0 .$$

The inputs measured in value terms and the input measured in physical terms should be combined in that proportion where

$$\frac{\alpha_H}{\alpha_i} = \frac{H}{i} \qquad i = W, D, R.$$

With these results in mind we can examine the optimal inputs proportions explicit in our regression results with the inputs proportions used in actual optometric practices.

Table 2 shows the optimal input proportions or the ratio of the regression coefficients and the ratios of the mean values of inputs used in optometric practices. Our particular interest in this chapter is whether optometric aides are used to their fullest potential and it is this question we consider first. By comparing the ratio of mean annual hours devoted to practice by optometrists to the mean annual wage bill of auxiliary manpower with the ratio of the respective regression coefficients, we can solve for that shadow price which the average optometrist assigns to the value of an hour of his time in terms of his employment of auxiliary manpower. That is:

$$\frac{\alpha_H}{\alpha_W} = \mu_4 \frac{\bar{H}}{\bar{W}} \; ; \text{ or } \mu_4 = \frac{\bar{W}}{\bar{H}} \frac{\alpha_H}{\alpha_W}.$$

This shadow price varies substantially depending on the number assigned to take the place of zero observations on the wage bill. When E=1, the optometrists' employment of auxiliary manpower and the Cobb-Douglas specification of the production process imply the average optometrist implicity places a value of $16.32 on an hour of his own time input. The computed shadow price falls to $11.21 and $6.36 when the assigned number is 10 and 100, respectively.

TABLE 2

OBSERVED AND OPTIMAL INPUT PROPORTIONS

	Ratio of Coefficients*				Ratio of Observed Sample Means		
	E=1	E=10	E=100		E=1	E=10	E=100
$\frac{\text{Ln Wage}}{\text{Ln Dep}}$	.25	.38	.73	$\frac{\bar{W}}{\bar{D}}$	3.16	3.17	3.20
$\frac{\text{Ln Rent}}{\text{Ln Wage}}$	1.05	.64	.25	$\frac{\bar{R}}{\bar{W}}$	.79	.79	.78
$\frac{\text{Ln Hours}}{\text{Ln Rent}}$	10.52	11.97	17.33	$\frac{\bar{H}}{\bar{R}}$	.86μ_4	.86μ_4	.86μ_4
$\frac{\text{Ln Rent}}{\text{Ln Dep}}$	.26	.24	.18	$\frac{\bar{R}}{\bar{D}}$	2.52	2.52	2.52
$\frac{\text{Ln Hours}}{\text{Ln Wages}}$	11.10	7.62	4.32	$\frac{\bar{H}}{\bar{W}}$	.68μ_4	.68μ_4	.67μ_4
$\frac{\text{Ln Hours}}{\text{Ln Dep}}$	2.74	2.87	3.16	$\frac{\bar{H}}{\bar{D}}$	2.15μ_4	2.15μ_4	2.15μ_4

*E = Number assigned to take the place of zero observations on the wage bill.

The average net income of the optometrists in our 1964 cross-section was 15,128 dollars before taxes. The net hourly wage before taxes was then 7.63 dollars, given the average 40 hour work week of the optometrists in the sample and the assumed number of working weeks of 49.5. If taxes came to 15% of taxable income, an estimate probably on the low side, the net hourly wage after taxes would be 6.49 dollars.

For E=1, the equating of the observed and optimal input proportions would require the optometrist to employ 1161 dollars of auxiliary aide input, given that the optometrist should evaluate his own time at 6.50 dollars, his approximate after tax market wage.[15] For E=10 and E=100, the optimal wage bill rises to 1692 and 2985 dollars, respectively. The latter figure is only 60 dollars in excess of the observed average of all the sampled optometrists. However, the optimal wage bills determined from the regression results for E=1 and E=10 indicate the average optometrist is placing too much value on his own time by spending too much on aide input, and that he should substitute some of his own time for that of his aides. At this point in our investigation, we are not able to say which of our computed shadow prices is the best approximation of the actual value that optometrists place on their own time. We are able to refine our estimates, below, as the investigation becomes more complete.

If we compare optometrist's hours with rent paid for office space and with the capital input, we can similarly compute the value the optometrist places on his own time as made evident by his expenditures on these inputs. For E=1, the imputed value of an hour of the optometrist's time is 12.23 dollars with respect to rent expense and 1.27 dollars with respect to the

use of the capital stock. The similar figures are 13.91 dollars and 1.33 dollars for E=10, and 20.20 dollars and 1.47 dollars for E=100. The differences in these estimated shadow prices are extreme and these results indicate that the input proportions used by optometrists in the production of optometric services substantially differ from the optimum proportions implicit in the estimated Cobb-Douglas production functions. Because the discrepencies between the observed and optimal input proportions, presented in Table 2 are large, we must question whether we have properly specified the production process.

Before we consider the estimation of a different functional form, there remains one interesting finding that must be discussed. The regression results indicate that optometrists in group practice may be less technically efficient than optometrists in solo practice. Holding input levels constant, the group dummy coefficient shows that, on average, each member of a group practice produces about five percent less output than solo practitioners. The results can be interpreted in this fashion because the group practitioners that were surveyed were asked to prorate the inputs and output of the group practice by practitioner, and to report only the portion which applied to themselves.

These results do not imply that the total output of the average group practitioner is less than his solo counterpart. In fact, the mean annual number of visual examinations provided by the average group practitioner is better than 10 percent higher than the number provided by the average solo practitioner. The results do imply that the group practitioner uses more inputs to produce a unit of output. The group practitioner is either more wasteful (less technically efficient) or provides

more expensive, higher quality care. Newhouse has argued that group medical practitioners are more wasteful than solo practitioners because cost sharing weakens the incentive to minimize the costs of practice.[16] The same could be true for optometrists.

The Reinhardt Functional Form

To further analyze the production of optometric services and the potential for expanding the output of optometrist's practices or increasing their efficiency by the increased employment of auxiliary personnel, we shall estimate an alternative production function based on Reinhardt's development of a production function for physician services.

The production function Reinhardt estimated for physician services is more versatile than the Cobb-Douglas production function that we have estimated. Reinhardt's production function permits positive rates of output to occur when some inputs are not included in the production process, allows the factors to be characterized by both increasing and decreasing marginal products, and does not constrain the elasticity of substitution to one. Since optometric services are produced in some instances without the use of one of our specified inputs, optometric aides, Reinhardt's production function has some appeal. The general specification of Reinhardt's production function is:

$$(1) \qquad Q = A \prod_s \left[X_s^{\alpha_s} e^{\beta_s X_s} \right] e^{\left[\sum_j \gamma_j L_j + \theta \left(\sum_j L_j \right)^2 + u \right]}$$

where X_s demotes inputs that must be used in the production process and L_j denotes inputs that can be excluded from the production process.[17]

Specific to the estimation of a production function for optometric services, we can rewrite (1) as

$$Q = A H^{b_1} e^{b_1' H} D^{b_2} e^{b_3 D} R^{b_4} e^{b_5 R} e^{r DG} e^{(b_6 W + b_7 W^2 + u)}$$

where H is annual hours worked by the optometrist; D is 10 percent of the value of the capital stock in the office: R is annual rent paid; and W is annual wages paid to assistants. DG is the group practice dummy. This function can be easily estimated in double log form. The estimation over the full sample of optometrists yields:

$$\log \text{exams} = 1.46 - \underset{(-2.5)}{.072}\ \text{Dummy Group} + \underset{(7.3)}{.115}\ \log \text{Depreciation}$$

$$+ \underset{(10.6)}{.384}\ \log \text{hours} + \underset{(1.5)}{.053}\ \log \text{rent} - \underset{(-1.3)}{.019 \times 10^{-3}}$$

$$\text{rent} + \underset{(16.6)}{.054 \times 10^{-3}}\ \text{wages}$$

$$- \underset{(-10.6)}{.081 \times 10^{-8}}\ \text{wages squared}$$

$$R^2 = .14$$

t statistics in parenthesis.

The variables $\log e^{b_1 H}$ and $\log e^{b_3 D}$ are not included in the estimated regression because they were found to have very low t values when incorporated in the model.

As with the Cobb-Douglas production function, we can use the first order conditions to investigate whether auxiliary personnel are optimally used in the production process. The relevant Lagrangian for constrained output maximization is

$$Z = Q + (C^{o} - W - R - K - \mu_4 H),$$

where Q is the production function and μ_4 is the shadow price of an hour of optometrist's time. The first order conditions with respect to wages and hours can be reduced to rather simple expressions:

$$\frac{\partial Z}{\partial W} = \frac{\partial Q}{\partial W} - \lambda = 0$$

$$\frac{\partial Z}{\partial H} = \frac{\partial Q}{\partial H} - \lambda \mu_4 = 0.$$

or, $$\mu_4 \frac{\partial Q}{\partial W} = \frac{\partial Q}{\partial H}.$$

Since $\frac{\partial Q}{\partial W} = \frac{Q}{H}(b_6 + 2b_7 W)$ and

$\frac{\partial Q}{\partial H} = b_1 \frac{Q}{H}$, it follows that

$$\mu_4 = H^{-1} b_1 (b_6 + 2b_7 W)^{-1}$$

If we assign H and W their sample mean values, μ_4 = \$3.32. This finding is contrary to the results derived from the Cobb-Douglas specification. According to this result, the average optometrist's expenditure on aides implies that the optometrist places a rather low value on his own time and should increase his expenditures on aides and substitute some of their time for his in the production process. It appears as if the results of our investigation of the optimal employment of aides in optometric practices are sensitive to the specification of the production function.

One way to further compare the two models of the production of optometric services is to delete from our sample all those optometrists who did not employ assisting manpower. By so doing, we eliminate the problem of dealing with zero observations that we encountered with the Cobb-Douglas specification. The primary advantage of Reinhardt's specification is that it permits positive rates of output to occur without the use of some inputs. This advantage is eliminated if we accept as our sample only those optometrists who used at least some of each input.

For this sample, the choice of the more appropriate specification of the two is difficult, a priori. This is particularly true given that the expotential expressions for depreciation and hours in Reinhardt's function estimated over the full sample were statistically insignificant. The result of this is to bring Reinhardt's model closer to the Cobb-Douglas specification.

The regression results are presented in Table 3. As done previously, we can use the first order conditions to solve for that shadow price which the average optometrist assigns to the value of an hour of his time in terms of his employment of auxiliary manpower. The shadow prices computed from the Cobb-Douglas specification are each about 3.90 dollars. The shadow price from the Reinhardt specification is 3.78 dollars. The Cobb-Douglas shadow price has fallen considerably from its levels calculated from the model estimated over the entire sample. The Reinhardt shadow price has increased from 3.32 dollars.

The implication of the change in the Reinhardt shadow price is that optometrists who do not employ aides are more likely to undervalue their own time than are optometrists who do employ aides. The drop in the Cobb-Douglas shadow price implies the reverse; optometrists who do not employ auxiliaries value their time higher than optometrists who do. This is an impossibility when the shadow price of optometrist's time that we have calculated is determined by assisting manpower expenditures. Optometrists with a zero wage bill would implicitly value their own time at zero.

The implications of both the production functions estimated over this abreviated sample are the same. The low shadow prices indicate that

TABLE 3

ABBRIEVIATED SAMPLE REGRESSION RESULTS*

COBB-DOUGLAS

	Intercept	In Dep	In Hours	In Wage	In Rent	Group Dummy	R^2
1.	2.161	.039 (2.7)	.390 (10.0)	.223 (18.5)	-.039 (-1.5)	-.040 (-1.6)	.16
2.	2.019	.035 (2.4)	.383 (9.9)	.214 (18.5)		-.044 (-1.8)	.16

REINHARDT

$$\text{In exams} = 2.581 + \underset{(4.2)}{.061}\ \text{In Dep} + \underset{(.9)}{.021}\ \text{In Rent} - \underset{(-1.3)}{.016 \times 10^{-3}}\ \text{Rent}$$

$$+ \underset{(10.2)}{.399}\ \text{In Hours} + \underset{(15.3)}{.047 \times 10^{-3}}\ \text{Wages} - \underset{(-10.3)}{.068 \times 10^{-8}}\ \text{Wages Sq.}$$

$$- \underset{(-1.5)}{.038}\ \text{Group Dummy} \qquad R^2 = .14$$

* Zero observations on wage bill deleted from sample

t statistics in parentheses

N = 3124

optometrists' place too small a value on their own time relative to what it is worth in the market, and that optometric services could be more efficiently produced if the optometrist substituted the time of auxiliaries for his own in the production process. This conclusion is consistent with the findings derived from the Reinhardt specification estimated over the entire sample. It differs from the conclusion drawn from the analysis of the regression results of the Cobb-Douglas model run over the entire sample. However, the initial Cobb-Douglas estimates are open to question. The results were sensitive to the size of the arbitrarily small number assigned to take the place of zero observations on the wage bill and there is no satisfactory way to determine which small number should be assigned. Also, there were wide discrepancies between the optimal input proportions determined from the production function parameters and the input proportions used in actual practices. And, as already mentioned, the high shadow price estimates from the initial Cobb-Douglas estimates are not consistent with the low shadow prices derived from the Cobb-Douglas regressions run over the abbreviated sample when the problem of zero observations was eliminated. For these reasons we do not place much confidence in the initial Cobb-Douglas estimates.

The optimal input proportions calculated from the Cobb-Douglas production function estimated over the abbreviated sample and the input proportions used in actual optometric practices are shown in Table 4.[17]. Because rent was statistically insignificant, only the input proportions for the other inputs are presented. The discrepancy between the optimal and actual wage/depreciation ratio is not nearly as large as was the case for the Cobb-Douglas function estimated over the entire sample. The

TABLE 4

OBSERVED AND OPTIMAL INPUT PROPORTIONS

Ratio of Coefficients*		Ratio of Observed Sample Means		
$\frac{\text{Ln Wage}}{\text{Ln Dep}}$	= 6.11	$\frac{\bar{W}}{\bar{D}}$	=	4.32
$\frac{\text{Ln Hours}}{\text{Ln Wage}}$	= 1.79	$\frac{\bar{H}}{\bar{W}}$	=	.464
$\frac{\text{Ln Hours}}{\text{Ln Dep}}$	= 10.94	$\frac{\bar{H}}{\bar{D}}$	=	1.914

* From Cobb-Douglas production function estimated over sample with zero wage observations deleted

implicit shadow prices of an hour of the average optometrist's time are 3.9 and 5.7 dollars in terms of wages and depreciation, respectively. These results also appear more reasonable than the comparable figures determined from the full sample Cobb-Douglas production estimates. The data presented in Table 4 suggest that optometric services could be produced more efficiently if the substitution of auxiliary manpower for capital and optometrist's hours was extended. The extent to which optometrists could profitably expand their employment of assisting manpower is considered in the next section.

The Profit Maximizing Level of Aide Input

To pursue our investigation further, we can use the production functions to determine the profit maximizing wage bill or the approximate number of assistants that optometrists could profitably employ at the given output price. If we consider the optometrist to be a profit maximizer, his decision rule for the determination of the optimal wage bill can be derived as follows:

Profit = Total Revenue - Total Cost

$$TT = P.f(W,D,H,R) - (W+D+R+\mu H)$$

$$\frac{\partial TT}{\partial W} = \frac{\partial f}{\partial W} P - 1 = 0$$

$$P\frac{\partial f}{\partial W} = 1$$

where P is price of output, f is the production function.

In the case of the Cobb-Douglas production function, our decision rule is:

$$TT = P \cdot A W^{\alpha_W} D^{\alpha_D} H^{\alpha_H} R^{\alpha_R} e^{\tau DG} - (W + D + \mu H + R)$$

$$\frac{\partial TT}{\partial W} = \alpha_W P A W^{\alpha_W - 1} D^{\alpha_D} H^{\alpha_H} R^{\alpha_R} e^{\tau DG} - 1 = 0$$

By substituting the mean sample values for all variables but the wage

bill and by using the regression results we can solve for what the optimal wage bill of the "average" optometric practice should be.

The price of optometric services was determined by computing the average gross annual income per visual examination of the responding optometrists, weighted by the number of examinations performed. According to the Cobb-Douglas model estimated over the abbreviated sample, the profit maximizing wage bill of the average optometric practice in 1964 was \$7960.[18] The same procedure can be followed for the Rheinhardt specification. The relevant first order condition is:

$$(2)\quad P.A\, H^{b1}\, D^{b2}\, R^{b3}\, e^{b4R}\, e^{b5DG}\, e^{(b_6W + b_7W^2)}\,(b_6 + 2b_7W) = 1$$

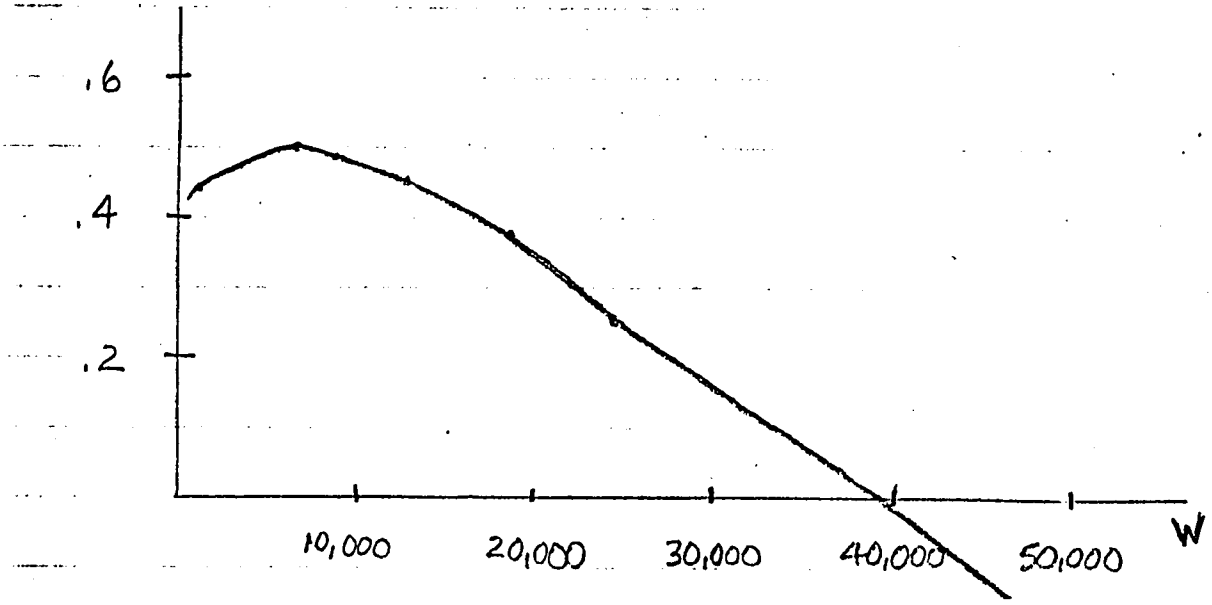
There is n positive value of W that solves this expression if mean values are substituted for all other variables and the regression coefficients from the runs over, the abbreviated sample are used. The same is true for the expression when the full sample results are applied. However, we can trace out the left hand side of (2) for different values of W, using both the full and abbreviated sample results. As shown in , W is closest to one at approximately a value of 8000 dollars in both cases, although the function is fairly flat upto 15,000 dollars.

Therefore, the profit maximizing condition for the optimal employment of W, as determined by the functional form, regression results and sample means, can be best approximated if the wage bill equals about 8,000 dollars. This result is close to the optimal wage bill derived from the Cobb-Douglas abbreviated sample results. It is worth mentioning again that the mean wage bill for the full and abbreviated samples of

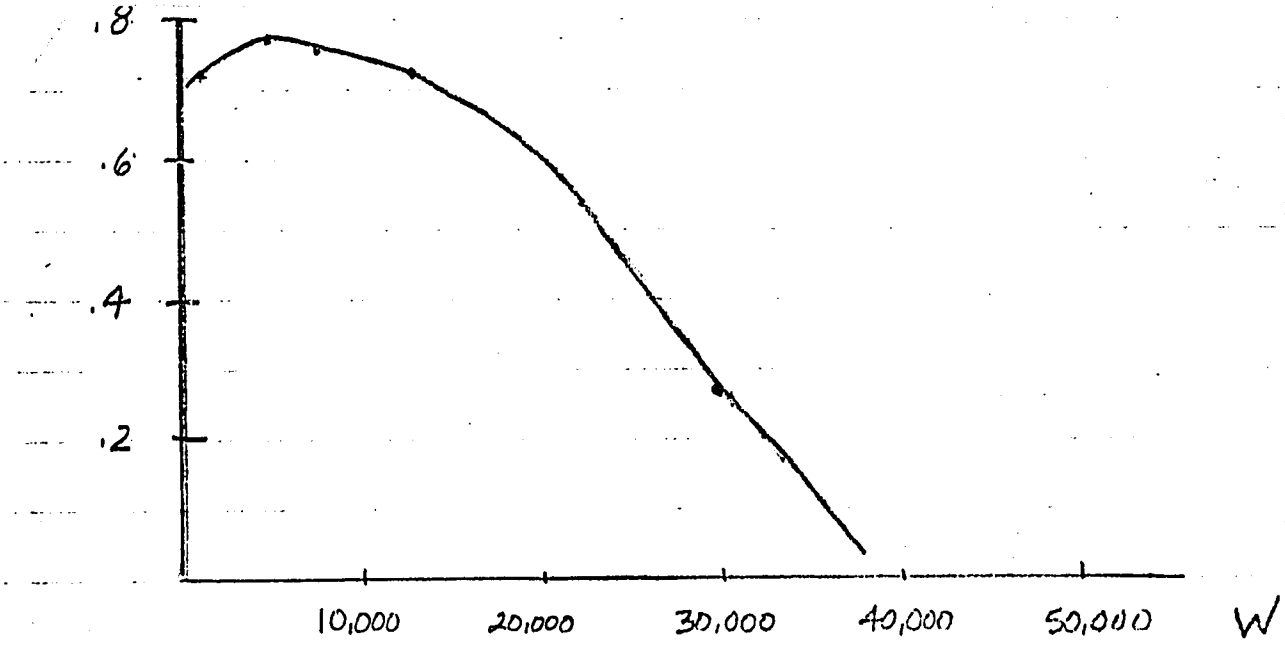
TABLE 5

VALUES OF F(W) FOR POSITIVE W*

FULL SAMPLE RESULTS



ABBRIEVIATED SAMPLE RESULTS



*f(W) = l.h.s. of (2) with sample means and regression coefficients substituted for all parameters and variables but W

optometric practices was 2,921 and 4,353 dollars respectively.

Concluding Remarks

The results of our investigation support the claim that optometrists are underutilizing aide input in the production of optometric services.[19] The average optometrist could profitably increase his employment of auxiliaries to about two and one-half times their present level, according to the results presented in the preceding section. According to our estimated production functions, the output of the average optometric practice would increase by about 30 percent if such an expansion in aide employment took place.[20]

The unsettling question that remains to be answered is why optometrists have not chosen to increase their profits and output by expanding their employment of aides. One assumption we have been operating under is that optometrists can sell all the services they want at the going market price. However, this may not be true. Haffner found in his 1970 national survey of optometrists that 22% of all respondents felt their optometric practice under its present structure could accomodate greater than 30% more patients. The median respondent felt his optometric practice could accommodate 18% more patients under its present structure. It is possible then that optometrists have not hired more aides because it is not profitable for them to do so. The increase in output that more aide input would make possible may come only at lower output prices. In fact our production function results are perfectly consistent with the notion that many optometrists are underutilized. These optometrists may place a low value on their own time because many of their hours are idle, but

must be spent in their offices waiting for patients, most of which are non-appointment. During this time they can complete much of the activities they would delegate to aides if they were busier. Similarly, they can afford to spend a substantial portion of time with each patient they do serve, and would be less concerned with task delegation in the treatment process.

There are other possible explanations for the apparent reluctance of optometrists to employ the profit maximizing amount of aide input. For one, optometrists could be unaware of the value of aides in the production process. Or, if not unaware of their value, optometrists may be reluctant to expand their numbers because of a fear of a compromise in the quality of care. Reinhardt hypothesizes that these reasons may partially explain why physicians do not expand their employment of auxiliary manpower.[21]

FOOTNOTES TO CHAPTER V

1. U. Rheinhardt, "A Production Function for Physician Services," Review of Economics and Statistics, Feb.1972, p.55.

2. K.R. Smith, M. Miller, and F.L. Golladay, "An Analysis of the Optimal Use of Inputs in the Production of Medical Services," Journal of Human Resources, Vol.7, #2, Sp.72, p.218. Physician assistants is not used generally in this instance but refers to a category of para-professionals specifically trained to perform a variety of tasks.

3. M. Feldstein, "The Rising Price of Physician Services," Review of Economics and Statistics, May 1970.

4. M. Feldstein, Economic Analysis for Health Services Efficiency : Econometric Studies of the British Health Service, North Holland Publishing Co., 1967, p.100-101.

5. Boaz, R.F., "Manpower Utilization by Subsidized Family Planning Clinics : An Economic Criterion for Determining the Professional Skill Mix," Journal of Human Resources, Vol.7, #2, Spring 72, p.204.

6. A.N. Haffner and J. Sherman, A National Study of Assisting Manpower in Optometry, Dept. of Labor contract 81-34-70-11, 1971, p.36.

7. Ibid, p.37.

8. Ibid, p.38.

9. Ibid, p.44-52.

10. This can be easily shown. To illustrate, we will use the Cobb-Douglas production function, but these results apply equally to other specifications. We assume the firm is a profit maximizer and employs two factor inputs in the production process. If so, profit, TT can be expressed as

$$(1)\quad TT = P.AK^{\alpha} L^{\beta} U - WL - rK$$

where P is price of output, U is the error term, and W and r are the factor prices. Maximizing (1) with respect to a factor input, say L, yields

$$(2)\quad \frac{\partial TT}{\partial L} = PAK^{\alpha}\beta\, L^{\beta-1} \quad U-W=0.$$

The derived demand for L can be determined by solving 2 for L.

This expression is presented in logarithmic form for ease of exposition.

(3) $\ln L = \frac{1}{1-\beta} (\ln P + \ln A + \alpha \ln K + \ln \beta + \ln U - \ln W)$

The simultaneous equation bias results from the correlation between a dependent variable, in this case L, and the error term in the Cobb-Douglas production function. The Cobb-Douglas production function can be written as

$$\ln Q = \ln A + \alpha \ln K + \beta \ln L + \ln U.$$

Assuming that ln U is not correlated with lnP, lnK or ln W, the

$$E(\ln L, \ln U) = \frac{1}{1-\beta} \sigma^2_{\ln U} > 0 \quad \text{because} \quad 0<\beta<1$$

The implication of this result is that bias is introduced into the ordinary least squares (OLS) estimators of α and β. To show this let

$$B = \begin{bmatrix} \alpha \\ \beta \end{bmatrix} \qquad \hat{B} = \begin{bmatrix} \hat{\alpha} \\ \hat{\beta} \end{bmatrix}$$

$\hat{B} = (X'X)^{-1} X'Y$ is the OLS estimator

where X is the matrix of observations of the independent variables (factor inputs) and Y is the matrix of observations on the dependent variable (output).

$$\hat{B} = (X'X)^{-1} X'X B + (X'X)^{-1}X'U$$

$$E(\hat{B}) = B + (X'X)^{-1} X'U$$

If $E(X'U)$ equals zero, that is, if the dependent variables and the error term are uncorrelated the OLS estimators are unbiased. However, bias is introduced if $X'U$ does not equal zero. In our example, $\hat{\beta}$ would be upward biased because $E(l_i, u_i) > 0$ where the l_i and u_i represent observations on the natural logs of L_i and U_i.

Note, however, that the bias is not large if $E(l_i, u_i)$ is small. This would occur if variations in lnL could be explained predominantly by variations in other explanatory factors rather

than lnU. This result is likely if there is substantial variation in the other explanatory variables in the derived demand equation. In our example these variables include lnP, lnW and lnK. Furthermore, we can add an additional variable, lnV to represent the error term in the derived demand equation. This expression would represent economic efficiency, or the ability or willingness of the entreprenuer to secure the profit maximizing input level. The greater the variation in this variable, as well as the others we have mentioned, the smaller should be the simultaneous equation bias. Reinhardt argues that variations in V are greater than variations in U because physicians are more equal in technical ability than in economic ability. This conjecture cannot be verified.

It is probable, however, that variation in U is quite large for physicians and optometrists. This is because there is likely to be substantial errors in the measurement of the physician's (or optometrist's) input in the production process. Physicians, whose work effort is self regulated in their private practices, would supply different amounts of true input per unit of measured input. For example, if measured physician input was hours devoted to practice and if physicians varied in their work effort per hour, then true input would differ from measured input. Since physician input is likely to have a high output elasticity in the production of physician services, the variation in U resulting from errors in measurement is likely to be considerable. To show this, let us assume that output Q is produced only by one input H, which is measured with error. Let

$$Q = bH + V,$$

and let

$$h = H + c \qquad E(C) = 0,$$

where h is a measure of the true input, H. It follows that

$$Q = bh - bc + V.$$

The error term in the production relation is bc + V. The variance of the error term will increase the larger the measurement error and the larger the output elasticity.

11. Reinhardt, op.cit., p.56.

12. Ibid.

13. M. Feldstein, op.cit., 1967, p.97.

14a. Reinhardt, op.cit., p.56.

14b. The mean wage bills over our sample of optometrists by visual exams produced are presented below.

Visual Exams	Mean Wage Bill in 000's	N
< 500	$1.1	714
500 - 1000	2.3	2002
1000 - 1500	4.1	1300
1500 - 2000	5.2	466
> 2000	5.6	203

15. We assume here that the hours worked per year by the average optometrist remain constant.

16. Joseph Newhouse, "The Economics of Group Practice," Journal of Human Resources, VIII, 1, Winter, 1973, p.37-56.

17. The mean wage bill increased from 2,921 dollars to 4,353 dollars when the zero wage observations were deleted. The average depreciation expense increased from 922 to 1,024 dollars, the mean rent bill changed from 2,320 to 2,495 dollars, and mean annual hours worked by optometrists changed from 1984 to 1995.

18. As discussed in the text, the full sample Cobb-Douglas estimates appear biased because of the problem of the zero observations on the wage bill. The profit maximizing wage bills implicit in these regression results are:

$1,050 for E=1; $1,490 for E=10; and $2,590 for E=100

These results again demonstrate the sensitivity of the parameter estimates to the size of the number assigned to take the place of the zero observations.

19. See, for example, Haffner, op.cit., p.1.

20. The wage bill output elasticity is equal to the wage coefficient in the case of the Cobb-Douglas specification. This value is .21 in the abbreviated sample runs. To compute the wage elasticity for the Reinhardt specification, write (1) in logs. Then

$$\frac{\partial \ln Q}{\partial W} = b_6 + 2b_7 W \text{ , or}$$

$$\frac{\partial \ln Q}{\partial W} \cdot W = b_6 W + 2b_7 W^2 .$$

This elasticity is .17 for the full model regressions and .15 for the abbreviated model runs.

21. Reinhardt, op.cit., p.65.

APPENDIX A

The 1964 American Optometric Association Economic Survey

In 1965, nearly every member of the American Optometric Association (AOA) was mailed a questionnaire that solicited data on the economics of conducting an optometric practice. About 70 percent of practicing optometrists are AOA members. The number of questionnaires returned coded and punched by the AOA totaled 4,750, which represented approximately 40 percent of all AOA members. The percent of AOA members responding to the survey by regional division of the United States ranged from 33 to 45 percent. The means and standard deviations of the variables used in the production analysis are reported below.

Variable	Mean	Standard Deviation
Group Dummy	.09	.29
Wages	$2921	4480
Depreciation	$922	635
Rent	$2320	1251
Hours worked per year	$1984	357
Visual Exams	$1042	664

The AOA sample is further described in the following issues of the Journal of the American Optometric Association : April 1966, p.364-366; May 1966, p.477-481; June 1966, p.566-570; July 1966, p.683-685; August 1966, p.781-785; September 1966, p.883-886; October 1966, p.955-957.

APPENDIX B

The Haffner Survey

The Haffner survey of optometrists was conducted as part of A National Study of Assisting Manpower in Optometry, Grant #DL 81-34-70-11, August 1971, Alden N. Haffner, principal investigator. A complete description of the data, including summary statistics, is contained in this report. To quote from appendix B of the study:

> A questionnaire was sent to every third practitioner listed in alphabetical order on the revised American Optometric Association membership list. A total of 4,268 optometrists were selected for the study. If the questionnaire was not returned within a one month time period, another questionnaire was sent with an additional cover letter urging the practitioner to reply. Following this, a night letter was sent urging reply. One month after the night letter and last request, a cut off date was set and the computer analysis began. Each questionnaire was punched entirely on three standard IBM cards. A total of 2,393 usable sets of data were eventually analyzed or a 56.3% of the total.

Since the sampling procedure was so precisely identified, the addresses of the responding optometrists could be determined. As a result, the socioeconomic characteristics of the place in which the optometrist practices could be collected from the 1970 census.

There are two sources of bias which the reader should be aware of. First, all responding optometrists from a place with less than 1500 people were deleted from the sample because the socioeconomic characteristics of their communities could not be determined from the 1970 census. Also, those optometrists whose place of practice could not be located in the Blue Book of Optometry, 1970, or in the Red Book of Ophthalmology and Otolaryngology, 1970, were deleted from the survey sample because the number of competing eye professionals in the place of practice could not be determined. The result of these deletions was a reduction in sample size to 18.[50]

BIBLIOGRAPHY

Lee Benham, "The Effect of Advertising on the Price of Eyeglasses," Journal of Law and Economics, October 1972.

L. Benham, A. Maurizi, and M.W. Reder, "Migration, Location, and Remuneration of Medical Personnel : Physicians and Dentists," Review of Economics & Statistics, 50 : 332-347, August 1966.

R.F. Boaz, "Manpower Utilization by Subsidized Family Planning Clinics : An Economic Criterion for Determining the Professional Skill Mix," Journal of Human Resources, Vol.7, #2, Spring 72.

Fred Chipman, "AOA 1969 Economic Survey - Part I," Journal of American Optometric Association, Vol.40, #12, December 1969.

Rashi Fein, The Doctor Shortage, The Brookings Institute, Washington D.C., 1967.

M. Feldstein, "The Rising Price of Physician Services," Review of Economics and Statistics, May 1970.

M. Feldstein, Economic Analysis for Health Services Efficiency : Econometric Studies of the British Health Service, North Holland Publishing Co., 1967.

Victor Fuchs and Marcia Kramer, The Determinants of the Expenditures for Physician Services in the United States, 1948-68, National Bureau of Economic Research Research Occasional Paper 117, 1973.

Victor Fuchs, "Differences in Hourly Earnings Between Men and Women," Monthly Labor Review, 94, May 1971.

A.N. Haffner and J. Sherman, A National Study of Assisting Manpower in Optometry, U.S. Department of Labor, DL 81-34-70-11-1, August 1971.

Monroe J. Hirsh and Ralph E. Wick, The Optometric Profession, Chilton Books, 1968.

Jacob Mincer, "The Distribution of Labor Incomes : A Survey with Special Reference to the Human Capital Approach," Journal of Economic Literature, March 1970, V.VIII, #1.

Ophthalmology Manpower : Characteristics of Clinical Practice, United States - 1968, Dept. of Health, Education and Welfare publication #(HSM) 73-1802, Vital Health Statistics - Series 14, #7.

Opticians Employed in Health Services, United States, 1969, Dept. of Health, Education and Welfare publication # (HSM) 72-1052, Vital Health Statistics - Series 14, #3.

Optometrists Employed in Health Services, United States, 1968, Dept. of Health, Education and Welfare publication # (HSM) 73-1803, Vital Health Statistics - Series 14, #8.

M.Y. Pennell and M.B. Delong, "Optometric Education and Manpower," Journal of the American Optometric Association, Vol.41, #1, Nov.1970.

U. Reinhardt, "A Production Function for Physician Services," Review of Economics and Statistics, February 1972.

Frank Sloan, "The Demand for Higher Education : The Case of Medical School Applicants," The Journal of Human Resources, VI, #4, Fall 1971.

K.R. Smith, M. Miller, and F.L. Golladay, "An Analysis of the Optimal Use of Inputs in the Production of Medical Services," Journal of Human Resources, Vol.7, #2, Spring 1972.