THE DEMAND FOR EDUCATION: AN HEDONIC APPROACH

A THESIS

SUBMITTED TO THE FACULTY OF THE GRADUATE SCHOOL

OF THE UNIVERSITY OF MINNESOTA

BY

THOMAS FRANKLIN STINSON

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

DECEMBER 1973

ACKNOWLEDGEMENTS

I wish to thank a number of people for their contributions to the success of this project. My thesis chairman, Professor Anne Krueger, did more than provide a great deal of guidance and assistance. She also helped provide a stimulating atmosphere for work through her leadership in the Human Capital Workshop. To her I am deeply grateful. Professors W. Keith Bryant and John Hause, the other members of my committee, also made important contributions to the project at all stages of development.

Professors Uri Ben-Zion, Christopher Sims, Steven Hoenack, Norman Simler, Peter Clark, and Gary Alkire also provided assistance and made useful suggestions at some time during study. Gerald Setter and John Sanders helped by serving as sounding boards for my ideas. Mark Smaby provided access to the Multiple Listing Service Data without which the study would not have been possible, and David Groaner assisted in obtaining the MSAT scores.

The Rural Development Service, U.S. Department of Agriculture provided the financial support for this project. Thomas Hady and Melvin Janssen provided assistance in the early stages and a large amount of moral support which I appreciated a great deal.

Finally, I would like to thank my wife Susie for all the little things that she did to make life easier for me. Her understanding and assistance made the completion of the research much easier.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Expenditures for elementary and secondary education comprise a large and important part of each consumer's budget. In 1970 state and local governments spent over one-third of their budgets or more than forty-five billion dollars for this service. But, even though the consumer spends more for education than for most food products or consumer durables, little is known about the demand for this service. Only recently have studies dealing specifically with the demand for elementary and secondary education been conducted.[1]

All empirical studies of the demand for public education face several difficult conceptual problems. First, the unit of educational output must be defined. Somehow, one must take account of both the number of units of education produced and the quality of the product and combine them into an output measure. No satisfactory way of indexing these two components has yet been devised. This problem is more serious for production and cost studies than for demand studies, however, since the number of physical units of education purchased by each consumer can be

---

[1] An extensive literature does exist on the determinants of educational expenditures by communities. However, as McMahon and others observe, most of this literature has little basis in economic theory. See Walter McMahon, "An Economic Analysis of Major Determinants of Expenditure for Education", Review of Economics and Statistics (August, 1970), pp. 242-257.

realistically considered predetermined. Under this assumption the consumer decides only the quality of education to be purchased given the number of children in the family.

Defining educational quality is not a simple task, however, and the education profession has been unable to reach general agreement on a way of measuring the quality of the local schools. Further, those measures of quality used are so diverse that they provide little guidance on what an acceptable definition of educational quality may be. Usually the researcher must make an a priori judgment and choose a measure of quality, then proceed.

Research has also been hampered because the price schedule for educational quality is not known. Neither the price of an additional unit of quality nor the total expenditure by the consumer for education of any given quality can be directly observed. To overcome this, assumptions have usually been made that the price of education is equal to one's school tax levy, or to the per capita expenditure of the school district, even though no mechanism exists which insures that either equality holds. The price issue is further complicated by the requirement that those attending a school reside within its attendance district. This restriction forces the consumer to pay an extremely high price for an additional increment of quality since he must either relocate or send his children to private school.

This study concentrates on the problem of estimating a price schedule for public education. It begins by rejecting

the traditional assumption that the price paid for public education is equal to the school tax levy, and utilizes a more complex model based on the work of Lancaster[2] and Tiebout.[3] Here the purchase of a residence is viewed as the purchase of a joint product composed of a number of housing attributes and an educational quality attribute. Then, since a metropolitan area provides a large number of different combinations of housing and educational quality, the consumer is assumed to maximize his utility by selecting the location and structure which provides him with that bundle of attributes for which the rates of commodity substitution equal the ratios of their implicit prices. In this model the implicit price of educational quality is independent of both the school district's expenditures and the individual's tax levy. It depends solely on the marginal consumer's valuation of the quality of education provided in the district.

The study is divided into three major sections. Following this introduction, a more detailed description of the theoretical model is provided. In that section a model is developed which provides a framework for estimating an implicit price schedule for educational quality. In addition, the model is used to formulate several empirically testable hypotheses about the effects of particular socio-economic variables on the demand for education.

---

[2]Kelvin Lancaster, "A New Approach to Consumer Theory", Journal of Political Economy (April, 1966), pp. 132-57.

[3]Charles Tiebout, "A Pure Theory of Local Expenditures", Journal of Political Economy (October, 1956), pp. 416-24.

The second major section is devoted entirely to the problem of estimating the implicit price schedule for education. The estimates are obtained through the use of the hedonic technique originally popularized by Griliches for use in estimating the effects of quality changes over time on prices of goods.[4] As a by product, this section produces estimates of implicit prices for twenty-three housing attributes, allowing some comparisons to be made with the results of other studies of housing prices.

In the third section, as an example of one of the uses of the implicit price schedule, the income elasticity of demand for educational quality is estimated. In addition, the hypotheses formulated in Chapter II about the effect of number of children per family, percent of the population without children, and the percent of the population attending private school on expenditures for public education are tested.

---

[4]Zvi Griliches, "Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change", in The Price Statistics of the Federal Government (National Bureau of Economic Research, General Series, No. 73, 1961.

CHAPTER II

THE THEORETICAL MODEL

This chapter provides a theoretical framework for the empirical work on the price schedule for educational quality which follows. Here, education is considered to be a stock measured at the end of one's high school years. Each individual begins school with none of this stock, and it is assumed that only the schools produce education. The stock of education available from any school district is determined exogenously, and is in perfectly inelastic supply. However, because a large number of districts exist, each producing education of a different quality, the consumer can exercise a choice over the size of the stock of education purchased.

Education and housing attributes are first assumed to be normal goods which can be purchased separately at known prices. Additional assumptions, relaxed later, are that each family has only one child, that this child must attend the public schools, that each housing attribute has a known price and may be purchased separately, and that attributes may be combined at no cost. In addition, it is assumed that each individual's school property tax levy is exactly equal to the value he places on the quality of education provided by the district.

Later, many of these assumptions are relaxed, and the final form of the model allows the joint purchase of education and

housing attributes when only the price of the package of goods is known, and when property tax levies are not equal to the value of education received.

The Basic Model

Consider a world without transportation costs in which a consumer can select a set of housing attributes and have them placed on his desired location. He then can choose the school quality he desires for his child given the existing price schedule. The consumer is able to purchase this quality of education regardless of the school district in which his bundle of attributes is located.

The consumer is assumed to have a utility function of the general form

$$U = U(X, H_1, \ldots, H_n, E)$$

where X is the stock of other goods to be purchased over the period; H_i, i = 1, ..., n, is the stock of housing attribute i, and E is the quality of the stock of education that a child receives over his elementary and secondary school years.

The consumer is assumed to maximize utility subject to the budget constraint

$$Y = P_x X + \sum_{i=1}^{n} P_{H_i} H_i + P_e(E)$$

where Y is the present value of income over the next T years, exogenously determined, P_x is the price per unit of X, P_{H_i} the price per unit of H_i, and $P_e(E)$, the cost of a stock of education of quality E. It should be noted that this formulation puts

no restrictions on the form of the price-quality relationship between E and P_e. P_e may be thought of as a constant price or as a rate schedule similar to that used for natural gas or electricity.

Constrained maximization produces the following first order conditions

$$\delta U/\delta X = \lambda P_x$$

$$\delta U/\delta H_i = \lambda P_{H_i}$$

$$\delta U/\delta E = \lambda P_e(E)'$$

where $P_e(E)'$ is interpreted to be the marginal price of E. These conditions produce the standard result where each family consumes, X, H_i, and E to the point where the rates of commodity substitution between each pair of goods is equal to the respective price ratios.

The assumptions used make the problem trivial however. If the analysis is to be of any use in examining problems of public school finance, several of the more unrealistic assumptions must be modified. Specifically, the assumptions that education and housing can be purchased separately, that the school property tax is equal to the value of education received, and that all families have one child who must attend the public schools need modification to reflect more adequately the complexity of the consumer decision.

The assumptions that housing attributes can be purchased separately and later combined in an optimum location can be easily dropped. Although the metropolitan housing market offers a large number of choices, one must purchase a package of housing

and locational attributes; they cannot be purchased independently. For the purpose of this study this package of attributes will be termed a residence and, for the present, the general relation between it and its components will be said to be of the form

$$R = R(H_1, H_2, \ldots, H_n)$$

The purchase price of the residence, RP_r, is determined in the same way as that of any long lived asset

$$RP_R = \sum_{i=1}^{n} \sum_{t=1}^{T} BH_{it}/(1+r)^t$$

where BH_{it} is the total dollar benefit derived from housing attribute i in year t, r is the appropriate discount rate, and T the number of years one expects to use the package of housing attributes.[1] Since an education tax based on the value of education to the consumer is still assumed to exist, the quality of education does not enter the computation of the price of the residence at this time.[2]

Dropping the assumptions allowing the purchase of housing attributes separately has only a minor effect on the constrained maximization problem. The utility function for the consumer remains the same, all that changes is the budget constraint

---

[1] This assumes no increase in the value placed on any attribute over time, and that the individual derives no utility from leaving a bequest to his heirs. If the salvage value has any meaning to the consumer, the price he is willing to pay is $RP_R = \sum_i \sum_t BH_{it}/(1+r) + S_T/(1+r)^T$, where S_T is the salvage value at time T.

[2] Pashigian uses this framework with the assumption that the value of education is equal to the price paid in taxes only in the least efficient sized school district. He then attempts to determine the optimum size school district by determining the size of the district which has the most capitalized value of education included in the property value. See B. Peter Pashigian, "The Effect of Public Expenditures on Housing Values", unpublished paper given at the Econometric Society Meetings, New Orleans, La. (Dec., 1971).

where $P_R R$ replaces $\sum_{i=1}^{n} P_{H_i} H_i$. Now the budget constraint is

$$Y = P_x X + P_R R(H_1, H_2, \ldots, H_n) + P(E)$$

The first order conditions, although changing slightly in appearance still yield the same results. The difference is, assuming no jointness in the technical supply of characteristics, that $P_R(\frac{\delta R}{\delta H_i})$ now must be recognized as the marginal price of H_i.

The assumption that one can send his child to any school regardless of whether or not he resides in that school district must also be relaxed in order to conform with reality. Strong institutional and legal constraints exist to prevent children from attending schools outside their attendance district, and although these constraints are beginning to ease in some larger school districts with "freedom of choice" programs for high school attendance, cross district transfers between school districts are still virtually unheard of. Although private schools are possible alternatives, at present they are considered to be outside the analysis.

The need for free choice among school districts can be eliminated by allowing individuals to reveal their preferences for educational quality through their location decisions. Now, instead of purchasing education directly in the market and then locating in any site desired, the consumer must purchase a location as well as a set of housing attributes. Among the set of attributes purchased at the location is a certain quality of education for which the consumer must pay taxes equal to the value received from education.

The market situation can be thought of in terms of the familiar two-dimensional indifference curve diagram with the quality of education on one axis and a composite commodity on the other. The set of points available to the consumer are those with coordinates equal to the quality of education available in the set of school districts on one axis, and to the quantity of the composite commodity purchased with income minus school taxes on the other. If only one school district exists, the opportunity set is a single point. If a large number of choices of educational quality are available, as there are in a metropolitan area, an individual can maximize his utility by picking that combination of education and other goods for which the rate of commodity substitution is equal to the price ratio. The results are identical to those obtained in the traditional market analysis. In this model, however, the consumer reveals his preference for educational quality by moving to the area which provides him with the combination of education and housing which maximizes his utility instead of purchasing that combination in the market. This is essentially the mechanism that Tiebout proposed for the rational allocation of locally provided public goods.

In Tiebout's words

> The consumer may be viewed as picking that community which best satisfies his preference pattern for public goods ... at the local level governments have their revenue and expenditure patterns more or less set. Given these patterns the consumer moves to the community whose government best satisfies his particular set of preferences ... moving or failing to move replaces the usual market test of willingness to buy a good and reveals the consumer-voter's demand for public goods.[3]

---

[3]Tiebout, op. cit., p. 418.

Tiebout lists seven assumptions as necessary for his model to hold over time. For the purpose of this paper only four are necessary. Of the other three, one is readily incorporated into the first assumption, and the other two are necessary only to yield a determinate number of communities producing government services. The required assumptions are, first, consumers must be fully mobile. Restrictions due to employment are not considered to exist, nor are restrictions such as discrimination. Second, consumers must have full knowledge of differences in revenue and expenditures among communities. Third, a large number of communities must exist, providing the consumer with many choices of revenue and expenditure combinations. Finally, no external economies can exist among communities.

The elimination of a formal market for education and its replacement with a location choice model has no effect on the utility function or the budget constraint. All that has been done is to change the way education is purchased and how one's demand for it is revealed.

To this point the property tax levy has been assumed equal to the value one receives from education. This assumption is also unrealistic. Indeed, it is likely that school property tax levies are not equal in communities providing equal educational quality since differences in non-residential property values, intergovernmental transfers, and economies of scale should produce different school tax levies in communities.[4]

---

[4]Also, since the property tax is (at least in principle) based on the value of one's real property, financing the schools through the property tax requires that the income elasticities of demand for education and housing be identical if the tax paid is to equal the amount consumers are willing to pay at all income levels.

Returning to the indifference curve example, the opportunity set now includes two points providing the same amount of educational quality, but with different amounts of the composite good. The combination with the greater amount of the composite good would, of course, clearly dominate and would be preferred by all consumers. Given a scarcity of similar opportunities the value of the educational quality provided would be capitalized into property values in the district providing the dominant combination.

More formally this can be expressed by including the capitalized net benefit from local education in the purchase price of the residence. Now

$$R = R(H_1, H_2, \ldots, H_n, E)$$

and

$$P_R R = \sum_{t=1}^{T} \sum_{i=1}^{n} (BH_{it} - BE_t - Tax_t)/(1+r)^t$$

where BE_t is the dollar value of benefits of education at that particular location in year t, and Tax_t is the school tax levy in year t.

As an example, imagine two identical houses in the same school system where due to the vagaries of local assessment practices, the owner of one residence must pay an additional $100 per year in school taxes. A rational consumer would be willing to pay up to $\sum_{t=1}^{T} \$100/(1+r)^t$ more for the residence with the lower tax levy since at any price less than that the total cost of living in that structure will be less than that for living in the one with the higher tax levy.

It should be noted that property taxes have not been eliminated by allowing the purchase price of the residence to reflect the capitalized value of the education attribute. All that has been done is to remove the restriction that property tax levies must equal the value of the educational quality provided by the district.

The budget constraint now becomes

$$Y = P_X X + P_R R(H_1, H_2, \ldots, H_n, E) + \sum_{t=1}^{T} Tax_t/(1+r)^t$$

or, if property taxes are assumed to have some relation to property values, the budget constraint can be rewritten as

$$Y = P_X X + P_R R(H_1, H_2, \ldots, H_n, E)(1+m)$$

where

$$m = \frac{\sum_{t=1}^{T} Tax_t/(1+r)^t}{P_R R}$$

In this formulation $(1+m)P_R R$ is the cost of living in a residence for T years.

One final modification which can be made which sacrifices nothing in completeness but reduces confusion in notation is to choose units of R such that P_R is equal to one, and drops out of the budget constraint.

Summarizing, the more complete model is now

(1) $L = U(X, H_1, \ldots, H_n, E) - \lambda(Y - P_X X - (1+m)R(H_1, \ldots, H_n, E))$

with first order conditions

$$\delta U/\delta X = \lambda P_x$$

$$\delta U/\delta H_i = \lambda(1+m)\ \delta R/\delta H_i \qquad i = 1, \ldots n$$

$$\delta U/\delta E = \lambda(1+m)\ \delta R/\delta E$$

Again the first order conditions yield the expected results that an individual consumes each attribute until the rates of commodity substitution between pairs of attributes are equal to the ratios of their marginal prices. It is important to note, however, that these results hold for the H_i's and E, items which do not have any actual purchase price attached to them and which cannot be purchased separately in the market.

Allowing Families with More than One Child

If the assumption that all families have equal numbers of children is dropped, the effect of the number of children per family on the demand for educational quality cannot be determined analytically. The ambiguity arises from two sources. First, no generally accepted way exists to incorporate the effect of different numbers of children per family on the utility derived from educational quality. Simple models can be developed which support either a positive or a negative relationship between the quality demanded and family size, and there is little basis for choosing between them.[5]

---

[5]A simple model which yields a positive relationship can be obtained by replacing the argument E in the general model, equation (1) above, with ME where M is the number of children in the family. Under this formulation the price of education of any given quality for a family with M children is 1/Mth the price of the same quality of education for a family with one child. Consequently one would expect to observe, ceteris paribus, larger families in those districts which provide higher quality education. A slightly more complex model is suggested by Gary Becker. In this model it is assumed that parents receive utility from their children depending on their cost, indicating that a tradeoff exists between spending less per child on a greater number of children, or more on fewer. To the extent that this model holds, demand for educational quality may be negatively affected by the number of children

The more complex models used in the economic analysis of fertility offer little help in this area. Although they do provide an acceptable way of entering educational quality into the utility function through the use of the household produced good "child services", a function of the number and quality of the children the household produces, these models have not yet been refined to the point where they take account of the second problem, the unusual price structure which exists for public education. This situation, in which each family pays the same amount regardless of the number of children in the family attending school must be incorporated into a model for it to be acceptable.[6]

Although no theoretically predictable results can be obtained for the effect of a change in family size on demand, it appears that this variable should be included as a state variable in the demand function in order to allow for the effect that different family sizes may have on demand for educational quality.

Allowing Some Consumers to Have no Demand for Education

The assumption that all consumers have a demand for public education can also be removed. There are several groups of

---

in the family. See Gary S. Becker, "An Economic Analysis of Fertility", in Demographic and Economic Change in Developed Countries (Universities-National Bureau Conference Series 11, Princeton University Press, Princeton, N.J.), pp. 209-40.

[6]Examples of these models can be found in Dennis N. DeTray, "Child Quality and Demand for Children", Journal of Political Economy, Suppl. (March/April, 1973), pp. S70-96, and Robert J. Willis, "A New Approach to the Economic Theory of Fertility", Journal of Political Economy, Suppl. (March/April, 1973), pp. S25-30.

residents--those without children, those whose children have completed school, and those whose children attend private school--who can be supposed to receive no utility from the public schools. These people can be thought of as performing the following constrained utility maximization

$$L^* = U^*(X, H_1, \ldots, H_n) - \lambda(Y - P_X X - (1+m)R(H_1, \ldots, H_n, E))$$

obtaining the first order conditions

$$\delta U^*/\delta X = \lambda P_x$$

$$\delta U^*/\delta H_i = \lambda(1+m)\ \delta R/\delta H_i$$

$$\delta U^*/\delta E = 0$$

$$\lambda(1+m)\ \delta R/\delta E = 0$$

The first order conditions indicate that those with this utility function will maximize utility by locating where the price paid for education is zero. If there is no place where the price of education is zero, the consumer's preferred point will be that where the price of education is the lowest. This implies that one should observe a negative relationship between the percent of families without children and the quality of education, and a negative relationship between the percent of children attending private schools and the quality of education provided in a district. Both these relationships are empirically testable.

An important part of the ceteris paribus assumptions necessary for these assertions is costless transfer from one location to another. This assumption is violated, however, in terms of both the money costs of changing residences--the

physical cost of transporting one's goods, the broker's fees, title search and other closing costs, and the costs of redecorating the new home--and the psychic costs of leaving a neighborhood with which one is familiar. Depending on the time span involved and the difference in costs between the two locations, it may be rational for an individual to remain living in a high quality, and therefore higher cost school district after one's children are through school.

Similar arguments can be made for couples without children who are planning to have children in the future. Again depending on the cost differential, it may be most efficient to make only one move. This qualification does not seem to apply to parents of children attending private schools. For these families it would seem that their optimal strategy would be to always reside in areas with lower quality public education.

Policy Implications

The model, while not primarily designed for policy analysis, does provide insight into the economic effects of several of the changes in the public education system under current consideration. Two of these proposed changes, the elimination of differences in local school quality and the replacement of the property tax as the prime source of local revenue for the public schools, are particularly amenable to analysis within the framework of the model.

The Effects of Equalizing Educational Quality

Recently the courts have ruled that when large differences exist in the quality of education provided by the public schools, students who must attend a lower quality school are, through no fault of their own, being deprived of equal protection under the law in violation of the United States Constitution and many state constitutions. This argument served as the basis for the decisions ordering desegregation, the institution of busing, and the installation of pairing programs. More recently the same argument has been used to force changes in the way schools are financed in some states.

The injustices these suits sought to correct are real and need correction. However, the equalization of educational quality produces a cost to property owners in higher quality school districts that is generally overlooked. Even if the quality of education in the poorer area is raised to equal that of the higher quality district without increasing taxes in the higher quality district (a very big assumption), property owners in the higher quality district incur a capital loss. If taxes increase or the quality of education decreases the loss, of course, is even greater.

That this capital loss occurs can be demonstrated as follows. Assume that a large number of school districts exist, each providing a different quality of education and that consumers have allocated themselves among the districts so that the entire region is in equilibrium. That is, so that all those who

desire to live in a district which provides a certain quality of education and who can pay the price associated with it live in that district. As indicated above, the price of a residence in District I will reflect the marginal consumer's valuation of education of quality Q_I. Similarly, in District II residential prices reflect the valuation of education of quality Q_{II} by the marginal consumer in that district. If the educational quality in District II is raised to equal that of District I, any reason for paying a premium for the education provided by District I over that provided by District II disappears and the price of education in the two districts becomes the same.

The new equilibrium price is not that which existed in District I prior to equalization, however. The new price is the value that the marginal consumer in the combined district places on education of quality Q_I. Since the assumption of equilibrium requires that all who were willing to pay the previously existing price for education of quality Q_I live in districts providing education of at least that quality, the residents of District II must place a lower value on education of that quality than the marginal consumer residing in District I. The capital loss incurred by those residing in District I is then equal to the difference in the valuation of quality of education Q_I between the marginal consumer in District I and District II.

This result depends only on the assumption of equilibrium in the market for education. It is independent of any possible increases in taxes or decreases in quality. Only if the quality of education increases in both districts, or taxes in District I

decrease due to economies of scale, or if discrimination occurred in the market for education so that all those desiring to purchase higher quality education could not be accommodated in District I, will those who own property in District I not suffer a capital loss when the quality of education is equalized.

The Effects of Financing Schools from Non-Property Tax Revenues

Currently public schools in Minnesota derive more than half their revenue from the local property tax. As the financial requirements of the schools have increased, the accompanying increased burden on taxpayers of modest means has produced demands for a shift away from the local property tax as a source of revenue for the schools. The impact this shift has on local property values can also be determined using this model.

When a choice of educational quality is available, all who reside in a district pay a price equal to the value that the marginal consumer in the district places on that quality of service. As indicated above, this price is the sum of the present value of the school property tax due over time and the capitalized value of the education included in the selling price of the residence.

With constant prices any unanticipated change in the property tax levy has a direct effect on the property owner's wealth. Programs which shift the cost of financing the school system to non-property sources, thus reducing the individual's property tax levy provide a capital gain to the property owner, given that the marginal consumer's valuation of educational quality remains constant. Similarly, programs yielding increases

in the local tax bill with no compensating increase in the quality of education produced reduce the value of the school district capitalized into the property value and leave the owner with a capital loss.

In this framework it is clear that programs which shift the financing of education--or for that matter any other publicly provided service which is site specific--away from the property tax and on to more broadly based taxes such as the sales tax or a national value added tax, will result in a transfer of wealth to current property owners.

Conclusion

In this chapter a model providing a theoretical base for estimating the amount a consumer pays for education of any given quality has been developed. The model depends on the standard utility maximizing assumptions, and an additional assumption that the consumer reveals his preferences for public services through his choice of residential location. The price schedule for quality of education depends solely on the value the marginal consumer places on the quality of education provided and is independent of the amount of property tax levied in the district, or the taxes on individual residences.

The model also provides some insights into the economic effects of programs which attempt to equalize quality between districts and, on the effects of financing the schools through non-property tax revenues on the distribution of wealth. In both instances certain classes of property owners can be expected

to receive capital gains. The importance of these analytical results, however, depends largely on the differences in cost between districts with different qualities of education, a matter for empirical determination. The next chapter describes the results of an attempt to measure the implicit price schedule for education.

CHAPTER III

AN IMPLICIT PRICE SCHEDULE FOR EDUCATION

In this chapter the hedonic technique is used to obtain an implicit price schedule for elementary and secondary education. The chapter opens with a discussion of the hedonic technique and its use in estimating the implicit prices of attributes of goods. A review of earlier studies attempting to estimate prices for housing attributes is followed by sections describing the data and the form assumed for the independent variables in the regression. The chapter concludes with a discussion of the implicit price schedules obtained for educational quality and their implications. Although implicit prices for housing attributes are also obtained from the regression, these estimates are presented with little comment since they are outside the main focus of the study.

The Hedonic Technique

Hedonic price estimation techniques developed from a concern that price indexes were overestimating price increases because they failed to adjust properly for quality changes in the product. Griliches,[1] borrowing from the work of Court[2] and

[1] Griliches, op.cit.

[2] A. T. Court, "Hedonic Price Indexes with Automotive Examples", in The Dynamics of Automobile Demand (General Motors Corp., New York: 1939).

Stone,[3] made an early attempt to overcome this problem by attempting to disaggregate the services provided by automobiles into attributes or single characteristics of the vehicle. He then showed that since increased quantitites of the attributes, i.e. horsepower, weight, and length were associated with an increased total price but not necessarily increased prices per unit of attribute, the price index overstated the actual price increase. Later, Adelman and Griliches[4] provided a more formal basis for the technique giving it a firmer tie to micro-economic theory.

Although the hedonic approach has been used most often to estimate price increases attributable to changes in quality, it can also be used to estimate implicit prices for attributes of goods. Indeed, one author has noted,

> In some quarters the essential part of the hedonic technique has erroneously been identified as the estimation of quality adjusted price indexes directly from the regression. The essence of the hedonic technique is the disaggregation of products into characteristics and the estimation of implicit prices for units of the characteristics. The implicit prices are then available for adjusting market prices ... for the value of quality differences.[5]

Or, it might be added, for any other purpose which the researcher desires. In this study the implicit price schedule for different

---

[3]Richard Stone, Quantity and Price Indexes in National Accounts (Organization for European Economic Cooperation, Paris: 1956).

[4]Irma Adelman and Zvi Griliches, "On An Index of Quality Change", Journal of the American Statistical Association (Sept., 1961), pp. 535-548.

[5]Jack E. Triplett, The Theory of Hedonic Quality Measurement and its Use in Price Indexes, BLS Staff Paper 6 (U.S. Government Printing Office, Washington: 1971).

qualities of education is what is desired. No attempt is made to examine the change in price over time for either education or housing attributes. Questions such as the relative proportion of the increase in educational costs attributable to increases in quality and pure price increases are considered to be outside the analysis.

The key to understanding the hedonic technique is to shift one's thinking from the composite good to its characteristics or attributes. That is, to replace the good e.g., residence, in one's utility function with arguments reflecting its measurable attributes, e.g., number of bathrooms and bedrooms. This substitution appears justifiable for several reasons. First, it is likely that only a small amount of utility is derived from actually owning a home. Instead, utility is derived from the stream of services the attributes of the home provide. Without the attributes in the utility function there is no way that differences in these services can be accounted for.

More important, however, if residences remain in the utility function and attributes are excluded, the consumer choice problem has no satisfactory solution. Either all residences are considered identical, and the rational consumer chooses the one which is least expensive, or all are considered to be entirely different goods, and there is no way to compare between them. In either case it is extremely difficult to hypothesize a model which will produce a utility maximizing solution consistent with observed behavior.

With attributes as arguments in the utility function the situation is different. Now the individual is faced with the problem of selecting among a large number of options of the composite goods, R_1, R_2 ..., R_m, each providing a different mix of attributes H_1, H_2, ..., H_n, E, and selling at prices PR_1, PR_2, ..., PR_m. Assuming non-satiation, a consumer will prefer R_1 to R_2 if R_1 provides a greater quantity of at least one of the attributes than does R_2. Similarly, it must be true that if R_1 costs more than R_2 consumers will never purchase R_1 unless it represents a more desirable bundle of attributes than R_2, including more of at least one attribute. So, in general, price differentials between goods must be related to difference in the quantity of the attributes contained in the goods. And, choices of multi-attribute goods such as residences can be thought of as the result of a utility-maximizing process applied to their attributes consistent with that applied to single attribute goods.

Approaching the same question in a slightly different manner, assume that R_1 and R_2 contain identical amounts of H_1, H_2, ..., H_n and that R_1 contains one more unit of E than does R_2. If the additional unit of education provides the purchaser with any increase in utility, he can determine the maximum price differential he would be willing to pay. In equilibrium, with many consumers bidding, the price differential between R_1 and R_2 will reflect the valuation of that increment of education by the marginal purchaser. This marginal price per unit of attribute is precisely what is obtained when the

attributes are regressed on the cost of living in the residence, and it is this schedule of implicit prices that is desired for elementary and secondary education.

Literature Review

Estimates of the value of travel time have been the most frequent objective of studies of the implicit prices of housing attributes. The early location models which explained observed rent differentials as the result of travel cost minimization by consumers provided the theoretical model upon which these estimates were based. In their simplest form these studies argue that if two pieces of property have identical sets of characteristics except that one is closer to the source of all employment then no consumer will purchase the more distant property unless its price is less than the other by the present value of the differences in the stream of commuting costs. These studies then attempt through stratification or multiple regression analysis to hold all other characteristics of property constant and to isolate that portion of the rent due solely to differences in travel cost.

Mohring,[6] Brigham,[7] and Maslove[8] all have estimated travel

---

[6]Herbert W. Mohring, "Land Values and the Measurement of Highway Benefits", Journal of Political Economy (June, 1961), pp. 236-49.

[7]E. F. Brigham, "The Determinants of Residential Land Values", Land Economics (Aug., 1965), pp. 325-334.

[8]Alan Maslove, "Travel Rent Gradients and the Cost of Travel Time in a Multi-Nodal City", unpublished Ph.D. Dissertation, University of Minnesota, 1972.

costs in this manner.[9] Studies of this type have all met with some degree of success, and the accessibility of property to the sources of employment is generally accepted as having a significant impact on its rental value.

A relatively large portion of the price differential remains unexplained even after adjusting for the physical characteristics of the residence and its proximity to the central business district, however. This residual has usually been attributed to the amenities associated with the property. If a rather broad definition of amenities is used, one which includes both positive and negative influences on value, a number of studies can be considered to be attempts to determine the implicit prices of these residential attributes.

Harris, Tolley, and Harrel[10] attempted to estimate the amenity value associated with vacant land by subtracting the land's value at its least intensive use and the transportation savings associated with the location from its market value. The transportation savings were obtained through an extensive survey of travel patterns of residents in the vicinity of the vacant land parcels. Although an estimate of the value of amenities in that area was obtained through this method no implicit prices

---

[9]Maslove's work is of special interest since the data source for the housing attributes was the same as that used for this study. Direct comparisons of results are not possible, however, because Maslove concentrates on the City of Minneapolis, while this study examines suburban housing, and because of differences in the basic regression forms used.

[10]R.N.S. Harris, G.S. Tolley and C. Harrel, "The Residence Site Choice", Review of Economics and Statistics (May, 1968), pp. 241-247.

could be estimated for any specific amenity such as education.

Most other studies have used multiple regression techniques to hold other attributes constant while trying to determine the impact of one particular amenity on the price of the property. Usually they have examined the effect of an attribute which might be expected to make the location less desirable such as noise[11] or air pollution,[12, 13] or the integration of the neighborhood.[14] In general, these studies have been successful in attributing some of the variation in housing prices to the existence of the particular attribute under study.[15]

Perhaps the most important of the studies of amenities was that done by Ridker and Henning on the effects of air pollution on housing values in the St. Louis metropolitan region. While the results of this study were no great surprise (they found that an increase in the level of sulfation tended to decrease the property values), the criticism it has provoked has served

---

[11] Frank C. Emerson, "The Determinants of Residential Value with Special Reference to the Effects of Aircraft Nuisance and other Environmental Features", unpublished Ph.D. Dissertation, University of Minnesota, 1969.

[12] Ronald Ridker and John Henning, "The Determinants of Residential Property Values with Special Reference to Air Pollution", Review of Economics and Statistics (May, 1967), pp. 246-57.

[13] Thomas Crocker and Robert Anderson, "Air Pollution and Residential Property Values", Urban Studies (Oct., 1971), pp. 171-80.

[14] Martin J. Bailey, "The Effects of Race and Other Demographic Factors on the Values of Single Family Homes", Land Economics (May, 1966), pp. 215-220.

[15] Bailey's study of the effects of integration on housing values is a notable exception. He found no change in the property values in the immediate area due to integration when other factors such as overcrowding were held constant, a finding in conflict with popularly held beliefs.

to clarify several of the key problems with studies of this type. Two types of criticism have emerged. Anderson and Crocker assert that some variables are included for the wrong reason in the study. They argue that because census tract averages rather than individual sales data are used to provide estimates of housing values, the market has been divided into submarkets and that the tastes and incomes of the consumers can no longer be considered constant over the entire metropolitan area. Consequently, the influence of consumer characteristics must be taken into account in the hedonic regression, producing an identification problem in interpreting the meaning of the coefficients on variables such as income which Ridker and Henning had used as a proxy for neighborhood quality.

A second criticism, with direct relevance to the interpretation of results from this study is that of Freeman.[16] He notes that the extension of Ridker and Henning's results to estimate the net increase in property value for the region if air pollution were reduced to the background level is improper. He observes that the estimates obtained are valid only for a single residence given a pattern of sulfation and population distribution, and that any reduction in overall sulfation levels will produce a new equilibrium population distribution with an accompanying new set of prices for different levels of air pollution.

This point applies equally well to any implicit price schedule obtained for educational quality. Such a schedule will

---

[16] A. Myrick Freeman, "Air Pollution and Property Values: A Methodological Comment", Review of Economics and Statistics (Nov., 1971), pp. 415-16.

shift if the quality of education in any district changes or if new distributions of population occur. Given that the price schedule is the result of a single equilibrium it is then improper to conclude, for example, that if the quality of education in each district were to increase to the maximum observed in the region, the value of each residence would increase by an amount equal to the difference in prices estimated between that district and the highest quality district. Since the implicit price estimated is the price the marginal consumer is willing to pay for a given quality of education, property values would increase by less than that amount.

Most studies attempting to estimate implicit prices for residential attributes have ignored differences in property tax levies. While this may not be a major concern for studies where aggregate data are used, a study making use of individual observations of sales cannot assume that differences in tax levies between residences balance out over the entire sample. Instead, it seems more likely that property tax differentials may be capitalized into the value of the residence in the same manner as commuting cost differentials. Consequently, for this study the total cost of the residence is defined as the selling price plus the present value of the stream of expected tax payments associated with that particular residence.

Including tax costs in the total cost of the residence is especially important when estimates of implicit prices of public services are desired. Without the tax costs the implicit price will certainly be lower since it will not reflect the full cost

to the consumer. Further, it may not even be possible to obtain implicit price estimates since expensive housing with high tax levies and negative capitalization may cancel the impact of residences with low tax levies and positive capitalization of public service levels, in effect leaving an estimate of zero for the value of the service.

There have been few attempts to include school quality in the list of amenities for which implicit prices have been estimated. Ridker and Henning divided the schools into three categories, good, average and poor. Using a set of dummy variables to represent these qualities they found no relation between housing price and school quality. Oates, however, in a study which attempted to test the validity of the Tiebout hypothesis in New York City suburbs did find a significant relationship between per pupil expenditure and average housing values, after adjusting for such items as size and quality of house, socio-economic characteristics of the community, and distance from New York City.[17] Despite his use of an input variable as a proxy for the quality of education which makes for difficulty in interpreting results, and the possible bias to his results due to his attributing all local government service impact to the educational system, Oates' results indicated that a study along the lines of this one might be of value.

Finally, no review of the hedonic literature would be complete without mention of Brown's study of housing prices for

---

[17] Wallace E. Oates, "The Effects of Property Taxes and Local Public Spending on Property Values: An Empirical Study of Tax Capitalization and the Tiebout Hypothesis", Journal of Political Economy (Nov./Dec., 1969), pp. 957-71.

FHA insured homes.[18] This study is hedonic in the strict sense since its objective was the construction of a quality deflated price index for housing, not the estimation of implicit prices for particular attributes. The study does provide implicit prices for some housing attributes which can be used for comparison purposes, however.[19]

To summarize, there have been several studies estimating implicit prices for the attributes of residential housing. Most have concentrated on the value of travel time or on the savings of travel costs between locations. Much less effort has been devoted to estimating implicit prices for any amenity. Surprisingly, it appears that no one has made an attempt to estimate the effect of differences in the quality of education on housing values.

Data

Three general types of data were needed for this study: data on total residential cost, defined here to be the sum of the purchase price and the present value of the stream of expected tax levies; detailed data on housing attributes, and data on non-housing attributes, such as distance from the central business

---

[18] Samuel L. Brown, Price Variation in New FHA Housing, Staff Working Paper No. 6 (U.S. Government Printing Office, Washington: 1971).

[19] The regression form which Brown chose limits the comparisons since he used a series of dummy variables for the different characteristics. This resulted in the constant term in his equation being the average price in 1960 for a three bedroom, six room house with between 1,000 and 1,400 feet of living space.

district, the quality of the educational system, and the quality of non-educational amenities in the area.

Since all hedonic studies are open to the criticism that the implicit price estimated for any particular variable in some way reflects the price of other unspecified variables, a decision was made to obtain data on as large a number of residential attributes as possible.

The task of collecting the data on housing attributes and total residential cost was reduced considerably by the availability of Multiple Listing Service records of sales as a data source. For Minneapolis and its suburbs most homes are marketed through the Multiple Listing Service (MLS) handled by the Minneapolis Board of Realtors. MLS realtors account for a large majority of the sales of suburban real estate and the records of these sales provide a representative sample of sales for a single year. In addition, the type of information provided is such that reporting error is not likely to be great.[20]

The data obtained from the MLS records included the following variables: selling price, number of bedrooms, age of structure, first floor area, lot size, living room area, master bedroom area, number of bathrooms, garage size, number of floors, property taxes payable in 1970, and high school attendance district. Also noted were the existence or non-existence of the following items: dining room, basement, finished basement, attached garage,

---

[20] Many of the attributes noted reflect only the inclusion or exclusion of a feature of the house, and the possibility that any features would be inadvertently overlooked or included appears slight. Further, the tax levy listed for the property which might be a major source of reporting error is checked independently by the Board with the County Assessor before the listing is published.

fireplace, ceramic tile bath, wall to wall carpeting, central air conditioning, garbage disposal, dishwasher, range, refrigerator, and gas barbecue. Finally, the type of financing used, the date sold, and the address of the property were also noted.

Preliminary screening left 2338 usable observations located in twenty-six school districts and thirty-three high school attendance districts. Although observations were rejected most often because of missing data, some observations were eliminated for other purposes. Homes with lots larger than 50,000 square feet were rejected because the sale price might reflect the value of the lot for future subdivision. Lot sizes of "approximately a quarter acre" were rejected as imprecise. Some multi-level homes were omitted because the listing provided total floor area rather than first floor area.[21]

Since the tax levy desired was that which the new owner would pay, the levy net of the homestead exemption and special assessments was used. This figure was chosen because all special assessments are normally paid by the seller at the time of transfer, and because Minnesota's homestead exemption would apply for a resident owner. Observations with tax levies which could not be adjusted to that form were omitted.

Finally, lesser numbers of observations were not included because they had special features such as swimming pools, riding stables, or lakeshore frontage which would have a distinct effect on the market value of the property, but for which insufficient observations were available for analysis.

---

[21]Where it could be ascertained from the photograph provided of the residence that first floor area was one half the total floor area, the observations were corrected and included.

Data on non-housing attributes was not provided in the MLS records. The accessibility of the residence to employment was estimated by calculating the straight line distance from the center of Minneapolis to each residence using the addresses obtained from the MLS records. Non-educational amenities in the community were assumed to be reflected by several measures of local government expenditures. Per capita current expenditures on police, parks and recreation, and total per capita current expenditures for all local government services with the exception of sanitation and sewage were calculated for each of the municipalities in the suburban area and included in the regression.[22]

Finding an acceptable measure of educational quality was difficult. An ideal measure would be the effect that attending different schools has on an individual's lifetime utility. Since this would take into account differences in the quantity of goods consumed due to increased earnings as well as any changes in the utility function brought about by education, it would provide a measure of educational quality which would be acceptable to all. This definition is too abstract for use in empirical work, however, and unfortunately no general agreement exists on a more specific definition.

Most empirical studies have used either measures of inputs or measures of outputs as a substitute for a direct measure of

---

[22]Current expenditures on sanitation and sewerage were omitted because two municipalities appear to have shifted large amounts of capital expenditures on these functions into their current account producing per capita expenditures for these communities approximately five times greater than those of other communities.

educational quality. Those using inputs assume that while educational quality itself cannot be measured, the inputs into the educational process can, and that a direct relationship exists between the amount and quality of the inputs used and the quality of the output. Expenditures on education are the input measures used most often, although other measures such as differences in curriculum and differences in teacher training and experience have also been used.

Output measures, such as the results of standardized tests, high school dropout rates, or the percentage of graduating seniors going on to college, have been used less often to measure quality. While these measures are useful for comparing how well schools are meeting certain objectives, there may be no relation between the school's performance on a specific task and its overall quality. Further, comparisons of results between two non-homogeneous districts may reveal more about the characteristics of the groups sampled than about the quality of the schools they attend.

In this study neither a direct measure of output nor a measure of physical inputs is used to proxy educational quality. Instead, a measure of the quality of the student input based on student scores on the Minnesota Scholastic Aptitude Test (MSAT) has been chosen.[23] Although there is

---

[23]The MSAT is a standardized test given to all high school juniors to provide high school counselors and college admissions officers information about an individual student's probability of success in college. Although the test scores depend primarily on the individual's basic intelligence (the student input), the quality of instruction, breadth of curriculum,

evidence to suggest that student quality is one of the few inputs which make a difference in the production of educational quality (this was, for example, a finding of the Coleman Report)[24] the MSAT score was not chosen as a proxy for that reason. The district's score was selected as the best method of reflecting the type of information the public receives about the quality of a school system, information on student quality. Since information about the actual impact that schools have on students--such as differences in achievement test scores holding IQ constant--are usually not available, consumers must rely on other types of data to evaluate their schools. Information about the percentage of seniors who enter college, high school dropout rates, and honors won by students are often the only items available for consumers to use in comparing schools, even though these items probably reflect the quality of the student inputs rather than school quality. In this study consumers will be assumed to evaluate schools on the basis of the quality of their students, and the MSAT score will be used as a measure of the abilities of the

---

and general intellectual stimulation provided by the school undoubtedly have some effect on scores making them a partial measure of the quality of the school system. Also, it should be noted that there is some added significance to scoring above the fiftieth percentile on the MSAT since that score is used as a cutoff point for direct admission into the College of Liberal Arts of the University of Minnesota.

[24] James S. Coleman, et.al, Equality of Educational Opportunity (U.S. Government Printing Office, Washington: 1966).

student.[25]

Several measures of high school quality based on student MSAT scores were obtained.[26] However, because a direct relationship exists between admission to the University of Minnesota's College of Liberal Arts and scoring above the fiftieth percentile, that measure was chosen to approximate student quality. This measure should indicate the percentage of graduates who could expect a reasonable probability of success in a major college. It should also correlate highly with the actual percentage entering college. Since preparation for college is thought by most to be one of the primary tasks of the elementary and secondary schools, this provides additional justification for using this measure of the quality of the district.

Since all districts did not have similar frequency distributions of scores, a measure of the dispersion of the scores was calculated. If consumers are risk averse, then the district with the lower variance given the same percent scoring

---

[25]There is a possibility that the implicit price estimate will be biased since high socio-economic status may produce both high MSAT scores and a demand for higher quality housing. Although no direct measure of the quality of the residences is available, an attempt was made to reduce the omitted variable problem by including variables reflecting the quality of the residence in the hedonic regression. Attributes such as central air conditioning, ceramic tile bath, built-in dishwasher, and disposal all were assumed to reflect in part the quality of the structure.

[26]These were the median score, the percentage of students in the school scoring above the fiftieth percentile, the percentage scoring above the ninetieth percentile, and the percentage scoring below the tenth percentile. Simple correlations between all measures of student scores were on the order of .9, indicating that all the measures were close substitutes for each other.

above the fiftieth percentile might be considered to be of higher quality.[27] To take account of this possibility the range of scores associated with the middle fifty percent of the students was calculated and included as a separate variable in some of the regressions.

The Regression Equation

The form of the regression equation used to estimate the implicit prices of residential attributes is largely determined by the relationship assumed between the attributes, their prices, and the total price of the residence. In this study it was assumed that the total price of the residence was equal to the sum of the expenditures on the attributes. This assumption requires that the utility derived from any particular attribute be independent of the existence of all other attributes. Further, it was assumed that the price per unit was constant over the range of observations for all attributes except the quality of education. These assumptions are consistent with those made by Brown and Maslove, the other major studies using roughly comparable detail on housing attributes.

The assumptions of additivity indicated that a linear regression of housing attributes on total cost would perform best.

---

[27] An alternative explanation is that consumers might pay more for a school with a smaller range of scores in order to enroll their children in a more homogeneous student body. These individuals may feel that a school containing a more homogeneous group of students is more apt to provide courses and instruction more directly in line with their child's needs. There is also the possibility that the school environment provided by a more homogeneous student body might be more tranquil and provide a better learning environment, and that some may be willing to pay more to purchase this possibility.

Only four variables were not entered in a linear form, the age of the structure, the existence of a finished basement, the existence of an attached garage, and the educational quality variable. Although the regression could have been specified to include a larger number of interaction terms it was felt that the gain in precision from adopting that procedure would be small. Further, the utility derived from most housing characteristics does appear to be fairly independent of the existence of other attributes, at least within the range of observations.

If age had been included as a linear term it would have implied that for each year a structure ages the value of the structure decreases by a constant dollar amount, no matter what the initial value of the structure. Since it seemed illogical to expect a $20,000 home and a $60,000 home to depreciate the same dollar amount each year, a different method of accounting for depreciation was used. In this study age was entered as an interaction term with first floor area, resulting in a simple depreciation treatment for the value of the structure.[28]

Finished basement and attached garage were not entered as dummy variables to avoid the illogical situation of having an estimate of the value of a finished basement or an attached

---

[28] Let the value of the depreciable attributes be represented as equal to a certain price a times the floor area of the structure. $V = aSQFT$. Simple depreciation at rate r for t years reduces the value of the structure to $V^* = aSQFT(1-rt)$ or $V^* = aSQFT - artSQFT$. The second term corresponds to the interaction term between age and floor area discussed above. Its coefficient is equal to the value of an additional square foot of floor space times the simple depreciation rate r. For slightly different treatment of depreciation see Maslove, op. cit.

garage when no basement or garage existed. Instead these attributes were entered as interaction terms with basement and garage and their coefficients are interpreted as the value added to a residence by a finished basement or an attached garage, given that a basement or garage exists.

The other variables not included in linear form were the educational quality proxies. These variables, the percent of students scoring above the fiftieth percentile and the range of scores of the middle fifty percent of the students, were entered in several different forms in order to find the formulation which best represented the cost to the consumer of a certain quality of education. Linear, quadratic, and cubic forms for the education quality proxy all were tried in the regression equation, both with and without the measure of the range of scores.

At least twenty-six independent variables were used in each regression. Although this is a large number of variables for most problems, hedonic studies are often questioned on the ground that the price estimated is not a particular attribute's implicit price, but rather the price paid for several highly correlated attributes. By including all attributes in the regression which might possibly influence the price of the residence it was hoped that criticisms of this type could be minimized.

Consistent with the model in Chapter II each attribute's coefficient or implicit price was expected to be positive with the exception of those for the distance from the central

business district and the age-floor area interaction term. These were expected to have negative signs reflecting a decrease in the value of the residence with both increasing distance and age. In addition it was expected that the price schedule for education would have a diminishing marginal price, requiring a negative sign on the quadratic term or some combination of negative signs in the cubic equation.

Although the form in which the housing attributes enter the regression appears self-explanatory, two independent variables representing conditions of sale need additional clarification. The financing variable was an attempt to take account of the commonly believed tendency of the seller to pass any points he must pay on to the consumer. It enters in the form of a dummy variable with value equal to one when the home was financed by either FHA or VA guaranteed loans and zero for all other forms of financing. The coefficient for the variable then should reflect any difference in price associated with the use of this type of financing.

The second variable, date, was an attempt to account for any seasonal differences in prices due to the concentration of home buying in the spring and summer months. It was also entered in dummy variable form with the value equal to one if the house was sold between April 1 and September 30, and zero otherwise. The coefficient on this variable should reflect any premium paid for a residence purchased during the spring and summer months.

Results: Housing

The result of a typical regression when total residential cost is regressed on a group of housing and education attributes is given below, t values in parentheses.

$$\begin{aligned}\text{Total Res. Cost} = {} & -4195 + \underset{(.47)}{861}\ \text{Finance} + \underset{(1.76)}{295}\ \text{Date} \\ & + \underset{(6.26)}{1057}\ (\text{Br} - 3) + \underset{(22.37)}{12.48}\ \text{Sq. Ft.} - \underset{(-12.47)}{.144}\ \text{Age x Sq. Ft.} + \underset{(4.67)}{.66}\ \text{Lot Size} \\ & + \underset{(9.57)}{2519}\ (\text{Floor} - 1) - \underset{(-4.87)}{112}\ \text{Distance} + \underset{(2.86)}{.59}\ \text{LR Size} + \underset{(12.46)}{5.04}\ \text{MBr Size} \\ & + \underset{(3.65)}{731}\ \text{Dining Room} + \underset{(11.78)}{2021}\ (\text{Bath} - 1) + \underset{(7.71)}{3005}\ \text{Bsmnt} + \underset{(3.10)}{602}\ \text{Fin x Bsmnt} \\ & + \underset{(7.59)}{1053}\ \text{Garage} + \underset{(2.22)}{477}\ \text{Att x Garage} + \underset{(10.31)}{1389}\ \text{Fireplace} + \underset{(4.99)}{1125}\ \text{Ceramic Tile} \\ & + \underset{(2.87)}{686}\ \text{Carpet} + \underset{(9.11)}{3068}\ \text{Air Conditioner} + \underset{(6.14)}{1511}\ \text{Disposal} + \underset{(7.52)}{1982}\ \text{Dishwasher} \\ & + \underset{(1.10)}{209}\ \text{Kitchen Stove} + \underset{(2.65)}{30}\ \text{Gov't Exp.} + \underset{(3.60)}{158}\ \text{MSAT GT 50} - \underset{(-2.01)}{.85}\ (\text{MSAT GT 50})^2\end{aligned}$$

$n = 2338 \qquad r^2 = .855$

Twenty four of the twenty-seven variables used, including both terms in the educational proxy, were significantly different from zero at the .05 level using the standard two tailed test, and all signs were as expected. The housing attributes which did not have significant coefficients were the dummies reflecting the existence of a kitchen stove, the conditions of financing, and the date of sale. The latter two results providing some support for the supposition that sellers actually do pay the additional points required on FHA and VA mortgages and that there are no seasonal differences in prices.[29]

---

[29] The latter finding conflicts with the findings of Maslove, op. cit., p. 72, although it agrees with the impression of local realtors.

Little interpretation is required for most of the coefficients. They are simply the marginal price in dollars of an additional unit of a particular attribute. Since no formal market exists for such attributes as a dining room or an extra bedroom, market prices cannot be used to check the accuracy of many of the estimates. Results of other studies are available for some comparisons, however. Brown, for example, using 1959 and 1960 data on new FHA housing estimates that a full basement adds $2223 to the price of a home and that an extra bedroom adds $609.[30] While these estimates are below those obtained in this study, price increases during the past ten years, and the fact that the dependent variable in this study is the sum of the present value of expected property tax payments and the selling price help to reconcile the difference. Unfortunately, the more recent studies of Emerson and Maslove offer little additional evidence. Emerson does not include either basement or number of bedrooms as attributes in his regression. Maslove also excludes basements in his study, and his estimate for the additional value of an additional bedroom is only $23.78.[31]

Many of the attributes can be purchased on the open market, however. Appliances and items such as wall to wall carpeting, ceramic tile, central air conditioning, garages, and even fireplaces can be purchased separately and added to a home at any time. To determine the current price for these attributes

---

[30] Brown, op. cit., pp. 52-53.

[31] Maslove, op. cit., p. 72.

in the new housing market an informal survey was made of several local builders. This survey indicated that with the exception of the costs of the appliances and the ceramic tile bath (all of which were obviously high), and the cost for an additional bathroom which was approximately $500 more than the average price charged for an additional bathroom by the builders, the price estimates correspond closely to the prices charged for the item in new construction.[32]

Actual lot prices ranged from $.50 to $1.25 per square foot, a range which included the $.65 per square foot estimate obtained in the regression. The cost of a fireplace was said to be between $1300 and $1500, consistent with the estimate of $1389 obtained in this study. Estimates of the cost of wall to wall carpeting for the living room varied greatly depending on the quality of carpet used. However, when carpeting, pad, and installation are included, $686 is not an extraordinarily large amount to spend. Prices quoted for additional garage space also varied greatly. The largest garage contractor in the metropolitan area indicated his average prices were $1600

---

[32]For those items whose implicit prices exceed their market price--such as ceramic tile bathroom, built in dishwasher, and disposal--a logical interpretation appears to be that these items reflect other quality dimensions unmeasured in that particular room. No other attributes reflecting the quality of bathroom, for example, are included in the regression, so if a correlation does exist between the use of ceramic tile and the overall quality of fixtures, cabinets, and floor tile in the bathroom, one would expect the implicit price estimated for the tile to exceed its true market value. Similar arguments can be made for interpreting the disposal and dishwasher variables as indicators of kitchen quality.

for a single car garage and $2600 for a two car garage, a price consistent with those found in this study. The developers surveyed, however, indicated much higher prices with one builder indicating a charge of $8 per square foot or more than $1600 for each additional garage space.

The only implicit price which might need some explanation, aside from that for education which will be dealt with in detail later, is that for the age-floor area interaction term. As indicated above, that coefficient is really the product of the price per square foot of floor area and the simple depreciation rate. By dividing the coefficient by the estimated price per square foot of floor area a simple depreciation rate of 1.15 percent was found. This suggests a useful life for residential housing of slightly more than eighty-five years, a result not out of line with current expectations.

Obtaining implicit prices for housing attributes was not a major objective of this study. The price estimates only result from attempts to hold other housing characteristics constant so that the effect of the school district on total residential cost can be determined. Despite this it is encouraging to find estimates of implicit prices for housing attributes which do not conflict greatly with observed market prices. Since it is hypothesized that the total cost of the residence is the sum of the costs of the attributes, reasonable estimates of those prices for housing attributes which can be independently checked, increases one's confidence in the estimate of the price obtained for educational quality.

In the next section the implicit price estimates for educational quality are discussed in detail. Because the effect of changes in the specification of the education variables on the housing coefficients was quite small, and the effect of changes in the housing attributes on the coefficients of the educational proxies was negligible, the housing portion of each regression is not reproduced. It should be noted, however, that for each regression indicated a set of housing attributes identical to those on page 44 were used, even though they are not shown in the table.

Results: Education

When the educational proxy was entered in the regression in quadratic form, the results are those given above.[33] The amount the marginal consumer pays for education of quality Q is estimated to be $158Q - .85Q^2$, where Q is the percent of students scoring above the fiftieth percentile on the MSAT. The coefficients on both terms are significantly different from zero at the .05 level, and the combination of signs indicates a diminishing marginal price for educational quality in the relevant range, consistent with expectations. The total amount paid reaches a maximum when ninety-three percent of the students exceed the fiftieth percentile, a point slightly below the theoretical maximum.

The coefficients on the education terms should be interpreted together. When the terms representing housing attributes

[33] See p. 44.

and the constant are dropped what remains is an equation for the total expenditure on educational quality by the consumer. Given this function, the average and marginal prices per unit of quality can easily be obtained. The expenditure, as indicated earlier (see Chapter II), is composed of both the stream of expected property tax payments and the value of education capitalized into the property. It is worth noting again, however, that even though a series of price-quantity combinations can be found, what is observed is a single equilibrium and not a series of price quantity combinations resulting from different market experiments between consumers and producers. A reasonable comparison for the schedule obtained is a natural gas rate schedule which also provides a series of price and quantity observations, but which is more obviously only a single equilibrium observation.

When actual values for the school quality proxy in the Minneapolis suburbs are substituted into the equation, the present value of the amount paid by consumers for education ranged from a low of $3184 in a district where only twenty-three percent of the students scored above the fiftieth percentile to a high of $7200 in a district where the scores of eighty percent of the students exceeded that mark. Over two-thirds of the schools had between thirty and fifty percent score above the fiftieth percentile, and the range of prices paid for education in these districts was $1800.

These estimates indicate that the most an individual could reduce his expenditures on education by living in the

lowest quality and therefore lowest cost district instead of the highest cost district is approximately $4000. While this sum is not insignificant, neither is it overwhelmingly large since it is the present value of savings over a twelve year period. Comparisons between districts other than the two extremes, of course, reveal much smaller savings. If for example, one were to move to the lowest cost district from a district in which only fifty percent of the students scored above the fiftieth percentile, the saving would be only $2591.

These estimates indicate that the savings available to consumers who move from more expensive to less expensive school districts are probably not enough to offset moving costs. Consequently, it appears unlikely that differences in the cost of education influence the migration of couples whose children have completed school. The relatively narrow range found for prices of different qualities of education also indicates that the size of any capital loss suffered by homeowners due to the imposition of programs equalizing quality of education among schools is likely to be small.

A more surprising finding is obtained when the $5300 which the marginal consumer pays for education in an average quality district is compared to the average school property tax bill of $3000. This comparison indicates that more than $2000 of what the consumer pays for education does not go to the school district. Instead, this sum goes to the former owner of the property and serves as an entry fee paid for the

right to purchase education of that quality for the property tax levy. For property not to reflect some capitalized value of the educational quality, the school tax levy would have to be more than $630 in this average district--an exceedingly large tax bill.[34] Consequently it is likely that almost all homes in the district have some capitalized value in their price.

Finding a large capitalized value of education in the price of an average home casts new light on the traditional analysis of school financing problems.[35] It indicates that consumers spend considerably more in the average district for education than the schools receive and that the financial problems facing the public schools may not be due to a relatively low consumer valuation of education. Instead, it appears, these problems are due partially to the fact that previous property owners capture a portion of the consumer's payment for education.

The situation can easily be examined in the traditional welfare economics framework. What exists in the production and consumption of elementary and secondary education is that

---

[34] A school tax levy of this size is approximately equivalent to a $1000 total tax levy since school taxes are roughly sixty-five percent of the total tax levy in those districts studied.

[35] This finding also casts some doubt on the validity of those estimates of income and price elasticities for public education derived from models in which expenditure per capita by the school district is assumed to be the product of the number of units of quality and the price paid per unit of quality by the consumer. Given the capitalization found it seems unlikely that per capita expenditure by a school district is equal to the amount spent by the consumer for education.

the price ratios for education and other goods seen by consumers and producers are not identical. The price for education paid by the consumer is much higher than the payment received by the producer. This yields less than optimum production of elementary and secondary education, and a per unit price to the consumer which is greater than it would be at a social optimum.

Although this analysis provides a better understanding of the school finance problem, it offers little in the way of a solution. Even though each prospective purchaser is willing to pay considerably more for education of a given quality than current residents, this surplus is captured by the seller when the property is sold, leaving the new resident at the point where his rate of commodity substitution between education and other goods is equal to their price ratio. In fact, the opposition to a tax increase may be greater under this model than if capitalization is not considered and the school tax levy is treated as the only expenditure for education.[36]

---

[36]Assume that taxes on the average home in the average district were increased by an amount equal to $1000 in present value with no accompanying increase in educational quality. The present value of the tax bill is now $4000 and the value of education capitalized in the home drops from $2300 to $1300, assuming the valuation of that quality of education by the marginal consumer does not change. Consequently, for the school district to receive an extra $1000 the property owner must pay an additional $1000 in taxes plus incur a capital loss of $1000 in the value of his property. It should be noted, however, that the property owner benefits from tax relief in a similar way. Each dollar of new tax relief both reduces the payments that must be made from current income and increases the capitalized value of education in the property. Similarly, any tax increase which goes to finance an increase in the quality of the school will be favored by those whose property taxes will increase less than the market value of the additional

Since school board decisions usually reflect the desires of current property owners, it seems unlikely that major increases in school property tax levies will occur.

If school districts are to recapture some of the rent currently going to property owners, some form of transfer fee, tax increase, or service charge effective at the time the property is transferred appears to have the greatest probability of gaining approval. Although the current property owner would bear the burden of the increase through a decline in the capitalized value of education, he would pay only the exact amount of the expected tax increase and not some additional amount as would occur if the taxes were increased prior to sale.

The Effect of Using Different Proxies for Educational Quality

Results obtained when different proxies for educational quality were used are summarized in Table 1. Equations 1, 2, and 3 show the results when linear, quadratic, and cubic forms are used with the percent scoring above the fiftieth percentile on the MSAT as the proxy for quality. The quadratic form, equation 2, appears to provide the best estimate, although the additional explanatory power gained by adding the quadratic term is slight. The coefficient for the quadratic term is significant at the .95 level, however, and on that basis its

---

unit of quality, and opposed by those for whom the tax increase is greater than the value of the increased quality. This result holds even for consumers who have no demand for education themselves.

Table 1. Alternative Estimates of an Implicit Price Schedule for Educational Quality, Regressions Using Different Educational Proxies, Education Terms Only.

(1)	71 PCT GT 50 - 2182 (11.36)	adj. r^2 = .854
(2)	158 PCT GT 50 - .85 (PCT GT 50)^2 - 4195 (3.60) (2.01)	adj. r^2 = .855
(3)	-181 PCT GT 50 + 6.04 (PCT GT 50)^2 - .04 (PCT GT 50)^3 + 1145 (.93) (1.56) (1.79)	adj. r^2 = .855
(4)	159 PCT GT 50 - 1.19 (PCT GT 50)^2 + 104 PCT GT 90 -4322 (3.65) (2.53) (1.62)	adj. r^2 = .855
(5)	275 PCT GT 50 - 2.12 (PCT GT 50)^2 - 72.8 Range -3117 (4.14) (3.08) (2.34)	adj. r^2 = .855

Absolute Values of t Statistic in Parentheses

use can be justified.[37]

Two combinations of proxies for quality of education were also tried. Equation 4 shows the result of adding the percentage of students scoring above the ninetieth percentile to the regression. As can be seen this had little effect on the coefficients on the other education terms. Since the coefficient on the ninetieth percentile term was not significant, this alternative was rejected.

The regression was also run with the addition of a variable representing the range of scores of the middle fifty percent of the school's students. In this formulation the coefficients for both the linear and quadratic terms did change and the range term had a significant coefficient. (See equation 5.) The effect of this formulation on the unadjusted r^2 of the regression was small, however, increasing it only from .8547 to .8550.

When the implicit price estimates for the school districts computed using equation 2 were compared with those using equation 5, no large differences in the prices were apparent. The mean difference between the two sets of estimates was $55, the standard deviation of the differences was $233, and the largest single difference was $490. This suggests that both equations are estimating the same price schedule. Under these conditions

---

[37] Since the hypothesis being tested is whether the quadratic term provides explanatory power in addition to that of the linear term, the correct test statistic is the t value for the quadratic term. This is a different question from whether the quadratic expression itself is significant. In the latter case the proper test is an F test of the significance of the pair of variables.

it appears that either formulation will provide an adquate measure of the price schedule for elementary and secondary education.

The Effect of Different Amenity Specifications

Since educational quality is often believed to be highly correlated with other desirable community attributes an attempt was made to eliminate some of the more obvious possibilities for intercorrelation. Table 2 indicates the results obtained when different measures of local government expenditures were included in the regression.

The effect of the addition of measures of local government services to the regression is slight as is indicated by the difference in coefficients between equation one where no government service variable other than education is included, and the other equations. Changes in the definition of local government services provided also seem to have only a slight effect on the estimates of the coefficients on the education terms, and it appears that to the extent that expenditures per capita represent current service levels the education coefficients are not picking up any strong biases due to a correlation with other publicly provided services.

Conclusion

In this chapter a price schedule for educational quality has been estimated using the hedonic approach. A measure of the student input in the school, the percent scoring above

Table 2. Alternative Estimates of an Implicit Price Schedule for Educational Quality: Regressions using Different Measures of Services Provided by Local Governments, Educational and Government Expenditure Terms Only.

---

(1) 159 PCT GT 50 - .88 (PCT GT 50)^2 + 30.0 Adj. Tot. Exp. - 4196
(3.60) (2.01) (2.65)

adj. r^2 = .855

(2) 152 PCT GT 50 - .76 (PCT GT 50)^2 - 1927
(4.07) (2.11)

adj. r^2 = .847

(3) 138 PCT GT 50 - .66 (PCT GT 50)^2 + 86 Police Exp. - 3189
(3.13) (1.55) (2.16)

adj. r^2 = .855

(4) 164 PCT GT 50 - .89 (PCT GT 50)^2 + 45 Parks and Rec. - 3784
(3.46) (2.04) (1.85)

adj. r^2 = .855

(5) 150 PCT GT 50 - .77 (PCT GT 50)^2 + 65 Police + 23 Parks and Rec.
(3.24) (1.73) (1.38) (.83)

- 3951

adj. r^2 = .855

Absolute Values of t Statistic in Parentheses

the fiftieth percentile on the MSAT, was used as a proxy for school quality. The estimated relationship was consistent with expectations about sign, and the price estimates were of reasonable magnitude. In addition, the price schedule was subject only to minor fluctuations when different methods of specifying the quality relationship were tried. The estimated price schedule was also unaffected by changes in the way other local government services provided in the area were measured.

These results indicate that hedonic studies have an important part to play in future research on local government finance. This technique appears to have direct application to the estimation of demand for publicly provided goods and to the estimation of local tax effort and fiscal capacity, two areas where empirical research has long been limited. In addition, by providing an indication of the value the consumer places on publicly provided services, this approach may also be used to indicate how resources might be reallocated between the public and the private sector in order to achieve greater efficiency. The next chapter describes the results obtained when these estimates of implicit prices are used to estimate the income elasticity of demand for educational quality.

CHAPTER IV

THE INCOME ELASTICITY OF DEMAND FOR EDUCATION

Three recent studies have produced similar estimates of the income elasticity of demand for elementary and secondary education. Barlow, in part of a larger study of public education, specifies a simple demand function for education of the form $Q_i = Q(Y_i, P)$. Operating expenditure per pupil in district i is used as a proxy for Q_i, Y_i is family personal income in the district, and P is measured by the percent of taxable property value classed as non-industrial.[1] When this function is estimated using cross section data for fifty-two Michigan school districts an income elasticity of .64 is obtained.

Borcherding and Deacon build a considerably more complex model beginning with the assumption that successful candidates equate the marginal tax price and the marginal benefit for the median voter.[2] Then, assuming that consumers pay for education only through taxes, a reduced form equation is derived which allows the estimation of the income elasticity of demand, as well as several other parameters. They find, using states

---

[1] Robin Barlow, "Efficiency Aspects of Local School Finance", Journal of Political Economy (Sept./Oct., 1970), pp. 1028-40.

[2] Thomas E. Borcherding and Robert T. Deacon, "The Demand for the Services of Non-Federal Governments", American Economic Review (Dec., 1972), pp. 891-901.

as observations, cross section income elasticities of .81 and 1.04.

The model used by Ohls and Wales falls between those of Barlow, and Borcherding and Deacon in complexity.[3] They assume that most demographic variables affect only supply conditions and that unit costs do not vary with the quality of output produced. They obtain a different reduced form equation, and using state data produce a cross section estimate of the income elasticity of .6, an estimate very near that of Barlow.

When one recalls that the income elasticity of the property tax is usually considered to be less than unity the results of these studies have important policy implications.[4] It appears, if these estimates are correct, that the financial problems of school districts may not be as great in the future, given increases in income in the community. The estimates indicate that the revenue generated by growth in income may be sufficient to finance any desired increase in the quality of education without requiring increases in the millage rates. Indeed, given the relatively low income elasticities found, reductions in millage rates may even be possible.

---

[3] James C. Ohls and Terrence J. Wales, "Supply and Demand for State and Local Services", Review of Economics and Statistics (Nov., 1972), pp. 424-30.

[4] For estimates of the income elasticity of the property tax, see Dick Netzer, Economics of the Property Tax (Brookings, Washington: 1966), p. 190, or Advisory Commission on Intergovernmental Relations, Federal-State Coordination of Personal Income Taxes (ACIR, Washington: 1965), p. 42.

Unfortunately, these income elasticity estimates depend on the assumption that school district expenditure per child or per capita is an adequate measure of the quality of education provided in the district. This assumption, while a standard one, is not easily justified. Although the market insures that private firms using less efficient technologies will be forced to change their methods or close, publicly provided goods and services do not have to meet the test of the market. Consequently, there is nothing to prevent local governments from spending more to produce a service than the consumer is willing to pay. No mechanism exists which equates the value consumers place on service of a certain quality and the amount actually spent by the agency to produce that service, and given a choice, one would expect that the consumer's valuation rather than the actual cost of production would provide a better indication of the quality of the product.

Since the estimates of implicit prices for school districts obtained in Chapter III are estimates of the value consumers place on the quality of education produced in the district, and since large differences were noted between these implicit price estimates and the amount actually spent by the district, it was decided to estimate the income elasticity of demand for education using the implicit price estimate as a proxy for quality. To provide as much comparability with other studies as possible, a single equation model similar to those used by Ohls and Wales, and Barlow was used.

The Model

The model developed in Chapter II suggests that a household's demand for elementary and secondary education is of the general form

$$E = E(Y,P;N,PS)$$

where E is the quality of public education demanded, Y is a measure of family income, P is the price per unit quality, N is the number of children in the family, and PS indicates whether the children attend private school.

Because the actual quality of education provided in a district is unknown, a proxy must be used. One alternative is to choose a measure such as the percentage of students scoring above the fiftieth percentile on the MSAT. Here, following Barlow, Borcherding and Deacon, and Ohls and Wales, an alternative approach is followed. It is assumed that price per unit of education is constant over the range of observations and the implicit price for each district as calculated in Chapter III is used to measure quality. Since the sample districts are all relatively homogeneous and located in Minneapolis suburbs, the demographic variables affecting the supply of education in the Ohls and Wales model are constant and need not be included.

Since data on income, number of children, and private school attendance were not available at the household level without a special survey, each high school attendance district was assumed to reflect the characteristics of a representative consumer. Although this is a standard assumption, aggregation

in this manner increases the possibility of formerly predetermined variables becoming endogenous. Specifically, while income and number of children per family in any family moving into a district can reasonably be assumed to be predetermined, and in no manner dependent on the quality of education provided in that district, the overall characteristics of the district are probably to some extent affected by the quality of education provided in that district. Similarly, while the effect of any single household in the district on the quality of education in the district through the quality of the student inputs the household provides is probably negligible, a large influx of families desiring high quality education may be able to increase the quality of education provided in the district by increasing the quality of the student input.

Despite the possible simultaneity, a single equation model was used initially. This choice was made to preserve comparability with earlier studies, and to allow the direct comparison of the income elasticities based on the implicit prices with those obtained using district per capita expenditure as a measure of quality. In addition, it was believed that any effects of the quality of the district on the income, number of children per family, or the quality of education supplied are relatively slow in taking place so that for cross section analysis these variables can be considered to be predetermined.

The use of the attendance district as a representative consumer and the assumption that consumer expenditure on education

and quality were linearly related force several changes in the definition of the independent variables to be used in the demand equation. The actual equation estimated was

$$X = X(Y;N,PNC,PS)$$

where X is the implicit expenditure on schools in the district by families who purchased homes in that year, Y is mean family income in the district, N is the average number of children per family with children in that district, PNC is the percentage of families with no children in the district, and PS is the percentage of school age children in the district who attend private school. Estimates of the independent variables were obtained from the 1970 Census of Population for the same thirty-three high school attendance districts included in the sample area. Later, however, one school district with three high schools was combined into one observation leaving a sample of thirty-one observations.[5]

---

[5]This change was made for two reasons. First, one school which had opened during the year of the study had operated at only partial capacity. The students attending the school at that time were not thought to be representative of the entire student body of the school in later years. Second and more important, the largest concentration of apartments for single individuals and childless married couples in the metropolitan area dominated another high school attendance district. Since it was likely that those living in these apartments chose to reside in the district because of the existence of the apartment facilities rather than the quality of education provided, and since this group had a strong influence on the socio-economic characteristics of the attendance district, the three high schools were combined and treated as a single observation in order to reduce the impact of this special group of residents. In all other multi-school districts, however, each school attendance district continued to be treated as a single observation.

The desired independent variables were obtained by aggregating from census tract data with the assistance of a set of weights developed by the Minnesota Analysis and Planning System for allocating the population in census tracts included in two or more school districts into the appropriate districts. Estimates of the cost of education to the consumer in each district were obtained by inserting the proper values for the district in the two implicit price functions discussed in Chapter III. Although the two estimates of school prices were similar for the entire sample, a possibility existed that one set of prices might provide better estimates of the income elasticity of demand for education.

Results

The results of the regression using the quadratic price function to estimate consumer expenditures for elementary and secondary education are given below, absolute values of t statistic in parentheses.

$$\text{Log } EXP_1 = 3.08 + .58 \log Y - .29 \log N + .09 \log PNC - .07 \log PS$$
$$\qquad\qquad (3.34) \qquad (.82) \qquad (.54) \qquad (1.09)$$

$$n = 31 \qquad \text{adj. } r^2 = .29$$

When expenditures were calculated using both the quadratic expression and the range (equation 5, Table 1) the results were

$$\text{Log } EXP_2 = 3.51 + .52 \log Y - .14 \log N + .08 \log PNC - .05 \log PS$$
$$\qquad\qquad (3.07) \qquad (.40) \qquad (.41) \qquad (.82)$$

$$n = 31 \qquad \text{adj. } r^2 = .22$$

The estimated income elasticities of .58 and .52 correspond closely to the estimates of Barlow, and Ohls and Wales. The coefficients on the state variables N, PNC, and PS were not significant under either method of calculating consumer expenditures. The use of the simple quadratic representation of quality did produce a slightly higher r^2 for the regression, however.

The lack of significance of the demographic variables can probably be attributed to two causes. First, the use of the school district as a representative consumer may have masked the true effect of these variables. If all districts are not at the same stage of family development, for example, the average number of children per family in the district does not provide a good measure of the desired variable, the expected or desired number of children per family. Better estimates could probably be obtained by using the characteristics of those individuals actually purchasing residences in the district as data.

Similarly, data on the percentage of students attending private school may also be misleading since with aggregate data there is no way to separate those who will attend private school for all twelve grades from those who attend only through elementary school or those who attend only a private secondary school. The latter two groups can be expected to place different values on the public education system than those who intend to send their child to private school at both the elementary and secondary levels. These problems indicate that data on the characteristics of individual consumers is probably necessary to provide better estimates of the effect of these parameters.

A second possible explanation for the lack of significance of PNC and PS is suggested by the results of Chapter III. They indicate that there may be little financial incentive to move to a different school district once one's children have finished school since in general inter-district savings in school costs appear to be small. The size of the coefficients in these regressions also suggest this possibility. The sign on the term representing the percent of families without children is in the wrong direction, however, although the size of the coefficient is extremely small.

In an attempt to increase the explanatory power of the regression an additional state variable, parental education (PE), here defined as the median education of males over age twenty-five, was included in the regression. It is popularly believed that the educational level of parents has some effect on the demand for education apart from its influence through income, and it was hoped to test this hypothesis.

Typical of the results obtained using this form was the following

$$\text{Log } EXP_1 = -.10 + .09 \log Y - .39 \log N + 3.12 \log PE +$$
$$\qquad\qquad (.33) \qquad (1.18) \qquad (2.34)$$
$$.09 \log PNC - .04 \log PS$$
$$(.49) \qquad (.74) \qquad n = 31 \qquad r^2 = .39$$

In these regressions the parental education variable completely dominated the income variable, reducing the coefficient from .58 to .09, and removing its significance. Neither the

coefficients nor the lack of significance of the other variables were affected to any significant degree by the inclusion of this variable, however.

The small and statistically insignificant income elasticity and the large education elasticity resulting from this regression can be accounted for in several ways. First, they can be accepted as realistic estimates of the actual education and income elasticities of demand for educational quality. The demand for elementary and secondary education may be almost entirely determined by individual tastes, and parental education may be a good measure of taste for education. If this is true, there is no reason to expect any income elasticity of demand for education, and the estimates of the income elasticities obtained by others may be due to the omission of the parental education variable.

The low income elasticities can also be attributed to the measure of district income used in the regression. The measure used, mean family income, may not be a good measure of permanent income for the district. This may be due to measurement error, or it may be due to variation in transitory income between districts.[6] To investigate the possibility that either of these measurement problems were biasing the results, a two equation model was developed and the income and education

---

[6]For example, if districts are completely homogeneous, with regard to occupational class and skill level, one can imagine that transitory components unrelated to the occupation and skill level would net out over the district, but there would be no reason for the current income of each occupation and skill level to have identical relations to their permanent income.

elasticities were re-estimated using two stage least squares. The first equation estimated a new income variable as a function of parental education and the median age of males over twenty-five. This estimated family income was then substituted for measured income in the regression estimating the demand equation.[7]

The results obtained were surprising. The estimated income elasticity increased to between 1.4 and 1.9, depending on the form of the regression used to generate the estimates. These estimates were usually statistically significant at the .05 level. Further, the adjusted r^2 increased from .39 to between .45 and .68 depending on the form of the equation used and whether an additional variable, percent college graduates, was also included. The pure education elasticity, that is, the effect that an increase in the education of parents has on demand for educational quality apart from its effect through income, was on the order of -3.0 and insignificant. Both the income and education elasticities found in the two stage model contrasted sharply with the single equation estimates.

These estimates, while not necessarily any better than those of the single equation model, have important policy implications for school finance if they can be verified. An income elasticity of demand of greater than unity, given that the income elasticity of most revenue sources used to finance education is less than one, suggests that problems of school financing will continue no matter what level of income the

---

[7] A more complete discussion of both the method and the results obtained is contained in the Appendix.

community reaches, given current revenue sources. The problems of estimation using school districts as representative consumers are great, however, and these estimates of income elasticities greater than unity appear to require substantiation through a study using observations on individual households before they can be used with confidence. The results do suggest, however, that a variable representing parental education should be included in any equation attempting to explain the demand for educational quality.

CHAPTER V

CONCLUSION

This study had three major objectives. The first was to explore the usefulness of the hedonic technique for estimating implicit prices for publicly provided services. The results presented above indicate that the technique produces reasonable estimates of the value the marginal consumer places on the quality of public services supplied in a particular location. In addition, these price estimates appear relatively insensitive to changes in the specification of the other attributes of the property, and to changes in the way quality is proxied. The success of this study indicates that the hedonic approach may provide a method of estimating prices paid by consumers for other publicly provided goods and services, and this opens up several new areas of research in local public finance.

The second objective of the study was to obtain actual estimates of the implicit prices associated with the different qualities of education provided in the Minneapolis suburbs. Although a range of more than $4000 was found between the highest quality and the lowest quality school districts, the price differentials between most schools were relatively small, with nearly two-thirds of the schools falling in a price range of less than $1800. This finding has some policy significance

when applied to programs designed to equalize school quality since it indicates that any capital loss due to these programs will be relatively minor. The similarity in costs between most districts also indicates that there is not a large financial incentive to move to a lower quality district after one's children complete school.

A more important finding, however, is that only about one half the average consumer's total payment for education actually goes to the school district for use in the production of education. The rest goes to the previous property owner as capitalized net rent. This finding suggests that a misallocation of resources is occurring and that less public education is being produced than is socially desirable. It appears that social welfare could be increased if more of what the consumer spends to purchase education actually went to the school district for the production of quality education and the capitalized value of the education system in local property values was reduced.[1]

---

[1] If student inputs are important in the production of educational quality, an argument can be made for allowing those households providing children who increase the quality of the education system while they are students, and thus attract other high quality student inputs who further increase the quality of education provided, to realize a return from the use of their children by the schools. In this instance, some capitalization of the quality of the district in some home values would not automatically produce a misallocation of resources. However, in this case the amount of capitalized value should depend on the contribution of the household's children to the quality of education provided in the district, and one would expect to see both positive and negative capitalizations in each district, depending on the contribution of the children.

Finally, an attempt was made to obtain a new estimate of the income elasticity of demand for education making use of the actual expenditures by the consumers rather than expenditures by the school district to represent educational quality. The large differences found between the amount paid to the district and the total cost of education in the district raised some doubt about the validity of those earlier estimates which have used school district expenditures as a measure of quality. Using school districts as representative consumers, cross section income elasticities of .52 and .58 were found consistent with earlier estimates made by others. When a measure of parental education was included as a state variable in the regression, however, the estimated income elasticities were quite different. In a single equation model using ordinary least squares the parental education variable completely dominated the income variable, reducing it in size to .09 and eliminating any statistical significance. When the demand equation was re-estimated using a two stage model and two stage least squares, the estimated income elasticities obtained were between 1.4 and 1.9 depending on the data set used and the form of the regression. The income coefficient was not always significant in these regressions, however.

The results of this study do indicate that further investigation of the income elasticity of demand for education using household data is important. The differences between existing estimates of between .6 and 1.0 and the estimates discussed above when parental education is included in the

regression, are important for planning purposes. Income elasticities of either zero or greater than unity have vastly different implications for financing the education to be demanded in the future, and resolution of this question is of high priority.

Although the estimates of the prices paid for educational quality, and the elasticity of demand for education are interesting and important, probably the most important finding of this study is that the hedonic technique is useful for addressing the question of the value the public places on local government services. The hedonic method of estimating implicit prices for hitherto unpriceable publicly provided goods opens a wide area for research in the analysis of local public finance.

APPENDIX

FURTHER ESTIMATES OF THE INCOME ELASTICITY OF DEMAND FOR EDUCATION

The possibility that errors in the measurement of family income biased the income elasticity estimates obtained from the single equation model was investigated using a two stage model. In the first equation a human capital approach was used to obtain an estimated family income for each school district.[1] The income generating function was assumed to be of the general form

$$Y = Y(PE,A)$$

where Y was mean family income in the district, PE was median education of males over age twenty-five, and A was median age of males over twenty-five. This model requires that age have no influence on the quality of education demanded. However, given the aggregate data, and the fact that median ages in the school district range only from thirty-five to forty-six, this assumption appears to cause few difficulties.

Income generating functions in log-log, long-linear, and linear forms were estimated using census tract data for suburban

[1] Much of the recent literature in this field is reviewed in Jacob Mincer, "The Distribution of Labor Incomes: A Survey with Special Reference to the Human Capital Approach", Journal of Economic Literature, VIII (March, 1970), pp. 1-20.

Minneapolis. Typical of the results obtained was the following, t values in parentheses.

$$\log Y = -.972 + 3.42 \log PE + .48 \log A$$
$$(16.9) \qquad (6.2) \qquad n = 192 \quad \text{ad. } r^2 = .68$$

Using the income generating function, estimates of family income were made for each district. These estimates of family income were then substituted for mean family income in the demand equation so that the actual form of the equation estimated was

$$X = X^*(Y^*;N,PNC,PS,PE)$$

where Y^* is the estimate of family income obtained from the income generating function and all other variables are the same as those used earlier.[2]

As indicated in Chapter IV the results were unexpected (see Table A.2). Ignoring the lack of significance on the income term for the moment, the income elasticity increased to 1.67, a value more than double the estimate obtained by OLS when the parental education variable was not included. The state variables PNC and PS both had the predicted sign although the coefficients remained small and insignificant. The most surprising result, however, was that the pure education elasticity, that is the effect that an increase in the education of the parent has on the demand for educational quality apart

---

[2]The procedure followed is equivalent to two stage least squares even though it was done in two separate stages using ordinary least squares. The t statistics on all coefficients have been adjusted to take into account the fact that the standard errors resulting from using OLS in the second stage are incorrect.

Table A.1. Correlation Matrix for Regressions on Demand for Educational Quality, 31 School Attendance Districts, Minneapolis Suburbs.

	log Y	log N	log PE	log A	log PNC	log PS	log CG	log Exp
LOG Y	1.00							
log N	-.27	1.00						
log PE	.95	-.05	1.00					
log A	.65	-.66	.43	1.00				
log PNC	.39	-.76	.19	.77	1.00			
log PS	.20	-.51	.07	.47	.61	1.00		
log CG	.86	-.21	.78	.41	.24	.13	1.00	
log EXP	.77	-.42	.74	.65	.46	.22	.77	1.00

Table A.2. Demand Functions for Educational Quality: Regressions Including Parental Education, 31 School Attendance Districts, Minneapolis Suburbs, 1970. All Variables in Log Frm.

Constant	Est. Income	N	PE	PNC	PS	adj. r^2
.98	1.67	-.31	-3.07	-.03	-.02	.52
	(1.76)	(1.31)	(.84)	(.17)	(.45)	
.97	1.66	-.30	-3.02	-.03		.54
	(1.60)	(1.08)	(.76)	(.32)		
.93	1.59	-.29	-2.81		-.02	.54
	(1.77)	(1.17)	(.78)		(.51)	
.85	1.49	-.26	-2.44			.55
	(1.69)	(1.08)	(.71)			

Absolute Values of t Values in Parentheses

from its influence through income, was negative and relatively large in absolute value, on the order of -3.0.

Although there is no theoretical reason to suspect that the education elasticity should be positive, a negative elasticity does conflict with most a priori judgments about sign, and raises strong questions about the validity of the estimates. The concern is even greater since the findings directly conflict with those obtained by ordinary least squares. Further, the lack of significance of either the education or the income variable is also disturbing.

Several attempts were made to improve the estimates. Other forms of the income generating function were tried with no noticeable change in results. Generally the income elasticities remained negative.

Examination of the data revealed that the education variable had only a small range, from approximately 12.2 to 13.6 with most observations falling in the range from 12.3 to 13.2. Since one usually considers a much larger range of educational attainment when thinking about the effect of parental education on the quality of education demanded by the family, another variable--the percent of residents with four or more years of college was included in the regression. The results of these regressions are shown in Table A.3.

The results were similar although both the income and education elasticities increased in absolute value. In addition the coefficient on estimated income was significant, providing more confidence in the estimates. Under this formulation the

Table A.3. Demand Functions for Educational Quality: Regressions Including Parental Education and Percentage College Graduates, 31 School Attendance Districts, Minneapolis Surburbs, 1970. All Variables in Log Form.

Constant	Y*	N	PE	PNC	PS	CG	adj. r^2
.66	1.79	-.09	-6.16	.10	-.23	.26	.67
	(2.12)	(.38)	(1.84)	(.08)	(.58)	(3.69)	
.66	1.78	-.08	-6.09	-.17		.26	.68
	(1.91)	(.33)	(1.65)	(.12)		(3.35)	
.66	1.82	-.10	-6.26		-.21	.26	.68
	(2.24)	(.44)	(1.88)		(.21)	(3.41)	
.65	1.72	-.07	-5.89			.26	.69
	(2.30)	(.32)	(1.89)			(3.61)	

Absolute Values of t Values in Parentheses

income elasticity was generally in the neighborhood of 1.8 and the pure education elasticity approximately -6.0. The percent college graduate term was also significant and it had the expected positive sign. Again it made little difference which form was used for the income generating equation or the demand equation. In fact a new income generating function was estimated where income of the district was a function of the percentage of college graduates as well as the age and median education variables, and even with that change there was no appreciable difference in the elasticity estimates.

The negative coefficient on the parental education variable was not significant in any of the regressions. The coefficient did approach conventional significance levels, however, and consequently it cannot be easily dismissed, especially since there was a high degree of multi-collinearity in the regression. Although any explanation of the unusual education elasticity is somewhat strained, the observations of median educational attainment do fall in a rather narrow range, suggesting that the data cover only a small segment of the parental education-educational quality demanded relationship. What may be being observed is the differences between skilled tradesmen and white collar workers with only slightly more formal education. Explanations of the negative elasticity using the desire often attributed to blue collar workers to have their children go to college then become plausible. These explanations are by no means completely satisfying, however, and hopefully future research using observations of individual households will be

better able to test the education elasticity of demand for educational quality.

A more important subject for future verification is the estimates of the income elasticity of demand for educational quality. If, as this set of estimates suggest, the income elasticity of demand is greater than unity, the finding is of great importance to educational planners since the income elasticity of most revenue sources is less than unity. Confirmation of the large elasticities found through the two stage technique would suggest that not only will the problems of financing schools not diminish over time, they will actually worsen unless a more income elastic revenue source such as the income tax is used to finance local education.

BIBLIOGRAPHY

Adelman, Irma, and Zvi Griliches. "On an Index of Quality Change", Journal of the American Statistical Association, 535-48, September, 1961.

Anderson, R. J., and T. D. Crocker. "Air Pollution and Property Values", Urban Studies, 171-180, October, 1971.

Bailey, Martin J. "The Effects of Race and Other Demographic Factors on the Value of Single Family Homes", Land Economics, 215-20, May, 1966.

Borcherding, Thomas E., and Robert T. Deacon. "The Demand for the Services of Non-Federal Governments", American Economic Review, 891-901, December, 1972.

Brigham, E. F. "The Determinants of Residential Land Values", Land Economics, 325-34, August, 1965.

Brown, Samuel L. "Price Variation in New FHA Housing", Staff Working Paper #31, Bureau of Census (Government Printing Office, Washington: 1971).

Emerson, Frank C. "The Determinants of Residential Value with Special Reference to the Effects of Aircraft Nuisance and Other Environmental Features", Unpublished Ph.D. Dissertation, University of Minnesota, 1969.

Freeman, A. Myrick. "Air Pollution and Property Values: A Methodological Comment", Review of Economics and Statistics, 415-16, November, 1971.

Griliches, Zvi. "Hedonic Price Indexes for Automobiles: An Econometric Analysis of Quality Change", in The Price Statistics of the Federal Government (National Bureau of Economic Research, 1971).

Griliches, Zvi, ed. Price Indexes and Quality Change, Harvard University Press, Cambridge, Mass.: 1970.

Harris, R. N. S., George Tolley and C. Harrel. "The Residence Site Choice", Review of Economics and Statistics, 241-47, May, 1968.

Maslove, Allan. "Travel Rent Gradients and the Cost of Travel Time in a Multi-Nodal City", Unpublished Ph.D. Dissertation, University of Minnesota, 1972.

McMahon, Walter W. "An Economic Analysis of Major Determinants of Expenditures for Education", Review of Economics and Statistics, 242-57, August, 1970.

Mohring, Herbert. "Land Values and the Measurement of Highway Benefits", Journal of Political Economy, 236-49, June, 1961.

Oates, Wallace E. "The Effects of Property Taxes and Local Public Spending on Property Values: An Empirical Study of Tax Capitalization and the Tiebout Hypothesis", Journal of Political Economy, 957-71, November/December, 1969.

Ohls, James C., and Terrence J. Wales. "Supply and Demand for State and Local Services", Review of Economics and Statistics, 424-30, November, 1972.

Pashigian, B. Peter. "The Effect of Public Expenditures on House Values", Unpublished paper given at Econometric Society Meetings, New Orleans, La., 1971.

Ridker, Ronald G. and John A. Henning, "The Determinants of Residential Property Values with Special Reference to Air Pollution", Review of Economics and Statistics, 246-57, May, 1967.

Tiebout, Charles. "A Pure Theory of Local Expenditure", Journal of Political Economy, 416-24, October, 1956.

Triplett, Jack E. "Measurement of Quality Change", Unpublished Ph.D. Dissertation, University of California, Berkeley, 1966.

Triplett, Jack E. "The Theory of Hedonic Quality Measurement and Its Uses in Price Indexes", BLS Staff Paper 6, Department of Labor (Government Printing Office, Washington: 1971).