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THE DEMAND FOR TEACHERS BY PUBLIC SCHOOL DISTRICTS UNDER THREE DIFFERENT MARKET STRUCTURES

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The demand for teachers by public school districts under three different market structures

by

David S. Pate

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I. INTRODUCTION

A better understanding of the personnel decisions made by public school systems and the market forces that shape these decisions is desirable because of its relevance to several public policy issues. This study attempts to further this understanding by examining the demand for teachers and for two measures of teacher quality, education and experience levels, by Maryland public school districts for the 1955-1956 through 1979-1980 school years.

In estimating demand functions for teacher services by school districts, the responsiveness of the quantity of teacher services demanded to the price of teacher services will be measured. Knowledge of the elasticity of demand for teacher services should be of interest to school board members and local government officials to the extent that they desire to minimize the cost of local government services. Current educational expenses take up a large part of the budget of local governments and the salaries of educational employees comprise a large part of these current education expenses. Thus, any force that puts upward pressure on teacher salaries will have a significant impact on current educational expenditures. This would leave local government officials with the unpopular options of raising local tax revenues or cutting back on other locally provided services

A teachers' union is one such force to put upward pressure on teacher salaries. The determination of teacher salaries within the framework of a collective bargaining agreement between school boards and

teachers' unions has become commonplace. One determinant of the intensity with which teachers' unions are likely to push for salary increases is the elasticity of demand for teacher services. The more inelastic the demand for teacher services, the more attractive it will be to the union to push for salary increases as there will be a smaller decrease in the quantity of teacher services demanded for any given level of wage increase.

A second issue involves the perceived decline in the quality of public education in the United States. This decline has been partially attributed to the decline in the quality of public school teachers. It is suggested that many of the better teachers have left public school teaching for work in the private sector in response to better wages and working conditions. It is further suggested that many of the better quality college students have opted for curricula other than education for the same reason. Insofar as this study will attempt to provide a better understanding of the process determining the stock of teachers within a public school district, it may provide suggestions towards cost-efficient routes to improve the quality of public education.

A final issue is the choice of a proper formula for the determination of state educational aid to school districts. One justification for the provision of state funds to local school districts is that if such funding is properly distributed among school districts within the state, students will face equal educational opportunities regardless of the public school district they attend. This can be illustrated by considering a situation where school districts rely solely on local

property tax revenues for funds. Suppose that educational opportunities to students are positively related to the educational inputs of the school district to which they belong. Examples of educational inputs include the quality and size of the teacher stock as well as the physical facilities of the school system. Further, suppose that all school districts within the state face the same prices for educational inputs. School districts that have greater levels of assessable wealth per pupil can provide their students with more educational opportunities for a given level of tax effort (local property tax rate) than can less wealthy districts. To remedy this situation, state educational aid programs have been enacted to ensure that for a given level of tax effort, school districts have an equal ability to provide their students with a state-determined, minimum acceptable level of educational opportunity. One requirement that must be satisfied by the aid formula if the program is to achieve its purpose is that it must account for any differences in the price of educational inputs faced by school districts within the state. This study will examine the extent to which the price of teacher services vary within the state of Maryland and will attempt to identify the source of such variation.

Previous studies of teacher demand have been conducted by Boardman, Darling-Hammond, and Mullin (1982), Wentzler (1981), Hall and Carroll (1973), Ehrenberg (1973), and Brown (1972). By building on previous work, this study will attempt to resolve some of the theoretical and empirical issues that have arisen in the studies mentioned above, as well

as providing a better understanding of the determination of a school district's teaching stock for public policy purposes.

The remainder of this dissertation will proceed as follows. Chapter II will review the five studies of teacher demand. Attention will be focused on the theoretical structure employed and the empirical results of each paper. Chapter III models the school district's demand for teacher services under the assumption that the school district is a price taker in the market for teacher services and thus faces a perfectly elastic supply of teacher services at the market determined price. The data set employed by this study is described along with the empirical results of the econometric model. Chapter IV examines one case which would cause the price of teacher services to be endogenous to the school district. The supply of teacher services is assumed to be responsive to not only the wage offer, but also to the amenities and disamenities of the job. Within this hedonic approach, class size, a choice variable of the school district, is one of the job characteristics that teachers respond to. Thus, a simultaneous equations system is used to test if the price and quantity of teacher services are jointly determined by the school district. Chapter V also examines the possibility that the price and quantity of teacher services are jointly determined by the school district, this time postulating that this situation arises from the school district possessing a degree of monopsony power in the market for teacher services. Chapter VI provides a brief overview of the empirical results of the previous chapters, comments on their policy implications, and suggests directions for further research in this area.

II. LITERATURE REVIEW

The purpose of this section is to review recent studies that examine the demand for teachers by public school districts. Four aspects of each article will be dealt with. First, the goal of the study and in light of this goal, the issues addressed by the paper are described. Next, the view that each takes of the output from the educational process is mentioned. Third, the theoretical framework employed to describe the determination of the price and quantity of teacher services is set forth. Finally, the type of data, the empirical techniques used, and the relevant findings of the study are briefly summarized.

Hall and Carroll (1973) investigated the effect that collective bargaining had on wage levels and class size among Chicago-area school districts during the 1968-1969 school year. They felt that to discover the true impact of unions in the public school setting, it was necessary to view teachers' organizations as negotiating to achieve both financial goals and work conditions. Class size was seen as an important component of working conditions. Hall and Carroll postulated that schools produce educational quality and in an ad hoc fashion described it as being functionally related to class size (average number of students per teacher), the percent of per pupil expenditures paid by the state, the presence of a collective bargaining agreement, teacher salaries, and two measures of community characteristics, population and percent white-collar workers. They also set up an ad hoc functional relationship between teacher salaries and district characteristics including class

size and the presence of a collective bargaining agreement. Hall and Carroll used two-stage least squares with their cross sectional data to estimate teacher salaries and average class size. Given the nature of their model, the interpretation and reliability of their estimates are questionable. However, they did find that class size has a significant, positive effect on salaries, while salaries had a significant, positive effect on class size.

A paper by Wentzler (1981) examined differences in the price of teacher services across Wisconsin school districts during the 1974-1975 school year. Wentzler was concerned with the effect of state education aid formulas on the ability of state educational aid programs to insure equality of educational opportunity across school districts within a state. The issue can be briefly described as follows. Suppose that school districts rely completely on local funding, say through a local property tax, and also assume that all school districts face the same prices of educational inputs. Wealthier districts are able to provide more resources to public education for a given tax effort (property tax rate) than are less wealthy districts, resulting in unequal educational opportunities for students across the state. A state educational aid plan that insures that school districts possess the same ability to provide education to their students for the same tax effort, regardless of local wealth, provides a degree of equality of educational opportunity to students within the sate. If the cost of educational inputs varies across school districts, the state educational aid formula must take this into account if the program is to achieve its goal. Wentzler attempted

to identify characteristics of school districts that influence the price of educational inputs they face. She focused on the supply price of teachers as teacher compensation makes up the bulk of current educational expense for school districts (Wentzler, 1981, p. 434).

Wentzler asserted that school districts produce educational services. These services are not identified, but are assumed to be produced according to a well-behaved production function which has as its arguments quantities of different types of teachers and a vector of other inputs not subject to the school administrator's control. The amount of educational services to be produced is determined through a median-voter framework. The function of the school district administrator is to provide this level of educational services at the minimum cost. Teacher supply to the district is derived through a household production model. Although not explicitly stated, Wentzler's model implied that school districts possess a degree of monopsony power as the supply price faced by each district was determined by the quantity of teacher services along with the quality of teacher services and measures of the district's amenities and disamenities.

Wentzler estimated the demand and supply functions for elementary and secondary teachers by two-stage least squares. She found that the demand for teachers at both levels decreased as the price of teacher services increased while the supply price of teachers increased with the quantity of teachers. Both results were statistically significant. Wentzler made no mention of the latter result which implied that school districts possess a degree of monopsony power. If one accepts this

interpretation of her results, estimation of a demand function for teachers was inappropriate as a monopsonist does not possess a true demand curve. It would have been proper to estimate a reduced-form equation for the number of teachers hired although this was not done.

Boardman, Darling-Hammond, and Mullin (1982) also addressed the issue of school finance reform. Their goal was to explain the sources of differences in the prices of teacher services faced by Pennsylvania school districts during the 1974-1975 school year. Boardman et al. viewed schools as multiproduct firms. Outputs of the schooling process include student achievement and the acquisition of self-esteem and societal values. A school district was assumed to be concerned with the average level of and the variance in each output across all students.

The school district services an area coterminous with the jurisdiction of the local county government. Through a framework consistent with the median-voter hypothesis, the taxing and spending decisions of the county government officials were assumed to maximize the social welfare of the county's residents. These officials determine the level of educational services to be provided by the public school system, the levels of other services to be provided by the county government, and the level of after-tax income available to residents with which to privately purchase goods and services. Thus, the demand for teacher services was derived at the margin from their impact on social welfare through their contribution to the production of educational services.

Boardman et al. examine three cases, two of which are of relevant concern here. First, teacher demand was modeled under the assumption

that school districts are price takers in the market for teacher services. In the second case, school districts were assumed to possess a degree of monopsony power. The data describe 504 Pennsylvania school districts for the 1974-1975 school year and were not broken down into elementary and secondary levels.

Assuming the school district to be a price taker in the input market, teacher demand was estimated as a function of the price of teacher services, the price of alternative goods which the county government could supply, variables describing the resources and tastes of county residents, and variables describing student and school district characteristics. The demand for teachers was found to be unaffected by the price of teacher services, measured by the average teacher salary. They also found that both the demand for teachers of higher education levels, presumably those with a master's degree or Ph.D., and the demand for experienced teachers increased the higher was the price of teacher services.

Next, under the assumption that school districts possess a degree of monopsony power, the teacher supply price was estimated using two-stage least squares as a function of the quantity of teachers and of student, teacher, and school district characteristics. Boardman et al. found that the quantity of teachers had a positive and significant affect on teacher supply price, indicating that school districts possess a degree of monopsony power.

Brown (1972) also addressed the issue of promoting equal educational opportunity through the public school system. He examined whether

cognitive achievement was a measurable output of Michigan school districts and then attempted to describe school districts' behavior in pursuit of their goals. Brown questioned whether the practice of providing school districts with state money so that they can purchase additional educational inputs serves any useful purpose. He found no consistent positive relationship between the levels of educational inputs of school districts and the cognitive achievement of fourth grade students within those districts.

Brown next described a model of school district behavior from which the demand function for teachers was derived. In his model, school district officials maximize the district's welfare by allocating their budget, consisting of local revenues and state aid, among purchases of educational inputs and purchases of other goods and services for public provision. The exact nature of the output of the school district was not explicitly stated. The amount of "education" provided by the school district is produced according to an educational production function which has as its arguments purchased inputs, including teacher services, the number of students, and measures of student characteristics. The school district was assumed to be a price taker in the market for teacher services. The district's demand function for teacher services was derived form the district's demand for "education." The arguments of the demand function are the number of students, student characteristics, the school district's budget, the price of teacher services, and the price of other publicly provided goods and services.

Brown (1972) used data from 636 Michigan school districts from the 1970-1971 school year. The data set was not broken down into elementary and secondary levels. Demand functions for the student-teacher ratio, the percentage of teachers with a master's degree, and the average years of experience of the school district's instructional staff were estimated using the statewide sample and then were estimated for four subsamples--cities, urban fringe areas, towns, and rural districts. Ordinary least squares was used in all cases.

Brown found in all cases except school districts in urban fringe areas that the class size demanded increased as the average teacher salary increased. The average teacher salary had an insignificant effect on school districts in the urban fringe areas. However, the average teacher salary did not have the expected effect on the demand for teachers with a master's degree nor on the demand for teacher experience. Teacher salary had no significant effect on the demand for teachers with a master's degree in school districts located in cities or rural districts while it had a positive and significant effect on the demand for teachers with a master's degree using the statewide sample and the other two subgroups. Average teacher salary had no significant effect on the demand for average teacher experience by school districts located in cities. For the statewide sample and the other three subgroups, the demand for teacher experience increased as the average teacher salary increased. Brown suggested that the average teacher salary may be a poor measure of the actual salary schedule and that it may be endogenous as it reflects the mix of teachers chosen by the school district.

Ehrenberg (1973) measured the wage elasticity of demand for state and local government employees. This measure is of interest in that an inelastic demand for public sector employees would make it more attractive to public sector employee unions to push for higher member wages, all else equal. The wage elasticity of demand for state and local employees engaged in public education along with the wage elasticities of demand for ten other functional categories of public sector employees was estimated.

Ehrenberg modeled a single decision maker who derives utility from privately and publicly produced goods and services. The utility function was assumed strongly separable so that the state's resources are first allocated among private and public provision of goods and services and then the public revenues are allocated among the 11 functional categories of public production. The outputs of public sector employees were not explicitly described. It was asserted that the per capita flow of services from each type of public agency is proportional to the per capita public employment within that agency. A system of demand functions for the 11 public employment categories was derived from this framework. Per capita employment in each category is a function of its own wage, the state's per capita total public employment budget, and sociodemographic variables presumed to affect the tastes of the decision maker. The wage levels were assumed exogenous.

The data were state-level observations pooled over the period from 1958 to 1969. The system of demand functions was estimated over the pooled data set using three-stage least squares. Initially, the state's

functional distribution of public employment funds was assumed to be determined each year independently of the previous year's decision (zero-based budgeting for each public agency). Next, the system of equations was estimated assuming that each agency's funding is determined by increments to the previous year's budget. Ehrenberg found the partial own-wage elasticity of demand for public education employees to be negative and inelastic. This partial elasticity holds the state's total employment budget constant. Since Ehrenberg found that a wage increase in any or all public employment categories served to increase the state's total employment budget, this partial elasticity estimate is an upper bound in absolute terms on the total own-wage elasticity of demand (Ehrenberg, 1973, p. 376).

All of the above mentioned studies estimated the demand for teachers. They differ with respect to the source and type of data used, the theoretical structure employed, and in some empirical results. What follows is a brief description of the similarities and differences among the papers reviewed.

All of the papers except Ehrenberg's used data describing school districts of a single state for a single academic year. Ehrenberg pooled cross-sectional observations at the state level over an 11-year period. Only Wentzler's (1981) study examined the demand for elementary and secondary teachers separately. Ehrenberg's (1973) measure of teachers combined teachers with administrators and all other personnel employed in the field of public education at the state and local level and used this figure on a per capita basis. The other studies used the teacher-student

ratio or its inverse, average class size. Two papers, those by Brown (1972) and Boardman et al. (1982), also estimated the demand for education and experience levels of teachers but did not clearly state the construction of the dependent variables that they used. Finally, all studies used an average salary to measure the price of teacher services. Hall and Carroll (1973) and Wentzler (1981) calculated this average from the school district's salary schedule. The other studies used the average of actual salaries paid.

There was also a degree of diversity in the theoretical approaches taken to describe the school district behavior. Generally, the welfare or utility of the population of the area served by the school district was maximized through the provision of education by the public schools and the provision of a composite measure of goods and services by other local government agencies. Teacher demand was derived through its contribution to the production of education, education being an argument in the utility or welfare function being maximized. Brown (1972), Boardman et al. (1982) (for one of the cases that they proposed), and Ehrenberg (1973) assumed the determination of the price of teacher services to be exogenous to the school district so that each school district faced an infinitely elastic supply of teacher services at the market determined price. Boardman et al. (1982) also considered a case where the school district was assumed to be a monopsonist in the market for teacher services. Papers by Hall and Carroll (1973) and Wentzler (1981) described the price of teacher services as being endogenous to the school district without mention of the nature of the market for teacher

services. Hall and Carroll (1973) considered class size, the inverse of the teacher-student ratio, to be determined by the school district and to be an indicator of the quality of the work environment of teachers. They expected that as class size increased, the school district would have to increase the salary it offered in order to attract teachers to work in the district. Wentzler (1981) included the number of teachers employed by the district as an argument in the function describing the supply price of teachers, implying that the school district possessed a degree of monopsony power.

Three papers estimated the demand for teacher services assuming that the price of teacher services was exogenous to the school district. Brown (1972) found that the quantity of teachers demanded decreased as the average teacher salary increased for the statewide sample and three of the four subsamples. Ehrenberg (1973) estimated the own-wage elasticity of demand for state and local public education employees to be negative and inelastic. Boardman et al. (1982), however, found that average teacher salary had no statistically significant effect on the demand for teachers by school districts. The Brown (1972) and Boardman et al. (1982) papers also estimated the demand for teachers with higher education levels and the demand for teacher experience under the assumption that the supply price of teachers was exogenous to the district. Boardman et al. (1982) found that both the demand for teachers of higher education levels and the demand for average teacher experience increased as the average teacher salary increased. Brown (1972) estimated that the demand for the percentage of teachers with a Master's degree increased as

average teacher salary increased for the statewide sample and two of the four subsamples. He also found that average teacher salary had a positive and statistically significant effect on the demand for average teacher experience for the statewide sample and three of the four subsamples.

Wentzler (1981), Boardman et al. (1982), and Hall and Carroll (1973) estimated teacher demand and teacher supply price with two-stage least squares under the assumption that both are endogenous to the school district. Wentzler (1981) and Boardman et al. (1982) found that the teacher-student ratio had a statistically significant positive impact on teacher supply price which can be interpreted as evidence that school districts possess a degree of monopsony power in the market for teacher services. Hall and Carroll (1973) found that the price of teacher services decreased as the teacher-student ratio increased. This finding supports their contention that teacher compensation consists of both pay and work conditions and that as work conditions, measured by class size, improve, the school district can offer a lower wage. Boardman et al. (1982) estimated only a reduced-form equation for teacher demand under the monopsony hypothesis. Finally, Wentzler (1981) and Hall and Carroll (1973) found that the demand for teachers decreased as average salary increased within the two-stage least squares format.

This study hopes to improve on those discussed above by taking advantage of a rich data set and through a more complete treatment of the supply side of the market. The data to be used describe 23 public school systems of the state of Maryland. Like Wentzler's (1981) paper, school,

teacher, and pupil characteristics are available at the elementary (kindergarten through the sixth grades) and the secondary (seventh through twelfth grades) levels. Separate examination of the markets for elementary and secondary teachers may be warranted in view of the different skills required for teaching at the two school levels (Wentzler, 1981, p. 446). Brown (1972) and Boardman et al. (1982) estimated the demand for teacher quality using measures of teachers' education and experience levels to capture teacher quality. The Maryland data allows for the contruction of a number of measures of teacher quality under the assumption that higher levels of educational preparation and greater years of teaching experience do make for a higher quality teacher. The demand for teachers with levels of educational preparation of less than a bachelor's degree, a bachelor's degree, and a master's degree or more are estimated on a per student basis.

The demand for several measures of teacher experience are also estimated. These measures include average teacher experience, the number of less experienced teachers per student (those with four or less years of teaching experience at the end of the current school year), the number of more experienced teachers per student (those with five or more years of teaching experience at the end of the current school year), and total years of teaching experience per student. The four-year mark is used to separate teachers into the more and less experienced categories based upon data availability and a finding concerning teacher mobility by Murnane (1984, pp. 516-518). Murnane provides evidence from an urban school district that selective attrition occurs among teachers in their

first years of teaching experience. Teachers receive feedback concerning their productivity which provides them with information concerning the quality of "job match" they have made. Individuals who find that their productivity in their current position is low leave teaching in that school district in order to find a better quality "job match." Murnane found evidence of selective attrition among teachers in their first years of teaching experience but found no evidence of such attrition taking place among teachers with four or more years of teaching experience. This result tends to support the belief that more experienced teachers are better quality teachers, all else equal. Total years of teacher experience per student provides a measure of the average quality of teacher each student interacts with. Also, the per student measurement is consistent with the measurement of other inputs in the educational production function.

Both the salary schedule and the average of actual teacher salaries paid are available for each school district. Thus, it is possible to see how sensitive the regression results are to the wage specification chosen. Brown (1972) and Boardman et al. (1982), assuming the price of teacher services to be exogenous to the school district, found in a number of cases that the price of teacher services had an insignificant or even a positive significant effect on the demand for various measures of teacher services. A possible explanation of these findings is that the wage variable used in each case was not a good measure of the price the school district faced for teacher services. Also, the salary schedule enables the construction of prices of teacher services for

teachers of different quality levels (i.e., teachers with varying levels of educational preparation and teaching experience). Finally, like Ehrenberg's (1973), the Maryland data is cross-sectional and pooled over time.

The demand for teacher services is derived within the context of a welfare maximization process as were the papers discussed above, with the exception of the study by Hall and Carroll (1973). Another route by which this study hopes to further knowledge of teacher demand is the consideration of three possible frameworks within which the stock of teachers may be determined by a school district. In the simplest case, the school district is assumed to face a perfectly elastic supply curve of teacher services at the market determined price. The advantage of such an approach is its simplicity. Boardman et al. (1982), Brown (1972), and Ehrenberg (1973) used this approach to estimate the demand for teachers.

The second framework of analysis treats both the quantity of teachers demanded and the price of teacher services as being endogenous to the school district. As in the first situation, the school district purchases teacher services in a competitive market. Using the hedonic approach, teachers are assumed to respond to a wage/job characteristics package, requiring a higher wage to compensate for less desirable working conditions (Antos and Rosen, 1975, p. 126).

Literature dealing with teacher bargaining suggests that class size, the inverse of the teacher-student ratio, is considered to be an important job characteristic by teachers (Perry, 1979, pp. 13-14). Since

the number of students is assumed exogenous to the school district, and smaller class sizes are taken to be a positive amenity, the school district should find that as it employs more teachers, it is able to pay a lower wage (price of teacher services) as class sizes become smaller. As with the Hall and Carroll (1973), Wentzler (1981), and Boardman et al. (1982) studies, two-stage least squares is used to estimate both the price and quantity of teacher services.

The third framework also treats the price and quantity of teacher services as endogenous. In this case, the endogeneity of the price of teacher services results from the school district possessing a degree of monopsony power in the market for teacher services. Landon and Baird (1971, pp. 68-70) have suggested that large school districts may possess some degree of monopsony power over teachers. Boardman et al. (1982) found that Pennsylvania school districts possessed a degree of monopsony power. A model similar to that used by Boardman et al. is used to test for monopsony power by Maryland school districts.

III. MODEL OF THE SCHOOL DISTRICT AS A PRICE TAKER

A. Derivation of the Demand Function for Teacher Services

This section models the demand for teacher services by a public school district under the assumption that the public school district is a price taker in the market for teacher services. The public school system is composed of elementary and secondary schools. The public school system superintendent is the decision maker who allocates the system's resources to educate its students. Hanushek (1979, p. 355) defines education as "a service that transforms fixed quantities of inputs (i.e., individuals) into individuals with different quality attributes."

There exist several views as to what the nature of this transformation is. Hanushek (1979, 1981) and Cohn (1979) have surveyed a number of studies that focus on the human capital aspect of schooling. This approach views students as acquiring market skills through the schooling process in order to increase their future earnings. Bowles and Gintis (1975, p. 75) assert that while schooling may increase the individual's productivity, the true transformation that takes place within the public schools is the socialization of students. They view the schooling process as being a tool of the capitalist class with which to reproduce the social and economic order. Still a third view proposes that schools do not transform the individual at all. Wolpin (1977) and Spence (1973) have suggested that the function of schools may simply be to sort students. Students attend school in order to acquire a signal that indicates their future productivity to prospective future employers.

For the purposes of this dissertation, the public school system is assumed to produce educational services. This approach is similar to that taken by Hall and Carroll (1973), Wentzler (1981), Brown (1972), and Ehrenberg (1973). The superintendent is concerned with QC, the average level of educational services produced per student. Production of QC is described by an educational production function. Studies estimating educational production functions have used the following measures of school output: achievement test scores, student and parent attitudes, school retention rates, college freshman grades, the percentage of students completing high school, and the percentage of high school graduates that attend college (Cohn, 1979, pp. 168-191). The educational production function used here is assumed well-behaved and its arguments are the standard ones employed in the educational production function literature (Hanushek, 1981, Cohn, 1979, Summers and Wolfe, 1977, and Levin, 1976). It is of the form

$$QC = Q(\Theta_T, \Theta_S, \Theta_P, \Theta_H). \tag{3.1}$$

Θ_T is a vector indicating the number of teachers of type i (i = 1, 2, 3, ..., z), per student. Teachers can be classified by a number of different criteria including education levels, experience levels, and certification levels. It is expected that different types of teachers have varying effects on the production of educational services. Student contact with or access to teachers of type i is described by the ratio of type i teachers to the student body (T_i/S). Also, the overall teacher-

student ratio is the inverse of the average class size in the district. It is generally assumed that smaller class sizes allow teachers to devote more attention to the needs of individual students, thus increasing the quantity of educational services produced.

Θ_S is a vector of nonteacher school district characteristics describing the physical learning environment facing the district's students. Measures describing school characteristics in the literature include the number of library books per pupil (Summers and Wolfe, 1977, p. 645), measures of the quantity and quality of equipment such as audiovisual aids (Cohn, 1979, p. 165), and the age and the nature of school buildings (Levin, 1976, p. 152).

Here, Θ_S is interpreted as a vector of relevant nonteacher school characteristics, each expressed on a per student basis. Of the school district characteristics included in the vector Θ_S, some are subject to the control of the superintendent, while others are not. Let the vector Θ_S be broken down into two vectors, Θ_{Sd} and Θ_{SN}. Θ_{Sd} consists of those characteristics that are subject to the superintendent's discretion, such as the number of nonteacher educational personnel and the quantity and quality of textbooks and audiovisual aids. Θ_{SN} is made up of the remaining school district characteristics, those not controllable by the superintendent. Purchases of (or investments in) buildings may be financed through borrowing and are often subject to separate state legislation and thus would be included in Θ_{SN} (Boardman et al., 1982, p. 135).

Θ_P is a vector of relevant pupil characteristics. It enters as an argument of the educational production function as the ability and prior learning experiences of a student are likely to affect the quality and quantity of learning that takes place. Prior studies have used measures such as the mean level and standard deviation in the socioeconomic status of students, the percent white students in the district (Brown and Saks, 1975, pp. 586-592), and the student's sex, IQ, and attendance records (Summers and Wolfe, 1977, p. 642) to capture the effect of student characteristics on the production of education.

Finally, home environment and community characteristics are expected to affect the level of educational services produced. These characteristics, represented by the vector Θ_H, attempt to capture the degree to which education is nurtured, encouraged, and rewarded within the home and within the community. Measures previously used to capture these effects include the degree of urbanization and poverty within the district, the educational attainment of the parents and the community as a whole, and the income, race, and size of the family (Cohn, 1979, pp. 166-167).

Thus, not all of the arguments of the educational production function are subject to the superintendent's control. Θ_{SN}, Θ_P, and Θ_H, as well as the number of students, S, are taken to be exogenous to the school district. Θ_T, the vector of teachers of each type, and Θ_{Sd}, the vector describing those nonteacher school district characteristics which are discretionary, are endogenous to the school district.

As the superintendent must operate within a budget, the determination of which is described below, his decisions concerning the levels of

utilization of each of the educational inputs to use are conditioned not only on the productivities of each at the margin, but also on their prices. Here, the school district is assumed to be a price taker in all of its input markets.

Teacher salaries are commonly determined according to a salary schedule which rewards educational preparation and teaching experience. Thus, p_i, the price of a teacher of type i (i = 1, 2, 3, ..., Z), can be represented as

$$p_i \equiv p_i^e + p_i^x. \tag{3.2}$$

Type i teachers possess a level of educational preparation for which they are paid, p_i^e, and a level of experience for which they are paid, p_i^x. There is a base level of pay for the minimum level of educational preparation, say the bachelor's degree. Teachers with higher levels of educational preparation, say a master's degree or a Ph.D., receive progressively higher levels of pay for their level of educational preparation. Similarly, while new, inexperienced teachers receive no pay component for experience ($p_i^x = 0$); teachers receive progressively higher pay levels for experience as they acquire more years of teaching experience. Thus, the total current expenses that arise from hiring teachers, E_T, can be represented as

$$E_T \equiv \sum_{i=1}^{z} (p_i * T_i). \tag{3.3}$$

Let Θ_{Sd} consist of W discretionary nonteacher school district characteristics. The price of each of these inputs, D_m (m = 1, 2, 3, ..., W), is exogenous to the school district and is equal to p_m^d, m = (1, ..., W). Total current expenses arising from the purchases of nonteacher discretionary inputs, E_D, are represented as

$$E_D = \sum_{m=1}^{W} p_m^d \cdot D_m. \tag{3.4}$$

The current educational expenses of the school district, E_C, are represented as

$$E_C = E_T + E_D. \tag{3.5}$$

As described above, the school system produces a service which is provided to residents of the school district by the local government. The local government provides other goods and services, such as police and fire protection and recreational facilities, to residents. Previous studies of teacher demand (Boardman et al., 1982, Brown, 1972, and Wentzler, 1981), along with several recent papers which have applied the median-voter hypothesis to the analysis of the provision of goods and services by local governments (Megdal, 1984, Munley, 1984, Romer and Rosenthal, 1982, and Gramlich and Rubinfeld, 1982), suggest that local government officials act so as to maximize the welfare of the residents of the school district or maximize the utility of the median voter in order to maintain their elected positions. Following is a brief

description of the framework within which the superintendent of the school district operates.

Local government officials tax and spend in such a way as to maximize the welfare of the residents of the school district, represented by a welfare function of the form

$$V = V(QC, L, C). \tag{3.6}$$

QC has been described above. L is a composite measure of all other goods and services provided by the local government. C is the level of goods and services privately purchased and consumed by the district's residents. Income levels of residents, state and federal taxes, and state and federal aid levels are assumed exogenous to local officials. Local revenues are raised through a property tax on assessed wealth in the district. Through determination of the local property tax rate, local officials determine the ability of residents to privately purchase and consume goods and services. These officials then allocate the local budget, consisting of state and federal aid and local property tax revenues, among the provision of educational services and the composite measure of other goods and services, L. Suppose the price of QC is P_Q, and the price indices for purchases of L and C are P_L and P_C, respectively. Local government officials choose the property tax rate and the levels of QC and L to be provided so that the local budget is exhausted and the following condition is satisfied:

$$\frac{\partial V/\partial QC}{P_Q} = \frac{\partial V/\partial L}{P_L} = \frac{\partial V/\partial C}{P_C}. \qquad (3.7)$$

The result of the above process is that the school system superintendent will be given a budget for current educational expenditures, B_E. His charge is to maximize the quantity of educational services produced per student given his budget, the prices of educational inputs, and the educational production function. In terms of the model described above, this involves the maximization of (3.1) subject to equations (3.3), (3.4), and (3.5). This yields demand functions for teacher services and discretionary school inputs of the form

$$X = f^d[P_1, \ldots, P_z, P_1^d, \ldots, P_w^d, BE/S, \Theta_{SN}, \Theta_P, \Theta_H] \qquad (3.8)$$
$$\text{for } X = (T_1/S, \ldots, T_z/S, D_1/S, \ldots, D_w/S).$$

The per student demand for each educational input is a function of all variable educational input prices, the total current educational funds per students, and the vectors of home and community characteristics, Θ_H, pupil characteristics, Θ_P, and nondiscretionary school characteristics, Θ_{SN}. The quantity of type i teachers demanded (on a per student basis) is expected to decrease as their price, p_i, increases. In response to an increase in p_i, there will be a substitution away from T_i/S towards the other discretionary educational inputs. The scale effect should reinforce this movement as the quantity of T_i/S demanded decreases further as the quantity of educational services produced drops.

Similar results are expected for nonteacher discretionary educational inputs as for the teacher inputs described above.

The direction of the change in quantity demanded of any discretionary educational input in response to a change in the price of another educational input depends on the production technology and the size of the scale effect. If two inputs are gross complements, the quantity demanded of one will decrease in response to an increase in the price of the other. If they are gross substitutes, the quantity demanded of one will increase in response to an increase in the price of the second. If the per student educational budget increases, there will be a pure scale effect, increasing the quantity demanded of normal inputs and decreasing the quantity demanded of inferior inputs. Finally, the nondiscretionary educational inputs are included to control for their effects on the marginal productivities of the discretionary inputs.

B. Model Estimation

1. Introduction

This section estimates the demand for teacher services by school district under the assumption that the school district is a price taker in the market for teacher services. First, the combined demand for elementary and secondary teachers is examined, and then the demand for these two groups is estimated separately. This allows for comparison of results with the previous studies and will indicate whether the market for teacher services differs at the two schooling levels. Next, the

demand for teacher quality is estimated--first the demand for the three levels of educational preparation, and then the demand for the various experience measures. The demand for teacher quality by school districts and then by elementary and secondary systems separately are estimated.

The demand functions are of the same form as equation (3.8). All dependent variables are in per student terms, except for average teacher experience. Three alternative specifications of the price of teacher services, TPRICE, are used. The first form, AVSALSD, AVSALEL, and AVSALHS, is the average of actual salaries paid by the school district as a whole, by the elementary system, and by the secondary system, respectively. The second, BSAL, is the base salary for new teachers with a bachelor's degree. The third, MIDSAL, is the midpoint of the salary schedule for teachers with a bachelor's degree. Both the first and third wage specifications were used in studies reviewed in Chapter II. Use of the three should indicate which best captures the price of teacher services. All three specifications are in 1972 dollars.

Two budget measures are used. Both are in 1972 dollars and are in per pupil terms. The school district is modelled as operating under a single budget constraint. However, for estimation purposes the budget for current educational expenditures is broken down into local funds, LOCFUND, and combined state and federal funds, OSFUND, as the state and federal funds may have restrictions put on their use by the granting agencies and, therefore, may have differing effects on the demand for teacher services.

PNW, the percent of the school district's population that is nonwhite, is included to capture both the home and community characteristics, as well as the student's ability and previous educational experiences. The attendance measures for the school district, the elementary system, and the secondary system--PCA, PCAE, and PCAH--are included to capture the home environment of the students. It is assumed that parents that are supportive of their children's educational pursuits will take steps to ensure that their children are attending regularly.

VPROPSD, VPROPEL, and VPROPHS are the value of school property and equipment per pupil within the school district, the elementary system, and the secondary system, respectively. They are expressed in 1972 dollars. These measures are included to control for the effect that the quality of educational facility has on the production of education and, thus, on the demand for teacher services.

Finally, TREND is the time trend variable. It is included in order to pick up the effect that unmeasured characteristics that change over the period have on the demand for teachers.

2. Data description

The data have been collected from three sources: the State of Maryland Annual Report for the years ending June 30, 1956 through June 30, 1980, The Salary Schedules of Professional Personnel, Maryland Public Schools for the 1957-1958 through 1979-1980 school years, and the County and City Data Book, 1952, 1956, 1962, 1967, 1972, and 1983 editions. Data pertaining to the 1957-1958 school year will hereafter be

referred to as 1958 data; data from the 1958-1959 school year will be referred to as 1959 data, and so on.

Table 1 lists and briefly describes the dependent and independent variables used in the regressions discussed in the next section. All of the dependent variables, except those measuring average years of experience per teacher, are in per student terms in order to be consistent with the model. Professional personnel are members of the professional staff who are considered to be engaged in instructional activity by the Department of Education. They consist of principals, vice-principals, teachers, librarians, guidance counselors, audio-visual personnel, and psychological personnel. Data on educational preparation and experience levels pertain to these professional personnel. Finally, the implicit price deflator for gross national product relevent to state and local government purchases of goods and services has been used to convert all monetary variables in 1972 dollars.

Each of the dependent variables is in groups of three because each variable has been collected for the school district as a whole, the elementary system, and the secondary system. The first category of dependent variables measures the teacher-student ratio. The next breaks down teachers into three levels of educational preparation. The third category contains four measures of teacher experience. These last two categories make it possible to estimate the demand for teacher quality by school districts, quality being measured by the experience and education levels of the teachers.

Table 1. Descriptive variable list

Dependent variables

Teacher-student ratio

PTS, PTES, PTHS--the per student number of professional personnel within the school district, the elementary school system, and the secondary school system, respectively

Levels of educational preparation

LDS, LDES, HDES--the per student number of professional personnel whose education level is less than a bachelor's degree for the school district, the elementary system, and the secondary system, respectively

BDS, BDES, BDHS--the per student number of professional personnel whose highest relevant educational degree is a bachelor's degree for the school district, the elementary system, and the secondary system, respectively

HDS, HDES, HDHS--the per student number of professional personnel who possesses a master's degree or a higher degree for the school district, the elementary system, and the secondary system, respectively

Experience measures

EXPSD, EXPSEL, EXPSHS--the per student total years of teaching experience within the school district, the elementary system, and the secondary system, respectively

LXSD, LXES, LXHS--the per student number of teachers with four or less years of teaching experience within the school district, the elementary system, and the secondary system, respectively

MXSD, MXES, MXHS--the per student number of teachers with more than four years of teaching experience within the school district, the elementary system, and the secondary system, respectively

ATEXSD, ATEXEL, ATEXHS--average years of experience per teacher within the school district, the elementary system, and the secondary system, respectively

Table 1. continued

Independent variables

Prices of teacher services

AVSALSD, AVSALEL, AVSALHS--the average of actual salaries paid to professional personnel within the school district, the elementary system, and the secondary system, respectively, in 1972 dollars

BSAL--the base salary for a teacher with no prior experience possessing a bachelor's degree, 1972 dollars

MIDSAL--the average salary for teachers with a bachelor's degree in 1972 dollars, derived from the salary schedule

INCED--the average increment to the base salary for a teacher possessing a master's degree, 1972 dollars

Budget variables

LOCFUND--local funds for current educational expenditures per pupil, 1972 dollars

OSFUND--state and federal funds for current educational expenditures per pupil, 1972 dollars

TOTFUND--total funds (local, state, and federal combined) for current educational expenditures per pupil, 1972 dollars

Home, pupil, and school district characteristics

PNW--percent of the population within the school district that is nonwhite

PCA, PCAE, PCAH--the average percentage of students attending for the school district, at the elementary level, and at the secondary level, respectively

VPROPSD, VPROPEL, VPROPHS--the value of school property and equipment per student within the school district, the elementary system, and the secondary systems, respectively, in 1972 dollars

TREND--the time trend variable, defined such that Q=1 if the observation pertains to the 1957-1958 school year, Q=2 if the observation pertains to the 1958-1959 school year, and so on

The first category of independent variables contains a number of variables that capture the price of teacher services. The first group represents the average of actual salaries paid while BSAL, MIDSAL, INCEX, and INCED are constructed from the salary schedules of the school districts. This makes it possible to determine which of the price variables best captures the price of teacher services faced by the school district. It also allows for more accuracy in the pricing of the services of teachers of different education or experience levels. The next category of explanatory variables describes the budget variables. The final group of variables represents the home, pupil, and school district characteristics that enter the educational production function.

3. Estimation techniques

Following the derivation of teacher demand in Section A of this chapter under the assumption that the price of teacher services is exogenous to the school district, this section describes the estimation of teacher demand by the school district. The demand function to be estimated is of the form:

$$PTS_j = f(TPRICE_j, LOCFUND_j, \Theta SFUND_j, PNW_j, PCA_j, VPROPSD_j, TREND_j) + \mu_j. \quad (3.9)$$

$j = (1, 2, 3, \ldots, n)$ where n = number of observations.

The dependent variable, PTS, is the number of professional personnel per pupil, hereafter teachers, demanded by the school district. Three

specifications of TPRICE, the price of teacher services, will be tested--AVSALSD, BSAL, and MIDSAL. As long as teachers are a normal input of the educational production function, the price of teacher services is expected to have a negative effect on the demand for teacher services. Increases in the per pupil educational budget through an increase in LOCFUND and/or OSFUND are expected to increase the demand for teacher services.

PNW, PCA, and VPROPSD are included to control for arguments of the educational production function which are not subject to the discretion of the school district superintendent. PCA, the average percentage of pupils attending, and PNW, the percentage of the population served by the school district that is nonwhite, attempt to capture the effects of relevant pupil, home environment, and community characteristics. The model developed in Section A of this chapter assumed that capital investment decisions are outside the superintendent's control. Thus, VPROPSD represents the effect of *nondiscretionary* school district characteristics upon educational production. Finally, TREND, the time trend variable, is included to capture the effect of any unmeasured determinants of teacher demand that change over time.

Equation (3.9) was initially estimated over the 23 counties for the 1958 through 1980 school years using ordinary least-squares techniques. It was assumed that the error term, μ_j (for $j = 1, 2, 3, \ldots, n$), where n is the number of observations, had an expected value of zero, a constant variance, and was pairwise independent (i.e., $E(\mu_t * \mu_{t+s}) = 0$ for $s \neq 0$). Examination of the Durbin-Watson statistic indicated that the

assumption that the error terms were pairwise independent was violated. Durbin's two-step correction procedure is used to transform the data to correct for autocorrelation (Johnston, 1972, pp. 263-265).

Following is a description of the correction procedure used in the estimation of equation (3.9). The data used in the estimation of all models in this chapter were also transformed using this procedure. The presence of autocorrelation is not unexpected given the time-series component of the data. It implies that the error term for the observation of county "A" in year t is functionally related to the error term for the observation of county "A" in year t-1. Let the error term of equation (3.9) exhibit a positive first-order autoregressive process described as follows:

$$\mu_j = \rho * \mu_{j-1} + \varepsilon_j \tag{3.10}$$

where $0 < \rho < 1$ satisfies the assumptions.

$$\begin{aligned} &E(\varepsilon_j) = 0; \\ &E(\varepsilon_t * \varepsilon_{t+s}) = \sigma^2_\varepsilon, \qquad s=0; \\ &E(\varepsilon_t * \varepsilon_{t+s}) = 0, \qquad s\neq 0. \end{aligned} \tag{3.11}$$

Durbin's two-stage procedure is used to estimate ρ, then to transform the original data with that statistic, $\hat{\rho}$, and, finally, through the application of ordinary least squares to the transformed data, derive

the estimated generalized least-squares estimators of the unknown coefficients of equation (3.9) (Judge et al., 1982, pp. 462-465).

Estimation of the following equation,

$$\begin{aligned} PTS_j = {} & \gamma_0 + \rho PTS_{j-1} + \gamma_1 TPRICE_j + \gamma_2 TPRICE_{j-1} + \gamma_3 LOCFUND_j \\ & + \gamma_4 LOCFUND_{j-1} + \gamma_5 OSFUND_j + \gamma_6 OSFUND_{j-1} + \gamma_7 PNW_j \\ & + \gamma_8 PNW_{j-1} + \gamma_9 PCA_j + \gamma_{10} PCA_{j-1} + \gamma_{11} VPROPSD_j \\ & + \gamma_{12} VPROPSD_{j-1} + \gamma_{13} TREND_j + \varepsilon_j, \qquad j = (2, \ldots, n), \end{aligned} \tag{3.12}$$

by ordinary least squares yields consistent estimators of the parameters (Johnston, 1972, p. 263).

One modification of the above procedure had to be made due to the nature of the data set (i.e., cross-sectional data pooled over time). Before estimation of equation (3.12), the 1958 observation for each of the 23 counties was dropped. Failure to do so would have implied that the disturbance term for the observation of county "B" in year 1958 is functionally related to the disturbance term for the observation of county "A" in year 1980 which is clearly not justified.

Using $\hat{\rho}$ from the estimation of equation (3.12), the original observations were transformed as follows:

$$\hat{X}_j = X_j - (\hat{\rho} * X_{j-1}), \text{ for all variables.} \tag{3.13}$$

Again, and for the same justification as above, the 1958 observation for each county was dropped. The next sections discuss the regression

results from the estimation of the demand functions for teachers using the data transformation described above to correct for positive first-order autocorrelation.

4. Estimation of the demand for teachers

This section describes the estimation of equation (3.9) using the transformed data. The expected coefficient signs, assuming that teachers are a normal input in the production of education, were justified in Section C(1) of this chapter and are as follows:

$$\underset{\text{PTS}}{} = f(\underset{(-)}{\text{TPRICE}}, \underset{(+)}{\text{LOCFUND}}, \underset{(+)}{\text{OSFUND}}, \underset{(?)}{\text{PNW}}, \underset{(?)}{\text{PCA}}, \underset{(?)}{\text{VPROPSD}}, \underset{(?)}{\text{TREND}}). \quad (3.14)$$

Table 2 describes the results from the estimation of equation (3.14) using three specifications of TPRICE, the price of teacher services. F-tests for each regression indicate that the hypothesis that there is no linear relationship among PTS and the independent variables can be rejected in all three cases. Between 37 and 39 percent of the variation in the demand for teachers is explained by each of the three regressions. Durbin-Watson tables were available up to only n=200 observations. Use of this table indicated that the hypothesis of no autocorrelation among the error terms using the transformed data can be accepted at the five percent significance level.

AVSALSD, the average of actual teacher salaries paid, was the only specification of the price of teacher services that was significant and showed the expected sign. According to the parameter estimate, an

Table 2. Estimation of teacher demand by school districts (1958-1980)

Independent variables	Dependent variable PTS (23 school district sample[a])		
Intercept	.004913315 (1.8408)**	.001790258 (.5626)	.001986487 (.6180)
AVSALSD	-9.48366 E-7 (-4.8123)*		
BSAL		7.62183 E-8 (.2006)	
MIDSAL			2.79098 E-9 (.0100)
LOCFUND	5.00013 E-7 (1.3050)	4.44853 E-7 (1.1216)	4.47922 E-7 (1.1295)
OSFUND	-4.02932 E-7 (-1.0220)	-3.30270 E-7 (-.8087)	-3.31565 E-7 (-.8117)
PNW	.00003836556 (.9812)	.00006598477 (1.8804)**	.00006585967 (1.8579)**
PCA	.0002173547 (1.6558)**	.0002698575 (1.9918)*	.000267795 (1.966)*
VPROPSD	3.37072 E-7 (1.1648)	4.903883 E-7 (1.6623)**	4.82284 E-7 (1.6368)**
TREND	.00105262 (13.0792)*	.001090657 (12.8028)*	.00108275 (12.9513)*
F	41.32	43.99	43.87
R^2	.38	.39	.39
D.W.	2.05	2.14	2.14
n	488	488	488

[a]t-statistics in parentheses (2-tailed test).

*Significant at five percent.

**Significant at ten percent.

increase in average teacher salaries of 1,000 1972 dollars would result in a decrease of one teacher demanded for every 1,000 students.

Neither of the budget measures, local or state and local educational funds per pupil, were significant in any of the regressions. To test whether this lack of significance resulted from improperly disaggregating the budget into two measures, the same regressions were run combining all current educational funds per student into one measure, TOTFUND. However, the estimated coefficients of TOTFUND were found to be insignificant in all three cases.

For a one percentage point increase in PNW, the percent of the population served by the school district that is nonwhite, the school district demands approximately one more teacher for every 1,500 students according to the two regressions where PNW came in significantly. A one percentage point increase in PCA, the average percent of pupils attending, increases the demand for teachers by the school district by between one teacher for every 3,700 students and one teacher for every 4,750 students. According to the two regressions in which VPROPSD came in significantly, a school district with an additional $100 in plant and equipment per pupil will employ one additional teacher per 20,000 students. Finally, determinants of teacher demand that change over time and are not captured by the variables discussed above caused an increase in one teacher per 1,000 students each year.

Thus, AVSALSD did a better job of capturing the true price of teacher services faced by the school district than did the other measures which were constructed by the salary schedule of the school district.

Although the estimated coefficient of LOCFUND, local educational funds per pupil, was positive and had a t-statistic greater than one in all three cases, it was not significant at the ten percent level in any of the three regressions. The coefficient estimate for OSFUND, state and federal funds per pupil, was also insignificant in each case and actually came in with a negative sign which was not as expected. PCA and VPROPSD generally came in positive and significant which can be taken to imply that a home environment supportive of education and a higher quality physical learning environment both increase the productivity of teachers at the margin, causing more to be hired. As PNW was included to control for home, community, and pupil characteristics, it is difficult to pinpoint the cause of its positive effect on the demand for teachers. Finally, the strongly significant effect of the time trend variable indicates that factors not measured by this model but that change over time have a positive effect on the demand for teachers for the period studied.

Past studies of school districts have employed locational dummy variables (Wentzler, 1981, pp. 438-445) or have broken the data set down into groups based upon population size (Landon and Baird, 1971, p. 968) or community types (Brown, 1972, pp. 203-218) in order to control for the effects of community tastes and attitudes towards education and district size on the demand for teachers. In order to see whether school district size affects the responsiveness of teacher demand to the price of teacher services, the data set was broken down into three groups--small, medium-sized, and large school districts. The criteria chosen were as follows.

The four "large" school districts had a 1958 population greater than 100,000 and had over 20,000 pupils belonging to the public school system. The ten "medium-sized" school districts had a 1958 population of between 29,500 and 100,000 and had between 6,000 and 20,000 pupils. "Small" districts had a 1958 population less than 29,500 and had less than 6,000 pupils in the public school system. All of the school districts exhibited varying degrees of growth over the next 22 years, however it was such that the school districts remained in their respective categories. In 1980, the "large" school districts had a population of over 120,000 and over 25,000 students enrolled, "medium-sized" districts had a population of between 35,000 and 120,000 and between 8,000 and 25,000 students, and, finally, the "small" school districts had a population less than 35,000 and less than 8,000 students.

Equation (3.14) was estimated using the three subsets of the data described above. The data were transformed by the procedure detailed in Section C(1) of this chapter to correct for positive first-order autocorrelation of the error terms. Regression results are shown in Tables 3, 4, and 5 of the small, medium, and large school districts, respectively. For each, separate regressions were run for the three specifications of TPRICE, the price of teacher services.

F-tests indicate that the hypothesis of no linear relationship between teachers and the independent variables can be rejected in all nine cases. The data transformation was successful in removing the positive first-order autorcorrelation. The percentage of the variation in the demand for teachers explained by the independent variables ranges

Table 3. Estimation of the demand for teachers by small school districts (1958-1980)

Independent variables	Dependent variable PTS (small school district sample)[a]		
Intercept	.000404805 (.0668)	-.00175592 (-.2691)	.001381359 (.2145)
AVSALSD	-.0000012029 (-3.7638)*		
BSAL		-6.00780 E-7 (-1.0488)	
MIDSAL			-9.83740 E-7 (-2.2985)*
LOCFUND	.00001470735 (5.4311)*	.00001303325 (4.6766)*	.00001470713 (5.0854)*
OSFUND	2.68753 E-8 (.0402)	4.71821 E-8 (.0681)	-2.03525 E-8 (-.0298)
PNW	.000041981 (1.0333)	.00004387903 (1.0502)	.00004466664 (1.0719)
PCA	.0004466171 (2.3407)*	.0004445116 (2.2492)*	.0003951003 (2.0123)*
VPROPSD	6.61299 E-7 (1.6967)**	7.26943 E-7 (1.7954)**	6.27579 E-7 (1.5573)
TREND	.000834835 (7.9793)*	.0008639194 (7.3176)*	.0007988464 (6.7645)*
	- - - - - - - -		
F	60.56	56.40	56.68
R^2	.69	.68	.68
D.W.	1.92	1.91	1.94
n	197	197	197

[a]t-statistics in parentheses (2-tailed test).

*Significant at five percent.

**Significant at ten percent.

Table 4. Estimation of the demand for teachers by medium-sized school districts (1958-1980)

Independent variables	Dependent variable PTS (medium-sized school district sample)[a]		
Intercept	.013862 (1.5745)	.005443046 (.5505)	.005375242 (.5439)
AVSALSD	-.0000011367 (-3.6278)*		
BSAL		2.19212 E-7 (.4333)	
MIDSAL			1.66006 E-7 (.4668)
LOCFUND	3.84012 E-7 (.6976)	2.71845 E-7 (.5951)	2.72644 E-7 (.5967)
OSFUND	-2.68324 E-7 (-.4701)	-7.15078 E-8 (-.1204)	-7.40046 E-8 (-.1246)
PNW	-.0000097439 (-.2454)	.00001877313 (.500)	.00002036694 (.5438)
PCA	.0001929503 (.9506)	.0002589274 (1.2421)	.0002612754 (1.2525)
VPROPSD	-2.63013 E-7 (-.6303)	-1.51063 E-7 (-.3501)	-1.42152 E-7 (-.3270)
TREND	.0008846982 (13.6691)*	.0009101606 (13.2194)	.0009066226 (13.8603)
	- - - - - - - -		
F	42.76	43.88	44.10
R^2	.60	.61	.61
D.W.	2.05	2.12	2.12
n	208	208	208

[a]t-statistics in parentheses.

*Significant at five percent.

Table 5. Estimation of the demand for teachers by large school districts (1958-1980)

Independent variables	Dependent variable PTS (large school district sample)[a]		
Intercept	-.010754 (.4821)	-.026787 (-1.1650)	-.027895 (-1.2396)
AVSALSD	-3.68408 E-7 (-1.0476)		
BSAL		9.37476 E-8 (.2031)	
MIDSAL			1.96329 E-7 (.7916)
LOCFUND	.00001454854 (5.8094)*	.00001322562 (8.1854)*	.00001348509 (8.5463)*
OSFUND	.00000146129 (2.5156)*	.00001373958 (2.6393)*	.00001390186 (2.7832)*
PNW	-.000124384 (-2.2949)*	-.000103489 (-2.0668)*	-.0000992859 (-2.1007)*
PCA	.0005343299 (1.5893)	.0006921371 (2.2241)*	.0006777479 (2.2339)*
VPROPSD	.00000110097 (2.2546)*	.00000138372 (2.9740)*	.00000144434 (3.2249)*
TREND	.0004825729 (5.0400)*	.0004930393 (5.5553)*	.0004919614 (5.8923)*
	- - - - - - - -		
F	100.28	125.37	135.17
R^2	.90	.92	.93
D.W.	2.24	2.22	2.22
n	83	83	83

[a]t-statistics in parentheses.

*Significant at five percent.

from 60 percent for the medium-sized school districts to over 90 percent for the large school district sample. This compares with R-squared values of between 37 and 39 for the combined 23 school district sample.

The Chow test was used to determine whether the disaggregation of the data set into the three groups was justified on the basis that the three samples were actually drawn from three separate populations (Intriligator, 1978, pp. 123-125). The test statistic,

$$F_c = \frac{[SSE_{23} - (SSE_S + SSE_M + SSE_L)]/k}{(SSE_S + SSE_M + SSE_L)/(n_1 + n_2 + n_3 - 3k)}, \qquad (3.15)$$

is distributed as $F(2*k, n_1 + n_2 + n_3 - 3*k)$ where n_1, n_2, and n_3 are the sample sizes of the three groups of school districts, k is the number of independent explanatory variables including the intercept, and SSE_{23}, SSE_S, SSE_M, and SSE_L are the error sums of squares for the 23--the small, the medium, and the large school district samples, respectively. F_c values of 4.8, 4.4, and 4.9 were obtained for the three specifications of the price of teacher services, AVSALSD, BSAL, and MIDSAL, respectively. Thus, the hypothesis that the three subsamples are drawn from the same population, implying that parameters are the same over the three subsamples, is rejected at the one percent significance level for each of the three wage specifications. This result suggests that factors related to the size of the school district do affect the determination of teacher demand by school districts.

Use of AVSALSD to capture the price of teacher services yielded the expected negative effect on the quantity of teacher services demanded,

but this effect was significant for only the small and medium-sized school districts. Actually, none of the three wage specifications had a significant effect on the demand for teacher services by large school districts. For the small school districts, the two "average" specifications, AVSALSD and MIDSAL, had the expected negative and significant effect. For the medium-sized school districts, only AVSALSD, the average of actual salaries paid, showed the expected negative effect and came in significantly.

The three regressions using data from the medium-sized school districts yielded poor results. The time trend variable was the only variable that was significant across all three regressions.

LOCFUND, local educational funds per pupil, had the expected positive sign and came in significantly in all cases for the small and the large school district samples. For these two samples, the parameter estimates were of comparable magnitudes. OSFUND, state and federal educational funds, had a significant positive effect on the demand for teachers among the large school districts only.

PNW, the percentage of the population that is nonwhite, had a significant negative effect on the quantity of teachers demanded in large school districts but mixed effects, none significant, in the small and medium-sized school districts. PCA, the attendance measure, had a positive effect on the demand for teachers in the small and large school district samples, this effect being significant in two of three large sample regressions and in all three of the small school district regressions. The size of the effect is slightly larger within the large school districts.

The value of school property and equipment per student had a positive effect on the demand for teachers in all of the regressions using the small and large school district samples. This effect was significant in all three of the regressions using the large school district data and was significant or approached significance in the three regressions using the small district data. Its impact on the demand for teachers is roughly twice as large among large school districts as among the small. Finally, the time trend variable had a positive significant effect across all nine regressions, the size of the effect among the large districts being about 60 percent of that within the small and medium-sized districts.

5. Estimation of the demand for elementary and secondary teachers

This section describes the estimation of equation (3.9), now using PTES and PTHS, the teacher-student ratios at the elementary and secondary levels, respectively, as the dependent variables. This breakdown is made to examine the possibility that the markets for teacher services differ at the two schooling levels as was suggested by Wentzler (1981, p. 437). Wentzler considered this to be a possibility because of the different skill requirements and work conditions at each level. The expected signs of the parameter estimates are the same as in the estimation of the demand for teachers by the whole school district.

Durbin's two-step procedure is again used to correct for positive first-order autocorrelation among the error terms. Several changes in the estimation procedure should be noted. First, AVSALEL, the average of

actual salaries paid to teachers within the elementary system, is used in the estimation of the demand for elementary teachers, while AVSALHS, a similar measure for secondary teachers, is used in the estimation of the demand for secondary teachers. PCAE, the average percent of elementary pupils attending, is used to capture the effect of the home environment in the production of education by the school district. The average attendance measure for secondary students is not used in the estimation of PTHS as the attendance record of older pupils is more likely to be a choice variable of those students reflecting the perceived quality of the secondary school system. Finally, VPROPEL and VPROPHS, the value of school property and equipment per elementary and per secondary student, respectively, are used in place of VPROPSD.

The results of the estimation of equation (3.14) using the full 23 school district sample are presented in Tables 6 and 7. Here, due to data availability, the data describe the school systems for the 1958 through 1977 school years. The R-squared values for the estimation of teacher demand at the elementary level are about 70 percent of those from the estimation of teacher demand by the whole school district, while the R-squared values using the secondary level data range from 41 to 54 percent of the R-squared values using the data from the whole school district. F-statistics for the model indicate that the hypothesis of no linear relationship between PTES and PTHS and the independent variables can be rejected at the one percent significance level as had been the case with PTS. The data transformation removed the positive autocorrelation among the error terms.

Table 6. Estimation of the demand for elementary teachers (1958-1977)

Independent variables	Dependent variable PTES (23 school district sample)[a]		
Intercept	.006241828 (1.9834)*	.00273025 (.7264)	.003064846 (.8137)
AVSALEL	-9.25455 E-7 (-4.0542)*		
BSAL		3.05154 E-7 (.6121)	
MIDSAL			1.24772 E-7 (.3546)
LOCFUND	6.79239 E-7 (1.3064)	5.75254 E-7 (1.0749)	5.81527 E-7 (1.0866)
OSFUND	7.88454 E-7 (1.4720)	8.56209 E-7 (1.5507)	8.56286 E-7 (1.5502)
PNW	-.0000473016 (-1.1193)	-.0000279484 (-.7271)	-.0000268353 (-.6892)
VPROPEL	.00000128914 (3.2916)*	.00000143366 (3.6279)*	.00000142147 (3.5957)*
PCAE	.0001814116 (1.4680)	.0002042444 (1.6026)	.0002047551 (1.6027)
TREND	.0008148957 (8.5845)*	.0008731826 (9.1431)*	-.0008609751 (9.2300)
	- - - - - - - -		
F	21.81	22.53	22.40
R^2	.26	.27	.27
D.W.	2.13	2.19	2.19
n	437	437	437

[a] t-statistics in parentheses.

*Significant at five percent.

Table 7. Estimation of the demand for secondary teachers (1958-1977)

Independent variables	Dependent variable PTHS (23 school district sample)[a]		
Intercept	.013758 (16.3541)*	.009190919 (6.3496)*	.009355419 (7.0422)*
AVSALHS	-.0000013274 (-5.2880)*		
BSAL		-.668736 E-7 (1.3052)	
MIDSAL			4.95145 E-7 (1.1806)
LOCFUND	3.61924 E-7 (.6061)	2.40616 E-7 (.3875)	2.40164 E-7 (.3873)
OSFUND	-.000020584 (-3.3511)*	-.000001909 (-2.9905)*	-.0000019012 (-2.9810)*
PNW	.00008517957 (1.6211)**	.0001428973 (2.9300)*	.0001488463 (2.9835)*
VPROPHS	6.14147 E-7 (2.0939)*	7.90438 E-7 (2.6213)*	7.75703 E-7 (2.5765)*
TREND	.0007386722 (6.5504)*	.0008279625 (6.9667)*	.0008149603 (6.9341)*
	- - - - - - - -		
F	18.39	14.55	14.50
R^2	.20	.17	.17
D.W.	2.30	2.30	2.30
n	437	437	437

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Again, as with the estimation of the demand for teachers by the school district, the average of actual salaries paid, here AVSALEL and AVSALHS, is the only specification of the price of teacher services that has a significant negative effect on the demand for teacher services. This effect is slightly larger at the secondary level than at the elementary level. The parameter estimates for the specifications of TPRICE constructed from the salary schedules, BSAL and MIDSAL, had positive signs but were nonsignificant in all cases. LOCFUND, local funds per pupil for current educational expense, had a positive but nonsignificant effect on the demand for teacher services in all of the regressions. OSFUND, combined state and federal funds per pupil for current educational expense, had a positive but insignificant effect on the demand for elementary teachers for all three specifications of the price of teacher services and a significant negative effect on the demand for secondary teachers for the three cases.

It was initially hypothesized that both budget measures would have a positive effect on the demand for teacher services. In order to examine the possibility that the insignificance of both measures in explaining the demand for elementary teachers was due to improperly breaking down the budget constraint into the two measures, another set of regressions for estimating the demand for elementary teachers was run. The same procedures were followed to correct for autocorrelation, but LOCFUND and OSFUND were combined in constructing TOTFUND, total educational funds per pupil for current expenditures. Results of these regressions are shown in Table 8.

Table 8. Estimation of the demand for elementary teachers (1958-1977)

Independent variables	Dependent variable PTES (23 school district sample)[a]		
Intercept	.005924092 (2.0729)*	.002766115 (.7893)	.0031314 (.8867)
AVSALEL	-9.81960 E-7 (-4.2990)*		
BSAL		2.48330 E-7 (.4950)	
MIDSAL			7.40955 E-7 (.2077)
TOTFUND	7.20302 E-7 (1.9366)**	7.03359 E-7 (1.8249)**	7.06797 E-7 (1.8332)**
PNW	-.0000464163 (-1.0082)	-.0000263316 (-.6429)	-.000025921 (-.6277)
VPROPEL	.00000126107 (3.1976)*	.00000140747 (3.5354)*	.00000139608 (3.5071)*
PCAE	.0001790271 (1.4660)	.0002006361 (1.5880)	.0002006193 (1.5830)
TREND	.0008087431 (7.8646)*	.0008720872 (8.5952)*	.008584065 (8.6892)*
	- - - - - - - -		
F	22.70	23.50	23.54
R^2	.24	.25	.25
D.W.	2.18	2.23	2.23
n	437	437	437

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

The R-squared values for the regressions shown in Table 8 were lower, but only by about two percentage points for each regression. The F-statistics of the models increased in each case. Parameter estimates for the nonbudget variables were virtually unchanged and TOTFUND had the expected positive effect on the demand for elementary teachers for the three specifications of TPRICE. This suggests that it is best to use a single budget measure to explain the demand for teacher services at the elementary level.

Returning to the remainder of the parameter estimates in Table 6 (which follow the same pattern of significance and signs as those from Table 8), the percentage of the population that is nonwhite has a consistently negative but nonsignificant effect on the demand for elementary teachers. The parameter estimates for the value of school property and equipment per elementary student are consistently positive and significant at the five percent level. PCAE, the attendance measure, has a positive effect on the demand for elementary teachers for all three specifications of the price of teacher services and approaches significance at the ten percent level for all three cases. Finally, the time trend variable has positive effect on the demand for elementary teachers, significant at the five percent level for all three cases.

Turning to the regression results for estimating the demand for secondary teachers in Table 7, only one of the specifications of TPRICE, AVSALHS, has a negative effect on the demand for secondary teachers. It is significant at the five percent level. Local educational funds per pupil has a positive but nonsignificant effect on the demand for

secondary teachers while the parameter estimates of OSFUND are negative and significant at the five percent level in each case. One possible explanation for the negative effect of state and federal educational funds per pupil on the demand for secondary teachers is that the direction of causality between the two variables may flow in both directions. It was hypothesized that a larger budget would cause school districts to hire more teachers. If federal and state educational dollars are targeted towards disadvantaged school districts and these disadvantaged districts exhibit low teacher-student ratios, then this could account for such a finding. Unlike the coefficient estimates for the budget variables in the estimation of the demand for elementary teachers, the estimated coefficients of the budget measures used to estimate the demand for secondary teachers were of opposite signs. Estimation of the demand for secondary teachers using the single budget measure TOTFUND had little effect on the parameter estimates for the nonbudget variables, the R-squared values, or the F-statistics of the model. The parameter estimates of TOTFUND were significant and negative in each case, indicating that the weak positive effect of LOCFUND was overwhelmed by the negative effect of OSFUND.

The percentage of the population that is nonwhite had a consistently negative and nonsignificant effect on the demand for elementary teachers. This contrasted with the parameter estimates of PNW in the secondary regressions which were positive and significant for all three specifications of the price of teacher services. Estimated coefficients of the value of school property and equipment per pupil at the secondary level

were positive and significant at the five percent level and were a little more than half the size of those for the elementary system. Finally, the time trend variable had a consistently positive and significant effect on the demand for secondary teachers with estimated coefficients similar in size to those in the elementary regressions.

The data set was again broken down into small, medium, and large school districts to examine the possibility that factors related to school district size might affect the school district's responsiveness to the price of teacher services. The demand for teacher services by the elementary and the secondary school systems was estimated for each of the subsamples are for each of the three specifications of the price of teacher services. A single budget measure, TOTFUND, was used for the elementary level regressions while the two budget measures, LOCFUND and OSFUND, were used at the secondary level. The data in each case were transformed to correct for positive first-order autocorrelation among the error terms. The regression results are shown in Tables 9 through 14. Chow tests indicate that the hypothesis that the three subsamples are from the same population can be rejected at the elementary and secondary levels at the one percent significance level. F-tests of the models indicate that the hypothesis of no linear relationship between the dependent and the independent variables can be rejected at the one percent significance level in each case.

Of the specifications of the price of teacher services, AVSALEL and AVSALHS, the averages of actual salaries paid at the elementary and secondary levels, respectively, again perform best. Their estimated

Table 9. Estimation of the demand for elementary teachers by small school districts (1958-1977)

Independent variables	Dependent variable PTES (small school district sample)[a]		
Intercept	.004675271 (1.0588)	.002656181 (.4810)	.00400257 (.7332)
AVSALEL	-.0000012009 (-3.0880)*		
BSAL		-3.45845 E-8 (-.0455)	
MIDSAL			-4.76824 E-7 (-.8341)
TOTFUND	.00000155852 (1.8555)**	.00000144826 (1.6448)**	.00000145533 (1.6611)**
PNW	-.0000467064 (-.6209)	-.0000673395 (-1.0092)	-.0000601123 (-.8915)
VPROPEL	.00000141392 (2.8447)*	.00000154824 (3.1014)*	.00000150514 (3.0060)*
PCAE	.0002152891 (1.1619)	.0002069131 (1.0675)	.0001986365 (1.0287)
TREND	.001092891 (6.7202)*	.001134688 (7.4418)*	.001111886 (7.4672)*
	- - - - - - - - -		
F	19.57	21.35	21.03
R^2	.42	.44	.44
D.W.	2.15	2.20	2.18
n	171	171	171

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 10. Estimation of the demand for elementary teachers by medium-sized school districts (1958-1977)

Independent variables	Dependent variable PTES (medium school district sample)[a]		
Intercept	.008501043 (1.0782)	.003937103 (.4653)	.00267491 (.3189)
AVSALEL	-4.36859 E-7 (-1.2572)		
BSAL		5.58150 E-7 (.8062)	
MIDSAL			6.28580 E-7 (1.2941)
TOTFUND	6.19154 E-7 (1.3375)	6.42143 E-7 (1.3765)	6.40306 E-7 (1.3767)
PNW	-.000084018 (-1.6684)**	-.0000826504 (-1.6808)**	-.000078395 (-1.6025)**
VPROPEL	3.44768 E-7 (.4884)	4.34800 E-7 (.6064)	5.12982 E-7 (.7159)
PCAE	.0002082424 (1.1483)	.0002246559 (1.2314)	.0002322501 (1.2756)
TREND	.0006983323 (8.2987)*	.0007296688 (8.3594)*	.0007282527 (8.6916)
	- - - - - - - -		
F	16.01	16.67	16.90
R^2	.34	.35	.36
D.W.	2.10	2.12	2.12
n	190	190	190

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 11. Estimation of the demand for elementary teachers by large school districts (1958-1977)

Independent variables	Dependent variable PTES (large school district sample)[a]		
Intercept	.016201 (.7584)	-.044580 (-1.2452)	-.041467 (-1.0627)
AVSALEL	-.0000018125 (-3.4102)*		
BSAL		.00000173766 (1.9269)**	
MIDSAL			.00000114929 (2.6252)*
TOTFUND	.00001799453 (3.9936)*	.00001153149 (3.9237)*	.00001266922 (4.6949)*
PNW	-.0000854714 (-.8483)	-.0000027685 (-.0383)	-.0000055903 (-.0891)
VPROPEL	6.94844 E-7 (.7794)	.00000196231 (2.3625)*	.00000186459 (2.4459)*
PCAE	.0001011386 (.2064)	.000806289 (1.5534)	.000714528 (1.3743)
TREND	.0003128502 (1.6415)**	.0003849789 (2.7656)*	.000365073 (2.8910)*
	- - - - - - - -		
F	12.01	27.12	34.88
R^2	.51	.70	.75
D.W.	2.05	2.16	2.08
n	76	76	76

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 12. Estimation of the demand for secondary teachers by small school districts (1958-1977)

Independent variables	Dependent variable PTHS (small school district sample)[a]		
Intercept	.011431 (9.5111)*	.009087116 (4.9966)*	.009314361 (5.4268)*
AVSALHS	-.0000016887 (-4.1521)*		
BSAL		-2.43455 E-7 (-.2758)	
MIDSAL			-2.96482 E-7 (-.4391)
LOCFUND	.00001405771 (2.7091)*	.00001216996 (2.2640)*	.00001256835 (2.2878)*
OSFUND	-.0000016398 (-1.7987)**	-.0000014687 (-1.5181)	-.0000014757 (-1.5254)
PNW	.0001499888 (1.4980)	.0001597189 (1.6508)**	.000160232 (1.6640)**
VPROPHS	.0000010434 (2.5337)*	.00000106766 (2.5268)*	.00000106668 (2.5308)*
TREND	.0002235434 (.9081)	.0003585821 (1.3798)	.0003433427 (1.3357)
	- - - - - - - -		
F	9.72	6.86	6.90
R^2	.26	.20	.20
D.W.	2.14	1.99	1.98
n	181	181	181

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 13. Estimation of the demand for secondary teachers by medium-sized school districts (1958-1977)

Independent variables	Dependent variable PTHS (medium-sized school district sample)[a]		
Intercept	.023555 (11.8368)*	.011696 (3.4467)*	.013044 (4.1669)*
AVSALHS	-.0000019583 (-4.2871)*		
BSAL		.00000172719 (1.7774)**	
MIDSAL			9.78538 E-7 (1.3861)
LOCFUND	3.13467 E-8 (.0424)	4.40114 E-8 (.0563)	5.221322 E-8 (.0668)
OSFUND	-.0000018384 (-1.9235)**	-.0000016228 (-1.6074)	-.0000016621 (-1.6460)
PNW	.0000998582 (1.2373)	.0001558389 (2.0922)*	.0001679819 (2.2173)*
VPROPHS	7.73243 E-8 (.1557)	2.70234 E-7 (.5303)	2.88727 E-7 (.5592)
TREND	.0008217258 (6.2911)*	.0008986099 (6.7230)*	.008563224 (6.5574)*
	- - - - - - - -		
F	11.71	9.87	.936
R^2	.28	.24	.23
D.W.	2.31	2.30	2.31
n	190	190	190

[a] t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 14. Estimation of the demand for secondary teachers by large school districts (1958-1977)

Independent variables	Dependent variable PTHS (large school district sample)[a]		
Intercept	.035015 (11.5843)*	.033145 (7.9507)*	.030460 (9.0375)*
AVSALHS	-9.35829 E-7 (-2.5934)*		
BSAL		-.0000014016 (-2.0117)*	
MIDSAL			-4.77066 E-7 (-1.3442)
LOCFUND	.00001801104 (5.8786)*	.00001162325 (4.8277)*	.00001151457 (4.8488)*
OSFUND	.00002111669 (2.9731)*	.00001534377 (2.0580)*	.00001328373 (1.8545)**
PNW	-.000233311 (-3.6672)*	-.000234557 (-3.1659)*	-.000207471 (-2.9442)*
VPROPHS	3.01733 E-7 (.5206)	1.71529 E-7 (.2870)	3.61276 E-7 (.6018)
TREND	.00043196 (4.3312)*	.0004783139 (4.2029)*	.0004965613 (4.5144)*
F	81.12	56.40	59.97
R^2	.87	.83	.84
D.W.	1.85	1.84	1.86
n	76	76	76

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

coefficients are negative in all cases and are significant for all regressions except for the estimation of the demand for elementary teachers by medium-sized school districts. BSAL and AVSAL, both constructed from the salary schedules of the school districts, had a negative effect on the demand for secondary teachers in the large and small districts but only one case showed significance. Both had a positive effect on the demand for secondary teachers within the medium-sized districts but only the parameter estimate for BSAL showed significance. Neither BSAL nor MIDSAL performed as expected in explaining the demand for elementary teachers, both measures' coefficient estimates positive and significant among large school districts, positive but not significant for medium-sized school districts, and negative but not significant for small districts.

In estimating the demand for elementary teachers, coefficient estimates of the budget variable had a positive sign in all cases and were significant across all wage specifications for the small and large school districts and approached significance for the medium-sized school districts. The two budget measures had a positive and significant effect on the demand for secondary teachers within the large school districts. Among the small school districts, the positive and significant coefficient estimates on the local funds measure were much larger in size than the negative coefficient estimates on the measure of state and local funds. Within the medium-sized districts, the two budget measures showed the same pattern as they did in the estimation of the demand for secondary teachers using the combined 23 school district sample. Parameter

estimates for LOCFUND were positive for small and medium-sized districts, although significant within the small districts only. The estimated coefficients for OSFUND were negative among both groups, but were significant only in the regressions using AVSALHS as the measure of the price of teacher services.

The percentage of the population that is nonwhite, PNW, had a negative effect on the demand for elementary teachers for all three samples, however this effect was significant among medium-sized districts only. At the secondary level, coefficient estimates for PNW were negative and significant among the large school districts while they were positive and significant or approached significance among the small and medium-sized districts. The value of school property and equipment per pupil increased the quantity of teachers demanded in all cases. This effect was not significant in explaining the demand for elementary teachers by medium-sized districts, nor in explaining the demand for secondary teachers among medium and large districts. Attendance had a positive effect on the demand for elementary teachers. This effect was not significant at the ten percent level but t-statistics were greater than one in all but one of the regressions. Finally, coefficient estimates of the time trend variable were positive in all cases and significant in all except for explaining the demand for secondary teachers by small school districts.

6. Estimation of the demand for teacher experience

This section describes the estimation of demand functions for teacher quality, here quality being measured by years of teaching

experience. As before, the school district is assumed to be a price taker in the market for teacher services. Regressions for the school district as a whole (elementary and secondary combined), the elementary system, and the secondary system are performed. The data describe the 1961 through 1972 school years.

Four measures of teacher experience are used. LXSD, LXES, and LXHS represent the per student number of less experienced teachers within the school district, the elementary system, and the secondary system, respectively. Less experienced teachers are those with four or less years of teaching experience. MXSD, MXES, and MXHS are the per student number of more experienced teachers within the school district, the elementary system, and the secondary system, respectively. More experienced teachers are those with more than four years of teaching experience. The four-year mark is chosen as a dividing line based upon data availability and a finding by Murnane (1984, pp. 516-518) that teachers with more than four years of teaching experience tend to have found a successful "job match." Those individuals who are less productive realize that they have made a nonoptimal job match, causing them to leave in search of a better job match (Jovanovic, 1979, pp. 976-977). Thus, on average the more experienced teachers are more productive than those less experienced as selective attrition of the less productive teachers has already occurred among the more experienced group. Also, these more experienced teachers have acquired human capital through on-the-job experience.

A third measure, EXPSD, EXPSEL, and EXPSHS, total years of teaching experience per student within the school district, the elementary system,

rnd the secondary system, respectively, is constructed by summing the years of teaching experience of all teachers and dividing by the number of students. It is constructed so as to be consistent with the form of the dependent variables (i.e., on a per student basis). It is interpreted as a measure of the average quality of teacher that students interact with. Finally, ATEXSD, ATEXEL, and ATEXHS, average years of experience per teacher within the school district, the elementary system, and the secondary system, respectively, are included in order to compare results with those of the Brown (1972) study. It is the only dependent variable not measured in per student terms.

From equation (3.8), the demand functions and expected signs of the exogenous variables are

$$\underset{(-)\quad(?)\quad(+)\quad(+)\quad(?)\quad(?)\quad(?)\quad(?)}{LXSD = F(BSAL,\ INCEX,\ LOCFUND,\ OSFUND,\ PNW,\ PCA,\ VPROPSD,\ TREND)} \tag{3.16}$$

$$MXSD \tag{3.17}$$

$$\left.\begin{matrix} \\ EXPSD \\ \\ \end{matrix}\right\} \underset{(?)\quad(-)\quad(+)\quad(+)\quad(?)\quad(?)\quad(?)\quad(?)}{= F(BSAL,\ INCEX,\ LOCFUND,\ OSFUND,\ PNW,\ PCA,\ VPROPSD,\ TREND)} \tag{3.18}$$

$$ATEXSD \tag{3.19}$$

School districts have the option of purchasing the services of more or less experienced teachers. The price of the services of less experienced teachers is less than that of the more experienced teachers. However, these less experienced teachers are also assumed to be less productive. Thus, the quantity demanded of the less experienced teachers, LXSD, is expected to be lower the higher is their price, BSAL. BSAL is measured by the starting salary of teachers with a bachelor's

degree. INCEX, the price of teacher experience, is the average pay increment for a year of teaching experience. It is constructed from the salary schedules of each of the school districts. The effect of INCEX on the demand for LXSD depends on whether more and less experienced teachers are gross complements or substitutes. In estimating the demand for MXSD, EXPSD, and ATEXSD, INCEX is viewed as being the own-price of these inputs and is expected to have a negative sign. The sign of BSAL in equations (3.17) through (3.19) depends again on whether more and less experienced teachers are gross complements or substitutes. Assuming that each of the experience measures represents a normal input in the production of education, both budget measures are expected to have a positive effect on demand. The signs of the remainder of the explanatory variables are not determined a priori.

Initial model estimation indicated the presence of first-order autocorrelation. Durbin's two-step correction procedure was again used to transform the data. Regression results for the estimation of the demand for LXSD and MXSD using the transformed data are presented in Table 15. Estimates of EXPSD and ATEXSD were performed but not reported as the hypothesis of no linear relationship between the independent and dependent variables was not rejected at the ten percent significance level.

F-tests indicate that both models have significant explanatory power, at five percent for LXSD and at ten percent for MXSD. The correction procedure removed the positive first-order autocorrelation in both cases. Neither of the price variables had significant explanatory powers

Table 15. Estimation of the demand for teacher experience by school districts (1961-1972)

	23 school district sample[a]	
	LXSD	MXSD
Intercept	.0008835791 (.4557)	.001890429 (1.4757)
INCEX	3.95994 E-7 (.1185)	-.0000032508 (-1.2862)
BSAL	-1.70767 E-7 (-.4154)	-6.91714 E-7 (-2.2278)*
LOCFUND	.00000577673 (1.9468)**	.00000650236 (2.8410)*
OSFUND	.00000963866 (3.0650)*	.00000277962 (1.1594)
PNW	.00002443735 (.3089)	-.00000160426 (-.2223)
PCA	0.0000200443 (-.1315)	.000181115 (1.5719)
VPROPSD	3.89934 E-7 (1.0031)	1.89340 E-7 (.6410)
TREND	.0004640547 (1.4719)	-.00020156 (.7108)
	- - - - - - - -	
F	2.37	1.9
R^2	.07	.06
D.W.	2.14	1.99
n	253	253

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

in the estimation of the demand for less experienced teachers. Both budget measures had a positive and significant effect on the demand for LXSD as expected. None of the remainder of the explanatory variables were significant in determining the demand for less experienced teachers.

INCEX, the experience price measure, had the expected negative sign but was not significant in explaining the demand for MXSD. The estimated coefficient for BSAL, the base salary for teachers with a bachelor's degree, was negative and significant. It may be that because BSAL is a component of the total price of the services of an experienced teacher (e.g., price of the services of an experienced teacher = base salary + (pay increment for a year of experience) * (years of experience)), that BSAL also picks up the effect the own-price of more experienced teachers on the demand for MXSD. Local educational funds per pupil, LOCFUND, came in positive and significant. The remainder of the explanatory variables were not significant. Both equations were estimated using a budget measure which combined both the local and state and federal funds per pupil. This had no effect on the results.

Next, the data for the 23 school districts were broken down into elementary (K-6) and secondary (7-12) levels in order to see whether the market for teacher services differed at the two levels. The dependent variables used were LXES and LXHS, the number of less experienced teachers per pupil at the elementary and secondary levels, MXES, and MXHS, the number of more experienced teachers per student at the elementary and secondary levels, EXPSEL and EXPSHS, years of teaching experience per student at the elementary and secondary level, and ATEXEL

and ATEXHS, average years of experience per teacher at the elementary and secondary levels. In estimating demand at the elementary level, PCAE, the average percent of elementary students attending, and VPROPEL, the value of school property and equipment per student within the elementary system, were used in place of PCA and VPROPSD. Also, consistent with the estimation of teacher demand at the elementary level in Section C(5) of this chapter, the two budget measures are combined into one, TOTFUND. In estimating the demand for teachers at the secondary level, PCA was dropped and VPROPHS, the value of school property and equipment per secondary student, was used in place of VPROPSD. Expected coefficient signs are the same as before.

The data were again transformed to correct for autocorrelation. Regression results for estimating the demand for ATEXHS are not reported as the F-test indicated the model had no explanatory power. Estimation results for the remainder of the experience measures are presented in Tables 16 and 17. First-order autocorrelation was successfully removed in all cases except for the demand for MXHS.

The price variables were not significant in explaining the demand for less experienced teachers at the elementary or the secondary level. The estimated coefficients for the budget variables were positive at both the elementary and secondary levels, but were significant only in explaining LXES. PNW, the percent of the population that is nonwhite, had a significant negative effect on the demand for less experienced teachers at the elementary level while it had a positive and significant effect on the demand for less experienced teachers at the secondary

Table 16. Estimation of the demand for teacher experience at the elementary level (1961-1972)

	23 school district sample[a]			
	LXES	MXES	EXPSEL	ATEXEL
Intercept	.002228356 (.8131)	.005839087 (4.5960)*	.165394 (5.3254)*	1.250299 (2.9554)*
INCEX	.00000434455 (1.0238)	-5.55052 E-7 (-.1551)	.00000775148 (.1371)	.0005867598 (.4543)
BSAL	-1.62399 E-7 (-.3049)	-.0000014559 (-3.2913)*	-.0000167993 (-2.4178)*	.000255138 (1.6012)
TOTFUND	.00000880832 (2.8734)*	.00000365753 (1.3815)	.00006581373 (1.5571)	.00223705 (-2.3359)*
PNW	-.0000933699 (-1.6442)**	.0001044955 (.9623)	.011309 (2.0536)*	.066742 (1.2854)
PCAE	-.0000627346 (-.4802)	-.0000198598 (-.1847)	-.000369283 (-.2190)	-.00111219 (-.0287)
VPROPEL	-1.05209 E-7 (-.1825)	9.13016 E-7 (1.8436)**	.00002306952 (2.9266)*	.0002688033 (1.4997)
TREND	.0003391358 (1.3906)	-.00185629 (-4.3897)*	-.146038 (-5.5082)*	-.540559 (-2.7128)*
		- - - - - - - -		
F	3.73	3.95	6.15	3.6
R^2	.10	.10	.15	.09
D.W.	2.15	1.92	1.90	2.16
n	253	253	253	253

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 17. Estimation of the demand for teacher experience at the secondary level (1961-1972)

	23 school district sample[a]		
	LXHS	MXHS	EXPSHS
Intercept	-.000195794 (-.1973)	.004960101 (4.1538)*	.028751 (1.8645)**
INCEX	-.0000035743 (-.8350)	-.0000081265 (-1.7207)**	-.00007031658 (-1.1349)
BSAL	1.45873 E-7 (.2775)	3.99634 E-8 (-.0683)	3.57313 E-8 (.0041)
LOCFUND	.00000381449 (.9688)	.00000610891 (1.5823)	.00005955649 (.9568)
OSFUND	.00000511189 (1.2511)	.00000627175 (1.4648)	.0001401849 (2.1215)*
PNW	.0003119466 (2.1919)*	-.000087107 (-1.3440)	-.000946296 (-.5921)
VPROPHS	5.69859 E-7 (1.9299)**	-6.18777 E-8 (-.1941)	-1.91837 E-7 (-.0388)
TREND	.0008944892 (1.6381)	.0009183448 (3.4029)*	.022559 (3.5885)*
	- - - - - - - -		
F	2.2	4.1	3.5
R^2	.06	.11	.09
D.W.	1.95	1.68	1.73
n	253	253	253

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

level. The remainder of the explanatory variables had no significant effect on the demand for less experienced teachers at the elementary level. The value of school property and equipment per pupil was the only other variable to have a significant effect on the demand for less experienced teachers at the secondary level, this effect being positive.

Looking at the demand for more experienced teachers, the price increment of experience, INCEX, has a negative but nonsignificant effect on the demand for more experienced teachers at the elementary level while the base salary, BSAL, has a significant negative effect as it did for the combined sample. In explaining the demand for more experienced teachers at the secondary level, the coefficient estimate for INCEX has the expected negative sign and is significant while BSAL has no significant explanatory power. TOTFUND, total educational funds per pupil, has a positive effect on the demand for MXES, but is not significant. Coefficient estimates for both budget measures are positive in the estimation of the demand for more experienced teachers at the secondary level, but neither is significant. When the two budget measures were combined into one, the total educational funds per pupil had a significant positive effect on the demand for MXHS with little change in the other parameter estimates.

PNW, the percent of the population that is nonwhite, had no significant effect on the demand for more experienced teachers at either level. The value of school property and equipment per pupil had a positive and significant effect in the demand for more experienced

teachers at the elementary level but was insignificant in explaining the demand for more experienced teachers at the secondary level.

Estimation of the years of teaching experience per student at the two levels, EXPSEL and EXPSHS, yielded results consistent with those from the estimation of the demand for more experienced teachers. At the elementary level, the only noticeable difference was that PNW became a significant explanatory variable. It had a positive effect on the demand for EXPSEL. At the secondary level, the price increment of experience, INCEX, lost its significance while one of the budget variables, OSFUND, became significant.

Finally, in estimating the demand for ATEXEL, average years of experience per elementary teacher, it was expected that the parameter estimates would follow the same pattern as those in the estimation of the demand for MXES and EXPSEL. This, however, did not occur. INCEX again did not have any significant explanatory power. The coefficient estimate for BSAL was positive but not significant which differed from its effect in explaining MXES and EXPSEL. This finding is consistent with expectations as BSAL represents the price the school district must pay for inexperienced teachers, a potential substitute for experienced teachers. The budget measure, TOTFUND, had significant explanatory power but was of the wrong sign. The only other explanatory variable that showed significance was the time trend variable. Its coefficient estimate was negative which is consistent with the other regression results for the elementary system.

Brown (1972) found that an average salary measure, the average of actual salaries paid, had a positive and significant effect on the demand for average teacher experience by school districts. He considered this to be an unexpected result. Put within the context of this study which uses two prices in the estimation of the demand for teacher experience, his finding may have resulted from the use of a single price variable. If that price variable picked up the effect of the price of inexperienced teachers, a potential substitute for experienced teachers, a positive coefficient estimate could be a reasonable outcome.

The data were broken down into three groups, small, medium-sized, and large school districts as in Section C(3) of this chapter. However, the regression results yielded no additional information and thus are not reported here.

7. Estimation of the demand for teacher educational preparation

This section describes the estimation of demand functions for teacher quality, this time quality being measured by the teacher's level of educational preparation. Again, the school district is assumed to be a price taker in the market for teacher services. Regressions for the school district as a whole (elementary and secondary levels combined), the elementary system, and the secondary system are performed. The data describe the 1961 through 1972 school years. It is again transformed using Durbin's two-step procedure to correct for positive first-order autorcorrelation.

Three levels of educational preparation are considered. LDS represents the number of teachers in the school district who do not possess a bachelor's degree. BDS measures the number of teachers in the school district who possess a bachelor's degree. Finally, the number of teachers in the school district with a master's or higher degree is represented by HDS. All three measures are in per pupil terms. It is assumed that teachers who possess higher levels of educational preparation have acquired greater levels of human capital and thus are more productive in the production of education by the school system.

From equation (3.8) the demand functions to be estimated, along with the expected signs of the exogenous variables, are as follows:

$$\underset{(-)}{\text{BSAL}},\ \underset{(?)}{\text{INCED}},\ \underset{(+)}{\text{LOCFUND}},\ \underset{(+)}{\text{OSFUND}},\ \underset{(?)}{\text{PNW}},\ \underset{(?)}{\text{PCA}},\ \underset{(?)}{\text{VPROPSD}},\ \underset{(?)}{\text{TREND}}). \quad (3.20)$$

$$\underset{(-)}{\text{BSAL}},\ \underset{(?)}{\text{INCED}},\ \underset{(+)}{\text{LOCFUND}},\ \underset{(+)}{\text{OSFUND}},\ \underset{(?)}{\text{PNW}},\ \underset{(?)}{\text{PCA}},\ \underset{(?)}{\text{VPROPSD}},\ \underset{(?)}{\text{TREND}}). \quad (3.21)$$

$$\underset{(?)}{\text{BSAL}},\ \underset{(-)}{\text{INCED}},\ \underset{(+)}{\text{LOCFUND}},\ \underset{(+)}{\text{OSFUND}},\ \underset{(?)}{\text{PNW}},\ \underset{(?)}{\text{PCA}},\ \underset{(?)}{\text{VPROPSD}},\ \underset{(+)}{\text{TREND}}). \quad (3.22)$$

BSAL is the base salary paid to beginning teachers with a bachelor's degree. No information concerning the price of the services of teachers with less than a bachelor's degree was available. Thus, BSAL serves as the own-price of the services of teachers with less than a bachelor's degree and of those with a bachelor's degree. As such, it is expected to have a negative effect on the demand for these two categories of teacher. In estimating the demand for teachers with higher degrees, HDS, BSAL

represents the price of another variable input. Its sign depends on whether the inputs are gross complements or substitutes.

INCED represents the increased price that school districts must pay in order to purchase the services of teachers with higher educational degrees. It is constructed from the salary schedules of each of the school districts and is the average salary increment to teachers with a master's degree. It represents the price of other inputs in equations (3.20) and (3.21) and thus its sign depends on the gross complementarity or substitutability of the inputs. It comes in as the own-price of teachers with higher degrees and thus is expected to have a negative sign in equation (3.22). Assuming that all three categories of teacher are normal inputs in the production of education, both budget measures are expected to have positive signs in equations (3.20) through (3.22). Presuming that credentialism was occurring within the education industry during the period examined, it is expected that the time trend variable should have a positive effect on the demand for teachers with higher levels of educational preparation.

Regression results from the estimation of the demand for LDS, BDS, and HDS are presented in Table 18. In the estimation of the demand function for teachers with less than a bachelor's degree, the coefficient estimate on the base salary variable had the expected negative sign and approached significance at the ten percent level. The other price variables proved to have no significant explanatory power. Both of the budget variables had the expected positive signs, but LOCFUND, local educational funds per pupil, was the only one that was significant. The

Table 18. Estimation of the demand for teacher educational preparation by school districts (1961-1972)

	23 school district sample[a]		
	LDS	BDS	HDS
Intercept	.001456976 (1.9338)**	.004124375 (3.2672)*	-.0027033 (2.6766)*
BSAL	-2.67498 E-7 (-1.5370)	-7.64196 E-7 (-2.2794)*	-5.66186 E-8 (-.2097)
INCED	1.35864 E-7 (.5050)	-8.46044 E-8 (-.1631)	-1.53213 E-7 (-.3666)
LOCFUND	.0000022694 (1.6952)**	.00000586679 (2.2282)*	.00000362169 (1.7061)**
OSFUND	9.23247 E-7 (.6368)	.00001412245 (5.0095)*	2.16769 E-7 (.0954)
PNW	.00004673123 (1.1947)	.00007934151 (.8458)	-.000173647 (-2.2707)*
PCA	.0000261591 (-.3939)	.00004644677 (.3639)	.00005659545 (.5506)
VPROPSD	1.48331 E-7 (.8381)	-4.55423 E-8 (-.1329)	2.27653 E-7 (.8248)
TREND	-.00069519 (-5.0845)*	-.00129597 (-3.9261)*	.00231951 (8.6129)*
	- - - - - - - -		
F	3.73	5.06	15.30
R^2	.09	.11	.28
D.W.	1.75	2.11	1.95
n	322	322	322

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

time trend variable was the only other exogenous variable that had significant explanatory power. It was negative, indicating that unmeasured factors that changed over the period caused fewer teachers without a bachelor's degree to be demanded on a per student basis.

BSAL, the starting salary for teachers with a bachelor's degree, had a significant negative effect on the quantity demanded of teachers with a bachelor's degree as was expected. The price increment for the services of teachers with higher educational degrees was not significant. Both budget variables had significant positive coefficient estimates. The only other variable with significant explanatory powers was the time trend variable which was negative in this case also.

The demand for teachers with a master's degree or Ph.D. was not responsive to either of the price variables. Both budget variables had positive signs, but only LOCFUND was significant. The percent of the population that is nonwhite, PNW, had a significant negative effect on the demand for HDS. This was the only regression of the three in which PNW showed significance. Finally, the time trend variable had a positive significant effect on the demand for teachers with higher degrees. This indicates that the unmeasured factors that changed over time caused the school district to substitute away from teachers with a bachelor's degree or less towards those with higher levels of educational preparation.

The data were broken down into elementary and secondary levels to see if the market for the services of teachers with various levels of educational preparation differed at the two levels. As the results differed little from those in Table 18, they are not reported here.

Also, the data were broken down into the three school district groups, small, medium-sized, and large districts. Again, the regression results yielded no additional information and so are not reported here.

C. Summary

This chapter examined the demand for teachers by public school districts assuming that school districts were price takers in the market for teacher services. Previous studies which have assumed the price of teacher services to be exogenous to the school district have found the demand for teachers to be price inelastic (Ehrenberg, 1973, pp. 272-275; Brown, 1972, pp. 210-214) or to be not significantly affected by the price of teacher services (Boardman et al., 1982, pp. 142-145).

Demand functions for teachers were first estimated for the whole school district and then for elementary and secondary teachers separately. Next, the data set was broken down into small, medium, and large school districts and the same demand functions were estimated in order to see if the demand for teachers varied with district size.

In estimating teacher demand, three specifications of the price of teachers services were used. Of the three, only the average of actual salaries paid had consistently significant coefficient estimates of the expected sign. Neither of the other two measures, constructed from the salary schedules, performed well in explaining teacher demand. This seems to indicate that the average salary measure best captures the cost of teacher services faced by school districts. The average of actual salaries paid does reflect the current education and experience mix of a

school district's teachers. It also includes compensation for items not reflected in the salary schedule such as pay increments for coaching duties or additional administrative responsibilities. To the extent that teachers at the margin possess the same education and experience mix and will receive similar job responsibilities as the average teacher, the average salary measure will reflect the marginal cost of teachers to the school district.

Results from the regressions using the average actual salary measure are employed to calculate the price elasticity of demand for teachers. It was assumed that the budget for current educational expenditures was determined exogenously. Thus, the price elasticities which can be derived are, using Ehrenberg's (1973, pp. 371-375) terminology, partial price elasticities of demand. Ehrenberg, using pooled cross-section and time-series data observed at the state level, found that the budget for current educational expenditures increased in response to an increase in the price of educational manpower. If the same result were to hold true for the state of Maryland, it would imply that the elasticity measures derived here serve as upper bound estimates on the absolute values of the whole (variable budget) price elasticities. The price elasticities are calculated at the mean values of the teacher-student ratios and price measures. Table 19 presents the estimated elasticities while Table 20 contains the mean values of the relevant variables.

Consistent with the results found by Brown (1972) and Ehrenberg (1973), the demand for teachers was found to be price inelastic. Estimates varied across schooling levels and school district sizes,

Table 19. Estimates of the price elasticities of demand for teachers (η) evaluated at the means

School level	Whole sample	Small school districts	Medium-sized school districts	Large school districts
School district (η_{Sd})	-.185	-.216	-.227	-[a]
Elementary (η_{eL})	-.203	-.247	-[a]	-.417
Secondary (η_{HS})	-.241	-.282	-.364	-.198

[a]Elasticity not calculated as a result of a nonsignificant parameter estimate.

Table 20. Means of variables

Variable	Whole sample	Small school districts	Medium-sized school districts	Large school districts
PTS	.04968843	.05079481	.04834884	.0505481
PTES	.04341985	.04378641	.04212975	.0458203
PTHS	.05416648	.05559456	.05328474	.0531577
AVSALSD[a]	9674.85	9108.25	9674.04	10951.73
AVSALEL[a]	9539.20	9061.67	9565.92	10546.87
AVSALHS[a]	9897.14	9280.72	9905.35	11263.55

[a]The prices of teacher services are in 1972 dollars.

ranging from an estimated price elasticity of demand of -.198 for secondary teachers by small school districts to -.417 for elementary teachers in those same small school districts. However, all were strongly price inelastic, which indicates that teacher organizations, if they possessed sufficient bargaining power, could push for salary increases while suffering minimal disemployment effects.

The current educational budget variables were expected to have a positive effect on the demand for teachers. Two measures were used, local funds per pupil and combined state and federal funds per pupil. It was expected that the two sources might have differing effects on teacher demand as the outside dollars might have been targeted towards special programs and thus have their uses restricted. This results was not born out at the elementary level, thus a single, total budget measure was used which performed as expected. Both budget measures were used in estimating the demand for secondary teachers and the total demand for teachers by the school district. Coefficient estimates for the local funds variable always had the expected positive sign, however they did not have significant explanatory power in a number of regressions. Coefficient estimates for outside funds had the wrong sign in most regressions and were significant or approached significance in a number of those regressions. It may be that the direction of causality flows not only from outside funds to teachers but also from teachers to outside funds. One goal in the allocation of federal and state educational dollars is to achieve equality in educational opportunity across school districts. If these outside funds are targeted towards disadvantaged

districts and the disadvantaged districts exhibit low teacher-student ratios, this may account for the unexpected results.

Of the remaining outside variables, the attendance, value of school property, and time trend variables came in positively and were significant in a number of regressions. The percent of the population of the school district that is nonwhite was significant in a number of regressions, but the sign of its coefficient estimates varied over schooling levels and district sizes.

The models were less successful in estimating the demand for teacher education and experience levels as evidenced by the low R-squared and F-statistics. Positive first-order autocorrelation had to be corrected for in all regressions. This is not surprising since education and experience levels change slowly from year to year. A bright spot was that at least one of the price variables was significant in a number of the regressions and the budget variables had positive coefficient estimates (with one exception) and were significant or approached significance in the majority of the regressions.

Both Brown (1972, pp. 198-219) and Boardman et al. (1982, pp. 127-145) had found average salaries to have a positive effect on the demand for teachers of higher educational levels. Boardman et al. found the same result for teacher experience levels. This study improves on the previous studies in two ways. First, the dependent variables used are in per pupil terms, consistent with the model. The experience measure used by Boardman et al. was average years of experience per teacher. The demand for average teacher experience was estimated here in order to

compare results (Table 16). It performed the poorest of the experience measures in terms of the signs of the coefficient estimates being consistent with expectations. Brown and Boardman et al. both used the percentage of teachers with a master's degree as an independent variable. Here, teacher-student ratios for teachers with less than a bachelor's degree, a bachelor's degree, and a master's or higher degree were used as dependent variables. Coefficient estimates on the base teacher salary were negative for all three regressions, being significant in one and approaching significance in another.

The second difference between this and the previous studies was in the choice of price variables. Brown and Boardman et al. used the average of actual salaries paid as a price variable. Here, two price variables were used in each regression, both constructed from the school districts' salary schedules. The base salary for teachers was used to estimate both the demand for teacher experience and the demand for teacher educational levels. The average increment to the base salary for a year of teaching experience was used in estimating the demand for teacher experience while the pay increment to a master's degree (relative to a bachelor's degree) was used to estimate the demand for teacher education levels. Regression results suggest that the findings by Brown and Boardman et al. may have resulted from their use of a poor price measure rather than a positive relationship between teacher prices and the demand for teacher education and experience levels.

IV. DETERMINATION OF THE TEACHER-STUDENT RATIO AND THE PRICE FUNCTION OF TEACHER SERVICES USING HEDONIC METHODOLOGY TO MODEL TEACHER-SCHOOL DISTRICT TRANSACTIONS

A. Model

1. Introduction

This section examines the possibility that both the price of teacher services and the teacher-student ratio may be endogenous to the school district. Literature concerning the effects of collective bargaining between teachers and public school systems (Perry, 1979, and Hall and Carroll, 1973), has provided evidence that teachers view class size as an indicator of the quality of their work environment. If teachers perceive small class sizes (large teacher-student ratios) as a desirable job characteristic and are willing to accept lower pay for such a condition, all else equal, then the school district finds itself simultaneously determining its teacher-student ratio and the price that it pays for teacher services. As the price of teacher services increases, the school district demands a smaller quantity of teacher services. However, as the teacher-student ratio increases (i.e., class sizes become smaller), school districts find that they can pay a lower price for teacher services since the quality of work environment that they offer has improved.

The model that follows describes the simultaneous determination of the price of teacher services and the teacher-student ratio by school districts. It combines the model of teacher demand developed in

Chapter III with an hedonic modeling of labor market transactions between teachers and school districts originally used by Antos and Rosen (1975).

As described in Chapter III, the superintendent of the school district is charged with maximizing the production of education subject to the budget that he is given to work with. QC, the average level of educational services produced per student, is described by an educational production function of the form

$$QC = Q(\Theta_T, \Theta_S, \Theta_P, \Theta_H) \tag{4.1}$$

The arguments of the production function were justified in Section A of Chapter III. Θ_T is a vector representing the number of teachers of type i (i = 1, ..., Z), per student. Θ_S is a vector of (nonteacher) school district characteristics that contribute to the production of education by the school district. It describes the physical learning environment facing the school district's students. Θ_P contains relevant pupil characteristics that capture their ability and prior learning experiences. Finally, Θ_H is a vector of characteristics of the students' home and community environment. The only arguments of the production function that are subject to the superintendent's control are the number of teachers of each type. School district, pupil, home environment, and community characteristics, as well as the number of students in the district, are exogenous to the superintendent.

Local government officials present the superintendent with B_E, the budget for current educational expenditures. The superintendent uses B_E to purchase the services of various types of teachers so as to maximize the average educational services produced per student. School districts are assumed to pay a market determined equilibrium price for teacher services which is described by the price-characteristics function. This function has both teacher and school district characteristics as its arguments.

2. Price-characteristics function

The price of teacher services was assumed to be solely determined by the market in Chapter III. In Chapter III, the price of different types of teachers depended only upon their level of educational preparation and experience. Here, the transaction between teachers and school districts is viewed as being more complex. Teachers receive compensation for their services partially in the form of p, the price of teacher services. The remainder is received through the satisfaction or dissatisfaction they derive from the quality of their work environment. Antos and Rosen (1975, p. 123) view the transaction between teachers and school districts as follows.

> Teachers sell the services of their labor, but simultaneously purchase utility-bearing characteristics of the schools in which they work. On the other side of the bargain, school administrators purchase desired teacher services and jointly sell characteristics of schools and students to their teachers. Every contract quotes a price for the total package of labor services and on-the-job consumption, and the content of the package varies from school (district) to school (district).

Thus, a school district enters the market for teacher services possessing Θ_E, a vector of school district characteristics which yield utility or disutility to teachers. Some, but not necessarily all of the elements of Θ_s, the vector of school district characteristics that enter the educational production function, may be included in Θ_E. Also, some of the elements of Θ_E may be subject to the control of the superintendent. Each teacher enters the market possessing Θ_c, a vector of characteristics that indicate his or her desirability to school districts. Market equilibrium is reached when the supply and demand for teachers interact to determine prices for teacher and school district characteristics that clear the market. In equilibrium, the price-characteristics function that is observed across schools and teachers is consistent with the supply and demand functions for teachers at each school (Antos and Rosen, 1975, p. 125). It is of the form

$$p = p(\Theta_E, \Theta_c). \tag{4.2}$$

3. Teacher behavior

Teachers are assumed to be utility maximizers. Each has a utility function of the form

$$U = U(c, \Theta_E) \tag{4.3}$$

where c is a numeraire representing consumption and Θ_E is the vector of school district characteristics which yield utility or disutility to

teachers. A teacher with relevant characteristics $\overline{\Theta}_c$ maximizes (4.3) subject to the constraint

$$c = p(\Theta_E, \overline{\Theta}_c) + y \tag{4.4}$$

where y represents outside income. Teachers view the price-characteristics function as being exogenous to their decisions. They choose a school district by comparing the price the market places upon school characteristics with their subjective valuation of those characteristics. If Θ_E consists of n characteristics, $e_1, \ldots, e_n$, then at the margin a teacher with characteristics $\overline{\Theta}_c$ will choose the school district that satisfies

$$\frac{\partial p(\Theta_E, \overline{\Theta}_c)}{\partial e_i} = \frac{-\partial U/\partial e_i}{\partial U/\partial c}, \qquad i = 1, \ldots, n. \tag{4.5}$$

For the optimal vector of school characteristics, Θ_E^*, evaluation of $\frac{\partial p(\Theta_E^*, \overline{\Theta}_c)}{\partial e_i} \equiv p_{e_i}$ yields the price the marginal teacher is willing to pay for the marginal unit of e_i. If p_{e_i} is greater than zero, then e_i is a "bad" which the marginal teacher must be compensated for. If p_{e_i} is less than zero, e_i is a "good" which the marginal teacher is willing to pay for in the form of a lower price of teacher services (Antos and Rosen, 1975, p. 126).

4. School district behavior

The school district superintendent maximizes the average level of educational services provided to students by allocating the budget that he receives for current educational expenditures among purchases of the services of the z types of teachers. It is assumed here that teachers are the only discretionary inputs of the educational production function. The price of each type of teacher to a school district is indicated by the price-characteristics function. The price of the services of a teacher of type i, i = 1, ..., z, depends on the relevant characteristics of the school district and the characteristics of type i teachers. Let the price of type i teachers be represented as

$$p_i = p_i(\Theta_E, \Theta_c). \tag{4.6}$$

This framework for modeling the price of teacher services differs from that used in Chapter III by the fact that here, not just teacher characteristics, but school characteristics also affect the price that a school district must pay for teacher services.

It is assumed that one element of Θ_E, the vector of characteristics that describes the quality of a school district's work environment, is the average class size within the district. Note that average class size is the inverse of the district's teacher-student ratio. It is assumed that teachers prefer smaller class sizes as they entail less paperwork and fewer disciplinary problems. According to (4.5), school districts that provide smaller class sizes (i.e., larger teacher-student ratios)

should find that they can pay lower prices for teacher services, all else equal. Teachers are willing to pay for smaller class sizes through acceptance of lower wages in order to receive the utility from such a characteristic.

Thus, the superintendent maximizes (4.1) subject to the budget for current educational expenditures, B_E, and the price of the services of each type of teacher as described by (4.6). This can be represented as

$$f = Q(\Theta_T, \Theta_s, \Theta_p, \Theta_H) + \Lambda\left[B_E - \sum_{i=1}^{z} p_i(\Theta_E, \Theta_c) \cdot T_i\right] \qquad (4.7)$$

Differentiation of (4.7) with respect to the z types of teachers and the lagrangian multiplier yields first-order conditions of the form

$$\frac{\partial f}{\partial (T_i/s)} = \frac{\partial QC}{\partial (T_i/s)} - S \cdot \Lambda \cdot \left[p_i(\Theta_E, \Theta_c) + \sum_{i=1}^{z} (T_i/s) \frac{\partial p_i(\Theta_E, \Theta_c)}{\partial (T/s)}\right] = 0. \qquad (4.8)$$

$$\frac{\partial f}{\partial \Lambda} = B_E - \sum_{i=1}^{z} p_i(\Theta_E, \Theta_c) \cdot T_i = 0. \qquad (4.9)$$

Note that the marginal cost of purchasing the services of an additional teacher is equal to the price of that teacher less the reduction in expenditures as all teachers within the district are willing to accept lower pay in response to improved working conditions as class sizes become smaller. If second-order conditions for a maximum are satisfied, then the system of equations described by (4.8) and (4.9) determine the optimal number of teachers of each type demanded per

student, that is (T_i/s) for i = 1, ..., z. Demand functions are of the form

$$T_i/s = T_i^d\left(p_1(\Theta_E, \Theta_c) \ldots p_z(\Theta_E, \Theta_c), B_E/s, \Theta_s, \Theta_p, \Theta_H\right),$$

$$i = 1, \ldots, z. \tag{4.10}$$

Note that the prices of various types of teachers are not exogenous to the school district as they depend on the school district's overall teacher-student ratio, T/s. The next section will discuss the empirical techniques used to estimate the demand functions described by (4.10) along with the price-characteristics function in light of the simultaneous determination of both by school districts.

B. Model Estimation

1. Functional forms

This section describes the empirical model used to describe the price-characteristics and teacher demand functions derived in the previous section. Separate functions will be estimated for elementary and secondary level teachers. All variables measured in dollars are in constant 1972 dollars.

The price-characteristics function represented by equation (4.2) will be estimated as

$$AVSALEL = P(PTES, PNW, VPROPEL, NPROMEL, C1, \ldots, C23, ATEXEL, HIDGREL, TREND) \quad (4.11)$$

and

$$AVSALHS = P(PTHS, PNW, VPROPHS, NPROMHS, C1, \ldots, C23, ATEXHS, HIDGRHS, TREND) \quad (4.12)$$

The dependent variables, AVSALEL and AVSALHS, are the averages of actual salaries paid to elementary and secondary level teachers, respectively. The variables PTES through C23 and PTHS through C23 are measures of Θ_E, the vector of school district characteristics from which teachers derive positive or negative utility. PTES and PTHS are the teacher-student ratios within the elementary and secondary levels, respectively. PNW is the percent of the population served by the school district that is nonwhite. VPROPEL and VPROPHS are the value of school property and equipment per student at the elementary and secondary levels, respectively. NPROMEL and NPROMHS are the percentages of students at the elementary and secondary levels that are not promoted during the current year. C1 through C23 are zero-one school district dummy variables defined such that

$$C_i = \begin{cases} 1 \text{ for the i-th school district, and} \\ 0 \text{ otherwise.} \end{cases} \quad (4.13)$$

These dummy variables are included to capture the effect that unmeasured school district characteristics have on the price of teacher services faced by that school district.

ATEXEL and ATEXHS are the average years of teaching experience per teacher within the elementary and secondary school systems, repsectively. HIDGREL and HIDGRHS are the percentages of teachers with a Master's degree or higher within the elementary and secondary systems, respectively. These experience and educational background variables represent the teacher characteristics that school districts desire to purchase. Finally, TREND, a time trend variable, is included to capture the effect of changes in any unmeasured teacher or school district characteristics that change over time.

The elements of Θ_E, the vector of school district characteristics, yield either utility or disutility to teachers. As described by equation (4.5), the partial derivative of the price-characteristics function with respect to a desirable school district characteristic is negative while the partial derivative with respect to an undesirable school district is positive. It is expected that the teacher-student ratios and the values of school property and equipment per pupil are perceived as desirable characteristics by teachers. Teachers are assumed to be willing to receive a lower price for their services, all else equal, from school districts that offer smaller average class sizes and more and/or better quality facilities. Thus, estimation of (4.11) and (4.12) is expected to yield negative coefficient estimates for those variables. The teacher experience and educational preparation variables are assumed to be viewed as desirable teacher characteristics by school districts and thus are expected to have positive coefficient estimates.

The demand functions to be estimated are similar to those employed in Chapter III. The demand functions for elementary and secondary teachers are estimated separately and are of the form

$$PTES = T(AVSALEL, LOCFUND, OSFUND, PNW, PCAE, VPROPEL, TREND) \quad (4.14)$$

and

$$PTHS = T(AVSALHS, LOCFUND, OSFUND, PNW, FYCOL, VPROPHS, TREND). \quad (4.15)$$

PTES and PTHS are the teacher-student ratios at the elementary and secondary levels, respectively. AVSALEL and AVSALHS are the averages of actual salaries paid to elementary and secondary teachers. LOCFUND and OSFUND represent local and combined state and federal funds for current educational expenditures on a per pupil basis. PNW is the percent of the population served by the school district that is nonwhite. PCAE is the average percent of pupils attending at the elementary level while FYCOL is the percent of the population served by the school district that has completed at least four years of college. These two measures are included to control for the effect of the students' home environment on teacher demand. FYCOL is used instead of a pupil attendance measure at the secondary level as attendance at the secondary level is more likely to be a choice variable of students rather than a reflection of parental attitudes. Nonteacher school district characteristics are captured by VPROPEL and VPROPHS, the value of school property and equipment per pupil at the elementary and secondary levels, respectively. Finally, the time

trend variable, TREND, is included to capture the effect of changes in any nonmeasured demand determinants.

As in Chapter III, the price of teacher services is expected to have a negative effect on the demand for teacher services by school districts. Thus, the coefficient estimates of AVSALEL and AVSALHS are expected to be negative. Also, both budget variables are again expected to have a positive effect on the demand for teacher services. The remainder of the variables are included to control for the effects of student, school, community, and home environment characteristics on the demand for teacher services.

Equations (4.11) and (4.14), and (4.12) and (4.15) describe two simultaneous equation systems. Two-stage least squares is used to estimate both systems. Estimation results are discussed in the next section.

2. Empirical results

The two systems of equations were estimated using two-stage least squares. For each equation at the elementary and secondary levels, three regressions were performed. The first used observations from the 23 school districts for the 1961 through 1972 school years. This is the full period sample. The data were then broken down into two periods--the 1961 through 1969 and the 1970 through 1972 school years. This was done because beginning with the 1969-1970 school year, all school districts were required by law to negotiate collective bargaining agreements with teachers' organizations if teachers within the school district indicated

their desire for such representation. Robert Haugen (Maryland State Teachers' Association, Baltimore, Maryland, 1985, interview) stated that prior to the 1970 school year, no collective bargaining agreement existed between the 23 school districts and teacher organizations. Beginning with the 1969-1970 school year, collective bargaining agreements were in place between National Education Association-affiliated teacher organizations and the 23 school districts. This situation continued to exist throughout the period that this study examines. To the extent that teachers' unions were successful in negotiating for desirable work conditions, it is expected that school district characteristics should have a more pronounced effect on the price of teacher services in the unionized period, 1970 through 1972, than in the nonunionized period, 1961 through 1969.

Results from the estimation of the price-characteristics functions for elementary and secondary teachers are presented in Tables 21 and 22. The school district dummy variables were used to estimate the functions but their coefficient estimates are not reported here. The models have significant explanatory powers at both school levels and for all samples. The data had to be transformed to correct for positive first-order autocorrelation in the estimation of the price-characteristics function for secondary teachers when the full period sample, the 1961 through 1972 school years, was used. Durbin's two-step correction procedure, described in Section B(3) of Chapter III, was used to transform the data for that regression.

Table 21. Two-stage least squares estimation of the price-characteristics function for elementary teachers (1961-1972)

	Dependent variable AVSALEL[a]		
	1961-1972 (full sample)	1961-1969 (nonunion)	1970-1972 (union)
Intercept	4406.26 (2.1102)*	8528.57 (4.0368)*	23539.65 (4.4083)*
PTES	115696.90 (1.9678)*	30763.57 (.5355)	-119728.00 (-2.6879)*
PNW	-79.13 (-1.3543)	-98.10 (-1.409)	-205.16 (-1.4849)
VPROPEL	-.21 (-1.1843)	-.31 (-1.8121)**	.50 (1.9536)**
NPROMEL	-3.09 (.0950)	8.66 (.3039)	-189.68 (-2.1228)*
HIDGREL	378.10 (.3382)	2111.77 (1.1887)	-1025.02 (-.4488)
ATEXEL	209.28 (5.1149)*	182.56 (3.9816)*	33.24 (.3137)
TREND	48.95 (.7355)	134.13 (2.0084)*	-247.79 (-2.0291)*
F	15.30	21.30	14.40
R^2	.64	.78	.91
D.W.	1.82	2.12	2.37
n	276	207	69

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 22. Two-stage least squares estimation of the price-characteristics function for secondary teachers (1961-1972)

	Dependent variable AVSALHS[a]		
	1961-1972 (full sample)	1961-1969 (nonunion)	1970-1972 (union)
Intercept	-45185.00 (-3.7781)*	3724.98 (1.3061)	14877.49 (3.0885)*
PTHS	100887.00 (4.0456)*	84769.81 (2.3026)*	-51634.20 (-1.7012)**
PNW	21.25 (.3435)	-20.17 (-.2889)	-26.35 (-.2116)
VPROPHS	-.08 (-.9254)	-.26 (-1.8584)**	-.06 (-.4883)
NPROMHS	-11.62 (-.4232)	18.07 (.6492)	-129.89 (-1.4259)
HIDGRHS	-196.71 (-.2063)	1136.18 (.8828)	1514.27 (.6207)
ATEXHS	277.78 (3.6591)*	164.62 (1.8518)**	155.29 (.7699)
TREND	43934.85 (4.0582)*	97.12 (2.5075)*	-228.60 (-2.2406)*
F	15.33	18.03	27.17
R^2	.67	.75	.95
D.W.	1.99	1.97	2.90
n	253	207	69

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

It was expected that a higher teacher-student ratio, which indicates a lower average class size, would cause the price of teacher services to be lower, all else equal. For the full sample, estimated coefficients for the teacher-student ratios at the elementary and secondary levels are positive and significant, contrary to expectations. Coefficient estimates for these variables are also positive using the nonunionized period sample, but only the parameter estimate for PTHS has significant explanatory power. However, when regressions are performed using the unionized period sample, the estimated coefficients for the teacher-student ratios have negative signs and are significant at both the elementary and secondary levels. This suggests that the expected trade-off between smaller class sizes and the price of teacher services did occur once collective bargaining agreements between school districts and teachers' organizations were in place. In the union period, it is estimated that elementary teachers were willing to accept a 5.5 percent lower price for their services in return for a ten percent increase in the teacher-student ratio at the elementary level while secondary teachers were willing to accept a 2.8 percent decrease in the price received for their services in return for a ten percent increase in the teacher-student ratio at the secondary level.

It was also expected that teachers would accept a lower price for their services from school districts with more and/or better quality facilities, all else equal. This would imply negative coefficient estimates for the variables VPROPEL and VPROPHS. This result was obtained in all cases but one, that being the estimate of the price-

characteristics function for elementary teachers using the sample from the unionized period. There, VPROPEL had a positive sign and was significant at the ten percent level. The coefficient estimates for these measures of the quality of the school's facilities had the expected negative sign in the other five regressions, two of these coefficient estimates being significant. The parameter estimates for the other school characteristics had mixed effects. The nonpromotion measure had negative coefficient estimates at both the elementary and secondary level in the nonunion period. This variable was significant at the elementary level and approached significance at the secondary level.

Of the two measures of teacher characteristics, average years of experience per teacher performed better at both the elementary and the secondary levels. Coefficient estimates for the experience variable were positive and had significant explanatory power in four of the six regressions. The measure of teachers' educational backgrounds did not have significant explanatory power in any of the regressions. Finally, the regressions were also run excluding the experience and education measures due to their potential endogeneity. Those regressions had slightly lower F-statistic and R-squared values but coefficient estimates did not change appreciably and so the results are not presented here.

The time trend variable indicated that unmeasured factors that changed over time caused the real price of teacher services at both the elementary and secondary levels to increase during the 1961 through 1969 school years and to decrease during the 1970 through 1972 school years.

This variable was significant during both periods and at both schooling levels.

It was not possible to do a Chow test in order to test whether the samples from the nonunionized and unionized periods came from the same population as different correction factors were used to transform the data to correct for positive first-order autocorrelation for the different samples. However, the change in the signs of the coefficient estimates for PTES and PTHS from the nonunionized period to the unionized period samples suggest that such a breakdown is warranted, especially since the coefficient estimates are significant for both periods.

Results from the estimation of the demand for elementary and secondary teachers using two-stage least squares are presented in Tables 23 and 24. The data transformation described in Section B(3) of Chapter III is used to correct for positive first-order autocorrelation for each regression. Again, at each schooling level, regressions are performed using the full period sample, which spans the 1961 through 1972 school years, the nonunionized period sample, which includes the 1961 through 1969 school years, and the unionized period sample, which covers the 1970 through 1972 school years. The estimated model of the demand for secondary teachers during the unionized period was the only model that did not have significant explanatory power.

Measures of the price of teacher services, AVSALEL and AVSALHS, had a negative effect on the demand for teacher services in all six regressions. This result was significant for all regressions except those estimating the demand for elementary teachers using the full sample and

Table 23. Two-stage least squares estimation of the demand for elementary teachers (1961-1972)

	Dependent variable PTES[a]		
	1961-1972 (full sample)	1961-1969 (nonunion)	1970-1972 (union)
Intercept	.00861701 (1.1052)	.004922734 (.5937)	-.033658 (-.5139)
AVSALEL	-7.45958 E-7 (-.9743)	-2.79982 E-7 (-.3824)	-.0000030117 (-2.4580)*
LOCFUND	.00002203869 (4.5856)*	.000017234 (3.8971)*	.00002942079 (2.9720)*
OSFUND	.00000194255 (4.3466)*	.00001086157 (2.3409)*	.0000264099 (1.7689)**
PNW	-.0000453028 (-1.2556)	-.0000177738 (-.4822)	-.000154417 (-1.5031)
PCAE	.0001206466 (.6847)	.0001718089 (.9521)	.00154998 (1.0753)
VPROPEL	.00000108887 (1.6225)	.00000138362 (1.7672)**	.00000242868 (1.6628)
TREND	.0001013551 (.5866)	.0007175817 (2.9424)*	-.00730166 (-3.3761)*
F	11.58	13.39	3.62
R^2	.25	.35	.40
D.W.	2.11	2.11	2.58
n	253	184	46

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 24. Two-stage least squares estimation of the demand for secondary teachers (1961-1972)

	Dependent variable PTHS[a]		
	1961-1972 (full sample)	1961-1969 (nonunion)	1970-1972 (union)
Intercept	.023394 (5.4159)*	-.016636 (4.0555)*	.061078 (4.3465)*
AVSALHS	-.0000035472 (-2.7176)*	-.0000030313 (-2.0489)*	-.000003409 (-2.1379)*
LOCFUND	.00002940137 (4.4570)*	.00002272232 (3.4652)*	.00001211178 (.9141)
OSFUND	.00002269723 (3.8708)*	.00002186982 (3.3798)*	.0000119159 (-.7714)
PNW	.00003008874 (.5002)	.00002390153 (.3349)	.0001123673 (1.0160)
FYCOL	.0002289933 (1.5332)	.0002743052 (1.5346)	.0002582601 (.9720)
VPROPHS	6.26782 E-7 (1.3744)	.00000172912 (3.0112)*	9.80520 E-7 (-1.0150)
TREND	.0002372115 (1.0513)	.0008207542 (2.1047)*	.000297983 (-.1534)
	- - - - - - - -		
F	9.46	9.33	1.53
R^2	.21	.27	.22
D.W.	2.12	2.06	1.69
n	253	184	46

[a]t-statistics in parentheses.

*Significant at five percent.

the nonunionized period samples. Coefficient estimates for both budget measures were positive and significant as expected in all cases but the regression estimating the demand for secondary teachers during the unionized period. The variables included to control for school, student, community, and home environment characteristics, PNW, PCAE, FYCOL, VPROPEL, and VPROPHS, behaved essentially as they had in the single-stage estimation of teacher demand in Chapter III. Finally, the time trend variable indicated that unmeasured determinants of teacher demand that changed over time caused the demand for elementary teachers to increase over the 1961 through 1969 period and to decrease over the 1970 through 1972 period. This time trend variable also indicated an increase in the demand for secondary teachers over the earlier period and a decrease in demand over the later period. However, the coefficient estimates for the time trend variable were significant only in the earlier period sample.

3. Conclusion

This chapter examined the possibility that school districts face an endogenous price of teacher services. Through the hedonic modeling of a price-characteristics function, it was hypothesized that school districts that offer teachers smaller class sizes are able to pay a lower price for teacher services, all else equal. Two-stage least squares estimation of the price-characteristics functions for elementary and secondary level teachers using data from the 1961 through 1972 school years did not support this hypothesis. The data were then broken down into two time periods, a nonunionized period and a period when the terms and conditions of employment were defined by collective bargaining agreements negotiated

by each school district and teachers' union. The expectation was that if a teachers' union was effective in serving as a collective voice for its members and if the members viewed smaller class sizes as a desirable work characteristic, then estimation of the price-characteristics function during the later time period, the 1970 through 1972 school years, should provide evidence of the tradeoff between the price of teacher services and class sizes. Estimation results for the nonunion period yielded no evidence of such a tradeoff. However, regressions using the data from when collective bargaining agreements were in force did show evidence of the expected tradeoff at both the elementary and secondary levels.

Consistent with the hypothesized endogeneity of the price of teacher services, two-stage least squares estimations of the demand for elementary and secondary teachers were performed. The explanatory variables exhibited essentially the same pattern of significance as they had in Chapter III under the assumption that school districts were price takers in the market for teacher services. In Table 23, the price of teacher services was not found to have a significant effect on the demand for elementary teachers in the nonunion period. It did have a negative and significant coefficient estimate in the union period. This might have been a result of unions having differing degrees of effectiveness in the collective bargaining process. If the more effective unions were able to achieve wage increases, causing those school districts to decrease their teacher-student ratios, this may have accounted for the coefficient estimate on AVSALEL taking on significant explanatory power in the union period.

V. SCHOOL DISTRICTS AS MONOPSONISTS IN THE MARKET FOR TEACHER SERVICES

A. Introduction

The previous two chapters have proceeded under the assumption that school districts purchase teacher services within the framework of a competitive market. In Chapter III, school districts were assumed to face a perfectly elastic supply of teacher services at a market determined price. In Chapter IV, market competition determined the parameters of the price-characteristics function faced by school districts. The price of teacher services was endogenous to the school district since it was able to control the mix of the compensation package received by its teachers, that is, the amount of compensation provided in the form of job characteristics versus monetary remuneration. However, the total size of the compensation package in terms of the satisfaction the marginal teacher derived from it was still determined in the market.

Here, school districts will be assumed to possess monopsony power in the market for teacher services. Landon and Baird (1971, pp. 68-70) provided evidence that in metropolitan areas served by relatively few school districts, these school districts exert a degree of monopsony power in the market for the services for first-year teachers. In an ad hoc fashion, they modeled and estimated base teacher salaries as a function of a school district's ability to pay, tastes for education, and degree of monopsony power. The logarithm of the number of school districts in the county that the school district is located in was used

to indicate the degree of monopsony power possessed by the school district. It was assumed that a smaller number of school districts per county would imply a less competitive market for teacher services, causing the price of teacher services to be lower. This measure did have a significant positive coefficient estimate in school districts with between 25,000 and 100,000 students which Landon and Baird took as evidence of monopsony power. Boardman et al. (1982, p. 147) found evidence of monopsony power among Pennsylvania school districts. They modeled the supply and demand for teacher services and estimated the supply price of teacher services as a function of the teacher-student ratio and the job and locational characteristics of the school district. Using two-stage least squares, they found the teacher-student ratio to have a positive effect on average teacher salaries. Boardman et al. claimed that this provided evidence that the school districts studied did face upward-sloping supply schedules as a result of their possession of a degree of monopsony power.

For a school district to possess complete monopsony power, potential teachers within its boundaries must possess no labor market opportunities other than those offered by the school district. These alternative labor market opportunities include employment with other public school districts, positions with private schools, and nonteaching positions. Or, if these alternative labor market opportunities exist but are relatively few in number, a monopsonistic result may still be obtained if these potential employers collude by refraining from competing with one another (Fleisher and Kniesner, 1984, p. 212).

There are a relatively small number of school districts in the state of Maryland. School district boundaries are coterminous with those of county governments. These school districts may possess a degree of monopsony power to the extent that potential teachers are geographically immobile between school districts and occupationally immobile between occupations in the county of their residence. Geographic mobility may be limited if teachers are secondary wage earners in a two-income family. Nationally, 87.3 percent of elementary teachers and 50.7 percent of secondary teachers were female in the 1956-1957 school year. Although the percent of teachers that are male trended upward over the subsequent years, in the 1972-1973 school years, still 84.1 percent of elementary teachers and 46.2 percent of secondary teachers were female (National Education Association, 1974, p. 10). Given this, school districts may possess a greater degree of monopsony power over elementary teachers than over secondary teachers. Occupational immobility tends to occur in markets where there are specialized job skills and limited alternative occupations that reward those skills (Link and Landon, 1975, p. 649). Other than the option of teaching in the private schools, public school teaching seems to fulfill those conditions in light of the educational preparation and certification requirements it entails.

This chapter will first model teacher supply and school district demand for teacher services. Next, the procedure for model estimation will be discussed under the assumption that the school district possesses monopsony power. Finally, the empirical results will be derived and discussed.

B. Teacher and School District Behavior

1. Teacher supply

The model of teacher supply described below is similar to the model used by Boardman et al. (1982) in their search for monopsony power among Pennsylvania school districts. Based upon a paper by McFadden (1974, pp. 105-119), it is a multiple-choice model that describes an individual's choice of residence and occupation.

Individuals possess a utility function which depends upon their income, p, a vector of job-environment characteristics, Ω, a vector of locational characteristics, Ψ, and the characteristics of the individual that describe his or her tastes, A. Income is a function of the occupation, j, that the individual chooses (j = 1, ..., J), location choice, ℓ (ℓ = 1, ..., L), and the individual's characteristics, a (a=1, ..., A). Elements of Ω reflect the occupation and location an individual chooses, and Ψ describes the amenities and disamenities of his or her residential location. The utility function can thus be expressed as

$$U = U[p(j, \ell, a), \Omega(j, \ell), \Psi(\ell), A_a] = U[\cdot];$$
$$j = 1, \ldots, J; \ell = 1, \ldots, L; a = 1, \ldots, A. \qquad (5.1)$$

Consistent with McFadden's model of population choice behavior, (5.1) can be rewritten as

$$U = U[\cdot] = V(\cdot) + \varepsilon(\cdot) \qquad (5.2)$$

where $V(\cdot)$, a nonstochastic function, represents the normal, or standard, tastes of the population and $\varepsilon(\cdot)$ reflects the manner in which the individual's tastes differ from the norm. McFadden specifies conditions under which the probability of an individual choosing a given alternative is functionally related to the "normal" utility derived from this alternative relative to the "normal" utility derived from all possible alternatives (McFadden, 1974, pp. 107-109).

Multiplying this probability times the number of individuals in the labor market relates the expected number of individuals of a given type who are willing to supply their labor services to a particular location and occupation as a function of the arguments of the utility function. This function is transformed into a supply function of the form

$$p(j, \ell, a) = g(q_a(j, \ell), \Omega(j, \ell), \Psi(\ell), A_a; \quad j = 1, \ldots, J; \ell = 1, \ldots, L; a = 1, \ldots, A) \quad (5.3)$$

for all J occupations, L locations, and A types of individuals. $q_a(j, \ell)$ is the number of type-a individuals who are willing to supply their labor services to occupation j in location ℓ. For a more detailed presentation of the above material, see Boardman et al. (1982) and McFadden (1974).

2. Teacher demand

Teacher demand is determined according to the same model used in Chapter III. The superintendent is charged with maximizing the average

level of educational services produced per student which is described by the function

$$QC = Q(\Theta_T, \Theta_s, \Theta_p, \Theta_H). \tag{4.1}$$

Again, Θ_T is a vector of the number of teachers of each type per student, Θ_s is a vector of nonteacher school district characteristics, Θ_p is a vector of pupil characteristics, and, finally, Θ_H is a vector of relevant home and community characteristics. The superintendent is given B_E, a budget of current educational expenditures. He maximizes (4.1) by allocating B_E among purchases of the services of the various types of teachers, here assumed to be the only input of the educational production function over which he has control.

Demand functions for teacher services cannot be estimated within the current framework as monopsonists do not possess true demand curves for the monopsonized input. A reduced-form equation for teachers can be estimated. Its form will be discussed in the next section.

3. Monopsonist model

It is assumed that because of geographic and/or occupational immobility among potential teachers, each school district faces an upward-sloping supply curve of teacher services. Let the occupation of public school teaching be represented by $j = 1$. School district, or location $\ell = 1$, faces upward-sloping supply schedules for the A types of teachers. They are of the form

$$p(1, 1, a) = g(q_a(j, \ell), \Omega(j, \ell), \Psi(\ell), A_a;$$
$$j = 1, \ldots, J; \ell = 1, \ldots, L; \quad a = 1, \ldots, A). \quad (5.4)$$

The school superintendent maximizes (4.1) subject to the budget constraint, B_E, and to the supply schedules of teachers which are of the form of equation (5.4). If the prices of teacher services were exogenous to the school district, then demand functions of the form

$$q_a(1, 1) = f[p(1, 1, a), B_E/S, \Theta_s, \Theta_p, \Theta_H] \text{ for } a = 1, \ldots, A \quad (5.5)$$

could be estimated. This is not possible under the monopsony assumption as here the price of teacher services is endogenous to the school district. Actually, since the school district faces upward-sloping supply curves for the services of the various types of teachers, the marginal cost to the school district of employing another teacher is greater than the supply price of that teacher's services. This marginal factor cost increases with the number of teachers. The optimization process described above or, equivalently, the substitution of the supply function (5.4) into the demand function (5.5), yields an equation describing the optimal number of type-A teachers to be employed by School District One of the form

$$\frac{q_a(1, 1)}{S} = q_a(B_E/S, \Theta_s, \Theta_p, \Theta_H, \Omega(j, \ell), \Psi(\ell), A_a;$$
$$j = 1, \ldots, J; \ell = 1, \ldots, L; a = 1, \ldots, A) \quad (5.6)$$

for a = 1, .., A (Boardman et al., 1982, p. 138). Equation (5.6)

differs from (5.5) in that instead of containing the price of teacher services, it contains the determinants of that supply price. It is again expected that B_E/S, the per-pupil budget for current educational expense, should have a positive effect on the number of teachers per pupil. Θ_S, Θ_P, and Θ_H are included to control for the effects of school, student, home, and community characteristics on the demand for teachers. Elements of $\Omega(j, \ell)$ and $\Psi(\ell)$ that cause the supply schedule of teachers to School District One to shift upwards to the left, which would imply a higher marginal cost of teacher services, are expected to have a negative effect on the optimal number of teachers.

The supply functions of teacher services to School District One, represented by equation (5.4), can be estimated. They are determined within a simultaneous equation system composed of (5.4) and (5.6). The supply price of type "A" teachers to School District One is expected to increase as the number of type "A" teachers employed by that school district increases due to the upward-sloping supply schedule. The elements of $\Omega(j, \ell)$ and $\Psi(\ell)$ are included to control for job and location amenities and disamenities. The estimation of equations (5.4) and (5.6) will be discussed in the next section.

C. Model Estimation

1. Functional forms

This section describes the estimation of the supply function of teacher services and the reduced-form equation for the teacher-student

ratio. All variables measured in dollars are in constant 1972 dollars. Supply functions for elementary teachers, secondary teachers, and all teachers, elementary and secondary combined, are estimated. In the interest of simplicity, all teachers at each schooling level will be considered as being of the same type. Consistent with equation (5.4), each function will be estimated as

$$\text{AVSALEL} = P(\text{PTES}, \text{ALTWG}, \text{PNW}, \text{VPROPEL}, \text{NPROMEL}, \text{C1}, \ldots, \text{C23}, \text{TREND}), \tag{5.7}$$

$$\text{AVSALHS} = P(\text{PTHS}, \text{ALTWG}, \text{PNW}, \text{VPROPHS}, \text{NPROMHS}, \text{C1}, \ldots, \text{C23}, \text{TREND}), \tag{5.8}$$

and

$$\text{AVSALSD} = P(\text{PTS}, \text{ALTWG}, \text{PNW}, \text{VPROPSD}, \text{NPROMSD}, \text{C1}, \ldots, \text{C23}, \text{TREND}). \tag{5.9}$$

The dependent variables, AVSALEL, AVSALHS, and AVSALSD, are the averages of actual salaries paid at the elementary level, the secondary level, and by the school district as a whole, respectively. PTES, PTHS, and PTS are the numbers of teachers per student at the elementary level, the secondary level, and within the whole school district, respectively. If the school district does possess a degree of monopsony power and faces an upward-sloping supply curve of teacher services, then the number of teachers should have a positive effect on the price paid for teacher services. The number of teachers at each schooling level is divided by the appropriate student body size to control for district size.

ALTWG, the alternative wage available to potential teachers is included to capture the effect of characteristics of other jobs on the

supply of teacher services. All else equal, the higher the price that teachers could receive by supplying their services to other occupations is, the higher is the expected price of teacher services. This is because the supply curve of teacher services which the school district faces shifts upward to the left. ALTWG was constructed from county-level data in the County and City Data Book (1952 and various years) and state-level data from Employment, Hours, and Earnings, States and Areas (1972 and various years). Observations of the average salaries of manufacturing, wholesale, retail, and selected services employees are available at the county level every four or five years over the period in which the models are estimated. Observations for the intervening years were interpolated for each county by using the trend in average manufacturing wages in the state of Maryland over the relevant four or five year period. ALTWG is expressed in 1972 dollars.

The percent of the population served by the school district that is nonwhite, PNW, the value of school property and equipment per student within the elementary system, the secondary system, and the school district as a whole, VPROPEL, VPROPHS, and VPROPSD, respectively, and the percent of students not promoted at the elementary and secondary levels and the school district as a whole, NPROMEL, NPROMHS, and NPROMSD, respectively, are included to capture the effects of school district amenities and/or disamenities on the supply price of teachers. The expected coefficient signs on these variables are a priori ambiguous except for the value of school property and equipment per student. As in the previous chapter, it is expected that higher valued school facilities

indicate a more pleasant work environment. This would cause the supply of teacher services to shift downward to the right, all else equal, lowering the supply price of teacher services. C1 through C23 are zero-one school district dummy variables defined as in the previous chapter such that

$$C_i = \begin{cases} 1 \text{ for the i-th school district, and} \\ 0 \text{ otherwise.} \end{cases} \qquad (4.13)$$

They are included to control for the effect that unmeasured school district characteristics, locational or job-related, have on the supply price of teacher services. Finally, the time trend variable, TREND, is included to control for the effects of any unmeasured determinants of supply that change over time.

Reduced-form equations for the teacher-student ratio will be estimated at the elementary level, the secondary level, and for the school district as a whole. These reduced-form equations contain as explanatory variables determinants of both teacher supply and demand. Since a monopsonist does not possess a true demand curve, only the reduced-form equation for teachers can be estimated. Consistent with equation (5.6), each reduced-form equation will be estimated as

$$\text{PTES} = T(\text{LOCFUND}, \text{OSFUND}, \text{PCAE}, \text{PNW}, \text{VPROPEL}, \text{TREND}, \text{ALTWG}, \text{NPROMEL}, \text{C1}, \ldots, \text{C23}), \qquad (5.10)$$

$$PTHS = T(LOCFUND, OSFUND, FYCOL, PNW, VPROPHS, TREND, ALTWG, NPROMHS, C1, \ldots, C23), \quad (5.11)$$

$$PTS = T(LOCFUND, OSFUND, FYCOL, PNW, VPROPSD, TREND, ALTWG, NPROMSD, C1, \ldots, C23. \quad (5.12)$$

The dependent variables are the teacher-student ratios at the elementary and secondary levels, and for the school district as a whole, respectively. The budget measures, LOCFUND and OSFUND, represent the local and the combined state and federal funds for current educational expenditures, respectively. Both enter as demand-side determinants only and are expected to increase the teacher-student ratio. PCAE and PCA, the percent of pupils attending at the elementary level and within the school district as a whole, and FYCOL, the percent of the population served by the school district that has completed four or more years of college, are included to control for the effect that the student's home environment has on the demand for teachers. FYCOL is used at the secondary level instead of an attendance measure since attendance at the secondary level is likely to be a choice variable of students instead of being an indicator of the parent's attitude towards education.

The percent of the population that is nonwhite, the value of school property and equipment per pupil, and the time trend variable are determinants of both the supply and the demand for teachers. Their expected signs of their parameter estimates are a priori ambiguous. ALTWG, the alternative wage available to teachers, was expected to have a

positive effect on the supply price of teachers and thus should have a negative effect on the teacher-student ratio. Finally, the nonpromotion measures and the school district dummy variables enter through the supply function as controls for job and locational amenities and disamenities. Their effects on the teacher-student ratio are a priori ambiguous.

The reduced-form equations (5.10), (5.11), and (5.12) can be estimated with ordinary least squares. Since the number of teachers is not only a choice variable, but also is a determinant of the supply price of teachers, equations (5.7), (5.8), and (5.9) must be estimated using two-stage least squares. The model estimation procedures and empirical results from the monopsony model are presented in the next section.

2. Empirical results

This section discusses the empirical results from the estimation of equations (5.7) through (5.12). The estimation of the reduced-form equations for teachers was performed using ordinary least squares while the supply functions were estimated using two-stage least squares. Data were available for the 23 county school districts of Maryland for the 1955-1956 through 1974-1975 school years. As in Chapter IV, the data set was broken down into two periods. The nonunion period spans the 1956 through 1969 school years. No collective bargaining agreements between teachers' organizations and school districts existed during this period. The union period, 1970 through 1975, is a time when teachers in each of the 23 school districts were covered by a collective bargaining agreement negotiated between the school district and a National Education

Association-affiliated teachers' organization. The expectation is that if school districts did possess monopsony power, evidence of such should appear in the earlier period. To the extent that teachers' organizations were able to bargain successfully, it is expected that estimation of the monopsony model would fail to show evidence of monopsony power in the latter, unionized period. The results from the estimation of the teacher supply functions will be presented first, followed by the results from the estimation of the reduced-form equations for teachers.

The presence of the teacher-student ratio in the supply functions required equations (5.7), (5.8), and (5.9) to be estimated with two-stage least squares. Regression results using data from the nonunionized period are presented in Table 25. Results using the unionized period data are presented in Table 26. The school district dummy variables were used to estimate the supply functions but their coefficient estimates are not presented here. Supply price functions for elementary teachers, secondary teachers, and for all teachers in the school district are estimated. The data from the nonunionized period were transformed to correct for positive first-order autocorrelation using Durbin's two-step correction procedure as described in Section B(3) of Chapter III. It was not necessary to transform the data from the unionized period.

If school districts possess monopsony power in the market for teachers, both the number of teachers and the alternative wage are expected to have a positive effect on the supply price of teachers. This result is obtained using data from the nonunionized period as shown in Table 25. The number of teachers had a significant effect on the price

Table 25. Two-stage least squares estimation of the supply price of teacher services, nonunionized period (1956-1969)

Independent variables	Dependent variables		
	AVSALEL (elementary)	AVSALHS (secondary)	AVSALSD (school district)[a]
Intercept	4410.92	3021.86	3820.013
	(3.7298)*	(2.3079)*	(3.8104)*
PTES	35189.49		
	(1.3936)		
PTHS		88610.08	
		(4.1022)*	
PTS			57419.78
			(2.8334)*
ALTWG	.176676	.0259758	.165246
	(1.7619)**	(2.4259)*	(1.8572)**
PNW	23.706418	-24.158867	-6.052082
	(.6810)	(-.6770)	(-.1941)
VPROPEL	-.00688264		
	(-.0570)		
VPROPHS		-.276603	
		(-3.5649)*	
VPROPSD			.098939
			(-9.220)
NPROMEL	1.228112		
	(.0546)		
NPROMHS		27.540148	
		(1.6444)**	
NPROMSD			23.908739
			(1.1918)
TREND	93.889343	106.632250	100.231927
	(3.3066)*	(5.2213)*	(4.3954)*
F	27.12	36.70	38.73
R^2	.74	.79	.80
D.W.	2.00	1.90	1.96
n	290	290	290

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

Table 26. Two-stage least squares estimation of the supply price of teacher services, unionized period (1970-1975)

Independent variables	Dependent variables		
	AVSALEL (elementary)	AVSALHS (secondary)	AVSALSD (school district)[a]
Intercept	14991.39 (5.7435)*	13114.88 (4.3027)*	11587.54 (4.3993)*
PTES	-42580.7 (-1.1777)		
PTHS		-32263.8 (-1.060)	
PTS			10239.42 (.2456)
ALTWG	-.214036 (-.8418)	.410100 (1.5551)	.086680 (.4221)
PNW	18.487529 (.5044)	-91.690176 (-2.3872)*	-32.477022 (-1.0856)
VPROPEL	.167434 (1.5262)		
VPROPHS		-.030382 (-.3766)	
VPROPSD			.031986 (.3278)
NPROMEL	-32.461272 (-.5320)		
NPROMHS		26.082092 (.4779)	
NPROMSD			71.554062 (1.0309)
TREND	-183.339638 (-4.2537)*	-43.376045 (-1.2542)	-130.032910 (-3.7513)*
F	29.00	33.01	45.78
R^2	.88	.89	.92
D.W.	2.11	2.21	2.07
n	138	138	138

[a] t-statistics in parentheses.

*Significant at five percent.

of secondary teachers and on the supply price of teachers to the whole school district. The number of teachers had the expected sign in explaining the supply price of elementary teachers but only approached being significant at the ten percent level. The estimated supply elasticities, evaluated at the means, were all inelastic. The estimated supply elasticity measures for teachers to the elementary and secondary levels and to the whole school district were .15, .48, and .27, respectively. The supply of elementary teachers was estimated to be more inelastic than the supply of secondary teachers as was expected. However, it was surprising that the coefficient estimate for the number of elementary teachers did not have a stronger significant effect on the supply price of elementary teachers. The coefficient estimates for the alternative wage measure, ALTWG, were significant in all three supply equations. The value of school property and equipment was expected to capture the amenities of the work environment and to decrease the supply price of teachers. Coefficient estimates for this measure were negative in all cases but were significant only in explaining the supply price of secondary teachers. The time trend variable was strongly significant in all three regressions indicating that unmeasured supply determinants that changed over the period had a positive effect on the supply price of teacher services.

Regression results using data from the unionized period are presented in Table 26. They differ substantially from the results of the nonunion period. None of the coefficient estimates for the number of teachers are significant in explaining teacher supply prices and they

have the wrong sign in two of the three regressions. The alternative wage has the expected sign and approaches significance in explaining the supply price of secondary teachers. However, it has the wrong sign in the regression for elementary teachers and is not significant in that regression or in the estimation of the supply price of teachers to the whole school district. Finally, the time trend variable indicates that unmeasured supply determinants caused the real supply price to decrease over the period, this effect being significant in two of the three regressions.

An alternative measure of monopsony power was constructed and used to estimate the supply price of teachers. Results using data from the nonunion period are presented in Table 27. Again, two-stage least squares is used and the data are transformed to correct for positive first-order autocorrelation.

This alternative measure controls for district size and attempts to capture the effect of the size of the pool of potential teachers on the supply price of teachers. The number of teachers at the elementary level, the secondary level, and in the whole school district, T_E, T_H, and T_{SD}, respectively, are divided by the number of individuals in the population served by the school district who are 25 or more years old and who have completed four or more years of college. The size of this group, PP, is used to proxy the number of individuals who could potentially supply their services to the school district. It is expected that larger values of T_E/PP, T_H/PP, and T_{SD}/PP would indicate that the

Table 27. Two-stage least squares estimation of the supply price of teacher services, nonunionized period (1956-1969)

Independent variables	Dependent variables		
	AVSALEL (elementary)	AVSALHS (secondary)	AVSALSD (school district)[a]
Intercept	3709.049 (2.4198)*	6368.879 (4.6115)*	3763.832 (3.1287)*
T_E/PP	8695.428 (1.3975)		
T_H/PP		1508.66 (.3158)	
T_{SD}/PP			6001.396 (2.3943)*
ALTWG	.153417 (1.6012)	.136656 (1.3398)	.112674 (1.3765)
PNW	29.985183 (.9036)	-19.472998 (-.5537)	-1.261777 (-.0435)
VPROPEL	.023607 (.2007)		
VPROPHS		-.087947 (-1.3977)	
VPROPSD			-.039496 (-.4308)
NPROMEL	11.521545 (.5088)		
NPROMHS		25.88827 (1.4563)	
NPROMSD			51.298039 (2.5140)*
TREND	123.675219 (9.9423)*	172.713724 (13.6312)*	146.893959 (13.4711)*
F	28.82	37.48	44.92
R^2	.75	.79	.83
D.W.	1.93	1.79	1.82
n	293	293	293

[a] t-statistics in parentheses.

*Significant at five percent.

school district is operating further along the respective teacher supply schedule, implying a higher price of teacher services.

These measures have the expected positive sign in all of the regressions in Table 25, but only T_{SD}/PP has significant explanatory power in the estimation of the supply price of teachers to the whole school district. Although the alternative wage measure only approaches significance in one regression, its coefficient estimates are positive in all three regressions. The coefficient estimates for the remaining variables have the same signs as those in the regressions using the teacher-student ratios except for the one on VPROPEL. However, this variable had no explanatory power in either of the regressions in which it appeared. Supply functions were estimated using data from the union period, the 1970 through 1975 school years. They are not reported here as only the intercept terms and the school district dummy variables had significant explanatory power.

The reduced-form equations for elementary teachers, secondary teachers, and all teachers combined were estimated using data from the nonunion and the union periods. Only results for the whole school district are presented in Table 28 as they are essentially the same as the results found for elementary and secondary teachers separately. The data from the nonunion period had to be transformed to correct for positive first-order autocorrelation using Durbin's two-step correction procedure.

The budget measures, LOCFUND and OSFUND, enter as demand-side determinants. Consistent with expectations, they had a significant

Table 28. Estimation of the reduced-form equation for teachers at the school district level (1956-1975)

Independent variables	Dependent variables	
	Nonunionized period (1956-1969)	Unionized period[a] (1970-1975)
Intercept	.019953 (1.7979)**	-.051388 (-1.6110)
LOCFUND	.00002222409 (8.1016)*	.00001680905 (3.2247)*
OSFUND	.00002052289 (6.1945)*	.00002219603 (3.2963)*
PNW	.0001788135 (1.2470)	.00000702349 (.0481)
PCA	.0000502995 (-.03461)	.0007641905 (2.6801)*
VPROPSD	8.63334 E-7 (1.9820)*	6.31308 E-7 (1.4405)
TREND	.00032603 (3.7066)*	.0003867957 (2.3523)*
ALTWG	-5.66159 E-7 (-1.3848)	.00000171422 (1.5848)
NPROMSD	.0002254623 (2.5301)*	.000621761 (-2.0087)*
	- - - - - - - -	
F	38.92	14.32
R^2	.81	.80
D.W.	2.05	1.93
n	293	138

[a]t-statistics in parentheses.

*Significant at five percent.

**Significant at ten percent.

positive effect on teachers in both periods. The alternative wage measure was expected to have a negative effect on the number of teachers since a higher value for it implies a higher price of teachers. This result was obtained in the nonunion period, but only approached significance at the ten percent level. The alternative wage measure had the wrong sign using the unionized period data. The result is not surprising since estimation of the teacher supply functions gave no evidence of school districts possessing monopsony power in the unionized period. Finally, the time trend variable indicated that unmeasured supply and demand determinants caused the teacher-student ratio to increase over both periods.

D. Conclusion

This chapter tested for monopsony power in the market for public school teachers in the state of Maryland over the 1956 through 1975 school years. A supply function for teacher services was modeled and estimated using two-stage least squares. The data set was broken down into a nonunion and a union period, expecting that if monopsony power did exist, evidence of such would be more likely to be found in the nonunion period.

Empirical results from the estimation of teacher supply functions using the nonunion period data were consistent with the monopsony hypothesis as both the number of teachers and the alternative wage had a positive effect on the price of teacher services. It was expected that elementary school systems might possess a greater degree of monopsony

power than secondary systems as the predominantly female makeup of their teacher stock made potential elementary teachers more geographically immobile than potential secondary teachers. Although elementary teachers were estimated to have a more inelastic supply than secondary teachers, the coefficient estimate on the number of elementary teachers only approached having significant power in explaining the supply price of elementary teachers in the nonunion period. No evidence of monopsony power was found in the union period. This could be interpreted to mean that teacher organizations were successful in combatting the previously held market power of school districts in the market for teacher services. If unions were able to successfully counter the monopsony power of school districts, it would be expected that teachers would receive a higher price for their services and school districts would hire more teachers in the union period relative to the nonunion period. A relative teacher wage measure, the average salary to teachers in the school district divided by the alternative wage available to individuals residing within the school district, was calculated for the six years prior to unionization, 1964-1969, and for the first six years in which unions were in place, 1970-1975. Relative teacher wages in the union period were 3.1 percent higher than those in the nonunion period. Also, the average teacher-student ratio was 9.2 percent higher in the union period than in the nonunion period. However, this evidence is only consistent with the monopsony story, it is not conclusive proof of it as other factors may have been affecting relative wages and teacher-student ratios through the period. Finally, reduced-form equations were estimated for the two

periods. The results found were consistent with those from the estimation of the teacher supply functions.

VI. SUMMARY

A. Overview of the Empirical Results

Chapter III was generally successful in modeling and estimating the demand for teachers. Results were consistent with the assumed maximizing behavior of a school district administrator. Three measures of the price of teacher services were used in the estimation of teacher demand and one of those measures, the average of actual salaries paid, had consistently negative, and for the most part significant, effects on the demand for teacher services. There were some unexpected results, for instance the measure of state and local current educational funds had a negative and significant effect on the demand for teachers in a number of regressions. This may have been due to the simple approach taken towards budget determination in the model, assuming it to be exogenous. Consistent with previous studies employing similar methodology, the demand for teachers was found to be price inelastic. This result was obtained for the school district as a whole, for the elementary and secondary systems, and across small, medium, and large school districts. Elasticities varied for the different groups but all were within a fairly narrow bound. No pattern to such variation was discerned. Regressions estimating the demand for teacher experience and education levels were less successful than those estimating numbers of teachers in terms of the R-squared values and t-statistics that resulted. This was not surprising in light of the small changes from year to year in the average experience and education levels. The results were superior to previous studies in that the demand for

these teacher attributes was found to be negatively and significantly related to their prices in a number of the regressions, contrary to the results the other studies had achieved.

Chapter IV examined the possiblity that teachers were willing to accept a lower price for their services in exchange for better work conditions, focusing on the effects of smaller class sizes. No evidence was found of such a tradeoff in the 1961 through 1969 school years, a period when the 23 school districts were nonunionized. However, evidence of such a tradeoff was found during the 1970 through 1972 school years when collective bargaining agreements were in place between each of the school districts and a certified teachers' union. Both elementary and secondary teachers were found to be willing to accept lower prices for their services in exchange for smaller average class sizes.

Finally, Chapter V searched for evidence of monopsony power in the market for public school teachers. No such evidence was found using data from 1970 through 1975, a period when collective bargaining agreements existed between teachers' unions and each of the 23 school districts. However, during the period from 1956 through 1969, when no such agreements existed, evidence consistent with the hypothesized monopsony power of school districts was found. It should be stressed that this proof was not conclusive as the source of the monopsony power--geographical and/or occupational immobility, could not be identified.

B. Policy Implications

The demand for teachers was found to be price-inelastic across schooling levels and school district sizes using data from the 1958 through 1980 school years. The estimated elasticities were actually "partial" price elasticities to use Ehrenberg's terminology (Ehrenberg, 1973, pp. 373-377), since the size of the budget was not allowed to vary in response to changes in the price of teacher services. Ehrenberg found that state educational budgets increased in response to an increase in the price of educational manpower. If such an effect were to hold here, then the estimated price elasticities would serve as upper bound estimates on the absolute value of the whole (variable budget) price elasticity of demand for teachers.

An inelastic demand for teachers implies that teachers' unions may be able to achieve substantial pay increases for their members while suffering relatively small disemployment effects. Such a result could serve to further strain the budgets of local governments. However, several forces may act to restrain this effect. First, teachers' unions may not have sufficient bargaining power to achieve substantial wage increases. Laws in many states, including Maryland, prohibit public school teachers from using the strike as a tool in the bargaining process. Secondly, the results of Chapter IV suggest that teachers may be willing to tradeoff monetary remuneration in return for pleasant job characteristics. Individuals bargaining in the school district's behalf should be aware of the tradeoffs that teachers are willing to make between wages and working conditions and the costs to the school

districts of providing these amenities. By knowing the value placed upon various amenities by teachers and the costs to the school district of providing these amenities, the school district's representatives may be able to negotiate for a less costly employment package, consisting of pay and job characteristics, than would otherwise be arrived at. Finally, in the long run, school districts may be able to increase the price elasticity of demand for teachers by increasing the substitution possibilities between teachers and other educational inputs. For instance, as computer software improves, school districts may find it increasingly attractive to substitute towards computer-assisted instruction.

The final policy implication relates to state educational aid formulas designed to distribute state educational dollars so as to achieve equality of educational opportunity across school districts for comparable levels of tax effort by local residents. Suppose that equal educational opportunity results from equal student access to identifiable inputs into the educational process, teaching being one of those inputs. A formula designed to give school districts equal ability to purchase these inputs for a given level of tax effort requires that if prices of these inputs vary across school districts, the sources of such variation must be identified and incorporated into the aid formula if it is to be effective in achieving its goal. Chapter IV suggested that class sizes and the value of school facilities are two factors that cause the price of teacher services to vary. The school district dummy variables further suggest that interdistrict differences in the cost of living and

locational and job-related amenities and disamenities might also be considered in the determination of such a formula.

C. Future Research

The results of this study suggest several areas of future research. One extension would involve endogenizing the budget determination process, possibly by formally incorporating a median-voter framework into the analysis. Data describing the gross income and state and federal income tax payments by school district residents are available from the early 1960s to the present. Additional data describing property tax rates, the price of alternative government services, and community tastes and preferences would be needed. With this, the demand for teachers would be determined simultaneously with the determination of the community's demand for public education. This would allow for the measurement of the "whole" price elasticity of the demand for teachers, that is the response of the quantity of teachers demanded to their price, allowing the budget to vary in response to the change in the price of teacher services. At the same time, the level of outside educational funds could be more carefully modeled, accounting for those that are matching and those that are nonmatching. This might serve to indicate why the outside funding measure had an unexpected negative effect on the demand for teachers in some of the regressions in Chapter III.

A second extension would involve finding better data on the supply side of the market, for instance measures that would capture interschool district differences in the cost of living and locational amenities and

disamenities better than the school district dummy variables employed here. Also, it would be useful to get observations on individual teachers and schools as opposed to the school district averages employed here. Hopefully, this would allow for a more accurate estimation of the price-characteristics function derived in Chapter IV and the supply function of teacher services derived in Chapter V. It should also allow for the measurement of the different supply responses of various types of teachers, for instances males versus females, whites versus nonwhites, graduates of higher ranked colleges versus those from less pretigious institutions, new teachers versus experienced teachers, and the like. Also, the identification of the sources of teacher price differentials across school districts would allow for the construction of a more accurate state educational aid formula.

A third possibility would be to model school district behavior within a dynamic framework, focusing on the relationships among teacher demand, teacher turnover, and the price of teacher services. In this study, evidence was found of a relationship between teachers and the price of teacher services with Chapters IV and V suggesting that causality may flow in both directions. Teacher prices are also likely to affect turnover. If school districts face costs of adjusting their stock of teachers, say through hiring and training costs, then there is also likely to be a relationship among turnover, the price of teacher services, and teacher demand. For instance, school districts may opt to increase their teacher pay levels in order to reduce turnover up to the point where at the margin the increased salary expenditures are equal to

the decreased costs of teacher turnover. This would allow for the examination of school district responses to expected enrollment changes and to projected changes in the supply of teachers.

VII. REFERENCES

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