A Theoretical Model for Education Production and an Empirical Test of the Relative Importance of School and Nonschool Inputs

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(ABSTRACT)

The importance of public education in rural development has received increasing attention by local and state policy makers as competition for new industry has intensified throughout rural America. Uncertainty about the relationships of public and private inputs to education output, however, presents problems to state and local officals and parents interested in improving the quality and quantity of the public education system.

This research examines the education process in a production function framework to identify the relationships of education inputs to education output. A theoretical model that combines public and household decision making into an education production process is used as the basis for the empirical model that is developed. The estimated model includes input measures for school, family, volunteer and student inputs to education production and is estimated with cross-sectional data for Virginia counties. The expenditure measure used in the model is specified as a polynomial lag. The model also is specified as a joint-product production process.

The results of the analysis provide evidence of the importance of expenditures in education production and indicate that the impact of changes in expenditures occurs over time. The number of and educational levels of teachers also is associated with education output. Household and student inputs also are associated with education output. Volunteer input measures are not statistically significant in the estimated equations, a reflection of the difficulty of specifying and measuring specific volunteer inputs into the eduction production process. The empirical results do

not support a joint production hypothesis between outputs as measured by achievement test scores and the school continuation rate.

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CHAPTER I

INTRODUCTION

During the past four years the Reagan administration has pursued a number of policies under its "new federalism" program that have decreased the flow of federal monies to state and local governments for the provision of local public goods and services. While it is not certain what the full impact of the "new federalism" will be in Virginia, local governments already are experiencing problems maintaining public service levels because of what the Virginia Joint Legislative Audit and Review Commission (JLARC) calls severe financial stress for local governments that is the result of a number of economic problems and a restructuring of the institutional arrangements for financing the delivery of public services at the local government level. In a recent report, Local Mandates and Financial Resources, JLARC cites the principal causes of the current local government financial stress situation.

> First, the two recent economic recessions slowed growth of tax receipts and increased unemployment. Second, the federal government has reduced aid to localities, partly to reduce budget deficits and partly to return program control to states and localities. Third, local taxpayers have become increasingly reluctant to support or accept tax increases,.... Fourth, high interest rates have made local borrowing more difficult, or in some cases, prohibitive. And fifth, many localities are faced with increasing needs to replace or expand high-cost capital facilities.

Continued declines in federal transfer payments to state and local governments for the provision of local public services will force local government officials to address increasingly difficult decisions about which services to fund and at what level as they allocate resources to the mix of public goods and services that the government provides for its citizens. Careful consideration of the costs and benefits of each good and of technical efficiency in its provision will become exceedingly more important as decisionmakers allocate government resources to achieve a variety of community objectives.

Declines in federal funding to localities for public services have had a strong impact on the sources of support for local public services. Sources of support for local government spending have shifted from 10 percent federal, 32 percent state and 56 percent local in 1977, to 8 percent federal, 31 percent state and 60 percent local in 1983. Examining Virginia counties grouped in classifications established by the Virginia Rural Affairs Commission provides insight into the degree of stress that counties are facing because of federal funding cutbacks. Rural counties, in particular, will experience more financial stress as they must look to state and local sources to compensate for declines in federal transfers to state and local government.

The data in Table 1 show that "rural" and "most rural" counties were dependent on transfer payments from state and federal government sources for about two-thirds of the funds for total local government expenditures, while the "urban" counties depended on transfers from non-local sources for less than half of their expenditures. A "most rural" county is defined as a county in a non-standard metropoliton statistical area (SMSA) that does not have a town or city of 3,500 or more people within or on its borders. A "rural" county is defined as a county in a non-SMSA area with a town or city of more than 3,500 people within or on its borders. An "urban" county is a county that is classified as a standard metropolitan statistical area by the Bureau of the Budget. The mean per capita income for the "rural" and "most rural" juristictions was 69 percent and 68 percent, respectively, of the mean income level for the "urban" counties, indicating to a degree what the JLARC report calls stress from "high levels of poverty among local residents, and by revenue capacities which are low and stagnant by statewide standards." Any continued shift of local

TABLE 1: LOCAL GOVERNMENT EXPENDITURES BY SOURCE FOR VIRGINIA COUNTIES.

Classification	Number	Percent Federal	Percent State	Percent Local
Urban County Average	12	10	32	56
Rural County Average	35	14	47	38
Most Rural Average	48	18	45	36
State Average (1977)		11	31	58
State Average (1983)		8	31	60

government service funding responsibility from federal to state and local government undoubtedly will increase local government financial stress.

Reductions in federal funding of education, the most costly local government service, already have had an impact on the distribution of educational funding. Federal outlays for education, training and employment nationally declined 15 percent from 1978 to 1984 after adjusting for inflation. Total federal expenditures for elementary and secondary education declined 27 percent in real dollars between 1978 and 1982. Funding for education in Virginia from federal sources declined by 25 percent in real dollars between the 1978-79 and 1982-83 school years. Virginia local spending for education from local and state sources increased 19 percent and 24 percent, respectively, to offset declines in federal funding and slightly increase real dollar expenditures by 4 percent over the period. However, further declines in spending from non-local sources for education and other local government services will require additional local revenues (taxes) or cuts in funding for local services.

PROBLEM STATEMENT

As local governments adjust to the increased fiscal stress resulting, in part, from new institutional relationships that shift local public service funding responsibility from federal and state to local government sources, the communities that they serve are experiencing demographic and economic changes that are significantly altering demand for local public services. This change in the mix of public services demanded, coupled with the overburdened local fiscal capacities, is increasing the pressure on local officials to improve efficiency in the allocation of local public resources to public services.

Allocative efficiency, or economic efficiency, is achieved when the given pattern of resource allocation maximizes consumer satisfaction. To realize allocative efficiency in public service expenditures, a locality must not only produce the optimal mix of public services, but also must achieve technical efficiency in the production of each service. Limited understanding of the technical relationships in the production of many public services (education, police services, welfare) as well as difficulties in identifying and measuring the outputs of these and other public services, presents local officials with major obstacles in achieving technical efficiency in specific public services and allocative efficiency in local government spending. Improving technical efficiency in public service production is a necessary first step for local governments as they seek to improve allocative efficiency in the face of severe financial stress.

Of particular importance to local officials and community members as they examine local expenditures is the analysis of public primary and secondary education. First, increased local demand for a broader mix of public services, combined with the potential impact that small changes in non-local education funding can have on local government budgets since education accounts for such a large share of local government spending (52 percent of local government spending in Virginia in 1982), can have a major effect on the resources available for local allocation. Identification of the technical relationships of education production would enable local officials to respond to changes in education funding with minimum impact on output levels.

Second, technical efficiency in education production is important because of the increasing fiscal stress that local governments are experiencing. School officials need to understand technical relationships of education production to clarify issues regarding the efficiency of inputs in production of education outputs. Otherwise, allocation decisions must be made with uncertainty about the impact the decisions will have on education output.

Third, education output is important for achieving a variety of community and household objectives (economic growth, social stability and individual access to opportunity). Decisions regarding the funding level for education, however, are made through a political process that is based either on community concensus or some type of majority-rule decision model. If the education funding level is set according to a majority-rule model, a large minority of the community members would prefer a level of education production higher than that provided by the community. Knowledge of the technical relationships of education production would provide individuals who demand a higher level of education with better information for decisions about the allocation of household resources to education production to increase household members' education production.

Economists have examined the education production process (Burkhead, Hanushek, Katzman and others), but the efforts fall short of community and household decisionmakers' needs for guidance as they attempt to identify what constitutes "quality education" and evaluate alternatives available to communities for producing quality education. While economic studies have suggested that school systems are effective in producing some education outputs, they have not considered the multiple output nature of the education process or the implications of various funding levels on the production of education outputs that are jointly produced in the education production process. Consequently, the education production research that has been conducted provides limited usable information for school policy-makers to consider when making allocation decisions. Important community and household resource allocation decisions are being made without a clear understanding of the impact the decisions will have on education outputs, and without an understanding of what the implications of different funding levels for education will be for future economic growth or for individual access to opportunity.

The first problem that public policy makers and household decison makers face is the lack of guidance from theory and research for identifying and measuring a school's effectiveness in producing various school outputs. While a school generally focuses on achieving an average level of preformance for each student, households seek to maximize a particular family member's output, both community and household decisionmakers need specific school output measures to evaluate the education process's effectiveness in producing education outputs. Evaluations of school productivity must rely on assumptions about what the education production outputs are and how effective schools are in producing them. The difficulties that policy makers experience in attempting to measure school output is perhaps the reason that the General Assembly of Virginia specifies standard of quality for education in terms of resource input levels rather than measured education output.

The limited knowledge about school outputs also affects the general understanding of the technical relationships of the education production system. Policy makers and parents do not know the relationships of various education inputs to specific school outputs, or the relationship of one output to another in the production process. Decisions made concerning allocations of both public and household resources to specific education production inputs, therefore, must be made using strong assumptions about the input's effectiveness in achieving the desired outcome and with uncertainty about the impact of the allocation on other school outcomes. While researchers like Burkhead and Katzman, who divide education outputs into two broad catagories (cognitive skills and socialization skills), have recognized the issue of multiple school outputs, research has not incorporated multiple education outputs into education production models. Researchers generally have used education production models that focus on standardized achievment test scores or some other measure as a single education output. Levin warns of the potential problems of assuming a single output. Researchers, however, have failed to develop empirical models that account for this issue.

Community and household decisionmakers exploring local options for substituting school supplied inputs for each other, or substituting non-school inputs for school inputs in the education production process, also experience uncertainty in decisions relating to substituting school and non-school inputs in education production. The importance of non-school inputs in the education production process has been recognized (Barichello, Burkhead, Hanushek, Katzman, Rosenzweig). Research, however, has failed to include specific measures for non-school inputs in education production functions. Some researchers (Burkhead, Kesiling, Perl) have used measures to control for household influences on education production, but have used proxy measures to control for socioeconomic background (income, occupation, race). These measures are difficult to relate back to decisions concerning the allocation of either community or household resources to education production. Communities and households attempting to identify school inputs that are effective in producing specific outputs or non-school inputs that can be substituted for school inputs in education production must make strong assumptions about the relationship of the household input to the education process and about the impact that the inputs will have on education outcomes.

Another area of difficulty local community and household education policy makers confront as they evaluate possible resource allocation patterns is the impact that changes in the level of education funding and other inputs will have on the production of education output over time. Community decisionmakers must assume that they can achieve desired education output levels in a time horizon that fits the expenditure pattern that they propose over a specific period. Actual expenditure allocations, however, are made annually for a one-year period. They are not guided by research that defines the output changes that they can expect to realize over time in response to various patterns of resource allocations.

While research examining the impact of investments in education on gross national product have incorporated lag periods (Barnhouse-Walters and Rubinson), prior research on education production has failed to incorporate a lag structure into the analysis of the production process to identify the lags in the time it takes inputs to have an impact on outputs. An understanding of both of these issues is particularly important to household decisionmakers who are concerned with the impact of community and household resource allocation patterns on the education output of specific students in a specific time frame, rather than on the performance of the student body on average.

In summary, local financial stress and changing demand for public services at the local level are forcing both local leaders and household decisionmakers to make critical decisions about how community and household resources are to be allocated to the production of education. Limited understanding of how to measure education outputs and of the technical relationships in education production mean that decisionmakers must make these critical decisions with little awareness of the implications the decisions will have on the production of education in the community.

RESEARCH OBJECTIVES

The primary objective of this research is to identify technical relationships in the education production process that will assist community and household decisionmakers in the formation of local public education policy and in decisions regarding the allocation of public and household resources to the education production process. To achieve this objective, an education production function will be examined.

As an initial step in the research, it will be necessary to identify multiple measures for education output. While prior education production studies have recognized the multiple output nature of the education process, these studies have focused on single-equation models that use a representative measure of school output as the dependent variable in empirical estimation. Following Hirsch's suggestion of the need to differentiate between the quality and quantity dimensions of public service outputs, this research will focus on the quality and quantity dimensions of education output and develop measures for both dimensions of education output. While this limits the range of education outputs, this approach will provide a means of examining the relationship between types of school outputs and will provide policy makers and parents with a clearer understanding of the multiple output nature of the education process.

The second step in the research will be to estimate an education production function that utilizes multiple measures for education outputs. This will provide education decision makers with insight into the jointness of production of the quality and quantity dimensions of education, as well as give a clearer understanding of the relationship of both the quality and quantity dimensions of education to various inputs in the education production process. This will give decisionmakers additional insight into the relative importance of various types of education production inputs on education outcomes and will enable community as well as household decisionmakers to consider the impact of various resource allocation decisions on both the quality and quantity of local education. Also, it will suggest resource allocation options for school systems responding to local demand for increased quantity or quality education, and to parents seeking to increase their household's investment in either quality or quantity of education.

The third step of this research will be to examine the structure of education production over time to determine if there is a lagged effect on changes in education output from changes in education inputs. The nature of the lag structure, if any, has been generally ignored in education production research. While a few household production studies (Barichello, Rosenzweig) of education have recognized the importance of inputs from prior years on education outputs, neither these studies nor education production function studies have incorporated measures of lagged relationships in order to examine this important issue. A clearer understanding of any lags in output production will help both community members and households evaluate the implications of various education funding patterns on local education output.

Improving understanding of education output measurement, identifying the technical relationships in the education production process, and determining the impact of changes in education input levels on education output over time will enable community and household decisionmakers to analyze the pattern of their community's allocation of resources to education and make adjustments to either public or household expenditures to both increase technical efficiency and increase school average or individual student performance, or both.

RESEARCH HYPOTHESIS

Three sets of hypotheses, one primary and two corollary, will be tested in order to satisfy the research objective. The discussion above suggests that community and household decisionmakers need to know the technical relationships of education production to improve the technical efficiency of education and to improve the allocation efficiency of local public expenditures. A clear understanding of the extent to which school and nonschool resources influence education production and the complementarity of these resources in the production process is critical to questions concerning the efficient allocation of public expenditures. It is also important in the consideration of the allocation of household resources to the education process. The primary research hypothesis is stated as follows:

- Education output is a measurable function of school and nonschool inputs.

The test of the hypothesis will indicate whether certain inputs into the education production process have a significant impact on the production of school outputs. While understanding the importance of nonschool inputs in education production is important to school policy- makers, it is essential to household heads allocating resources to education production to supplement school inputs in the production process.

A corollary hypothesis will be tested to determine the relationship between the quality and quantity dimensions of education output in the production process. The hypothesis is stated as follows:

- Education quality and quantity are joint products in the education production process.

Tests of this hypothesis will provide insight into the relationship between the quality and quantity dimensions of education which will in turn provide a clearer understanding of the effects of investments in one or the other dimension on production. It is important for both community and household decisionmakers to know if the quality and quantity of education are joint products of the education process, or if increased production of one will be at the expense of production of the other. Understanding this relationship will enable decisionmakers to make both public and household resource allocation decisions knowing the implications of the allocations on the production of both the quantity and quality of education.

The second corollary hypothesis will test for the presence of output lags in the education production process. The hypothesis is stated as follows:

- A lag period exists before discernible output changes result from changes in education production inputs.

The testing of this hypotheis will provide policy makers with a clearer understanding of the period required to realize changes in education outputs resulting from input changes. This will help both community and household decisionmakers plan resource allocations to achieve desired education outcomes.

RESEARCH APPROACH

This study is a macro-level study of the education system as defined by Rist, in that it focuses on the school district as the unit of analysis. Aggregate data are used to estimate the technical relationships between school district output measures and school, household and peer inputs into the education system. Macro-level studies are generally concerned with the performance of a school system in an aggregate sense and not with the effectiveness of the school in production of education outputs in individual students. This study will attempt to identify the aggregate technical relationship in the school's education production process to provide community and household decisionmakers with an understanding of the relationships between inputs and outputs in the school system. These relationships are key factors in local decisions to allocate public resources to the education system, as well as household decisions to allocate additional resources to education production to supplement or complement public provision of inputs.

The main limitation of the marco-level approach to education research is that it does not provide student-specific results. The relationships identified in the study will apply directly to aggregate inputs and aggregate outputs at the school district level. While the results should be useful to individuals considering micro school issues, the research focus is the relationship between public sector inputs and household inputs in local education production.

ORGANIZATION OF DISSERTATION

The first chapter of this dissertation has discussed the research problem and the hypotheses that will be tested in the study. The chapter also discussed the research approach and the advantages and limitations of the approach.

Chapter II presents the theoretical framework from which the empirical model used to test the research hypotheses is developed. The chapter includes a discussion of prior research on education production and education demand that is related to the study. The last section of Chapter II presents the theoretical model that is the basis for deriving the estimating equations used in the study.

A discussion of the specification of the empirical model and the data used in the study are presented in Chapter III. Estimation issues, estimation techniques and estimation strategies also are discussed in the chapter.

The empirical analysis and results are presented and discussed in Chapter IV. A summary of the research findings and the implications of the results for policy and for future research are discussed in Chapter V.

CHAPTER II

THEORY AND LITERATURE REVIEW

INTRODUCTION

Education is a complex process that draws on both public and private resources to produce educated individuals. While the public school system provides the formal structure for the education process, non-school resources are recognized as important factors in the education process (Hanushek). This chapter presents the theoretical framework for examining the education production process. In the first section, welfare economics is used to examine education as a public good. Then a decision model from the economics of public choice is utilized as a basis for a model that establishes the level of funding that the community will provide for the public good: education service. The third section develops a general education production function model and discusses results from applications of production theory in prior research. The fourth section presents a household production model, discusses research that has applied household production theory to analysis of education issues, and develops a household model to examine education production issues. The next section develops a theoretical model for education production that considers both the private and public inputs to the education process. A summary of the chapter is presented in the last section.

EDUCATION: A PUBLIC GOOD

The literature on public goods begins with Samuelson's definition of a public good as one for which one person's consumption of the good does not interfere with another person's consumption. Margolis and Mishan have pointed to some of the limits or ambiguity of this definition. Margolis has shown that generally the assumption that one person's consumption of a public good does not affect another person's consumption of the good does not hold. Mishan points out that Samuelson's definition does not specify the distribution of the public good.

The two general characteristics often referred to as the distinguishing characteristics of a public good are that it is nonexclusive and that it is indivisible in consumption. As a result of the confusion that the Samuelson definition and others present, Randall introduced a classification system that treats exclusiveness and divisibility as two separate phenomena. Under his classification, goods are divided into four groups: divisible, exclusive goods; divisible, nonexclusive goods; indivisible, exclusive goods; and, indivisible, nonexclusive goods. Randall defines an indivisible good exactly the same as Samuelson's public good. Divisible refers to the effect that one person's consumption of the good has on another person's ability to consume the good. Exclusiveness refers to the ability to exclude people from consumption of the good. If access to the good can be controlled, the good is exclusive.

Under Randall's system, education is an indivisible, nonexclusive good. While it is possible to exclude people from a school, or from direct consumption of education services, the external benefits of education, such as good citizens, are jointly consumed by everyone. Education, therefore is an indivisible, nonexclusive good because of its jointness in consumption. Buchanan discusses the provision of education as a public service because of the jointness of education in consumption. Because of the positive external benefits of education, the good would be supplied at an inefficient level if it were supplied only as a private good.

A COMMUNITY DECISION-MODEL: THE MEDIAN VOTER MODEL

The median voter model (Bowen) presents a theoretical decision making model through which a community's decision to provide a specific supply of a public service can be examined. Barlow applied this theoretical framework to a study of school finance. The model assumes that each decision maker seeks to maximize his or her vote in an election for public office and, therefore, selects the policy option favored by the median voter to satisfy the greatest number of voters. The model also assumes that one man one vote applies, that everyone votes his/her true preference, that there is no private provision of the public good, and that there is a uniform tax-rate.

In the model, decision makers consider W_i policy option for the community, where i = 1,..., n. The private good, X, is a numeraire good. The policy that is selected in the community decision process, or the public service level that is provided, is the median voter's most preferred choice. Any deviation above or below this preference would result in a majority of the voters opposing it and, consequently, decision makers not favoring it.

The median voter's preference is determined by maximizing his/her utility function subject to his/her income constraint. The median voter's utility function is written (Atkinson and Stiglitz),

$$U = U(I - P_G(G/H),\ G)$$

where I is income, G is the public service provided, P_G is the unit price of the public service, and H is the number of households. P_G/H is the marginal tax share of each household, and $(I - P_G G/H)$ is income spent on consumption of private goods, X.

The voting equilibrium is characterized by the median voter's preference,

$$\frac{\partial U_g}{\partial U_x} = \frac{(P_g)}{(H)},$$

the point at which the ratio of the median voter's marginal utilities equals the ratio of prices or the point when the marginal rate of substitution equals the marginal-tax share.

The level of the public good provided is the level at which the marginal tax share (MTS), or P_G/H, equals the median voter's marginal rate of substitution (MRS_{GX}) of G for X, or

$$MTS = P_G/H = MRS_{GX}$$

The service level funding is established by multiplying the MTS, or MRS, of the median voter by the number of voters, and providing service at the level where this sum is equal to the marginal rate of transformation of G for X, or

$$H \times \overline{MTS} = MRT$$

Samuelson optimality for a public good is achieved when the public good is supplied at the level where the sum of the marginal rates of substitution for the consumers is equal to the marginal rate of transformation, or

$$\Sigma MRS = MRT$$

Since,

$$\Sigma MRS = MTS$$

$$H \times \overline{MRS} = P_G$$

so

$$\overline{MRS} = P_G/H$$

The level of funding provided through the median voter model is only equal to the Samuelson optimal level when the median voter's preference is equal to the average voter's preference. Otherwise the distribution of the tastes and preferences of the people in the community determines whether the good is over- or under-supplied. The over- or under-supply of the good would depend on whether the median voter's marginal rate of substitution is greater than, equal to, or less than the voters' average marginal rate of substitution.

While the median voter model fails to recognize that a voting equilibrium may not always exist, and treats decisions as a single dimension, the model does present a framework in which the decision making process can be modeled and illustrates how a particular level of service delivery is determined for a specific community. The model shows how 50 percent minus one of the voters in the community could demand and be willing to pay for a service level greater than is being provided by the community. Through the median voter model, a community determines the level of public funding that will be allocated to education production through the public education system. Households demanding a higher level of service must either obtain the additional service in the private sector or produce it themselves.

AN EDUCATION PRODUCTION MODEL

Estimating the relationship between education production inputs and outputs has been the focus of several studies attempting to gain insight into issues concerning resource allocation in the school system. Most of the studies (Coleman, Burkhead, Hanushek, Katzman, Kiesling, Levin and Bowles, Perl, Summers and Wolfe) have used a production function framework to focus on the influences of various school supplied inputs on some measure of education outputs. Two studies (Leibowitz; Murnane, Maynard and Ohls) used a production model to analyze the relationship between household inputs and achievement, as measured by standardized achievement test scores.

The general education production function model presented in the economics literature by Burkhead, Hanushek, Katzman and others is based on the simple production model,

$$O = f(K, L)$$

where some output , O, is a function of capital, K, and labor, L, inputs.

The education production function is specified as a multiple-product, multi-period production process with inputs from varying sources. The model can be stated,

$$O_t = O(S_t, F_t, P_t, I_t)$$

where,

t = time,

O = a vector of education outputs or outcomes,

S = a vector of school inputs,

F = a vector of family inputs,

P = a vector of peer inputs,

I = a vector of student inputs,

The education output vector, O, includes a variety of school outputs that are the desired outcomes of a multiple-objective school which is directed by a community objective function. Specific education outputs and their measurement will be discussed below.

The school input vector, S, contains capital and labor inputs to the education production process that are supplied by the public school system. This vector has been the focus of most education production research because of the policy applications to allocations of public funds. Teacher labor, administrative labor, school facilities, and educational supplies are examples of the school inputs.

The family input vector, F, includes household inputs of time and purchased goods into the education production process. Household inputs are both direct and indirect. Helping students with school work, developing attitudes toward school and learning, and purchasing materials to be used in school are examples of direct inputs into education production. Examples of indirect inputs include a range of family factors that influence the educational process, such as developing a value system, respect for authority, and basic communication skills. Both the indirect and direct inputs are related to the level of human capital the adult family members have to transfer to children and the value that the family puts on human capital development. These factors are difficult to quantify, but influence the education production process.

The last two input vectors, peer influences (P) and student inputs (I) are inputs to the education process by students and their peers. Some of these inputs are easy to quantify and measure, like student time on school activities or specific academic endeavors. Others, like ability, attitude, and motivation are less easily understood and measured. Peer influences, although generally recognized as having a strong influence on education outcomes (Burkhead, Hanushek, Katzman), are even more difficult to specify and measure. Peer inputs affect attitudes, ambition and work habits, and can have either positive or negative influences on education outcomes.

Production decisions for the vector of education outputs in this model result from a community process, such as that evidenced in decisions reached through the median voter model above, that establishes the community's objective function for education. That is, the community establishes a mix of education outputs in response to state and federal mandates and community demand that the school system is directed to achieve for each student in the school system. School administrators then attempt to achieve this minimum output level for each student and have little flexibility when making production decisions that would allow trade-offs between the various outputs the school is producing, regardless of changes in input costs, input flows, or technology changes. Administrators are constrained in their ability to substitute inputs for each other because of salary structures, staff-tenure systems, state-mandated input levels and other policy decisions that are not under their control.

Viewed this way, the education production process is a system for which administrators analyze alternative allocation decisions in attempts to achieve production of a multiattribute education product, or multiple outputs. That is, specific levels of desired education outcomes are articulated in the community and production decisions are made that allocate resources to achieve these specified outcomes at minimum cost. Resource allocation decisions can be modeled as lexicographic utility orderings. This occurs when a multiattribute situation exists, and the decision maker cannot make tradeoffs between the attributes. The decision maker (in this case the school administrator) attaches dominant priorities to attributes, or outputs, in some specified order reflecting the hierarchy of wants (Anderson, Dillion, and Hardaker, p 87). The community's wants and desires approximate an objective function. It is important to note, however, that school officials have limited understanding of specific school outputs demanded or how to measure many of the outputs (citizenship, motivation, attitude). They lack a theoretical understanding of education production technical relationships. And, while they have some control over the allocation of the resources in the vector of school inputs, S, they have only limited influence over the inputs from the other input vectors. Due to the unique nature of each student in the education system and the variation of the nonschool inputs applied to each student's education, school administrators must allocate resources to school inputs in an attempt to produce a specific school average for each education output.

THE EDUCATION PRODUCTION PROCESS

Education production has several characteristics similar to characteristics that Weaver identifies for agricultural production that make it a unique production process. Education, however, does not have profit maximization as a decision rule for its production mix. Education administrators also have limited flexibility in the allocation of resources to input markets to achieve least cost production. Consideration of education's uniqueness raises several conceptual issues that must be addressed when estimating production relationships and in developing households' derived demand for quantity and quality of education.

The nature of the education process and the difficulties associated with defining inputs and outputs combined with a limited understanding of the technical relationships create problems in modelling the production of education. These problems can be grouped into two categories: those related to output identification and measurement, and those related to limited knowledge of the production process and to constraints in resource allocation to input markets.

Output Characteristics of Education. Diversity of education goals and objectives presents problems in the estimation of education production functions across school systems (Fox). Standard production theory concentrates on varying quantities of homogeneous outputs which are difficult to translate into an education equivalent. Katzman, Levin and Summers and Wolfe discuss the multiple output of education and the issues it raises for education production model estimation as well as the difficulties it creates for interpretation of estimation results. Prior research has generally estimated education as a single output process with researchers assuming that all schools are trying to produce the same output mix. This assumption introduces bias to the degree that output objectives of the education systems being studied vary across schools in the study. Additional bias is introduced because of the variation in the technical efficiency that exists across school systems.

Several economists (Burkhead, Hansuhek, Perl) recognized the difficulty of product specification and the lack of a theory of the learning process to guide researchers in model specification in attempting to estimate education production relationships. So, while economists have broadly classified education outcomes as either cognitive skills or socialization skills (Burkhead, Katzman), measures developed for specific skills lack clear linkages to intended educational outcomes, or to conceptual outcomes drawn from learning theory.

Another difficulty arises because many of the education outputs are not easy to quantify. General socialization skills, such as, citizenship, motivation, and social stability, may be societal objectives of the education production process, but are difficult to measure with variables that are quantifiable and relate to a school system's or to individual student's performance. One approach suggested in the literature to resolve this problem is the use of representation or fractional measurement (Katzman, p. 34). This approach requires the selection of a single measure for education outputs that is deemed representative of all education outputs and can serve as an indicator for output level in the evaluation of education production. For example, the number of students completing high school is a measure that has been used in economic research to represent socialization skill output (Katzman).

Ostrom, in discussing the need for multiple output measures for public services, emphasized the link between measuring public service outputs and increasing productivity in the public sector. Her discussion stresses the need for research to develop measures that represent public service outputs to provide for better management of public service production. Clearly, education research would benefit from both better output specification and the use of multiple quality and quantity output measures.

Production Characteristics of Education. Limited knowledge of production relationships and resource allocation constraints in public education presents researchers and policy makers with additional problems in education production research. First among these is the multiple input and multiple output nature of the education production process. While this characteristic is not unique among production processes, the limited theoretical specification of the technical relationships between inputs and outputs of education complicate research and make it difficult to interpret research results. Joint production relationships are not known. Allocation of resources to produce specific outputs is not based on the equation of marginal value products of inputs because the production relationships are not known. Economic efficiency is, therefore, difficult to address because of the limited knowledge of the technical relationships involved, the constraints on input substitution caused by the fixity of inputs, and variation of input cost across individual suppliers (households and individuals) for the school system.

While the technical relationships of education are not known, the importance of student and family factors on education attainment is well known (Burkhead). School level production decisions must account for variation in these non-school inputs without being able to adjust the quality or quantity of the inputs, and without knowing the exact technical relationships of the inputs to production or the elasticities of substitution between the non-school inputs and school supplied inputs. Family and student inputs, as with school inputs, vary in both quality and quantity.

The education process can be formulated as a process to maximize human capital development potential. At grade one a specific student has the potential to achieve level X of human capital accumulation by year 12, or the completion of high school, if production inputs are supplied at specific levels over the 12-year production process. At the begining of year two the student faces a potential accumulation level X minus any potential lost due to year one input supplies at a level below the maximizing level. Identification of input factors that affect the production process and the relative importance of the inputs at different points in the production process would aid policy makers trying to allocate resources to specific grade levels to achieve education output objectives.

Issues regarding the optimal levels of education production inputs and the impact of variation in the quantity and quality of inputs over time are critical to public and private decisions regarding human capital investment. The complexity of the education process and a limited understanding of the relationships involved, however, has left these issues unresolved.

Critical to this issue is differentiating between input quality and quantity. Various human capital investment measures can be utilized to examine labor input quality. Capital inputs must rely more on the value or cost of the inputs to capture quality and quantity.

Another characteristic of the production of education is dependence of the education process on labor inputs. While technical advances in education over time have shifted the capital to labor ratio to a higher plateau, education can still be referred to as what Baumol calls a non-progressive industry. That is, an industry in which there has been limited substitution of capital for labor due either to the nature of the production process or the lack of research or institutional support to shift resources from labor to capital inputs. While writers like Jequier suggest that innovation and application of appropriate technology may alter the relative labor intensity of public services like education, evidence to that effect is limited. The implications of innovations that increase the capital intensity of education could greatly alter each individual's and the nation's potential stock of human capital.

A MODEL FOR EDUCATION PRODUCTION

Education is a multiproduct production process with inputs that are both allocable and nonallocable. Beattie and Taylor define an allocable factor as one for which the amount of the input used in the production of one product can be distinguished from the amount used in the production of another output. They define a nonallocable input as one for which no distinction can be made between the units used in producing one output versus another.

The mathematical representation of this joint production process is presented by Beattie and Taylor as:

$$P_{1}: F_1(Y_1, Y_2, Z, X_{11}) = 0$$
$$P_{2}: F_2(Y_1, Y_2, Z, X_{12}) = 0$$

where P_1 is the production process for Y_1 and P_2 is the production process for Y_2. The production processes are interrelated because of jointness of Y_1 and Y_2 in production. Nonallocable inputs are represented by Z. These are resources that cannot be allocated to the production of a particular education output, such as school facilities which are needed to produce each school outcome. Allocable inputs, X_{11} and X_{12} , indicate the amounts of X_{1i} that are used specifically in the production of a school output. For example, reading materials are resources that are inputs to increase a specific cognitive skill and are specifically related to the production of that skill as opposed to other intended school outputs.

The difficulty that the joint production nature of education presents for researchers is that neither specific output measures for education nor technical relationships of inputs to outputs are known.

Related to the multiple output nature of education production is the issue of differentiating between the quality and quantity dimensions of education. As most studies have failed to recognize the multiproduct nature of education production, they also have not recognized output quality and quantity differences. The earlier studies have assumed either explicitly or implicitly that the output measures used are what Katzman calls fractional measures of all education outputs to a great enough degree to provide policy makers with at least some insight into education production issues. Hirsch's discussion of the quantity and quality issue indicates the difficulties inherent in this concept to public services in a broad context. He presents a model where public service output is a function of both quality and quantity dimensions,

$$O = O(A, Q)$$

where O is the public service output, A is its quantity dimension, and Q the quality dimension. The education production function also must be specified to reflect both the quality and quantity dimensions. Hirsch presents the public service production function,

$$AQ = M(I, S, T, R)$$

where A is the quantity dimension of the output, Q is the quality dimension, I is a vector of inputs, S is a vector of service conditions, T is a vector of the state of technology and R is a vector of institutional arrangements. To account for the quality/quantity issue, the function can be rewritten,

$$A = A(Q, I, S, T, R)$$

The quality, Q, production can be stated similarly as,

$$Q = Q(A, I, S, T, R).$$

As Hirsch's model illustrates, public service outputs are a function of both the quantity levels and the quality levels of the service outputs. The ability to vary both of the dimensions independently necessitates that models used to estimate production relationships of one dimension control for variation in the other. Examining the quantity dimension of education independently of the quality dimensions, such as in the production function studies and the demand studies by Barichello and Edwards, might be acceptable for samples of pupils from within one school with the assumption that the school can and does maintain a standard-quality of education output. Increases in the sample beyond a single school, however, weaken the assumption of standard quality education. Past education research has used years of schooling, cost measures, or achievement test scores as school output proxies, while little attention has been given to measuring the quality and quantity dimension of outputs produced.

Incorporating Hirsch's discussion of the quantity and quality dimensions of a public service with Beattie and Taylor's joint production model, the education production model can be restated, as above,

$$P_1: F_1(Y_1, Y_2, Z, X_{11}) = 0$$
$$P_2: F_2(Y_1, Y_2, Z, X_{12}) = 0$$

where Y_1 is education quality and Y_2 is education quantity. This model presents the education production process as a multiproduct production process and explicitly recognizes differences in output quantity and quality.

REVIEW OF EDUCATION PRODUCTION FUNCTION LITERATURE

Limits to the theoretical understanding of the production of education have presented researchers with a severe constraint in dealing with economic issues involving education. However, some important insights into education production have been gained by researchers through the application of economic theory to the education production process. Education inputs can be classified broadly as school inputs and non-school inputs. The majority of the research has attempted to isolate school inputs to the education production process that affect education outcomes. Some attention also has been given to the affect of household resource allocations on cognitive development. A review of education production function literature follows. The literature, however, has not recognized that education production is a partnership between the community, the school, the household, and the student. Interaction between these input sectors is critical to the education production process.

EDUCATION PRODUCTION STUDIES: SCHOOL INPUTS

Research to investigate the effectiveness of various education inputs in producing education outcomes gained the interest of economists in the mid-1960s in response to the release of the Equality of Education Opportunity Report, commonly refered to as the Coleman Report after its principal author. The study's controversial findings suggested that school purchased inputs had little or no effect on education outcomes as measured by standardized achievement test scores after controlling for socio-economic factors. The study used a linear regression model with individual students as the unit of observation.

Two studies were conducted re-analyzing the data used in the Coleman Report. In one, Bowles and Levin suggested that poor sample-response and the treatment of non-response to specific questions in the Coleman study introduced bias into the study's estimates. They re-estimated the models after correcting the error and found that teacher experience or teacher verbal test scores had a significant influence on school outcomes as measured by standardized achievement test scores. Bowles and Levin also recognize the potential specification error in both the Coleman and their own study because the analyses ignored the possible effects of inputs from prior years on current achievement levels. The other re-estimation of the Coleman study was done by Hanushek, using a subset of the original Coleman data. The study found both teacher experience and teacher verbal test scores to be significant in explaining achievement.

Kiesling used a student intelligence measure and the father's occupation as controls for non-school inputs in a study of 97 New York high schools districts using regression analysis to determine the effectiveness of school inputs on education. Student achievement and intelligence scores were aggregated for each school district by students in each of six household-occupational groups. The study found the aggregate school input measure, per pupil expenditures, to have a weak influence on education output except in large urban school districts. Again, this cast doubt on the effectiveness of schools in influencing cognitive development.

A study by Perl used regression to analyze the influence of 14 school-characteristics on the effectiveness of school inputs with a sample of over 3,000 students. Family income and father's occupation were used to control for non-school inputs. No control was used for student inputs. The study found teacher's starting salary, percent of teachers with a graduate degree, percent of teachers with specializations, class size, school library holdings, and the percent of male teachers to have statistically significant influences on student achievement test scores. Perl used multiple regression analysis in the study, but stated that because of the simultaneous nature of education production, there was a possibility that "at any given input levels, schools can increase the production of the first output by decreasing production of the second, and vice versa" (page 163).

An education production study by Burkhead of large city and rural area high schools found school building age, teacher experience and beginning teacher salary to be significantly related to student achievement test scores in small town schools, but found no school input measures significant in linear models of achievement for large schools. The age of the school physical plant was included as a measure for the quality of physical inputs. As a proxy for nonschool inputs, the study used median income; it was significant and positive. Burkhead's study, while using standardized achievement test scores as output measures, also included models that used student I. Q. scores, post high school plans, and school dropout rates as measures for school outcomes. The model with I. Q. as a dependent variable had results similar to the achievement test models. The post-high-school plans model had no statistically significant independent variables. The model with dropout-rate as the dependent variable found school building age to have a significant and positive influence on the dropout-rate, while per pupil expenditures on materials and supplies had a negative influence. This suggests that increasing investments in facilities and supplies is associated with the school's ability to retain students. This suggests that students recognize community interest in education as expressed by investment in the school structure and schools supplies and react by remaining in school.

Katzman's production study of students in the Boston school system further expanded the use of output measures. The study included linear models with achievement test scores, attendance records, entrance exam scores, and dropout-rates as dependent variables. White collar employment was used as a control for socioeconomic background or non-school inputs. The achievement test measure was the difference between mean reading scores for students taken in the second grade and the sixth grade, attempting to measure the change in cognitive ability during the production period being investigated. The study results suggest that several inputs have a positive influence on education production. Staff/student ratio, school district size, and teachers with master's degree were all significant and positive in two or more of the models. Percentage of teachers with one to ten years of experience, however, had a significant positive impact on the school holding-power measures (average daily attendance and percent of primary school graduates who continue through high school) and a significant negative influence on reading achievement. This suggests that while some outcomes may be joint products of the production process, other sets of outcomes may be in competition with each other in production as mentioned by Perl.

A study by Summers and Wolfe of 627 school children in 103 Philadelphia elementary schools used the change in a composite achievement test score over a three-year period as the school output measure in a production model analyzing the impact of school inputs. The study used linear and non-linear functional forms, but found only linear models and models with interactive terms to be significant. The study used income and race measures as non-school input controls for individual students and school racial mix as a control for peer influences. The study results indicated that teacher quality, non-teacher school quality, and the efforts of peer group effects influence education achievement test outcomes. The authors also conclude that the significance of several interaction terms suggests a need to examine the impact of various inputs on achievement, differentiating students by income, race, and other variables.

The education production studies, in general, have demonstrated weak relationships between school inputs and outputs as measured by standardized achievement test scores or other measures, although a few variables, such as teacher experience and teacher verbal ability, have been significant in several studies. While most of the studies refute the Coleman Report's pessimistic conclusion that school inputs have no major effect on educational outcomes, they provide little guidance toward estimating a model for general education production parameters.

EDUCATION PRODUCTION STUDIES: FAMILY INPUTS

While a number of studies have been undertaken to identify the relationship between school inputs and education outputs, few have been conducted to identify the influence of household inputs on education. Studies by Leibowitz, and Murnane, Maynard and Ohls looked at the impact of household-time and -goods allocations on children's achievement.

Household or family inputs into the education process are generally considered to be important factors. The family influences individuals' attitudes toward self, school, the community and society, as well as many other factors that relate to the way a student interacts with other people and approaches learning. The family also makes an input to the education process through the allocation of time and money to children's education. Health and nutrition factors are household inputs to education. So are parental time helping students with homework, family time volunteered in school, and household time allocated to school organizations such as parent-teacher organizations. Household expenditures on material to support education influence education as well. While much of the household contribution is independent of the school, it is not independent of the socioeconomic class and the factors that influence the public-choice decision. The success of the student is greatly affected by family inputs.

Leibowitz specified a theoretical household production model for child development in a production function framework where child development is a function of parents' time-inputs, goods inputs, child's genetic stock (not included in the empirical model), and parents' attributes. The study used a standardized verbal ability test score to test the hypothesis that adult time spent with children develops the children's verbal skills. The results suggest that child verbal development is related to parents' time-inputs. Reading to children had a positive influence on reading achievement, while watching televison with children had a negative influence on it. Liebowetz's research also suggests that the mother's educational attainment is an important factor in a child's human capital production process.

Murnane, Maynard, and Ohls used a linear regression model to analyze the influence of household time and goods allocations on children's achievement. The results indicated that child care provided by mothers with different levels of education has different influences on children's achievement test scores. The higher the education, the greater the positive influence of the child care on achievement. The study found no evidence that specific-goods inputs were related to children's achievement.

The limited research on household resource allocation to education and earlier research by Leibowitz on time allocation suggests the importance of household inputs in education production. The lack of a learning theory to guide research and limited data on household resource allocation seem to have constrained research in this area by economists.

SUMMARY OF EDUCATION PRODUCTION LITERATURE

The education production studies have provided interesting, although inconclusive results. While various school, family and community attributes have been identified as influencing education outcomes, general conclusions from the studies about the effectiveness of specific school inputs is lacking. Four issues that have not been adequatly addressed in prior research may explain the reason for the dissappointing results of earlier studies.

First, there has been a failure in prior research to consider the possibility of joint production in education. Education is described as a multiple output production process in the conceptual models of several prior studies (Burkhead, Hanushek, Katzman, Perl). The empirical models used in the prior research, however, treats education as single output process, or as a multiple output process with a series of independent production processes. Joint production, which has the potential of introducing bias into the parameter estimates of the equations estimated, is not considered. Among the empirical issues that single equation estimation raises is the question of efficiency. The single equation models make the implicit assumption that the school systems in the study sample are placing the same emphasis on the production of the output that the empirical model is using as a dependent variable. Assumptions about both efficiency in production and the importance of the production of a specific school output in a school's objective function present possibilities of introducing bias into the parameter estimates (Levin, Hanushek).

Another issue in education production function estimation is the selection of output and input measures for use in the empirical models. Many studies lack a conceptual basis for the selection of the variables used in the studies (Hansuhek). They seem instead to simply rely on the variables available for use in the study. Differentiation of capital and labor input, as well as the quantity and quality of the inputs, is not discussed or analyzed. This limited conceptual guidance in the specification of the empirical models brings into question the nature of the models being estimated and the interpretation of the results that the models yield.

Third, the prior studies, while recognizing the importance of the household sector in education production, have failed to link household resource allocations to education production. Education is provided as a public service. Households allocate resources to education to supplement or complement the level of education provided by the community as a public service. Recognition of the importance of household allocations to education production and their relationship to school inputs is a critical issue for education policy makers. The exclusion of household input variables may be biasing the coefficients of the aggregate measures used as variables for school inputs.

Another issue not addressed by prior research is the lag structure in the education production process. Research examining the relationship between school expenditures and standardized achievement test scores suggests that a lag relationship does exist (Connors). A few studies have attempted to measure the incremental change in school output in a year by using the difference on achievement test scores administered at the begining and end of the year (Katzman, and Summer and Wolfe). They, however, examined the change that occured in the same year as the inputs were made. The issues of lags in education production has not been adequately addressed.

Prior education research has examined either school production factors or household production factors in an education production framework. Research has not considered, however, the relationship between the level of education provided as a public good and the allocation of household resources to the education production process to supplement or complement public provision. The household production model is introduced below to link household allocations for education production to the community's education production process in an education production function model and to recognize explicitly the value of household inputs in education production.

HOUSEHOLD PRODUCTION THEORY

The general household production model has been developed by Willis, DeTray, and Becker and Lewis to focus on child quality and demand for children. The model developed by DeTray, similar to that of the others, begins with a household utility function,

$$U = U(C, Z)$$

where C is the family's consumption of child services and Z is its consumption of all non-child services. The household allocates its resources, both time and income, directly or indirectly to household production processes that yield utility to the household. The model is completed with four production constraints and a budget constraint.

$$C = C(N, Q)$$
$$N = N(t_{mn}, t_{fn}, X_{mn}, X_{fn}, \beta, \alpha)$$
$$Q = Q(t_{mq}, t_{fq}, X_{mq}, X_{fq}, \beta, \alpha)$$
$$Z = Z(t_{mz}, t_{fz}, X_{mz}, X_{fz}, \beta, \alpha)$$
$$I = \pi_c \times C + \pi_z \times Z$$

where N is the number of children in the family, Q is the quality of each child which DeTray defines as the resource intensity with which the children are produced, t_{ij} is the ith household member's time in the production of the jth commodity, X_j are the market goods and services in the production of the jth commodity, and β and α respectively, are the husband's and wife's efficiency in non-market production. I is the household's full income and, π_c and π_z are the shadow prices to the household for C and Z .

Willis, using price and income arguments, maximized the household production model

$$U(N, Q, Z) + \lambda(\pi_c \times NQ + \pi_z \times Z)$$

to obtain derived demand equations for children, child quality and Z, consumption of other goods and services with price and income arguments. The resulting equations were:

$$N = N(I,\ \pi_c,\ \pi_z)$$

$$Q = Q(I,\ \pi_c,\ \pi_z)$$

$$Z = Z(I,\ \pi_c,\ \pi_z)$$

$$C = N(I,\ \pi_c,\ \pi_z)Q(I,\ \pi_c,\ \pi_z)$$

First order conditions for utility maximization require that households allocate resources so that the ratios of the marginal utilities to the marginal costs for each argument in the utility function are equal.

Variations of Willis's model have been applied to demand for education questions and used by Edwards and Barichello to derive demand for years of schooling and by Rosenzweig to derive demand for quantity and quality of schooling.

Review of Education Demand Studies

Demand theory states that demand for a standard good is dependent on income, price of the good, and prices of other goods. Education offers a special demand estimation situation because it is a public good and is provided as a public service. There are two types of demand for education. The first is the social demand for education that relates to national welfare. Society has mandated through federal, state and local governments that individuals consume a specific quantity of education to insure economic growth, advance in knowledge and social stability. These factors are postive externalities of education and are the general justification for public provision of education. Studies by Denison and Schultz have estimated these benefits to exceed education costs.

The second level of education demand is individual or household demand for education. This is demand for education by individuals because of the direct benefits provided to people receiving the education (Becker, Hines, Weiss). Benefits would include the ability to communicate in a complex information society and to increasing access to desired professions, income, or social status.

Various public-choice models have been used to explain the provision of a particular level (quality and quantity) of education in a community. Only a limited amount of research has been undertaken, however, applying a public choice model to the demand for education. Hirsch, Miner and Grams conducted studies in the late 50s and early 60s that used expenditure determinant models to identify factors that affect local funding levels, or that identify expenditure- or demand-influencing factors that can be locally influenced to increase demand for education or alter its level of funding. The results indicated that community wealth and per capita income were strong determinants of education expenditure levels suggesting that education may have been highly income elastic. Education demand studies have failed to estimate community demand for a specific level of education quantity or quality and have not identified factors that can be locally influenced that will affect education demand.

Edwards, Rosenzweig and Barichello estimated household demand for education in household production. They obtained the derived demand equations for years of schooling by setting the ratio of factor marginal products equal to the ratio of factor prices. Edwards, for example, used the child quality function in her model,

$$Q = Q(Z,\ X_c,\ t_c;\ \beta)$$

where Z is standard years of schooling, X_c is all other child services, t_c is parental time in quality production and β is a parent's efficiency in child quality production. Using this child quality constraint and maximizing the household utility function with respect to t yields a years-of-school demand function with income and price arguments,

$$Z = Z(I, P_z, P_c, P_s, W; \beta)$$

where I is income, P_s is the price of a standard year of schooling, P_c is the shadow price for other child services, P_f is the price of other goods, W is the shadow price for parents' time, and β is parents' efficiency in child-quality production.

Rosenzweig and Barichello used a similar approach to estimate demand for years of schooling. Both used a per pupil expenditure measure to control for education quality in their demand models. This means an implicit assumption of constant output quality across school districts because the measure represents input cost and does not account for possible variation in technical efficiency across school districts.

Demand for education studies have identified factors that are associated with high local per pupil expenditures for education and with years of schooling. The recent studies have introduced household production theory to education demand research, expanding the theoretical basis for examining education issues.

The demand studies have used weak measures for education output (per pupil expenditures and years of schooling) and have not identified demand factors that can be considered in policy options to alter household or community demand for education.

HOUSEHOLD PRODUCTION MODEL FOR EDUCATION PRODUCTION

The model developed below will be similar to earlier models (Willis, DeTray, Rosenzweig, Barichello), but will include a few modifications to present the models of demand for education and education production.

The first difference between the model developed below and the earlier models is with the treatment of child quality. Edwards' treatment of child quality, consistent with Becker, Willis and DeTray, views quality as a function of resource intensity in the production of child services. The intensity of input resources substitutes for attributes or outcomes of children that determine quality. Rosenzweig equates child quality with human capital without an explicit definition of human capital. School quality is defined as the incremental increase in human capital through the school system. Following Tomes, Barichello defines child quality as the level of future income to be enjoyed by the children. He defined future income as a function of human capital accumulation and the probability of migration to an urban wage-area. Research on the psychic costs of migration (Deaton, Morgan and Anschel) brings into question the assumption that higher wages and migration are quality attributes. The treatment below is a more general one and incorporates an array of attributes that reflect a broad definition of quality of life issues, some of which may not be dependent on education.

The second difference between the model below and the earlier ones concerns the human capital production function. The model developed here recognizes human capital as the outcome of an education production process that includes inputs from both school and non-school sources. Household inputs into the Edwards' model equate quality with input intensity. She separated standard years of schooling from other inputs to child quality and did not explicitly consider issues related to school quality, the relationship between school and non-school education inputs, or other education production issues. Rosenzweig and Barichello defined human capital production narrowly to include only investments made in school. Rosenzweig used per pupil expenditures as a school quality proxy and Barichello used the percentage of teachers with a graduate degree to measure school quality. Barichello specified an education production function, however, that recognized pre-school household resource allocations as education production inputs.

The model presented below will contain only the components of the household model central to the analysis of human capital demand and production issues. These include the household utility function, the child quality production function, the education production function, and the household budget constraint. However, it should be recognized that similar relationships can be developed for all household decisions.

The model begins with a household utility function,

$$U = U(N, Q, Z)$$

where N is the number of children, Q is the quality of each child and Z is the consumption of all non-child services and goods. It is assumed that the family size is complete for the age groups under consideration (4th, 8th and 11th grades), so no child production constraint is included (i.e., the number of children is exogenous). Child quality, as mentioned above, is broadly defined to include a vector of attributes that add to parents' utility. The function is stated,

$$Q = Q(H, A)$$

where H is the level of human capital accumulated through the education production function and A is a vector of all other attributes that parents view as quality factors in their children. Included in these factors are good health, cognitive skills, socialization skills and future income. The education production function can be written,

$$H = H(X_s, T_g, X_h, T_p, C;\ \beta, \alpha)$$

where X_s are school purchased inputs, T_g is the student's time in school, X_h are household allocations of non-time resources to the production of education, T_p are non-student household time allocations to education, C are community resources allocated to production of education, and β and α represent , respectively, the husband's and the wife's efficiency in child-quality production.

The education production function in the household production model can be re-stated in the general form used above as the basis for examining the production of education quality and quantity:

$$P_1: F_1(Y_1, Y_2, Z, X_{11}) = 0$$

$$P_2: F_2(Y_1, Y_2, Z, X_{12}) = 0$$

The difference in the two models is not in the technical relationships of the production process since both school and household resources are applied to the same production process. The objective functions of schools and households are, however, different. The school focuses attention on attainment of average or aggregate school outcomes and utilizes public resources in doing so. The family, on the other hand, attempts to maximize individual family members' education attainment subject to their budget constraint through the allocation of household resources to supplement or complement school resources.

The budget constraint is written,

$$I = \pi_c \times C + \pi_z \times Z$$

where I is full income and π_c and π_z are shadow prices for C and Z, respectively.

First order conditions for utility maximization and the derived demand equations can be obtained by maximizing the utility function subject to production constraints for N, Q, and Z and the budget constraint.

Household resource allocations determine the level of inputs to the education production process throught the F vector of inputs. This level is determined for each student according to his/her family's resource allocation pattern. Household demand for a level of education greater than that level which is publicly supplied would result in allocation of more household resources to education production, ceteris paribus.

A THEORETICAL MODEL FOR ESTIMATING EDUCATION PRODUCTION

Two areas of economic thought, theory of the firm and household production theory, have provided the primary guidance for economic research on education production. The general production model discussed above has been the basis of the research examining school system effectiveness in education production as well as some of the research on home production of human capital. Household production theory has provided the theoretical base for research on household demand for education and home production of education. Prior research, however, has not combined these areas to develop a theoretical model that explicitly recognizes incentives for both public (government) and private (household) allocation of resources to the production of education due to the jointness of education output in consumption. Public and private resources for human capital development are not inputs into two distinct production processes, but into a single process that utilizes inputs from the school, the household, the community and the students to produce education outputs.

The theoretical education production model for this research combines the production model from the theory of the firm with the child quality production constraint from household production theory. The median-voter model provides the theoretical link to do this. The community determines the level of public resources that are allocated to education production through a public-choice process such as the median-voter model. Central to the public allocation of resources to provide education as a public service is the commonly held social view that access to education is the right of every citizen and that the public sector should provide education services to insure every person access. There also are external benefits to the community that accure from education and provide significant returns to the community for its public investment in education.

Households respond to the level of public supply of education services with the allocation of household resources to supplement or complement the school inputs provided publicly. Household decisions are associated with human capital investments for family members. The household that wishes to invest more in education of its members than the community decides to invest through the public choice model, responds to the public supply with the allocation of additional resources to increase the human capital investment in its members.

The theoretical model can be written,

$$P_1: F_1(Y_1, Y_2, S, F, P, I) = 0$$
$$P_2: F_2(Y_1, Y_2, S, F, P, I) = 0$$

where Y_1 is education quantity, Y_2 is education quality, S is a vector of allocable and nonallocable school resources, F is a vector of allocable and nonallocable family resources, P is a vector of peer allocable and nonallocable resources, and I is a vector of student allocable and nonallocable resources.

This model explicitly recognizes the multiple output nature of education production. It includes school resources that are allocated to the production function on the basis of decisions that are made through a public-choice model such as the median voter model discussed above. It includes inputs that are family resource allocations based on household decisions for production of a specific level of child quality. The model also includes peer and student resources which greatly affect the efficiency with which the school and family resources are used in the production process.

SUMMARY OF CHAPTER

The complexity of the education production process and the difficulty of isolating production objectives and specifying the technical relationships of the education production function present researchers with complex analytical issues. This chapter has developed a theoretical model that explicitly recognizes education as a multiple output production process. A public-choice model, theory of the firm and household production theory are discussed and incorporated into a theoretical model that presents the education process as a dynamic process that combines resources from the public and the household sectors to produce various levels of education output for people in the community. The chapter includes a review of prior research on education of relevance to this study. The chapter concludes with a conceptual model for education production that recognizes education as a multiproduct process that is dependent on inputs from the school, the community, the household and the student. The next chapter will discuss the data used in this research and will specify an empirical model recognizing these issues in order to address the research objectives presented in Chapter I.

CHAPTER III

DATA AND EMPIRICAL MODEL

INTRODUCTION

This chapter includes a discussion of the variables specified as education output and input measures, the estimation procedures to be used, and the data used in the study. The variables specified for the model and the estimation strategy are presented in the first section. The second section of the chapter presents and discusses the data used in the study. First, definitions for the variables and summary statistics are presented. Then, school divisions are grouped by type of jurisdiction and the variable means are compared.

SPECIFICATION OF THE ESTIMATING MODEL

INTRODUCTION

This theoretical model developed in Chapter II is based on the linkage of community and household decision making regarding the allocation of resources to human capital production through the education production process. The model is,

$$P_1: F_1(Y_1, Y_2, S, F, P, I) = 0$$
$$P_2: F_2(Y_1, Y_2, S, F, P, I) = 0$$

Conceptually the education production model is identified with four sets of input variables: school, family, student and peer. Data for this study are aggregated to the school division level. Student inputs, therefore, are combined with peer inputs. Family inputs are divided into household inputs and volunteer inputs to explicitly recognize the impact of family inputs in educating own children and in support of the school system. Variables to be used in the analysis are discussed below, grouped by the four input-categories. While these input areas are conceptually separate, variables used as measures for inputs are not discrete measures for the inputs of a specific set.

EDUCATION OUTPUT MEASURES

The dependent variables, Y_1 and Y_2, are measures for education quality and quantity. The quality measure represents what Burkhead refers to as cognitive skills and the quantity measure represents socialization skills. Recognizing that there are multiple cognitive and socialization skills that are school outputs, one quality and one quantity measure are used to account for both the multiple socialization skill and cognitive skill outputs by representative or fractional measurement (Katzman p. 34).

Specifying and measuring both socialization and cognitive outputs of education has been a difficult task for economists estimating education production functions, as discussed in Chapter II. Three measures used by researchers in earlier studies, however, do seem to embody either the social or the cognitive skills that society and the household value and believe individuals should possess in order to become responsible and productive adult members of society. They are, therefore, conceptually good-measures for education output. Two of the measures are quantity measures and the third is a quality measure.

The first of the variables that are education quantity measures used in prior research is the percentage of ninth grade students who graduate from high school four years later. Students who drop out of school, fail a grade, or have not earned enough credits to graduate four years later are the students counted as not finishing high school in the normal four-year period. Katzman used this measure to represent what he called a school's holding power, a school's relative success at motivating students to develop the social and cognitive skills required to successfully complete high school. Completion of high school, also, is a schooling achievement that is associated with employment opportunity and is generally viewed as the minimum requirement to meet the broader social goal of an educated society.

Conceptually, the high school graduation rate is a good measure for a school district's relative success at graduating students, a quantity of education output. Research has demonstrated the importance of high school education for future income (for example see Becker; Hines, Tweeten, and Redfern; Link and Ratledge). The measure, therefore, is associated with both individual and social goals for education quantity attainment goals.

There are two major limitations to the high school graduation rate as a school output measure. First, the measure does not differentiate between the quality and quantity dimensions of education output. School district graduation rate does not provide any indication of the quality of education that the students are receiving. Second, it does not provide insight into the output levels of any specific social or cognitive skills. Difficulty quantifying social skills, such as citizenship and motivation, discussed earlier indicates the problems with measurement. While the graduation rate was used as a representative measure for both socialization skills and cognitive skills in prior research, the measure is conceptually a more suitable measure for education quantity, or the socialization skills of the education system. As Hirsch points out, the quality of a public service can vary greatly for any specific level of quantity.

The high school graduation rate measure reported in Virginia is based on data collected by the Virginia Department of Education for Virginia school districts. The variable is not corrected for population mobility. The variable, therefore, is biased by a community's migration pattern. Localities that are experiencing population growth would have an upward bias as new students increase the number of graduates relative to the ninth grade membership four years earlier. Communities with declining population, on the other hand, would have a negative bias as out-migration decreases the number of students graduating from high school. This greatly limits the interpretation of empirical results obtained from estimating a quantity equation that uses the high-school graduation rate as the dependent variable for education quantity. Because of the limitations that the mobility problem with the high school graduation rate causes for interpretation of the measure, the variable will not be used in this research.

Katzman does not mention whether the graduation rate variable used in his research is corrected for student mobility. If it is not, it would bring into question the interpretation of his results that found enrollment, pupil/teacher ratio and parent's occupation measures to be significant in explaining a school's holding power.

A second quantity, or socialization, variable used in prior research is the percentage of students continuing their education each year. The complement of this measure, the dropout rate, also has been used in prior research. The continuation measure is one minus the school division dropout rate. The variable provides a good measure of a school district's relative success in producing education quantity. This measure, or the dropout rate, was used as an output measure by both Burkhead and Katzman. Burkhead, who used the measure as the dependent variable in a single equation education production model, defined the variable as a measure of a school's success in producing the socialization aspects of education output.

The rate of students continuing school is a conceptually strong representative measure for socialization skill production of a school district. As students continue their participation in school, they must conform to school rules and regulations, organize their time to participate in school activities, and perform at least minimum academic work to enable their continued participation in school. All of these activities produce skills that will help socialize students to be productive members of society. The skills also are those that Bowles and Gintis suggest are the socialization skills that business and industry use the high school diploma to screen for.

The measure of students continuing their education in Virginia, HOLD, is one minus the dropout rate as reported by the Virginia Department of Education. Hereafter this measure will be referred to as the school retention rate. The dropout rate measure reported by the Virginia Department of Education is corrected for population mobility. That is, students who tranfer to other schools, move out of the district, or die are not included as dropouts. This measure, therefore, is not biased by in-migration or out-migration of students like the high school graduation rate measure.

HOLD provides a conceptual representative measure for school socialization skill production. Gintis contends that completing a given level of schooling implies some minimum ability as well as a mixture of socialization factors such as self-discipline and motivation. Completion of schooling can, therefore, be used as a screening device for various basic social and cognitive skills. Because of the conceptual soundness of HOLD as an output quantity measure and the mobility problem with the graduation rate measure, HOLD will be used as the quantity or socialization measure, the dependent variable, Y_2 in the quantity production equation P_2.

The limitation of the variable, HOLD, is that it not associated with the attainment of a particular level of schooling or a quality of education output. Also, HOLD does not provide insight into production of specific socialization outputs or to the quality of any outputs.

The third variable used in prior research as a representative measure for education output is a standardized achievement test score. Such a variable is a good representative measure for the relative success of schools in producing cognitive skill output. An achievement test score has been used as a school output measure in each of the production studies discussed above. While there is some recognition of the limitations of using this variable as a representative measure for total school output (Levin), conceptually it is a strong representative measure for cognitive skills produced by the school system (Kiesling). Kiesling used an achievement test score as a quality of education measure, emphasizing that the score may not capture the whole of education quality, but that it represents a large enough portion of the quality dimension of education to be of great use to policy makers.

Six standardized achievement test scores are used in this study as representative measures for education quality output. Using six different measures allows for the comparison of empirical results for models using similar, but different achievement test scores as a representative quality output measure. The appropriateness of using a single standardized achievement test score as a representative test score can then be tested. The achievement test scores used in this study, AR, M4, R8, M8, R11, M11, are school division means for the standardized test scores in reading achievement and math achievement for students in the 4th, 8th and 11th grades for each school district. The tests are administered annually to Virginia public school students in grades 4, 8 and 11. The test scores will be used as the dependent variables, Y_1 for equation P_1, the education quality or cognitive skills production function.

Conceptually, an achievement test score provides a good measure for education quality output. An achievement test measure has been used in prior studies as a representative measure for school output. It also is used as a measure of the relative quality of the education in a school division by the Virginia Department of Education and by individual school districts. Further support for the use of the Virginia schools' standardized test scores as quality measures is that local school divisions, as well as the Virginia Department of Education utilize test scores to measure a school's relative success at teaching students' various cognitive skills. The tests are specifically designed to measure students skills in cognitive areas. Since the tests are administered on an annual basis to Virginia public school students in grades 4, 8 and 11, they provide measures for education quality production at three points in the education production process. Using these measures, the relative importance of input factors can be examined at these three points in the production process.

SCHOOL INPUT MEASURES

Economic theory, empirical results from prior research, and actions by the Virginia Board of Education each provide insight into the specification of school-input measures. The focus of most education production function studies has been on the effect of school inputs on education outcomes. These studies have used a variety of variables to measure school inputs.

School production inputs closely conform to the types of labor and capital measures used for inputs into other types of production function studies, such as personnel, materials and supplies, and buildings and equipment (Burkhead). Consequently, many of the variables used in production function studies relate to labor and capital measures of inputs to the education process.

The Commonwealth of Virginia offers some direction for selecting personnel input measures to represent teacher quality and quantity levels. The state's Standards of Quality for Education specify two standards that relate to teacher inputs. One is a quality standard that requires teacher certification to qualify the teacher to work in the classroom. This certification is based on completion of a prescribed curriculum at an accredited institution. Periodic in-service education to insure that teachers maintain expertise in their area of specialization is required to maintain teacher certification. The other Standard of Quality requirement is a teacher quantity requirement that specifies a minimum teacher/pupil ratio for the school.

Variables that have been used as school input measures generally apply to teacher quality and quantity, education supplies and facilities, and school size. Teacher experience (Hanushek, Katzman, and Summer and Wolfe), teacher education achievement and training (Hanushek, Katzman, and Summer and Wolfe), teacher/pupil ratio (Katzman) and starting teacher salary (Perl) are teacher or labor measures that have been statistically significant in prior production studies. Per pupil expenditures on material and supplies (Burkhead), per pupil number of library books in a school (Summer and Wolfe), school-building age (Burkhead, Katzman), and per pupil expenditures (Kiesling, Perl) are school supplies and facilities or capital measures that have been significant in earlier studies. Average daily membership (Burkhead, Katzman, Kiesling) and class size (Katzman, and Summer and Wolfe) are the significant school size or size economy variables from the prior research. While most of these variables used to measure inputs are intuitively related to economic concepts of labor and capital inputs of education production, education theory was not presented in support of their inclusion.

Measures from prior research that relate to the Standards of Quality as well as to economic concepts of labor and capital are teacher graduate education and pupil/teacher ratio. While these measures are linked to both Virginia's Standards of Quality and prior research as teacher quantity and quality measures, they also are conceptually linked to the economic concept of labor. The teacher graduate education measure represents an investment in education. Human capital theory holds that investments in education improve the value, or quality, of the labor of the person investing in the education (Schultz). Investment in graduate education by teachers, therefore, would be expected to increase the quality of their labor input or the value of the time that they allocate to their teaching responsibilities.

According to production theory, increases in inputs, *ceteris paribus* , increases outputs. The pupil/teacher ratio is a measure of the relative number of teacher inputs in a school district.

Districts with lower pupil/teacher ratios have a higher level quantity of teacher input. These localities should have a higher rate of education output other things being even. Increases in MSD, the percentage of teachers in a school division with a professional teachers certification, increase the total value of the labor inputs of the school, and therefore the level of school output. Decreases in PTR, the pupil/teacher ratio, increase the relative number of teachers in a school and therefore the quantity of teacher input. MSD is hypothesized to be positively related to education output. PTR is hypothesized to be inversely related to education output.

Selecting a variable to measure supplies and facilities is not as straight forward as for labor inputs. Prior research has used school-building age, the number of books per pupil in the school library, and per pupil expenditure measures as school capital input measures. Most Virginia school divisions have more than one school building. Since the school system is the unit of observation, specifying school building age presents problems because of the variation of facility age in each district. Using a library-books-per-pupil measure presents the same type of problem in that there could be considerable variation in the number of library books among schools within a district. In addition, the intrinsic value of either an age variable or a per pupil book variable as a proxy for supply and facility inputs is not at all apparent.

The use of per pupil expenditure is an intuitively appropriate variable. It is also consistent with economic theory which suggests that the higher the inputs as measured by their dollar value, ceteris paribus, the greater the production output. The measure was significant and directly associated with education output as measured by achievement test scores in Perl's research. Keisling and Katzman also used a per pupil expenditure measure, but found it to be nonsignificant or negative in their studies.

Three per pupil expenditure measures were selected to measure the level of school support for supplies and facilities. The first is TPP83, total per pupil expenditures for school operations. The other two measures are obtained by partitioning total per pupil expenditures into expenditures from local sources and expenditures from nonlocal sources. The variables are per pupil school expenditures from local sources, LPP83, and per pupil expenditures from nonlocal sources, NLPP83. TPP83 is partitioned into LPP83 and NLPP83 to test if the level of support from local sources has a different influence on the education production system than that of funds from other sources. Kieseling suggested that the two variables would have different effects on education outcome because the LPP83 measure embodies the communities' attitude toward education. Two other issues concerning the effect of local and nonlocal funding relate to the use of the funds. Nonlocal funds are allocated to specific programs or expenditure items and are provided for several programs that were intended to increase human capital investment through the school system. The significance of the nonlocal per pupil expenditure measure is a partial test of the hypothesis that the nonlocal funds have an effect on education outcomes.

Use of expenditure measures as input variables does present some conceptual questions. Levin discusses the difficulties associated with high cost of inputs due to inefficiency in the education production process and because of variation in the emphasis placed on different outputs by each school or school division. Use of both a quantity and a quality measure as an output measure will control for the variation in emphasis placed on the quantity and quality dimensions of education by different school districts. The efficiency question, however, remains to caution interpretation of the results of the expenditure measures because of the limited understanding of the technical relationships in education production. Both LPP83 and NLPP83 are hypothesized to have a positive relationship to education output. The expenditure measures are specified as lagged variables to test the hypothesized lagged relationship between expenditures and changes in the output measure.

The average daily membership, ADM, for the school division will be included in the model as a proxy measure for size economies in the school system. Prior research on economies of size with the school as the unit of observation (Cohn, Riew for example) have generally found size economies to exist in the provision of schooling. Research that has focused on the school district as the unit of observation, however, has produced conflicting results. Hanson, Kiesling, Osburn and, White and Tweeten, for example, each found size economies to exist for school districts.

Debertin, Denzau, and Hirsch, on the other hand, found no evidence to support economies of size at the school division level. When White and Tweeten introduced transportation costs or population density to their model, they found a sharp decline in size economies as population density decreased. Due to the uncertain nature of economies of size in education production for school districts, the sign of the ADM measure in not hypothesized a priori.

HOUSEHOLD INPUT MEASURES

Household or family inputs into the education process are generally considered to be important factors as discussed in Chapter II. Inputs from the household sector have been recognized in theoretical models of education production developed by economists. The family influences individuals' attitudes toward self, school, the community and society, as well as many other factors that relate to the way a student interacts with other people and approaches learning. The family also makes an input to the education process through the allocation of time and purchased goods to children's education. Health and nutrition factors are household inputs to education; so are parental time helping students with homework, family time volunteered in school, and household time allocated to school organizations such as parent-teacher organizations. Household expenditures on materials to directly support education have an influence on education as well. While much of the household contribution is independent of the school, the success of the student in school is greatly affected by family inputs.

Empirical models for education research have generally ignored the household or family input issue, or have used a socioeconomic measure to control for household effects. The reason for this lack of attention is twofold. First, the focus of most of the research has been the effectiveness of school inputs in production education outputs. Research was conducted to identify a range of policy alternatives that could be applied to the allocation of public funds to education. While controls for non-school inputs were used, primary attention was given to school inputs. Second, while household or family inputs are conceptually recognized, identifying and measuring specific input factors has been a difficult proposition. Aggregation of household measures to the school or school-division level results in the identification of input variables that are linked to broad socioeconomic characteristics of the community. Interpretation of the significance of the results, therefore, becomes linked to the general characteristics of the community.

Despite the limited attention of past research to household inputs, these studies do provide some insight into the selection of variables to measure household inputs. Household measures used in prior studies have generally been related to income, occupation or race. Median income was used by Burkhead and Perl. Katzman, Kiesling and Perl used occupation measures. A racial composition measure was used by Hanushek and Summer and Wolfe. Hanushek also included father's education, family size, pre-school education, and family mobility to examine household effects on education.

Intuitively, these measures all relate to household or community characteristics that reflect the attitude toward value of education in a community. Three of the measures in particular, however, have a strong conceptual link to household investment in education: family size, income, and investment in pre-school education.

Significance of the above variables in education production studies indicates the importance of household and family inputs to the education process. The studies, however, used the variables to control for nonschool factors that influence education. No attempt was made to link household attributes of actions to a theoretical model for human capital development through investments in the education production process. Consequently, the measures used in prior research are not discussed as household allocations and are not interpreted in the context of houshold allocations to human capital investment through the education production function. Leibowitz's and Murnane, Maynard and Ohls's research focus on the importance of household allocations in the home production of education, and provide additional insights for variable selection. These studies used household data for individual families to analyze the influence that specific household's allocations had on its child's cognitive achievement.

The Leibowtiz and the Murnane, Maynard and Ohls studies both found mother's education, family size and goods consumption measures (eg., time saving goods like a dish washer, consumption goods like a color television, educational goods like an encyclopedia) to have a significant influence on education achievement. Leibowetz also found race, suburban housing and parental allocation of time to watching television with the child, playing with the child and reading to the child to be significant. Murnane, Maynard and Ohls found the number of rooms in child's residence, whether the family rented its home, household income and a family move in the past year to be significant.

Although the unit of analysis in this study is the school district, an hypothesis about the effectiveness of household inputs is included. While the unit of observation limits examination of specific allocations such as those specified by Leibowtz and Murnane, Marnard and Ohls, combining insights from the above research with economic theory suggests a few useful measures for examining the influence of household inputs on education outcomes through the theoretical model developed in Chapter III. Three variables are used for measures of household inputs into the education process: INC83, GRADS80 and PCRACE.

INC83, per capita income, is used as a measure of a household's ability to purchase goods to support a child's education. It also measures the family's relative ability to purchase work-saving goods included in the Leibowetz study. Leibowetz also found that working women, who have a higher value on their own time, allocate more time to their child's schooling, although the time available is inversely related to the time working. INC83 is used as a measure for household time and purchased goods inputs to the education process, even though it is recognized to be inversely related to the time that households have to allocate to children's education. INC83 is hypothesized to have a positive relationship to education output.

The second household input variable, GRADS80, is the percent of the adult population that has completed high school. This variable is a measure of the local stock of human capital and provides a relative measure for parents' efficiency in educating children, a concept introduced in the household production theory discussed above. Human capital theory says that education increased the value of the labor input in the household production function for the person receiving the education. Leibowitz's and Murnane, Maynard and Ohls' research support the use of a measure for the level of education of the students parents, as both of their studies found parents' education level to be significant in explaining cognitive achievement in models of household human capital production. GRADS80, a measure of the relative education investment in a community, is a strong measure for the quality of the time that households allocate to educational activities. It is hypothesized to have a positive influence on education output.

The third measure for household inputs used is PCRACE. This variable is included as a household input measure because of its use in earlier research when used as a proxy for either household or peer inputs. While earlier studies did little to explain the inclusion of this variable as a variable to control for household or family factors that influence education, it has been significant in several studies (Summer and Wolfe, Leibowetz). The variable is used in this research, not as a direct measure for family inputs, but as a measure to examine the impact that the historic denial of access to the non-white community nationally, and particularly in Virginia, has had on the intergenerational transfer of human capital, and on the non-white population's efficiency in education production. It is recognized that this measure could be accounting for the cultural differences in the value placed on education by the white and nonwhite populations. PCRACE is hypothesized to have a negative effect on education outcomes.

PEER AND STUDENT INPUT MEASURES

Limited attention has been given to peer influences in prior empirical work on school production, although theoretical models have mentioned peer influence as an input. Three measures have been used in prior research as peer input measures. Median income, racial composition of the school system, and percent of white collar workers in the community are the measures that have been used. While these measures have been statistically significant in prior studies (Burkhead; Katzman; Summers and Wolfe), their relationship to peer, or in some cases family, influences has been used to control for socioeconomic factors that influence education outcomes. The measures also were used in the models above as variables to measure household inputs.

Student inputs into the production of education also have been discussed in the education literature. Specification of measures for student inputs has generally not been an issue, as most studies focus on the school or school division as the level of observation. Measures, therefore, have been aggregated to the school or school-division level. Studies that have used the student as the unit of observation have used an intellegence measure as a measure for the students' ability input. The measure has been significant.

A measure that represents both individual and peer inputs, ATTEND, is used in this study. ATTEND is a measure of the percent of students who attend school on average each day. It provides a measure of the students' time input to school aggregated to the school division level. While ATTEND is a direct measure of pupils' time input to school, it is recognized that other factors that influence student preformance, such as student motivation, attitude and health, are correlated in the attendance measure. Also, the variable is a better measure for variation among school divisions that among students within a school division.

VOLUNTEER INPUT MEASURES

Althought volutneer inputs fit into the conceptual models that have been developed as the theoretical framework for the specification of education production models, the concept of allocation of nonschool input into the education process through the school system has not been a topic mentioned in prior education production. Prior research, therefore, provides little guidance in specification of measures for volunteer inputs through the school system.

Limited data concerning the scope of volunteer involvement in the public school system is available. The Virginia Department of Education maintains no data on the use of nonschool resources in the school system. The Virginia Congress on Parents and Teachers, the state association for PTAs in Virginia, does not collect data on the activities of member Parent-teacher Associations other than the number of dues paying members per association.

Data from one study, "A Survey of Volunteers in Virginia Secondary Schools," by Julia Broome are available. While the study does provide rich data on the use of volunteers in many schools in the state, the data were collected on a school by school basis, not through school district offices. Consequently, the data for a large number of localities are incomplete at the school division level. Two of the measures from the survey will be used in this research as measures for volunteer inputs into the school system. One is the per pupil rate of volunteer use in the school district. The other is the per pupil rate of volunteer time use in the school district. While these variables are conceptually linked to the use of volunteers in the school, the limited observations of the variables will reduce the number of observations in analysis using the measures to 52 observations. Both measures are hypothesized to have a positive relationship to education output as measured by standardized achievement test scores.

Another measure that is used for the level of volunteer input into the public school system is the parent-teacher organization participation rate. This measure is obtained by dividing the number of adult parent-teacher organization members by the average daily school membership in the school district. While this measure does not measure any specific inputs into the education production process, it provides a relative measure of the degree of parent involvement in the school system. It is assumed that the parent-teacher organization membership is positively correlated with the allocation of volunteer resources to the school district. The variable is hypothesized to be directly related to education output.

CITY/COUNTY CODE MEASURES

Evaluation of the data by city/county code indicates that the variables being used to measure both education inputs and outputs are likely to be higher in the S.M.S.A. localities. The structure of the communities in urban and rural localities also is different reflecting a different spatial distribution of people, varying levels of economic development, and different employment opportunities. The city/county code measure used above as a variable to sort the data will be included in the model to test whether there are differences in the localities by population and jurisdiction type (after controlling for other variables) that differentiate the localities' education production process.

ESTIMATION ISSUES AND STRATEGY

The strategy for conducting the empirical estimation to test the research hypotheses discussed in Chapter I is the application of the ordinary least squares procedure to the quantity and quality production models using the input variables specified in this chapter. The estimation will follow the following order. First, quality of education production equations will be estimated. Six linear equations, each using a different standardized achievement test score as the output measure, will be used. As discussed above, the models will use a reading and a math score, observed at three different grade levels, measuring the production of each measure at three points in the production process. Ordinary least squares procedure has been used on linear models in all of the prior studies reported above, although some multiplicative equations have been used as well (Summers and Wolfe). With no theory to suggest another functional form, the current research assumed the linear form.

The initial estimation was done with the model specified with eleven variables specified as school, household, student, or volunteer inputs. The measures of the rate of volunteer input, VOLMOR and HRMOR, will not be used in the initial estimation because of the limited number of observations. The quantity output measure, HOLD, will be specified as an independent variable in the quality model to determine if the level of school quality output is dependent on the level of school quantity output.

Although the variables used as input measures are based on conceptually discrete input measures, interrelationships between the measures are expected, especially the variables that have high pairwise correlation coefficients, TPP83, NLPP83, LPP83, GRADS80, and INC83. The specification of the estimating equation will then be adjusted based on multicollinearity diagnostics and explanatory power of the input measures to reduce any collinearity problems that exist.

Less guidance is available for specification of the quantity model than for the quality model. Only two of the prior studies have used a quantity output measure, and their results were weak. The quantity model, therefore, will be specified with the same variables as quality models. The model will be respecified based on the result of multicollinearity diagnostics and explanatory power of the independent variables. The quality measures, the standardized achievement test scores, will be used in the education quantity production model to determine if the level of quantity produced is dependent on the level of quality production.

The input and output measures being used in the study have a conceptual link to economic theory. The conceptual model developed in Chapter II recognizes the education production process as one that draws inputs from a variety of sources that are both collectively (i.e., by the community) and individually (i.e., by the household) determined. The variables specified to measure these inputs attempt to quantify and qualify the inputs from each of the input vectors aggregated to the school-division level. The specified model explicitly recognizes the interaction between the public sector and the household sector in the education production process.

The empirical model also is specified to recognize the potential for a lagged effect of changes in inputs on changes in outputs. This will be done by introducing polynomial lags for input measures. The per pupil expenditure variable will be specified as a polynomial lag in both the quality and quantity models to test for lagged impacts of per pupil spending on education oucomes.

THE DATA

The data used in this research are for 35 independent cities and 94 counties in Virginia.[1] School divisions in Virginia are units of local government and, except for the exceptions involving one local government contracting with another for the provision of schooling services and four counties with towns that have independent school districts, have the same jurisdictional boundries as the unit of government they serve.

All observations in this research are aggregated to city/county or school district level. Several sources were used to obtain data for the study. Data on school division attributes and outcomes are from the Virginia Department of Education. The primary sources are Facing Up: Statistical Data on Virginia's Public Schools, and Annual Report: Superintendent of Public Instruction, various years. Additional data were supplied directly by Department of Education staff. Income data are from the Bureau of Economic Analysis of the Tayloe Murphy Institute of the University of Virginia. Several city and county measures were obtained from the U.S. Bureau of Census, 1980 Census of Population.

The data on volunteer or household resource allocations to schools were obtained, as discussed below, from a report by the Virginia Congress of Parents and Teachers (the associations of Virginia Parent-teacher Associations), "Statistical Report, 1984-85," and from a study, "Survey of Volunteers in Virginia Secondary Schools," conducted by Ms. Julia Broome through the University of Virginia and the City of Charlottesville Public Schools. A telephone survey to twenty one Virginia school divisions was conducted to supplement data on PTA membership.

The data are pooled cross sectional-time series data for Virginia cities and counties. The symbol and definition for each variable is presented in Table 2. The summary statistics for the variables

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1 Data for these localities are included with the data for the jurisdiction providing the service.

are presented Table 3. Each listing includes the variable name, definition, mean value, standard deviation, and minimum and maximum values. Variables that were observed in only one year have the observation year listed. Statistics for variables that were observed over time are for the 1983 observation, the most recent in the data set.

Six school division mean scores from the Science Research Associates (SRA) Achievement Tests are used as variables in this study. The SRA tests are administered by the Virginia Department of Education on an annual basis to students in grades 4, 8, and 11. The purposes of the tests are:[2]

1. to compare the achievements of Virginia students to others at their grade level throughout the nation,

2. to compare the progress of individual students and groups to their expected performance,

3. to indentify in a broad way the instructional needs of individuals and groups.

The SRA test scores used in this study, R4, M4, R8, M8, R11, and M11, are the fourth grade reading, the fourth grade math test, the eighth grade reading test, the eighth grade math test, the eleventh grade reading test and the eleventh grade math test, respectively.

The percentage of students in grades 8 through 12 who continue their education each year, HOLD (one minus the dropout rate) is the school retention rate. The dropout rate as reported by the Virginia Department of Education is corrected for population mobility. The measure of dropouts was calculated to include those students who withdraw from school for reasons other than promotion, transfer, death, or graduation, and do not enter another school during the school year. Therefore, the measure appears to adequately capture a true measure of the school continuation rate.

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[2] 25, Februray 14, 1980, from S. John Davis, Superintendent of Public Instruction and R. L. Boyer, Assistant Superintendent for Planning and Evaluation.

TABLE 2: VARIABLE SYMBOLS AND DEFINITIONS.

VARIABLE SYMBOL	DEFINITION
SRA SCORES	SCORES FOR A BATTERY OF TESTS DEVELOPED BY THE SCIENCE RESEARCH ASSOCIATES (SRA) TO MEASURE STUDENTS' ACHIEVEMENTS IN MAJOR SKILL AND CONTENT AREAS. EACH SCORE IS A NATIONAL PERCENTILE THAT COMPARES AN AVERAGE SCORE IN A LOCALITY TO A NATIONAL SAMPLE
R4	FOURTH GRADE READING SRA SCORE
M4	FOURTH GRADE MATH SRA SCORE
R8	EIGHTH GRADE READING SRA SCORE
M8	EIGHTH GRADE MATH SRA SCORE
R11	ELEVENTH GRADE READING SRA SCORE
M11	ELEVENTH GRADE MATH SRA SCORE
HOLD	ONE MINUS THE DROPOUT RATE, WHICH IS CORRECTED FOR POPULATION MOBILITY AND STUDENT TRANSFERS
TPP83	TOTAL PER PUPIL EXPENDITURE FROM ALL SOURCES FOR SCHOOL OPERATION, WHICH INCLUDES REGULAR DAY SCHOOL, SCHOOL FOOD SERVICES, SUMMER SCHOOL, ADULT EDUCATION, AND OTHER EDUCATIONAL PROGRAMS
LLP83	PER PUPIL EXPENDITURE FROM LOCAL SOURCES FOR OPERATIONS, AS DEFINED ABOVE
NLPP	PER PUPIL EXPENDITURE FROM NON-LOCAL SOURCES (STATE AND FEDERAL SOURCES) FOR SCHOOL OPERATIONS, AS DEFINED ABOVE
PTR	RATIO OF TOTAL NUMBER OF PUPILS TO TOTAL NUMBER OF CLASSROOM TEACHING POSITIONS
MSD	PERCENT OF TEACHERS WITH A POSTGRADUATE PROFESSIONAL CERTIFICATE WHICH REQUIRES A POSTGRADUATE DEGREE
ADM	AVERAGE DAILY MEMBERSHIP, WHICH IS DETERMINED BY DIVIDING THE SUM OF DAYS PRESENT AND ABSENT OF ALL PUPILS WHEN SCHOOL IS IN SESSION DURING A GIVEN PERIOD DIVIDED BY THE NUMBER OF DAYS SCHOOL IS IN SESSION DURING THE PERIOD
ATTEND	AVERAGE DAILY MEMBERSHIP DIVIDED BY AVERAGE DAILY ATTENDANCE

PTOR	RATIO OF PARENT-TEACHER ORGANIZATION MEMBERS IN A SCHOOL DISTRICT TO STUDENTS IN THAT DISTRICT
VOLMOR	RATIO OF THE NUMBER OF VOLUNTEERS USED PER MONTH IN A SCHOOL DISTRICT TO THE NUMBER OF STUDENTS IN THAT DISTRICT
HRMOR	RATIO OF THE NUMBER OF VOLUNTEER HOURS PER MONTH IN A SCHOOL DISTRICT TO THE NUMBER OF STUDENTS IN THE DISTRICT
INC83	PER CAPITA INCOME IN THE LOCALITY
GRADS80	PERCENT OF POPULATION AGED 25 YEARS OR MORE THAT COMPLETED HIGH SCHOOL
PCRACE	PERCENT OF POPULATION THAT IS NON-WHITE
POP80	POPULATION FROM 1980 CENSUS OF POPULATION
CITY/ COUNTY CODE	CLASSIFICATION SYSTEM FOR SCHOOL DISTRICT BASED ON CODING SYSTEM ESTABLISHED BY VIRGINIA RURAL AFFAIRS COMMISSION

TABLE 3: SUMMARY STATISTICS FOR DATA.

VARIABLE SYMBOL	MEAN VALUE	STANDARD DIVIATION	MINIMUM VALUE	MAXIMUM VALUE	YEAR
R4	50.91	10.45	21.00	79.00	1983
M4	53.37	10.79	24.00	83.00	1983
R8	49.46	10.87	19.00	81.00	1983
M8	61.02	9.98	25.00	86.00	1983
R11	48.40	11.43	15.00	74.00	1983
M11	54.21	9.77	31.00	80.00	1983
HOLD	95.34	1.69	88.50	99.30	1983
TPP83	2602.73	513.05	1983.00	5076.00	1983
LPP83	1079.14	600.41	404.00	3935.00	1983
NLPP83	1523.09	192.45	1043.00	2008.00	1983
PTR	15.24	1.27	11.80	18.10	1983
MSD	30.16	8.19	12.80	50.60	1983
ADM	7034.51	13200.41	435.00	122830.00	1983
ATTEND	94.10	.93	91.00	96.00	1983
PTOR	.20	.15	0.00	.79	1984
VOLMOR	183.69	201.85	11.40	890.00	1984
HRMOR	74.75	98.40	2.74	436.00	1983
INC83	10099.50	2991.13	6468.00	23161.00	1983
GRADS80	51.78	12.82	32.80	88.50	1980
PCRACE	20.27	17.54	.05	70.62	1980
POP80	40975.87	68491.68	2937.00	596901.00	1980

The measures for per pupil expenditures, TPP83, NLPP83 and LPP83, are expenditures for operations, which includes day school, food service, summer school, adult education, and other education programs. TPP83 is the total per pupil expenditure measure. LPP83 is the portion of TPP83 that comes from local sources. The primary sources of funds for LPP83 are local real and personal property taxes, local option sales taxes, and other local taxes. NLPP83 is the nonlocal per pupil expenditure measure. Its sources include state categorical aid, federal "pass through" and direct aid, and state retail sales and other use tax funds.

The PTR variable is the ratio of average daily membership to instruction personnel. This measure is obtained by dividing the number of students in the average daily membership by the number of instructional personnel in classroom teaching positions. Standard 8 B of the 1982-84 Standards of Quality require each school division to have a division wide ratio of pupils in average daily membership to certified full-time equivalent certified instructional personnel in teaching positions in grades K-6 not greater than 25 pupils to one teacher.

The data on volunteer support of the school division are PTOR, HRMOR, and VOLMOR. PTOR was obtained by combining the variable PTAR with the results of a survey to identify the existence of non-parent-teacher organizations in school divisions that do not have state-affiliated parent-teacher associations. PTAR data were obtained by dividing the number of dues-paying members of Parent-teacher Association (PTA) members in a school division by the number of students in that district. The PTA membership is based strictly on dues paid to the Virginia Congress of Parents and Teachers. Of the 128 school districts in the sample, 101 districts have PTA's. The Congress does not collect data on local PTA activities or resource inputs provided to the school districts.

Thirty two school divisions in Virginia do not have Parent-teacher Associations that are affiliated with the state association, the Virginia Congress of Parents and Teachers. A telephone survey was conducted to determine if these 32 school districts had any local parent-teacher organizations. Data were obtained for 12 of the 32 school divisions through the survey. The data were added to the PTAR data to create the PTOR variable with 113 observations.

The HRMOR and VOLMOR measures were obtained from a survey of Virginia secondary schools to identify the level of volunteer inputs in the schools. Of the 517 secondary schools surveyed, 271, or 52 percent, were returned. Data for 53 complete school districts of the 134 districts in the study sample were obtained from the survey.

HRMOR, the volunteer-time input measure, was obtained by dividing the number of hours of volunteer time used in the secondary schools of a school division divided by the number of secondary students in the district. Thirty of the 53 school divisions responding to the survey reported using volunteer time.

The other volunteer input measure, VOLMOR, is the number of volunteers used in the secondary schools of a school division in a month divided by the number of secondary students. Twenty-nine school divisions reported the use of volunteer time.

Correlation coefficients for all variables are presented in Appendix A. The simple correlation coefficients indicate strong positive correlation between INC83, TPP83 , LPP83, and GRADS80. The high positive correlation coefficients between these variables suggest multicollinearity will be a problem for statistical estimation that includes more than one of the correlated variables.

REVIEW OF DATA GROUPED BY CITY/COUNTY CODE

The above discussion of the variable statistics presents an overview of the variation for each study variable for school divisions or local government jurisdictions across the state. Additional insight into the variation in the variables can be gained by examining the distribution of the study measures across jurisdictions of different type. To do this a classification system that was developed by the Virginia Rural Affairs Commission was used to classify each city and county in Virginia into one of four classifications. The classification system differentiates Virginia independent cities and counties based on population, local government type and access to an urban area.

The Virginia Rural Affairs Study Commission was established by the Virginia General Assembly in 1968 to examine human services policy, development policy, and natural resource policy to determine the balance between the application of the policies to urban and rural localities. The Commission divided Virginia cities and counties into four classifications to examine the policies. The classifications are referred to as city/county codes in the present study. The city/county codes are:

1. Metropolitan Counties: Counties classified as standard metropolitan statistical areas (S.M.S.A.s) by the Bureau of Budget. There are 11 study counties in this group.

2. Metropolitan Cities: Cities classisfied as S.M.S.A.s by the Bureau of Budget. There are 12 such cities in the study.

3. Cities and Counties of Lesser Urban Influence: Non-metropolitan cities and counties with a city or town of more than 3,500 people within or on their borders. There are 56 study localities in this classification.

4. Most Rural Counties: Counties without a city or town of 3,500 or more people within or on their borders. There are 49 such counties in the study.

Virginia cities and counties were assigned to these classifications by the Rural Affairs Commission based on data from the 1970 Census of Population. Re-assignment of localities to the city/county codes was done with data from the 1980 Census of Population to determine what shifts, if any, had occured over the decade.[3] While a few localities had merged, the reclassification of cities and counties resulted in only one reclassification , the City of Danville, changed from class 3 to class 2. Since the data for this study are from the 1974-1983 period, it was decided to retain the initial city/county code of 3 for the City of Danville.

The city/county code system is useful for examining differences in the distribution of the study variables within four classifications that type cities and counties as rural or urban. The codes, however, are limited in usefulness because they are classifications based strictly on population and jurisdiction type. However, the classification system does provide a useful measure for grouping Virginia localities to examine the differences in study variables as localities range from urban to rural. Of particular interest is whether there are differences in access to the resources being used as measures for education outputs and inputs revealed by the examination of the variables by city/county code.

Measures used in the study are grouped into four categories to be reviewed by city/county code for discussion of the following factors: school outputs, school inputs, household and community factors, and volunteer factors. Summary statistics for each measure grouped by city/county code are then examined.

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[3] Mr. H. Bland Franklin, Executive Director of the Rural Affairs Commission reviewed the locality assignments.

SCHOOL OUTPUT MEASURES

Summary statistics for school output measures (R4, M4, R8, M8, R11, M11, and HOLD) grouped by city/county code are presented in Table 4. The mean value for each of the SRA scores indicates that the more urban localities, on average, have higher achievement test scores than the non-S.M.S.A. localities. The mean values for a composite of the SRA scores by locality groups indicate that the more rural a community is, the lower on average the achievement of students as measured by the SRA achievement tests. Cities and counties of lesser urban influence, Code 3, have a mean value that is 82 percent of the composite mean for the S.M.S.A. counties, code 1. The code 4 localities, rural counties, have a mean value that is 73 percent of the code 1 mean. The S.M.S.A. cities, code 2, have a composite mean that is 87 percent of the code 1 mean.

The other school output measure, HOLD, is the school retention rate, or the percent of students that continue their education in the school system. The S.M.S.A. counties, code 1, have the highest mean rate, 96.29 percent. The non-S.M.S.A communities have slightly lower means of 95.05 and 95.59 percent. The S.M.S.A. cities have the lowest mean rate of 94.77 percent.

In summary, educational preformance of students in urban counties as measured by SRA scores and HOLD is higher than performance in cities and counties in the three other city-county classifications. The mean for each SRA score indicates a decline in the score by each city/county code classification.

TABLE 4: SUMMARY STATISTICS FOR SCHOOL OUTPUT MEASURES BY CITY/COUNTY CODE.

VARIABLE SYMBOL	CITY/ COUNTY CODE	NUMBER OBS	MEAN VALUE	STANDARD DIVIATION	MINIMUM VALUE	MAXIMUM VALUE
R4	STATE	128	50.91	10.44	21.00	79.00
R4	1	11	64.18	8.49	47.00	74.00
R4	2	12	53.15	12.39	42.00	83.00
R4	3	56	50.78	8.45	29.00	67.00
R4	4	49	47.53	10.17	21.00	71.00
M4	STATE	128	53.36	10.79	24.00	83.00
M4	1	11	65.27	12.26	38.00	78.00
M4	2	12	59.50	12.63	42.00	83.00
M4	3	56	53.82	8.01	40.00	71.00
M4	4	49	48.67	10.10	24.00	72.00
R8	STATE	128	49.46	10.87	19.00	81.00
R8	1	11	63.09	8.68	43.00	74.00
R8	2	12	53.00	12.35	39.00	81.00
R8	3	56	50.80	8.59	29.00	67.00
R8	4	49	44.46	10.21	19.00	65.00
M8	STATE	128	61.02	9.98	25.00	86.00
M8	1	11	73.36	7.89	57.00	85.00
M8	2	12	65.00	9.84	50.00	86.00
M8	3	56	62.07	8.10	42.00	80.00
M8	4	49	56.08	9.40	25.00	79.00
R11	STATE	128	48.38	11.44	15.00	74.00
R11	1	11	62.09	8.53	41.00	74.00
R11	2	12	52.00	9.66	35.00	66.00
R11	3	56	50.03	10.29	29.00	72.00
R11	4	49	42.57	10.19	15.00	61.00
M11	STATE	128	54.21	9.77	31.00	80.00
M11	1	11	66.54	9.12	45.00	80.00
M11	2	12	59.91	7.90	44.00	73.00
M11	3	56	54.98	8.55	39.00	75.00
M11	4	49	49.16	8.22	31.00	65.00
HOLD	STATE	128	95.34	1.69	88.50	99.30
HOLD	1	11	96.29	1.28	93.50	97.80
HOLD	2	12	94.76	2.72	88.50	98.90
HOLD	3	56	95.05	1.60	91.40	97.70
HOLD	4	49	95.59	1.45	92.50	99.30

SCHOOL INPUT MEASURES

The second set of study measures to examine by locality classification is the school-input group. Summary statistics for these measures ADM, TPP, LPP83, NLPP83, and MSD, are presented in Table 5. ATTEND, the student and peer input measure, is included with the other school-input measures.

The ADM variable illustrates the variation in school division size by city-county type. The S.M.S.A. counties have the largest school division size on average, followed by the S.M.S.A. cities. Localities of lesser urban influence have a mean value that is 49 percent of the code 1 countes. Rural counties have a mean value that is 9 percent of the code 1 counties.

The ATTEND variable mean values for each of the four city/county codes are clustered around the 94th percentile. The S.M.S.A. counties have a slightly higher attendance average than the non-S.M.S.A. cities and counties. The S.M.S.A cities' mean value is slightly lower yet. Variation in ATTEND across and within city/county classifications appears to be similar. Mean values are close in value, and the standard deviation for each group is small.

The LPP83 (local per pupil expenditures) variable's mean value is higher for the S.M.S.A. localities, codes 1 and 2, than for the non-S.M.S.A. cities and counties. The average for the two means for the S.M.S.A cities and counties is 1572. The average of the means for the non-S.M.S.A. cities and counties, codes 3 and 4, is 970, or slightly less than 62 percent of the S.M.S.A. groups. Clearly, the S.M.S.A. localities provide the schools with more resources on a per pupil basis than the non-S.M.S.A. communities.

The mean values for the NLPP83 (nonlocal per pupil expenditure) indicate that the non-S.M.S.A. cities and counties receive slightly more funds per pupil than the S.M.S.A communities. The S.M.S.A. counties, which have the highest LPP83 mean, have the lowest NLPP83 mean.

TABLE 5: SUMMARY STATISTICS FOR SCHOOL INPUT MEASURES BY CITY/COUNTY CODE.

VARIABLE SYMBOL	CITY/ COUNTY CODE	NUMBER OBS	MEAN VALUE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
ADM	STATE	128	7434.51	13200.41	435	122830
ADM	1	11	26932.18	33611.53	4923	122830
ADM	2	12	20492.08	15160.49	1033	56023
ADM	3	56	5106.96	2909.87	990	12180
ADM	4	49	2519.77	1606.23	435	8356
ATTEND	STATE	128	94.10	0.93	91	96
ATTEND	1	11	94.36	0.67	93	95
ATTEND	2	12	93.66	1.49	91	96
ATTEND	3	56	94.10	0.88	91	95
ATTEND	4	49	94.14	0.86	92	96
TPP	STATE	128	2602.23	513.05	1983	5076
TPP	1	11	2912.36	771.01	2232	4871
TPP	2	12	3152.50	1003.67	2188	5076
TPP	3	56	2490.50	346.17	1983	3927
TPP	4	49	2525.55	293.48	2089	3555
LPP	STATE	128	1079.14	600.41	404	3935
LPP	1	11	1509.09	899.42	620	3629
LPP	2	12	1635.66	1108.48	740	3935
LPP	3	56	966.01	434.78	404	2385
LPP	4	49	975.61	376.06	429	2342
NLPP	STATE	128	1523.09	192.45	1043	2008
NLPP	1	11	1803.77	244.86	1159	2008
NLPP	2	12	1516.83	198.25	1143	1836
NLPP	3	56	1524.48	180.52	1043	1874
NLPP	4	49	1549.93	187.41	1070	1918
PTR	STATE	128	15.24	1.27	11.80	18.10
PTR	1	11	15.72	0.88	14.20	16.80
PTR	2	12	15.43	1.46	13.30	18.10
PTR	3	56	15.27	1.36	11.80	18.10
PTR	4	49	15.05	1.19	11.90	17.30
MSD	STATE	128	30.16	8.19	12.80	50.60
MSD	1	11	33.48	6.64	25.10	46.90
MSD	2	12	37.11	7.76	19.30	49.70
MSD	3	56	31.83	8.00	17.10	50.60
MSD	4	49	25.80	6.63	12.80	40.10

The mean values for jurisdictions by city/county classification for TPP83 (total per pupil expenditure), the sum of LPP83 and NLPP83, provides insight into how well the higher level of non-local transfer payments for education to the non-S.M.S.A. cities and counties offsets the higher local per pupil expenditures for the S.M.S.A. cities and counties. The TPP83 means indicate that the non-S.M.S.A areas do not receive enough support through non-local transfer payments to offset the higher level of local support in S.M.S.A. cities and counties. The average of the TPP83 means for the two non-S.M.S.A. city/county classifications is only 80 percent of the average of the means for the S.M.S.A. classifications.

The PTR means indicate that the pupil/teacher ratio does not vary among city/county classifications as several of the other measures do. All four classifications have means slightly above 15. The non-S.M.S.A. cities and counties have means that are a little lower than those of the S.M.S.A. cities and counties, indicating a slight advantage in teacher quantity for the non-S.M.S.A. localities.

The mean values for MSD by city/county code indicate that the cities and counties in the S.M.S.A. areas have more teachers with a postgraduate professional teaching certificate. The mean value for the code 3 localities is about 90 percent of the average for the two S.M.S.A. codes. The mean for the "rural" counties, code 4 counties, is about 71 percent of the S.M.S.A. average. The large drop in the percentage of teachers in the "most rural" areas, code 4 counties, may be, in part, a reflection of the lower access that teachers in the "rural" communities have to graduate programs in education. The availability of part-time graduate education programs in most metropolitan areas of the state make it possible for most teachers in urban localities to earn a graduate degree.

HOUSEHOLD AND COMMUNITY INPUT MEASURES

The third group of study variables to be reviewed by city/county classification is the household and community resources measures. This group includes INCOME, PCRACE, GRADS80 and POP80. The summary statistics for the variables by city/county code are presented in Table 6.

Means for the first measure in the household group, INCOME, are similar for the S.M.S.A. cities and counties and for the non-S.M.S.A. cities and counties. The average of the S.M.S.A. means is $13,349. The average of the non-S.M.S.A. cities and counties' mean values, $9,352, is about 70 percent of the average of the means for the S.M.S.A. cities and counties.

The next measure, PCRACE, does not vary in any systematic manner across localities analyzed by city/county code. The S.M.S.A. cities and the most rural counties have mean values of about 25 percent. The S.M.S.A counties and the cities/counties of lesser urban influence have means of 11 and 16 percent, respectively. Variartion within city/county code, however, is evident. The range of values for the S.M.S.A. counties is from a low value of 2 percent to a high value of 20 percent. The range for the other three city/county codes is from under 1 percent to over 50 percent. The standard deviation for the PCRACE variable in the code 1 localities is less than one third the standard deviations of the three other city/county codes.

The GRADS80 variable varies by city/county code. The average of the S.M.S.A. cities and counties mean values is 68 compared to the non-S.M.S.A. average of 48, or 70 percent of the S.M.S.A localities' average high school attainment.

The last measure in this group is POP80. As would be expected with a population measure, the S.M.S.A. cities and counties have mean values that are greater than the non-S.M.S.A. localities. The mean for the lesser urban influence classification is about 20 percent of the S.M.S.A. means, while the mean for the rural county classification is about 10 percent of the S.M.S.A. means.

TABLE 6: SUMMARY STATISTICS FOR HOUSEHOLD INPUT MEASURES GROUPED BY CITY/COUNTY CODE.

VARIABLE SYMBOL	CITY/ COUNTY CODE	NUMBER OBS	MEAN VALUE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
INC83	STATE	128	10099	2691	6468	23161
INC83	1	11	13337	3540	8482	20917
INC83	2	12	13361	4107	10546	23161
INC83	3	56	9885	1924	6741	14496
INC83	4	49	8818	1283	6468	11561
GRADS80	STATE	128	51.79	12.83	32.80	88.50
GRADS80	1	11	70.31	14.38	42.40	88.50
GRADS80	2	12	66.92	10.74	54.60	86.10
GRADS80	3	56	50.76	10.66	32.80	79.20
GRADS80	4	49	45.09	7.26	33.40	63.20
PCRACE	STATE	128	20.27	17.54	0.05	70.62
PCRACE	1	11	11.46	5.41	2.31	20.47
PCRACE	2	12	25.46	15.66	0.28	51.25
PCRACE	3	56	16.81	16.82	0.31	61.08
PCRACE	4	49	24.94	19.15	0.05	70.62
POP80	STATE	128	40975	68491	2937	596901
POP80	1	11	137008	161867	29122	596901
POP80	2	12	126945	85320	8726	266979
POP80	3	56	27722	15874	4757	66147
POP80	4	49	13510	7759	2937	37989

The final group of variables to be examined by city/county code is volunteer inputs: PTOR, HRMOR AND VOLMOR. Summary statistics for these variables are presented in Table 7.

The mean values for the parent-teacher organization membership variable, PTOR, grouped by city/county code indicates a strong difference between the two S.M.S.A. codes and the non-S.M.S.A. codes. The average for the two S.M.S.A. codes is .345 parent-teacher association members per student. The average of the means for the two non S.M.S.A. codes is .115 members per student, about one-third the average in the urban areas.

Examination of the volunteer input measures, HRMOR and VOLMOR, by city/county code provides little insight into urban/rural differences. Of the 52 school divisions responding to a survey questionnaire about the use of volunteers in the schools, only 30 reported the number of hours of volunteer time per month or the number of volunteers used in the school per month. All but one of the districts were in non-S.M.S.A. localities. For the code 3 and 4 jurisdictions, the means for HRMOR were relatively close. Means for VOLMOR indicate that code 3 localities utilize about 25 percent more volunteer time than the code 4 counties. However, there were only data for 25 percent of the code 3 cities and counties and 28 percent of the code 4 counties. It is, therefore, difficult to obtain much insight from the analysis of these measures by city/county code.

SUMMARY OF REVIEW OF DATA GROUPED BY CITY/COUNTY CODE

The examination of the study variables means for localities grouped by city/county code provides considerable insight into the distribution of opportunity, resources, and access to human capital investment. First, schools in urban areas, codes 1 and 2, clearly out-perform the schools in the localities of lesser urban influence and rural counties, codes 3 and 4. In the case of each

TABLE 7: SUMMARY STATISTICS FOR VOLUNTEER INPUT MEASURES GROUPED BY CITY/COUNTY CODE.

VARIABLE SYMBOL	CITY/ COUNTY CODE	NUMBER OBS	MEAN VALUE	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
PTOR	STATE	128	.200	.156	0.0	.79
PTOR	1	11	.377	.235	0.098	.79
PTOR	2	12	.342	.167	0.103	.53
PTOR	3	56	.170	.117	0.005	.49
PTOR	4	49	.151	.112	0.0	.47
HRMOR	STATE	30	74.75	98.34	2.74	436.00
HRMOR	1	1	66.75	0.00	66.75	66.75
HRMOR	2	0	0.00	0.000	0.00	0.00
HRMOR	3	14	76.74	83.14	7.52	295.60
HRMOR	4	15	73.44	116.73	2.74	436.00
VOLMOR	STATE	29	183.69	201.85	11.40	890.00
VOLMOR	1	1	890.00	0.00	890.00	890.00
VOLMOR	2	0	0.00	0.00	0.00	0.00
VOLMOR	3	14	175.98	186.50	39.96	755.50
VOLMOR	4	14	140.94	112.09	11.40	412.00

standardized achievement test score, the code 1 county means were the highest, Code 2 cities means were second, followed by the code 3 and then code 4 localities. The result for HOLD, the education quantity measure was not as clear, but did indicate an advantage to the urban counties.

Review of the means for the school input measures also indicates that the urban areas have more resources. Two exceptions are with the PTR and NLPP83. The mean values for the two nonurban city/county codes indicate greater access to the resource for the nonurban localities than for the urban one. The ATTEND variable was the only other measure for which the mean value for both urban cities and counties was not higher than the attendance-rate variable and the nonlocal-per-pupil-expenditure measure. Both of the S.M.S.A. code means were higher than the means from the two non-S.M.S.A. cities and county codes.

The household variables indicated the same urban advantage. The mean values for the two urban codes were higher than the two non-urban codes' means for INC83, GRADS80 and, as would be expected, POP80. The PCRACE variable indicated that the two non-urban codes have a higher percent of nonwhite population than the urban counties.

The summary statistics for two of the volunteer measures can not be used to contrast urban and nonurban because of the data reporting problem mentioned above. The PTOR variable, however, indicates a strong advantage for the code 1 and code 2 jurisdictions in terms of parental support of education through a parent-teacher organization.

In summary the code 1 and code 2 localities, the urban cities and counties, have consistently higher education outcomes than the code 3 and code 4 localities. The urban localities also have greater access to the variables that are hypothesized to influence education outcomes. The statistics indicate that school division location, urban or nonurban, is a factor in the output level of the students and impacts the division's access to resources that are hypothesized to be related to eduction production.

SUMMARY OF CHAPTER

The specified models were discussed in this chapter as well as the data used in the study. The data also were divided into groups according to their city/county code number. Summary statistics of the variables by these groupings were then compared. The next chapter presents and discusses the empirical results.

CHAPTER IV

RESULTS AND INTERPRETATION

INTRODUCTION

This chapter presents the results of the regression analysis for estimation of education quality and quantity production functions. Equations for both education quality and quantity production were estimated using the ordinary least squares procedure. The results for the quality equations are presented and discussed first. The quantity analysis is then presented and discussed.

EDUCATION QUALITY MODELS

Education quality production models were estimated for three points in the education production process: the fourth grade, the eighth grade and the eleventh grade. Standardized achievement test scores for reading and math at each of these points in the production process were used as the dependent variables in the quality production models. Two measures are used as representative measures for the quality of education and the cognitive learning skills of the education system at each grade level. All models were specified with the same independent variables. In the first part of this section, the features of the regression models are discussed. The second part of the section presents and discusses the results of the quality models estimated with lagged per pupil expenditure measures included in the models. After the models with the lagged variables are discussed and compared, the results of this research are compared to the findings of earlier research.

GENERAL DISCUSSION

The education quality models were initially estimated with each of the variables discussed in Chapter III under the section on specification of the estimating model. As was anticipated due to the high pairwise correlations among several of the variables specified as exogenous, multicollinearity was a problem in each of the equations. INC83, TPP83, and GRADS80 were particular problems in each of the models. Respecifying the model without the income variable reduced the multicollinearity to only the lagged-expenditure measures. The resulting model specifications are reported in this chapter. Before discussing the results of the estimated equations, a few comments on the variables excluded are appropriate. The measure included as a size economy measure, ADM, was not significant in the initial models estimated. One of the dummy variables for the city/county codes included in the models was significant in some of the estimations. Because of the performance of the ADM measure in the initial estimations and since the city/county code measure is included to account for differences in the size and structure of the localities, ADM was dropped from the model.

Multicollinearity problems were present in estimated models that included INC83, GRADS80, PCRACE and any of the three per pupil expenditure measures. In general, models that included the INC83 measure exhibited multicollinearity between the income variable and the per pupil expenditure variables, ATTEND, GRADS80 and HOLD. The coefficients of the exogenous variables were unstable. In general, the relationship of the income measure to several measures in the model tended to introduce collinearity problems to the data and greatly reduce the explanatory power of other variables in the model, while not altering the adjusted R^2 of the models. The income measure was not significant in any of the models. In order to reduce the ill-conditioning of the data and to focus the research on the relationships of the other variables specified as inputs, or independent variables, to the education output measures, INC83 was removed from the model.

The per-pupil-expenditure measure, TPP83, was specified as a lagged variable in the model to examine the relationship between the lagged expenditure values and the dependent variable in the current year. The local and nonlocal per pupil expenditure measures, LPP83 and NLPP83, also were specified as lagged independent variables in separate models to test whether local and nonlocal expenditures are associated with different levels of changes in the dependent variables.

The quality production models discussed in this chapter are specified with standardized achievement test scores as the dependent variables. The production inputs, or independent variables, include HOLD, the quantity output measure, PTR, MSD, and either TPP83 or LPP83 and NLPP83 as school input variables, GRADS80, PCRACE, and PTOR as household input measures, and ATTEND as a student and peer input measure. A polynomial lag was specified for the total per pupil expenditure. While there is no theoretical or empirical work as a guide for the selection of a lag structure, the polynomial lag was chosen because the lag effect is hypothesized to increase and than decrease over time. It is hypothesized that the per pupil expenditure would have no measureable impact on education output as measured by the standardized achievement test scores in the current year. The impact of the expenditure is hypothesized to appear after a one- or two-period lag. The effect of the expenditure would then decline to zero after an additional one or two periods.

EDUCATION QUALITY MODELS WITH POLYNOMIAL LAGGED EXPENDITURES

Six education quality, or cognitive learning, production models were estimated. Each model was specified with the same independent variables. The dependent variables were the standardized achievement test scores for reading and math from students in the fourth, eighth and eleventh grades, aggregated to the school-division level. The scores represent two quality-measures from each of three points in the twelve-year education production process.

A polynomial lag was specified for the total per-pupil-expenditure measure and included in the model.[4] The general lag specification is,

$$Y = \alpha + \beta(w_0X_t + w_1X_{t-1} + ... + w_nX_{t-n}) + \Sigma\beta_jZ_j + \varepsilon$$

assuming,

$$w_i = c_0 + c_1i + c_2i^2, \quad where \quad i = 0,1,2,3,...,n.$$

where Y is the output measure, X_{t-n} are the lagged values of per pupil expenditures, and Z_j are the other independent variables in the model, and w_i is the lag weight for the ith year. The model assumes that the lag weights can be specified by a continuous function that can be approximated by evaluating a polynomial function at discrete points (Pendyck and Rubinfeld).

Substituting the w_i equations for a second order, four year lag into the original equation,

$$Y = \alpha + \beta c_0X_t + \beta(c_0 + c_1 + c_2)X_{t-1} + ...$$

$$+ \beta(c_0 + 4c_1 + 16c_2)X_{t-4} + Z_j + \varepsilon$$

---

[4] The results for the current expenditure variables in all six quality models indicated that current expenditures were inversely associated with the achievement test scores used as dependent variables.

Combining terms yields the estimating equation,

$$Y = \alpha + \beta c_0(X_t + X_{t-1} + X_{t-2} + X_{t-3} + X_{t-4})$$

$$+ \beta c_1(X_{t-1} + 2X_{t-2} + 3X_{t-3} + 4X_{t-4})$$

$$+ \beta c_2(X_{t-1} + 4X_{t-3} + 9X_{t-3} + 16X_{t-4}) + Z_j + \varepsilon$$

The models were estimated with the ordinary least squares procedure. The lagged expenditure amounts are adjusted for inflation to 1983 real dollars with the Consumer Price Index. Several formulations of the polynomial lag structure were estimated. The second-order, four-year lag presented the best fit, and is used in the models reported below. Third order, as well as longer period lags, 5, 6, 7, and 8 years, also were estimated. The resulting lag weights did not follow the common inverted U of the polynomial lag and did not present consistent results.

The inclusion of the polynomial lag structure introduces lagged values of variables from the cross sectional data set into the data, introducing the possibility of heteroscedasticity. Generalized Park-Glejser Tests were performed on each of the six equations with the polynomial lags to test for heteroscedasticity. The test is conducted by regressing the natural log of squared error terms from the initial OLS equations on the natural log of the independent variables in the model, or

$$\ln \varepsilon_i^2 = \gamma_o + \delta_i \ln X_i + V_i$$

An F test is then performed to determine if the null hypothesis,

$$H_o\colon \delta_1 = \delta_2 = \delta_k = 0$$

can be rejected. If H_o is rejected, then heteroscedasticity exists. If the null hypothesis is not rejected the data are assumed to be homoscedastic.

The F tests for the hypothesis $H_1: \delta_1 \neq \delta_2 \neq \delta_k \neq 0$ for each of the six Generalized Park-Glejser test equation are presented in Table 8. The results indicate that the $\delta_k s$ are not all equal to zero, and therefore, heteroscedasdicity is present.

Information obtained from the Park-Glejser test was used to correct for heteroscedasticity. A weight was developed using the coefficients of the regressors in the Park-Glejser test equation. The weight is

$$w = \prod_{l=1}^{k} \frac{1}{X_l^{\delta/2}}$$

The weight is multiplied times each observation in the data set to correct for the heteroscedasticity.

The weight values for the Park-Glejser correction were computed and used in the re-estimation of the equations. After examination of the results from the weighted ordinary least squares quality models and re-examination of the diagnostic statistics it was determined that the unweighted OLS results provided better estimates, since the mean squared error terms were not smaller with the Park-Glejser correction. The results of the equations estimated with the Park-Glejser weights, therefore, were abandoned.

The quality models with the polynomial lags also were examined for multicollinearity. The diagnostic statistics are presented in Table 9. There are high variance inflation factors associated with the variables that are a linear combination of the variables in the polynomial lag, S1, S2, and S3. The VIFs for the other variables do not suggest any collinearity problems. The condition indices (CI) are also small in magnitude except for the ones associated with the lag parameters. Again, since the structural parameters for the lagged variable are linear combinations of the same variable, a high CI is not surprising. Examination of the variance decomposition portions (VDP) for each of the variables indicated that the only variables with more than one VDP greater than .50 are the variables associated with the lag structure. Multicollinearity, or ill-conditioning, therefore,

TABLE 8: HETEROSCEDASTICITY TESTS FOR EDUCATION QUALITY MODELS

MODEL	F STATISTIC
R4 TEST MODEL	3.611*
M4 TEST MODEL	3.238*
R8 TEST MODEL	3.514*
M8 TEST MODEL	1.880**
R11 TEST MODEL	6.105*
M11 TEST MODEL	3.473*

* = SIGNIFICANT AT THE .01 LEVEL
** = SIGNIFICANT AT THE .10 LEVEL

DEGREES OF FREEDOM: $F_{k,n-k-1}$

was determined not to be a problem with the data, but is associated with current and past values of the lagged variable, LPP83.

FOURTH GRADE ACHIEVEMENT MODELS WITH POLYNOMIAL LAGS

The results for the fourth grade education quality production equations estimated with a polynomial lag are presented in Table 10. These models are estimated at the point in schooling when students have completed about four years of school, one third of the years of schooling required for a high school diploma. Both the reading and math achievement models include independent variables for education quantity output, HOLD; for teacher-input quality, MSD; for teacher-quantity input, PTR; for student- and peer-time inputs, ATTEND; for parents' time in support of the school system, PTOR; the household's level of human capital, GRADS80; for the effect of household cultural differences, PCRACE; and dummy variables for three of the four city/county codes, R1, R2, and R3. The models also include a second order polynomial lag for total per pupil expenditure for school operations, TPP83.

The results for the R4 model, reading achievement, indicate strong relationships between some of the independent variables and the education output measure. Two variables, PCRACE and GRADS80, are significant at the .01 level. Four variables are significant at the .05 level, S1, S2, S3 and R1. The signs for the parameters associated with the lag structure will be discussed after the method of computing the weights for the lag is discussed. The signs for the other three significant variables are as hypothesized. The teacher quantity measure, PTR, has a t value greater than one and has the hypothesized signs. MSD, the teacher quality measure, and ATTEND, the student and peer input measure, have the hypothesized signs, but have a t value less than one. PTOR, the parent input measure, has a negative sign, contrary to hypothesis. Its t value, however, is less than

TABLE 9: MULTICOLLINEARITY DIAGNOSTIC STATISTICS FOR EDUCATION QUALITY MODELS.

VARIABLE	VARIANCE INFLATION FACTOR	CONDITION INDEX
HOLD	1.946	2.789
PTR	2.071	2.981
MSD	1.727	3.275
ATTEND	1.474	5.745
PTOR	2.720	9.726
S1	51279	16.595
S2	83975	19.172
S3	499	26.141
R1	2.037	278.059
R2	4.977	516.454
R3	6.174	1722

TABLE 10: OLS REGRESSION RESULTS FOR FOURTH GRADE MODELS.[1]

VARIABLE	READING PRODUCTION MODEL	MATH PRODUCTION MODEL
INTERCEPT	-98.3848 (-1.334)	-109.3210 (-1.165)
HOLD	.8098*** (1.491)	-.440214 (-.637)
PTR	-.8636 (-1.273)	1.0869 (1.260)
MSD	.0126 (.259)	-.0003 (-.002)
ATTEND	.7322 (.827)	1.7289*** (1.536)
PTOR	-1.5551 (-.326)	-5.4000 (.-.889)
GRADS80	.4386* (5.542)	.4505* (4.474)
PCRACE	-.1983* (-4.761)	-.1077** (-2.034)
S1	.01356** (2.223)	-.0077 (.985)
S2	.0171** (2.223)	.0096 (.985)
S3	-.0035** (-2.217)	-.0016 (-.930)
R1	5.6982** (1.941)	3.9432 (1.056)
R2	1.3156 (.467)	1.7917 (.500)
R3	.6867 (.217)	1.1672 (-.290)
R SQUARE	.6325	.4436

[1]t statistic in parenthesis
* significant at the .01 level
** significant at the .05 level
*** significant at the .15 level

.5. The education quantity measure, HOLD, has a positive sign and a t value greater than one. The adjusted R^2 for the model is .6325.

The results for the fourth grade math achievement model are not as strong as the R4 model. The model has three variables that are significant. Both GRADS80 and PCRACE are significant at the .01 level and have signs consistent with the hypothesized signs. ATTEND is significant at the .15 level and has the hypothesized positive sign.

Two of the other variables in the R4 model have t values greater than one, PTR and R1. PTR has a positive sign. ATTEND and R1 have the hypothesized positive signs.

The remaining variables were not significant. Two of the variables, HOLD and PTOR, have signs contrary to the hypothesized signs. The other variables all have the expected sign. The adjusted R^2 for the model is .4436.

POLYNOMIAL LAG STRUCTURE FOR THE FOURTH GRADE QUALITY MODELS

The fourth grade education production functions were both specified with a second-order, four-year polynomial lag for TPP83, total per pupil expenditure. The coefficients, c_i , for the estimated equations are used to compute w_i , the weight for each year of the lag. The lag weights are computed by substituting the c_i into the weight equation, $W_i = c_0 + c_1 i + c_2 i^2$, where i = 0, 1, 2, 3, 4. The lag weights are interpreted as the change in the dependent variable associated with the change in lagged variable i periods ago.

The level of significance for each lag weight is computed with a t test, where the t statistic is the estimated weight divided by its standard error. The c_i and the lag weights, w_i , for both of the fourth grade quality models are presented in Table 11. Three of the weights in the R4 model, w_o, w_2 and w_3 are significant. Two of the weights in the M4 model, w_1 and w_2 are significant.

The weights for the polynomial lagged variable, TPP83, indicate an inverted U polynomial lag for total per pupil expenditures. The weights in the current year for both models, w_0 , indicate an inverse association between current year expenditures and the output measures, the achievement test scores. The weight value is about zero after a one-year lag, w_1 , for both models. The weight values at w_2 in both equations is positive. The value decreases in the third period, w_3 , and then declines to about zero in w_4 for both models. Graphs of the lag structure are presented in Figure 1. The graphs clearly illustrate the inverted u lag structure, beginning with a negative value in the current period, peaking in the second and third periods, and decreasing in periods three and four to a near zero effect in the fourth period.

GENERAL INTERPRETATION OF THE FOURTH GRADE QUALITY MODELS

The estimation results for the fourth grade reading and math achievement models provide mixed support for the research hypotheses presented in Chapter I. The first hypothesis concerns identification of relationships between education outputs and school and nonschool inputs in the education production function. The hypothesis was stated,

- School and nonschool inputs that have a significant impact on the production of school outputs can be identified for policy applications.

Several variables used as input measures support the hypothesis. Both models show the lagged expenditure measure to be directly associated with education output. The GRADS80 variable, the

TABLE 11: POLYNOMIAL LAG STRUCTURAL COEFFICIENTS AND LAG WEIGHTS FOR THE FOURTH GRADE ACHIEVEMENT MODELS.[1]

STRUCTURAL FACTOR	READING MODEL	MATH MODEL
X1	0.0136	-.0077
X2	.0171	.0096
X3	-.0035	-.0016

Weight	READING MODEL	MATH MODEL
w0	-.013575* (-2.220)	-.00772 (-.992)
w1	.000033 (.932)	.000108* (3.088)
w2	.027607* (7.248)	.015571* (4.088)
w3	.0063959** (1.738)	.004637 (1.260)
w4	-.000848 (-.592)	.001337 (.934)

[1]t statistic in parenthesis
* significant at the .01 level
** significant at the .10 level

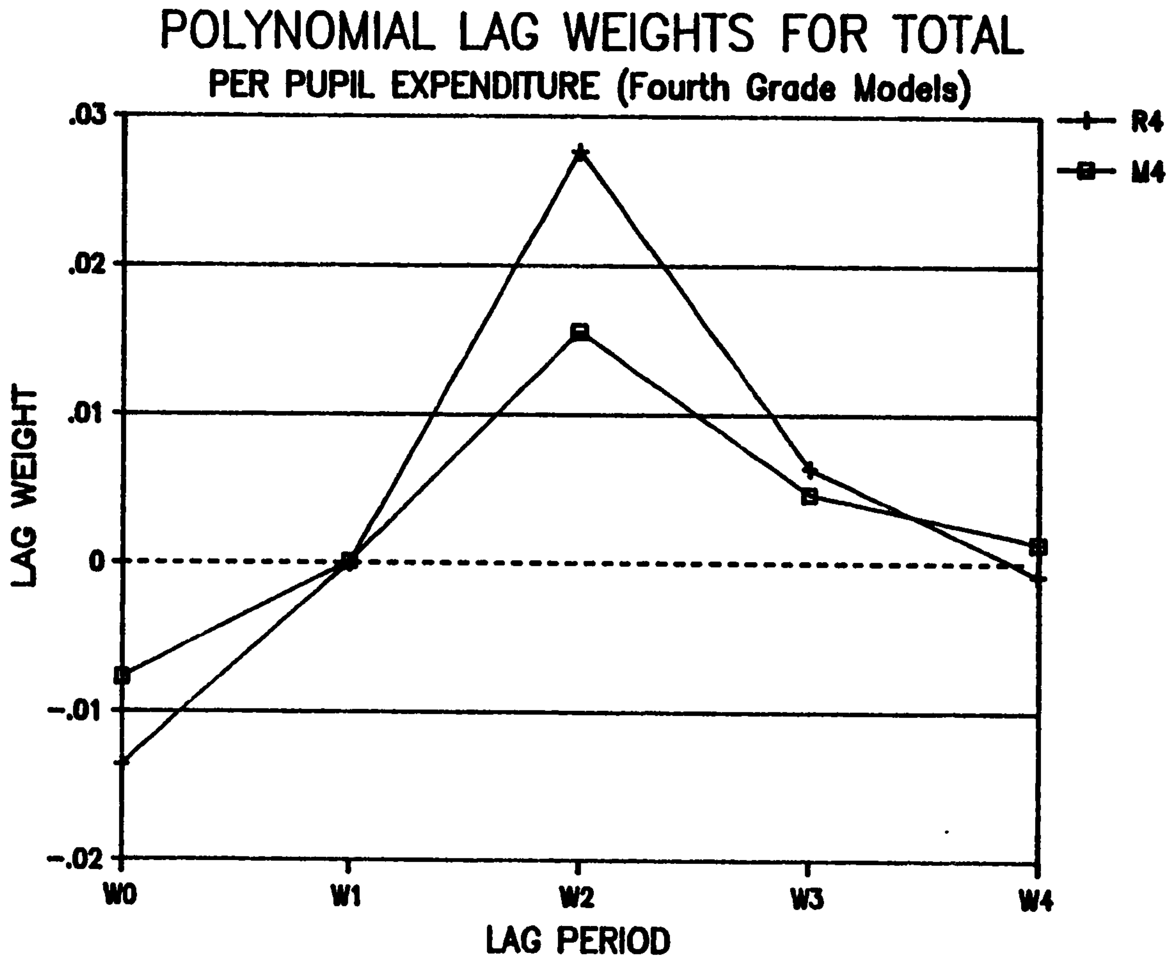

FIGURE 1. FOURTH GRADE EXPENDITURE LAGS

percent of the adult population with high-school diplomas, is significant and positive. The PCRACE variable, the percent of the population that is nonwhite, was negative and significant. The student and peer-time input measure, ATTEND, was positive in both models and significant at the .15 level in the M4 model. This result offers some support for the hypothesized relationship between student inputs and achievement test scores. The teacher quantity variable, PTR, in the R4 model has the hypothesized negative sign and a t value greater than one. This provides weak support for the hypothesized relationships between teacher quantity and education output. The MSD and PTOR variable are insignificant.

The results from the M4 model bring into question some of the hypothesized relationships between education outputs and production inputs. The sign on the PTR measure is contrary to the hypothesized signs. While the coefficient is not significant at the .1 level, it has a t value greater than one. The measure for parents' involvement in activities in support of the school, PTOR, has a negative sign, contrary to expectation, although the variable is not significant.

The fourth grade models indicate that several of the input measures are associated with education outcomes as measured by reading and math achievement test scores, although the school, student and peer, and the volunteer inputs do not show strong statistical relationships. Also, the strength of the variables in the two fourth grade models indicate that some of the inputs as measured by the model variables have different coefficients in the two models, suggesting that the inputs have varying influences on different outputs.

The results on the quantity-output measure, HOLD, support the second research hypothesis concerning the jointness of education output in production. However, the achievement test scores are for the fourth grade students while the student retention rate is for students in the upper grades, generally above the eighth grade, because of state law requiring school attendance until age sixteen. The hypothesis was stated,

- Education quality and quantity are joint products in the education production process.

The positive coefficient on the quantity variable, HOLD, in the R4 model is significant at the .15 level. The variable indicates that increases in quantity production are positively associated with increases in quality output. The M4 model, however, does not support the hypothesis. The coefficient on the HOLD variable is negative in sign. The t value, however, is less than one.

The third hypothesis discussed in Chapter I related to the time period, or lag structure, between education inputs and the effect of the inputs on education outputs. The hypothesis was stated,

- A lag period exists before output changes result from increases in education production inputs.

The polynomial lags in both the R4 and M4 models support the third hypothesis. The lag weights in the current year, w_0 , indicate a negative relationship between output and per pupil expenditures. The weights after 1, 2 and 3 years, however, indicate that the expenditure measure does have a positive relationship to education outcomes. Five of the ten lag-weights in the two models are significant at the .1 level of confidence. These include w_2 in both models, the weight that is associated with the greatest positive relationship between the expenditure measure and the achievement test scores.

In summary, the results from the estimation of the fourth-grade quality production function models offer some support for the research hypotheses, but also raise questions about the appropriateness of some of the measures used for specified variables. The insignificance of the PTOR variable in particular, is very likely a measurement problem which reflects the poor quality of data available for parent-teacher organization activities and volunteer school activities in general. The results of the R4 model, the model with reading achievement as the dependent variable, provide consistent support for all three of the hypotheses. Some of the variables used as input measures, however, demonstrate weak associations with the dependent variable used as an output measure. The M4 model, with the math achievement score as the dependent variable, on the other hand, supports the hypothesis regarding the lagged effect of inputs on outputs and for the effectiveness of some of the inputs on output production. The model results, however, raise questions about the appropriateness of some of the variables used as input measures, and provide no support for a joint relationship between education quality and quantity in the education production process.

EIGHTH GRADE QUALITY PRODUCTION MODELS WITH POLYNOMIAL LAGS

The eighth-grade quality production models, the R8 and M8 models, represent the level of education quality output after the students have been in the school system for almost eight of the twelve years of schooling required for a high school diploma. The models were estimated with the standardized achievement test scores for reading and math as the dependent variables. The specification of the independent variables is the same as for the fourth-grade models discussed above. The results of the eighth grade models are presented in Table 12.

The results for both eighth grade models are generally strong. Both models have six significant variables. In the R8 model GRADS80, PCRACE, S1, S2, and S3 are significant at the .01 level. HOLD is significant at the .05 level. All of the variables had the hypothesized signs. The teacher quantity input measure, PTR, has the hypothesized sign and a t values in excess of one. The parent support measure, PTOR, has the hypothesized positive sign. MSD, the teacher quality measure, and ATTEND, the student and peer input measure, are both insignificant. The adjusted R^2 for the model is .7403.

The M8 model, the model with the eighth grade math achievement test score as the dependent variable, had MSD, GRADS80, PCRACE, S1, S2, and S3 significant at the .01 level. All of the variables had the hypothesized signs. HOLD had the hypothesized sign and a t value greater than one. The R1 dummy variable had a t value greater than one and a positive sign. The ATTEND,

TABLE 12: OLS REGRESSION RESULTS FOR EIGHTH GRADE MODELS.[1]

VARIABLE	READING PRODUCTION MODEL	MATH PRODUCTION MODEL
INTERCEPT	-36.7554	61.4390
	(-.568)	(-.934)
HOLD	.9481**	.6244
	(1.989)	(1.289)
PTR	-.8824***	-.5246
	(-1.483)	(-.867)
MSD	-.0126	.1814**
	(-.143)	(2.023)
ATTEND	-.0475	.5466
	(-.061)	(.693)
PTOR	3.2520	.9781
	(.776)	(.693)
GRADS80	.4784*	.4760*
	(6.888)	(6.744)
PCRACE	-.2479*	-.1238*
	(-6.781)	(-3.333)
S1	-.0133*	-.0273*
	(-2.475)	(-5.010)
S2	.0167*	.0343*
	(2.484)	(5.011)
S3	-.0034*	-.0069*
	(-2.504)	(-4.993)
R1	3.4356	3.9867***
	(1.334)	(1.523)
R2	1.7642	1.5983
	(.714)	(.637)
R3	-.0970	-.3089
	(-.349)	(-.110)
R SQUARE	.7403	.6757

[1]t statistic in parenthesis
* significant at the .01 level
** significant at the .05 level
*** significant at the .15 level

PTR, and PTOR variables had the hypothesized signs, but had t values less than one. The adjusted R^2 for the model is .6757.

POLYNOMIAL LAG STRUCTURE FOR THE EIGHTH GRADE QUALITY MODELS

The polynomial lag-weights for the eighth-grade models were computed by substituting the c^i values into the weight equation, $w_i = c_0 + c_1 i + c_2 i^2$, as was done in the fourth grade models. The c_i values and the lag weights, w_i, are presented in Table 13. Graphs for the lag structures are presented in Figure 2. Four of the five weights in each model are significant.

As illustrated in the graphs of the lags, both polynomial lags are inverted U s . Both lag structures begin with negative w_0 values and increase to about zero after a one-year period. The w_2 and w_3 values are positive, with the third-year value decreasing slightly from the second-period weight in both models. The weights for the expenditure measure then decrease to near zero at w_4 in both models. models.

GENERAL INTERPRETATION FOR THE EIGHTH GRADE QUALITY MODELS

The regression results for the eighth grade quality models provide generally stronger support for the research hypotheses presented in Chapter I than the fourth-grade models. The variable signs in both models are generally consistent with expectation, and the models have more variables that have significant coefficients than the fourth grade models.

TABLE 13: POLYNOMIAL LAG STRUCTURAL COEFFICIENTS AND LAG WEIGHTS FOR THE EIGHTH GRADE ACHIEVEMENT MODELS.[1]

Structural Factor	READING MODEL	MATH MODEL
X1	-.0133	-.0273
X2	.0167	.0343
X3	-.0034	-.0069

Weight	READING MODEL	MATH MODEL
w0	-.013287*	-.027321*
	(-2.475)	(-5.010)
w1	.0000181	.0000338
	(.733)	(1.497)
w2	.027143*	.013428*
	(10.331)	(5.030)
w3	.005953*	.012618*
	(2.346)	(4.988)
w4	-.001417	.-.001665**
	(-1.433)	(-1.660)

[1]t statistic in parenthesis
* significant at the .01 level
** significant at the .10 level

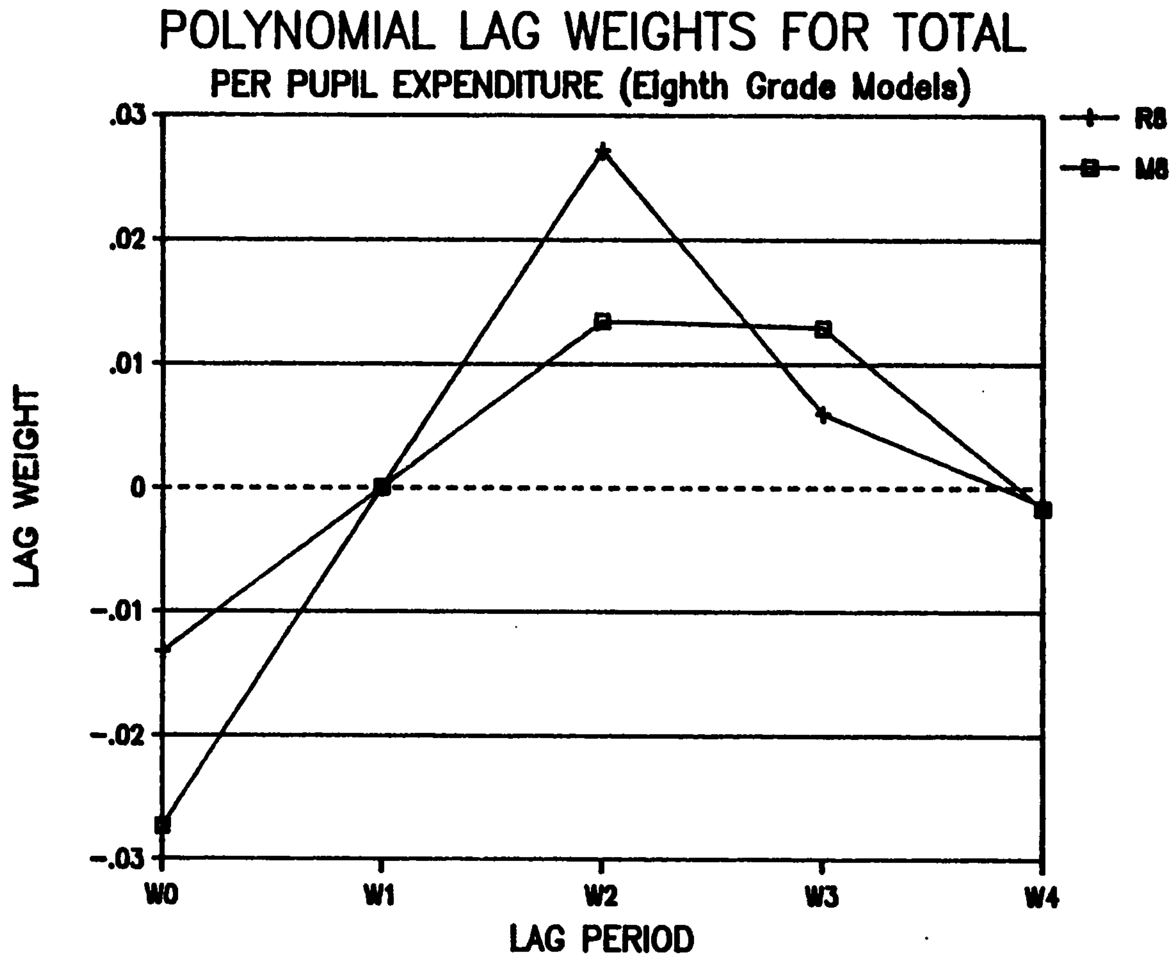

FIGURE 2. EIGHTH GRADE EXPENDITURE LAGS

The significance of the GRADS80, PCRACE and the lag structure variables in the R8 model and the significance of the MSD, GRADS80, PCRACE and lag structure variables in the M8 model provide support for the hypothesis that education production inputs influence educational outcomes. The signs of the coefficients of the PTR and PTOR variables in the R8 model are consistent with the hypotheses. The signs on MSD and ATTEND, however, are contrary to the hypothesis. The PTR, MSD and PTOR variables all have t values that are equal to or greater than one. The signs on the PTR, ATTEND and PTOR variables in the M8 model are all as hypothesized, although none has a t value of one or greater.

The positive sign on the coefficients on the quantity output measure in both models, HOLD, and the significance of the measure in the R8 model give some support to the hypothesis of joint production. Both models indicate that increases in education quantity output are positively associated with quality output.

The third research hypothesis is related to the structure of the lagged relationship between inputs and outputs. The polynomial lags in both models support the hypothesis that inputs have a lagged impact on output. The weights increase for two periods, becoming slightly positive after one year and increase to their peak after a two year lag. The weights then decline slightly in both models during the third year and decrease to about zero at the fourth period weight. Eight of the weights in the two models are significant at the .1 level.

In summary, the regression results for the eighth grade quality models provide support for the research hypotheses. The coefficients on the quantity variable in one models provide support for the joint production relationship between education outputs. However, the achievement test score is associated with eighth grade students while the student retention rate is associated with high school students because of the state law requiring stdents to attend school until they are 16 years old. The structure of the lags in both models provides support for the hypothesis concerning the lagged relationship in education production. All variables in general support the hypothesis that school and nonschool inputs have a positive impact on education outcomes. The effectiveness of the household inputs as measured by GRADS80 and PCRACE are much stronger than the results for student and peer variables, the parents' support measure, or teacher quantity or quality.

ELEVENTH GRADE ACHIEVEMENT MODELS WITH POLYNOMIAL LAGS

The eleventh grade quality models are specified with the eleventh grade reading and math scores as the dependent variables. These equations measure the quality output one year before the completion of the years of schooling required to earn a high school diploma. These equations, therefore, represents education production relationships toward the end of the multiperiod education production process. The results for the eleventh grade models are presented in Table 14.

The R11 and M11 models show some strong relationships between the dependent and independent variables in both models. The R11 model, the reading achievement model, has two significant variables. GRADS80 and PCRACE are significant at the .01 level. Both variables have the hypothesized signs. The HOLD measure has a negative sign contrary to hypothesis. All other variables have signs as hypothesized. PTR and R1 have t values greater than one.

The M11 model, which has the math achievement test score as the dependent variable, has five significant variables. GRADS80, PCRACE, S1 and S3 are significant at the .01 level. S2 is significant at the .05 level. The coefficients on MSD, PTR, ATTEND, and PTOR all have the hypothesized signs. PTR, MSD and PTOR have t values greater than one. HOLD has a negative sign.

TABLE 14: OLS REGRESSION RESULTS FOR EVEVENTH GRADE MODELS.[1]

VARIABLE	READING PRODUCTION MODEL	MATH PRODUCTION MODEL
INTERCEPT	31.4339 (.461)	-6.7990 (-.106)
HOLD	-.2383 (-.474)	-.1177 (-.250)
PTR	-.9922*** (-1.470)	-.8815*** (1.501)
MSD	.0401 (.430)	.0889 (1.021)
ATTEND	.4512 (.551)	.7636 (.995)
PTOR	3.5852 (.811)	5.1387 (1.242)
GRADS80	.5109* (6.978)	.4245* (6.194)
PCRACE	-.3149* (-8.174)	-.1863* (-5.167)
S1	-.0035 (-.625)	-.0115** (-2.170)
S2	.0047 (.663)	.0145** (2.186)
S3	-.0011 (-.779)	-.0030** (-2.218)
R1	3.1254 (1.151)	1.8264 (.719)
R2	1.2179 (.468)	-.7043 (-.287)
R3	-1.3447 (-.460)	-3.324 (-1.213)
R SQUARE	.7458	.6901

[1]t statistic in parenthesis
* significant at the .01 level
** significant at the .05 level
*** significant at the .15 level

POLYNOMIAL LAG STRUCTURE FOR ELEVENTH GRADE QUALITY MODELS

The polynomial lag weights, w_i , are presented in Table 15. Graphs for the lags are presented in Figure 3.

The polynomial lags in both models are inverted Us as illustrated by the graphs. The weights begin with a negative value in the current year. After a one-period lag, the weights in both models are equal to about zero. The weights in both models increase to a peak positive value at w_2 and then decline in the last two years of the lag period. The lag weights in the R11 model are lower in value for each year than the weights in the M11 model. Only one weight in the R11 model is significant. Four weights in the M11 model are significant.

GENERAL INTERPRETATION OF THE ELEVENTH GRADE QUALITY MODELS

The results of the eleventh-grade models provide additional support for two of the research hypotheses discussed in Chapter I. The measures for family inputs, GRADS80 and PCRACE, are significant. The weights for the polynomial lag on the per pupil expenditure measures are significant in the M11 model. All coefficients on the input variables in both models have the hypothesized signs. The PTR measure has a t values greater than one in both models. The MSD and PTOR variables have t values greater than one in the M11 model. The coefficients for the quantity variable are not significant in either of the eleventh grade models.

The results of the polynomial lags in the M11 model support the hypothesis that education inputs have a lagged effect on education outputs. The current-year weights for the lag structure in both

TABLE 15: POLYNOMIAL LAG STRUCTURAL COEFFICIENTS AND LAG WEIGHTS FOR THE ELEVENTH GRADE ACHIEVEMENT MODELS.[1]

STRUCTURAL FACTOR	READING MODEL	MATH MODEL
X1	-.0035	-.0115
X2	.0047	.0145
X3	-.0011	-.0030

Weight	READING MODEL	MATH MODEL
w0	-.003534 (-.625)	-.011491* (-2.170)
w1	.0000448** (1.718)	.0000444** (1.742)
w2	.001363 (.492)	.0055587* (2.144)
w3	.0004207 (.157)	.0050519* (2.017)
w4	-.002783 (-2.662)	-.001476 (-1.513)

[1]t statistic in parenthesis
* significant at the .01 level
** significant at the .10 level

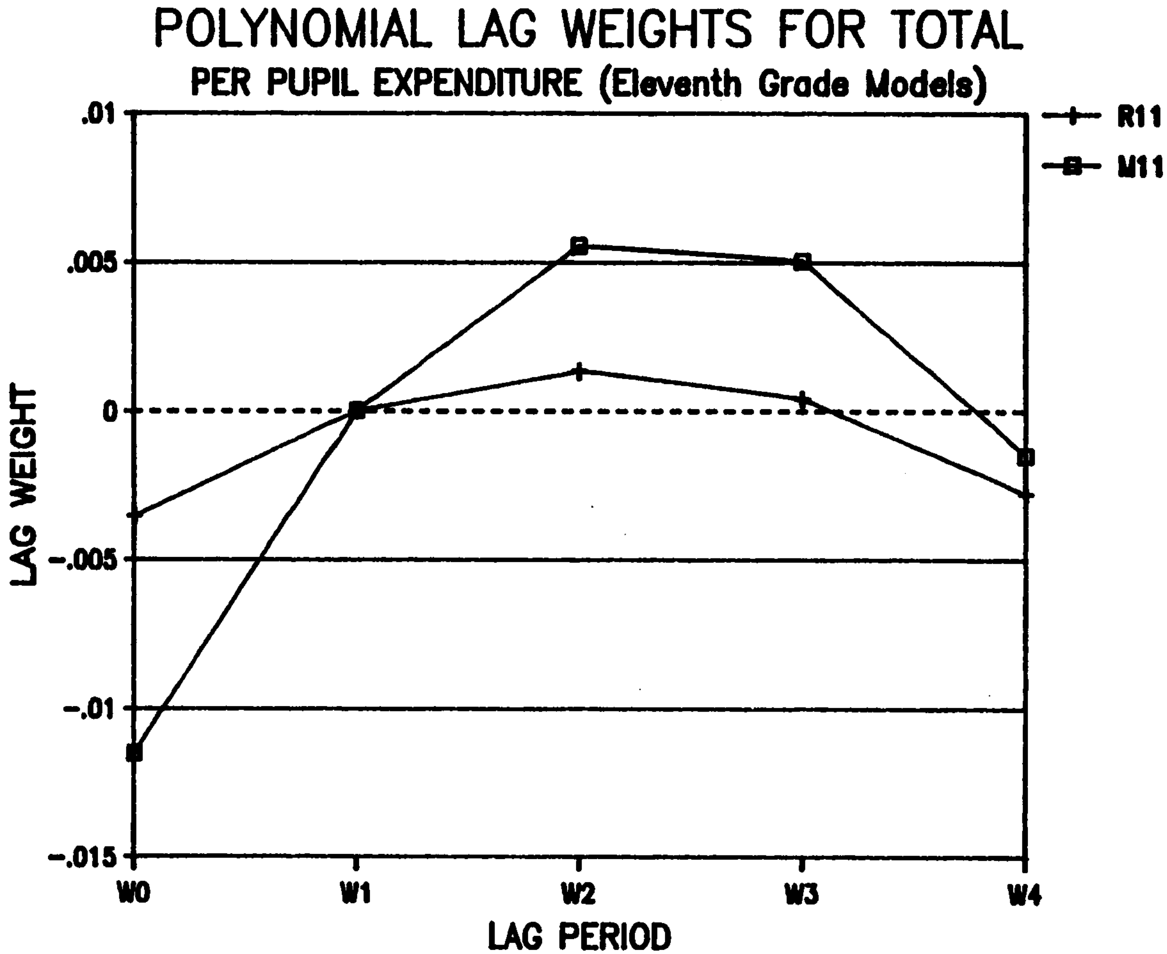

FIGURE 3. ELEVENTH GRADE EXPENDITURE LAGS

models are negative, indicating that the impact of per pupil expenditures is not associated with the quality measures in the current year. The weight values increase for two periods to peak after two years. The weights then decline with the lag in the R11 model approaching zero in year three and the lag in the M11 model approaching zero in year four. However, only one of the weights is statistically significant in the R11 model.

In summary, the results of the regression analysis for the eleventh-grade models provide support for two of the research hypotheses. The support for the effectiveness of the household inputs as measured by GRADS80 and PCRACE is much stronger than for teacher quality or quantity measures, the student and peer variable, or the PTOR measure. The results in the M11 model strongly support the hypothesized lag relationship between per pupil expenditures and education outputs. The results of the HOLD measure do not provide support for the joint production hypothesis, as the HOLD variable is not significant in either model.

ANALYSIS AND DISCUSSION OF THE QUALITY MODELS WITH POLYNOMIAL LAGS

The conceptual model developed in Chapter II is based on the combination of a public-choice model and the household production model. The public choice model, the median voter model, provides the theoretical framework depicting the way a community decides the level of education that will be provided as a public service. The household production model provides the conceptual framework for interpreting how households respond to the level of education supplied publicly. The response can be any of a range of household resource allocations that support or add to the public resources going into education. The resources can impact local education production directly if they are allocated directly to the school, such as through volunteer instruction.

Household allocations to increase the education output of specific household members, on the other hand, have an indirect effect on the community's production of education by increasing the output of a particular student.

The empirical models for education quality production were specified with aggregate measures for education quality, or cognitive learning skills, as the dependent variables. Measures for the two cognitive skills, reading and math, at grades four, eight, and eleven were used in separate models as the measure for education output. Aggregate measures for school, student, volunteer, and household inputs were used as independent variables to identify relationships between the dependent and independent variables at the aggregate level that reflect the effectiveness of allocations from each sector to the education production process. A measure for quantity output production, HOLD, also was specified as an independent variable in each of the quality models in order to examine the relationship between the quantity and quality dimensions of education output.

The results provide evidence that education production inputs can be identified that are directly associated with education output as measured by the standardized achievement test scores. The research also indicates that there is a lagged relationship between the changes in the level of per pupil funding for education, a measure of public inputs to education production, and changes in the level of education output as measured by the achievement test scores. The evidence concerning the joint production relationship between the quality and quantity dimensions of education as measured by achievement test scores and the school continuation rate, respectively, is less clear. The quality measure, HOLD, is significant and directly related to education output in two equations, and inversely related to education output in others.

The next section is organized as follows. First, the general results of each variable in the education-quality production models will be analyzed and discussed. Then, the general implications of the empirical results for the research hypotheses will be discussed.

HOUSEHOLD INPUT MEASURES

The empirical results for the household variables, GRADS80 and PCRACE, are consistently significant in each of the six estimated models. These measures were included in the models as measures of the human capital stock of the adult population and as a measure for racial composition, respectively. The GRADS80 measure was incorporated into the model because of the importance of parents' education in human capital development. Both Liebowitz and Murnane, Maynard and Ohls found parent education level significant in their models of household human capital production. Research (Liebowitz) also indicates that as the value of the mother's time increases, she is more likely to allocate time to children's human capital development. GRADS80 also provides a measure of the level of human capital stock in the community to be transferred from parents to children. The GRADS80 variable is correlated with per capita income. The measure may, therefore, reflect the influence of socioeconomic factors that are associated with income.

The PCRACE variable was specified as a measure of differential cultural factors affecting the production of education, be it due to the historic denial of access of the non-white community to education in Virginia resulting in a lower stock of human capital in the non-white population, or more simply to the distribution of wealth between the white and nonwhite communities or to the differences between the value placed on education achievement and resulting household allocations by the white and non-white communities. The education variable does control for income, as the income and education are strongly correlated. The PCRACE variable is negative as hypothesized in each of the six models. Their association with the dependent variables, the standardized achievement test scores, therefore supports the hypothesized relationship between household allocations and education production.

Examination of education production models estimated without the household variables provides insight into the interrelationship between the variables used to measure household inputs and the measures for school, student and peer, and volunteer inputs. The models that were estimated without the household measures had statistically significant relationships between MSD, the percentage of teachers with a professional teacher certification, ATTEND, the average daily attendance rate, and PTOR, the ratio of parent-teacher organization members to students. Introduction of either the GRADS80 variable or the PCRACE variable altered the significance of the measures for inputs from the other sectors. It appears, therefore, that communities with a higher percent of adults with a high school diploma, or that have a higher percent of the population that is white, have greater student and volunteer inputs into education.

In order to gain some insight into the interaction between the household measures and the variables used as input measures for the other sectors, a stepwise procedure was used to estimate the quality models entering the non-household variables before the household measures. Using this procedure, the school teacher quantity and quality variables, the PTOR measure and the ATTEND variable were each significantly related to achievement test scores. The significance of these measures dropped with the introduction of the household measures into the models. Clearly, interaction among the household measures and the other input variables influences the model relationships.

SCHOOL INPUT MEASURES

Three school input variables were used in the estimated equations as measures of the public inputs to education. Two of the measures related to the quality and quantity of the school teacher inputs to education. The third was a measure of per pupil public spending for education. All three of the variables were hypothesized to be directly related to education output as measured by the standardized achievement test scores.

The two teacher input measures, MSD and PTR, were selected to account for the quality and quantity of the teacher input to the school system. Conceptually, higher quantity or quality of the teacher input increases the inputs to the education production process and, therefore, should increase the level of school output. The MSD measure, the percent of instructional personnel with a professional teacher certification, represents one measure of teacher quality. The certification requires a graduate degree and also is associated with years of teacher experience, although no experience is required for the certificate. The measure may reflect the experience of the teachers who earn graduate degrees as well as the value of their investment in the graduate degree. This variable accounts for the variation in formal teacher training across school districts, and was hypothesized to be positively associated with education output. Human capital theory suggests that investments in human capital through education, and through experience, improve the value of the teacher input provided by the person who has made the human capital investment (Schultz). The inclusion of a variable that measures the educational level of the school labor force (teachers) as a teacher quality measure is conceptually sound.

In the statistical analysis, the MSD measure, however, was weakly associated with the standardized achievement test scores in most of the production models. The variable was significant in the eighth grade math model and positively related to the output measure. The measure was insignificant in the other five models.

These results seem to suggest one of two things. Either the MSD measure is not a good measure for the quality of the teacher input, or the quality of the teaching staff has little effect on education achievement except in the production of eighth grade math skills. However, since the quality of the teacher is conceptually linked to the production model, and the MSD measure seems to provide a good measure of the relative difference in quality, another explanation should be considered. The lack of strength of the association between the MSD variable and quality output might instead be linked to the interrelationship between the socioeconomic factors of the two household variables, GRADS80 and PCRACE, and the MSD variable. So, even though the MSD variable is conceptually related to teacher quality and is theoretically linked to the education production model, its association with the output measures in the production process is limited to a weak association with the school quality, except in the eighth grade math model. This could be a measurement problem in that a master's degree may not be a critical factor in determining the success of a teacher's cognitive teaching ability.

The other teacher input measure, PTR, is the pupil/teacher ratio. It provides a measure of the relative quantity of teacher input for the school district. Inclusion of the variable is linked to the theoretical model that differentiates between the quantity and quality of the labor input supplied by the public sector to the education production process. The PTR variable is a measure of the relative amounts of teacher inputs in school districts. Conceptually, the variable repesents the number of teachers per student and should be positively associated with standardized achievement test scores, the school output measure. That is, as the relative amount of the teacher input increases, the output should increase. The PTR variable is the ratio of pupils to teachers which decreases as the relative number of teachers increases. Therefore, the hypothesized relationship between PTR and the dependent variables is negative.

The PTR variable is not significant at the .1 level in any of the six models. It is significant, however, at the .15 level in three of the models, the eighth grade reading model and both eleventh grade models, with the hypothsized negative sign. The variable was not significant in the other three models. The results of this variable in the regression models could be interpreted to mean that within the range of pupil/teacher ratios of school divisions in Virginia (the range is 11.8 to 18.1 as reported in Chapter 3), changes in the ratio by increasing or decreasing the quantity of teachers are not associated with changes in education output for the lower grades, or the fourth grade. Lowering the pupil/teacher ratio within the range of Virginia school districts, however, is associated with increases in the standardized achievement test scores for eighth grade reading and for eleventh grade reading and math. In other words, decreasing the ratio of pupils to teachers becomes a critical factor in education production as the students advance in the twelve year production process. This might be a reflection of an increased need for teacher/pupil interaction as school work becomes more diversified in middle and secondary school. The PTR is a conceptually good measure for the relative quantity of teacher input for education. The results support the hypothesized direct relationship between teacher input and education quality production as measured by the achievement test scores.

The per pupil expenditure measure was included in the model as a measure of the public resource support for input into the education system. The expenditure variable is a theoretically strong measure for the public financial inputs to the education production process. Conceptually, the variable measures the per pupil level of public inputs, as it is based on a total dollar value for the public inputs to education. The measure is specified in a polynomial lag structure to incorporate the time, or lag, period that must pass before changes in the per pupil measure are positively associated with changes in the achievement test output measures.

The results of the regression models generally support the hypothesis that school expenditures have a positive impact on school output. The lag structures for the six equations are graphed in Figure 4.

The graph clearly shows the lagged expenditure weights to be positively associated with the achievement test scores in the second and third lag periods. Only one model, the eleventh grade reading model, had a lag structure with the majority of the lag weight values insignificant. The weights that were insignificant in the other models were the one-year lag, which had a coefficient close to zero in each models and the four-year lag which also had coefficients close to zero in each of the six models.

Examining the individual lag weights, the coefficient on the current year for each model is negative. While this could appear to indicate that increases in expenditures are negatively associated with achievement test scores, it may reflect school division decisions to increase funding for education in order to increase education output. Because of the lagged impact of expenditures on output, the increases in funding appear to be associated with lower student performance on the standardized achievement test scores. The increase in investment is recorded in the current year, while a time lag is needed before the investment is associated with higher test scores. The resulting relationship between expenditure and scores, therefore, is negative. The lag weights for each model after one

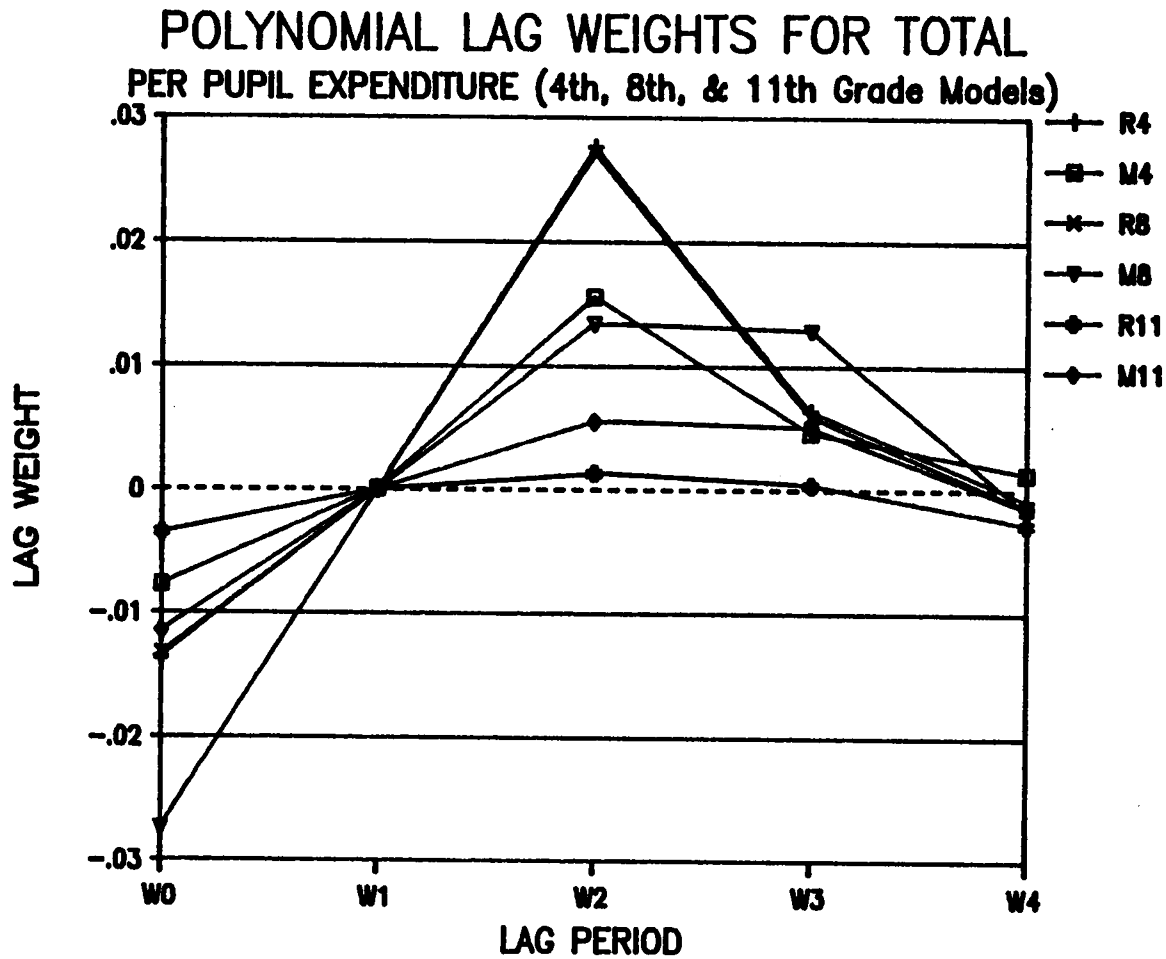

FIGURE 4. EXPENDITURE LAGS

year, w_1 , show a close to zero association between changes in the expenditure measure and the achievement test scores. After two years, w_2 , however, there is a strong positive association between changes in the expenditure measure and the output measures. The weights all decline for period three, w_3 , but remain positively related to the output measures. The fourth-year weight, w_4 , which is not statistically significant in most of the six models and has a coefficient near zero in all six models, indicates that the expenditure effect dissipates after four years.

These results do not provide any insight into the responce within specific localities that are increasing their investment in education. School divisions with relatively high achievement test scores can decide to increase per pupil expenditures in an attempt to improve their students' level of education output. The increase in expenditures likely would widen the gap between the achievement score levels and the expenditure level and be reflected by an inverse relationship until after the increased expenditure had an effect on the output measure.

Comparing the relative changes associated with the lag weights of the polynomial lag for the per-pupil-expenditure measure across models is difficult because of the differences in the values of the dependent variables. Converting the weights to elasticities, however, changes the regression coefficients to unit-free percentages of change in the dependent variable associated with percentage changes in the independent variable and allows for comparison of the effects across models. Elasticities are defined,

$$E_j = \beta_j \frac{\overline{X}_j}{\overline{Y}} = \frac{\frac{\partial Y}{\overline{Y}}}{\frac{\partial X}{\overline{X}}}$$

where E_j is the elasticity of the jth variable, β_j is the regression coefficient of the jth variable, $\overline{Y}$ is the mean value of the dependent variable, and $\overline{X}$ is the mean value for the independent variable. Elasticities are computed by multipling the regression coefficient (β_j) times the mean input value ($\overline{X}_j$) divided by the mean output value ($\overline{Y}$). An elasticity is interpreted as the percentage change in the dependent variable associated with a one percent change in the independent variable.

The elasticities for the polynomial lag weights of the per pupil expenditure measures for each of the six models are presented in Table 16. The elasticities are plotted in Figure 5.
As the table and graphs indicate, the largest positive relationships between the standardized achievement test scores and the school output measures is after a two year lag in each model. The changes associated with expenditures and output in the fourth grade and eighth grade reading models (the graphs are almost mirror images of each other) are the highest magnitude. The fourth grade and eighth grade math models have the next largest elasticities, followed by the eleventh grade math achievement and the eleventh grade reading achievement (which has statistically insignificant weights).

The relative differences in the elasticities can be seen with an example, Table 17. The example presents the changes in each of the achievement score measures over the four year lag period associated with a ten percent increase in expenditures. A one time ten percent change in per pupil expenditures, an amount of about $260 per student, would be associated with a 15 percent increase in student achievement in reading at the fourth and eighth grades, or about 7.647 and 7.529 points respectively, after a two-year lag period. Likewise, the ten percent increase in per pupil expenditure would be associated with a 2.8 percent, or a 1.540 point, change in eleventh grade math scores after the two year lag period.

The changes associated with the third year weights from the ten percent increase in expenditures range from an additional 3.1 percent change, or 1.613 and 1.502 points respectively, in the fourth and eighth grade reading models, to a 2.1 percent, or 1.170 points, change in the fourth grade math achievement model. The total change associated with each of the achievement measures for each of the lag weights that are statistically significant are presented in Table 17. The greatest total change associated with fourth and eighth grade reading models are 9.26 and 8.697 points, respectively. The total change for fourth and eighth grade math models are 4.341 and 6.571 points respectively. The totals for the eleventh grade reading and math models are .011 and 2.826 points respectively.

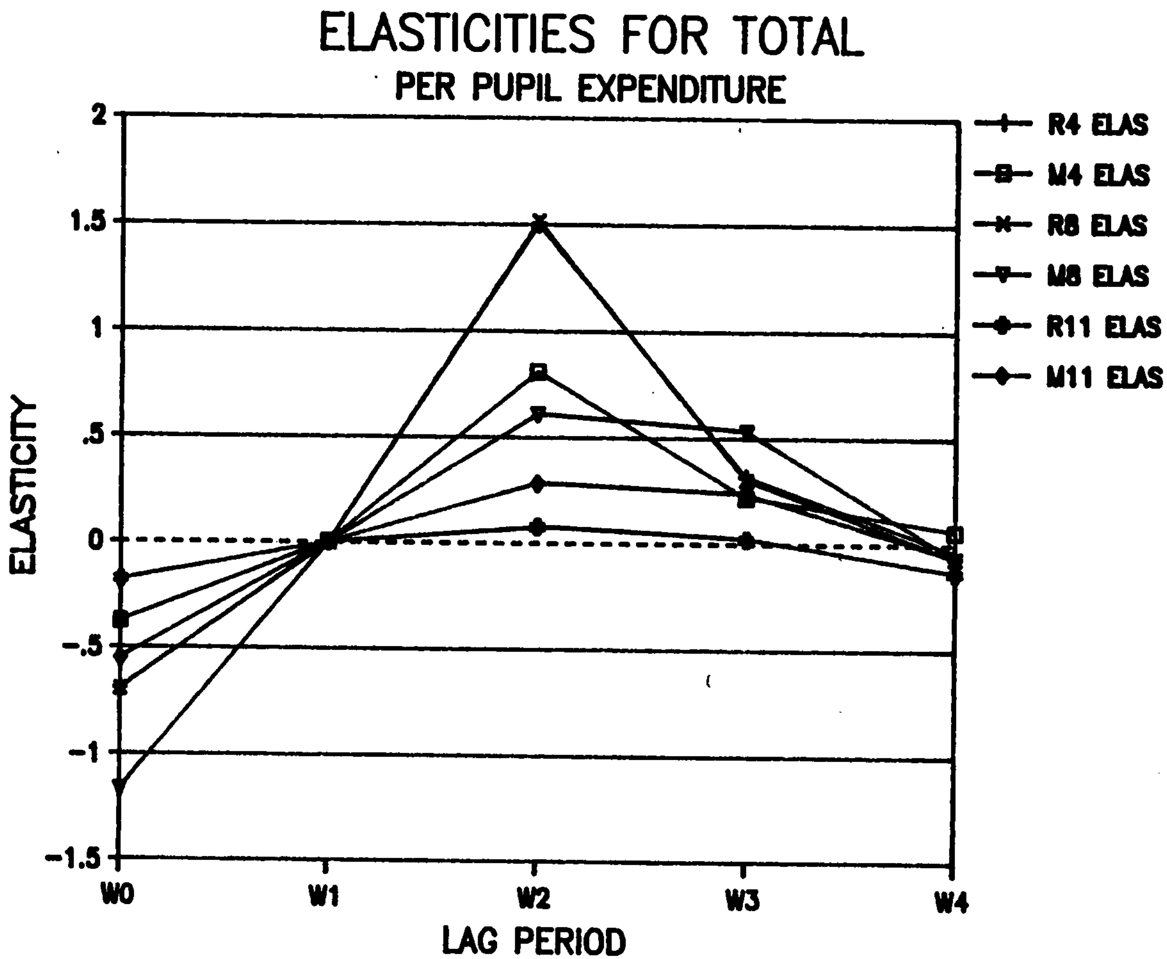

FIGURE 5. ELASTICITIES FOR EXPENDITURE LAGS

TABLE 16: ELASTICITIES FOR POLYNOMIAL LAG WEIGHTS IN QUALITY PRODUCTION MODELS

MODEL	W0	W1	W2	W3	W4
FOURTH GRADE READING	-.693816	.001600	1.502090	.316968	-.039244
FOURTH GRADE MATH	-.376451	.0050558	.808314	.21924	.059050
EIGHTH GRADE READING	-.696470	.000908	1.514628	.302577	-.067253
EIGHTH GRADE MATH	-1.16502	.001380	.609563	.531798	-.064286
ELEVENTH GRADE READING	-.180317	.002306	.078034	.021945	-.135498
ELEVENTH GRADE MATH	-.551551	.002040	.284036	.235122	-.064148

Table 17: EFFECTS OF A 10% CHANGE IN PER PUPIL EXPENDITURES. ON ACHIEVEMENT TEST SCORES OVER A FOUR YEAR PERIOD.

	FOURTH GRADE		EIGHTH GRADE		ELEVENTH GRADE	
	R*	M*	R	M	R	M
W1	.008	.027**	.004	.004	.011**	.011**
W2	7.647**	4.314**	7.529**	3.720**	.378	1.540**
W3	1.613**	1.170	1.502**	3.245**	.106	1.274**
W4	-.119	.315	-.334**	-.394**	.656	.-384
TOTAL***	9.269	4.341	8.697	6.571	.011	2.826

* R is reading achievement
M is math achievement

** Change associated with lag weight significant at .1 level

*** Total includes only changes that are associated with significant variables

The elasticities for the lagged expenditure variable clearly illustrates two points. First, a time lag of two years is needed before changes in total per pupil expenditure for education are positively associated with changes in education output as measured by standardized achievement test scores. Second, the greatest increases in the achievement test output scores associated with changes in expenditures occur at the earlier years of schooling. That is, the effects of changes in achievement test scores and lagged per pupil expenditures are greater at the fourth and eighth grade levels than at the eleventh grade level. Also, the results suggest that the changes between reading scores and the lagged per pupil expenditure variables are greater than the changes between the math achievement test scores and the per pupil expenditure variables.

The TPP83 variable was divided into the local and nonlocal portions based on the source of funds. The local and nonlocal measures, LPP83 and NLPP83, were specified in a polynomial lag structure to test the hypothesis that local and nonlocal funds have different influences on education outcomes. The results produced lag structures that were similar to those reported above for the total per pupil expenditure variable. However, the weights of the lags were not significant for most periods.

STUDENT AND PEER INPUT MEASURES

Conceptually, the time that students allocate to the education production process should have an impact on education output, as the students' time is a labor input into the production function. The variable selected to measure the students' time allocation to education was the measure of the students' average daily attendance. The variable provides a specific measure of the relative student time input to schools. However, the variable may be interrelated with socioeconomic factors that influence student education outcomes. The variable was hypothesized to be directly related to education output as measured by the achievement test scores.

The variable had the hypothesized positive sign in all six of the quality production models, but was only significant in the fourth grade math model. While the variable measures a portion of the students' time allocated to education, the measure is expected to be closely linked to the socioeconomic factors, and interrelated with the two household measures used in the study, GRADS80 and PCRACE. While there is strong theoretical justification for the inclusion of the student time in the model as a production input, the measure used is only one limited measure of the time input. It is concluded that the variable, ATTEND, is not effectively measuring the relationship between the student time input to school and education outputs as measured by the standardized achievement test scores.

VOLUNTEER INPUT MEASURES

The relationship of volunteer inputs to the education production process is conceptually the same as for any other inputs. The effectiveness of inputs is not a function of their source, but of their quality and quantity. Therefore, the inclusion of measures for volunteer inputs into the education production process improves the general specification of the model by explicitly recognizing an input sector that is theoretically justifiable. The difficulty with operationally specifiying a variable for volunteer inputs, however, is the limited understanding of the ways that volunteers contribute resources to the education production process, and the lack of systematic measures that document types of organizational and individual volunteer inputs into the education process.

Three measures were used in this research to attempt to capture the effect of volunteer inputs into the school system. Two of the measures, VOLMOR and HOMOR, were obtained from a survey of the use of volunteers in Virginia secondary schools. While the survey provided rich data on the use of volunteers in specific schools across the state, the survey was conducted at the school level. Aggregation of the school data to the school division level resulted in observations for only 30 school divisions because of the survey response pattern. The data were evaluated to attempt to identify any relationships between the volunteer measures and other input measures in the study or to the output measures. None, however, were identified. The variables, therefore, did not provide any useful insight into the effect of volunteer inputs on school outputs.

The third volunteer input measure used in this research was the ratio of parent-teacher organization members in a school division to the district's average daily membership. This measure was obtained from the Virginia Congress of Parents and Teachers membership data on local parent-teacher associations (PTA), and supplemented with data obtained through a telephone survey to school divisions that do not have a state-affiliated PTA. The variable was recognized to be a rough estimate of the relative strength of the parent-teacher organizations in the school districts, but was used on the assumption that the relative level of activities that a local PTA supports and is involved in for a school system is highly correlated with the number of PTA members in the school district. The variable was hypothesized to be directly related to the dependent variable.

The results of the PTOR variable, the parent-teacher organization membership in a school division divided by the average daily membership for the school district, provide no support for the hypothesis that volunteer inputs through parent-teacher organizations are positively associated with school output as measured by the standardized achievement test scores. The variable was not significant in any of the models and had a negative sign in three. The results could be an indication that the inputs of parents through organizations such as a PTA do not have an impact on education outcomes. More likely, the results indicate that the parent-teacher organization membership rate does not provide a good measure of the level of activities within the parent-teacher organization. It is also possible that the socioeconomic factors associated with the GRADS80 and PCRACE variables are related to factors that influence parent involvement in parent-teacher organizations. Whichever is the case, the PTOR variable does not provide support for the hypothesis that volunteer inputs through parent-teacher organizations have a positive impact on education outcomes.

CITY/COUNTY CODE MEASURES

The result of the dummy variables for the city/county code measures indicate that location is a factor in education output as measured by the standardized achievement test scores for the code 1 localities, the urban counties. R1, the dummy variable for urban counties, is significant in two models and has a t value greater than one in three models. The sign on the coefficients are positive indicating that school divisions in urban counties are associated with higher achievement than school divisions in urban cities, cities and counties of lesser urban influence, or rural counties. This result is consistent with the hypothesized relationship.

EDUCATION QUANTITY MEASURE

A measure for the quantity of education output was included in the models to test the hypothesis that education quality and education quantity were joint products. The theoretical model specifically recognizes the education production function as a multiple-output production process. The relationship between the theoretical concept of outputs and the measurement of specific outputs, however, presents conceptual difficulties. While several measures have been identified and used as education output measures in prior research, most studies have relied on standardized achievement test scores as a representative measure of school output. The school-quantity measure, HOLD, is included in these models as a measure of the quantity dimension of education production output. The measure represents the school's relative success at retaining students in school until they complete twelve years of schooling. The HOLD variable is assumed to be positively correlated with socialization outputs of the education production process.

The coefficients on the quantity output variable specified as an independent variable in the quality production equations do not provide consistent support for the hypothesis that education quantity and quality outputs are joint products. The quantity measure is significant and positive in the eighth grade reading model and positive with a t value greater than one in the fourth grade reading and eighth grade math models. The measure had insignificant coefficients in the other three models.

While these results suggest a weak relationship between production of the quantity and quality dimensions of education, interpretation of the results requires caution. The variation in levels of production efficiency in the school divisions included in the sample present a range of production efficiency levels. The reasons for the insignificant results of the quantity variable in the quality models are, therefore, difficult to identify.

SUMMARY OF THE EDUCATION QUALITY PRODUCTION ANALYSIS

The regression results for the six quality production models present some interesting findings, although the results do not provide support for each of the research hypotheses discussed in Chapter I. A summary of the significant variables and their signs for each model is presented in Table 18. First, the results provide strong support for the effectiveness of school expenditures on the production of education quality as measured by standardized achievement test scores. Increases in per pupil expenditures for education are associated with strong positive increases in the achievement test scores in the second and third years after the expenditures are made in five of the six quality models. This indicates that increases in per pupil expenditures will result in increased education output as measured by achievement test scores after a lag period of two years.

The results of regression analysis of the six models also indicate differences in relationships between the expenditure variable and the achievement test scores associated with the grade level of the achievement score. The results for the R4, R8, and M8 models, the fourth grade reading and eighth grade reading and math models, illustrate a larger positive association between the expenditure weights and the achievement test measures than occur at the eleventh grade level. A one percent

TABLE 18: QUALITY MODELS SUMMARY SIGNIFICANCE AND SIGN OF VARIABLES.

Variable	R4 MODEL	M4 MODEL	R8 MODEL	M8 MODEL	R11 MODEL	M11 MODEL
HOLD	*** +		** +			
PTR			*** -		*** -	***-
MSD				** +		
ATTEND		*** +				
PTOR						
GRADS80	* +	* +	* +	* +	* +	* +
PCRACE	* +	* +	* +	* +	* +	* +
S1	** -	* -	* -	* -		* -
S2	** +	* +	* +	* +		* +
S3	** -	* -	* -	* -		* -
R1	** +			*** +		
R2						
R3						

* Significant at the .01 level
** Significant at the .05 level
*** Significant at the .15 level
\+ Positive coefficient on variable
\- Negative coefficient on variable

change in per pupil expenditures is associated with a 1.5 percent change in the fourth and eighth grade reading achievement test scores after a two year lag as compared to a .07 percent change in eleventh grade reading scores. Likewise, the changes associated with fourth and eighth grade math achievement test scores are .8 and .6 percent respectively, compared to a .2 percent change for eleventh grade math skills. This suggests that there may be decreasing returns to investment in formal education as the pupils get older. The results also suggest that increased education expenditures are associated with greater increases for the reading achievement test scores than for the math test scores.

The lag variable results suggest that investment in students in the early years of schooling provide the greatest returns. Caution is needed in interpretation of the results because the input measures used in the empirical estimation are school division averages. That is, the measures are based on the per student average input rather than an actual measure of the per student inputs or the average level of inputs for a specific grade-level.

The evidence to support the hypothesis that teacher quality and quantity are factors of production in the education process is not strong for all grade levels, but does indicate that teacher quality and quantity are positively associated with education output as measured by the standardized achievement test scores as the student advances in the education production process. The MSD variable, a measure of teacher quality, is significant in the eighth grade math model and has a t value greater than one in the eleventh grade math model. The variable also has the hypothesized positive sign in each model. The variable is insignificant in the fourth grade math model and in the three reading-models. These results support the hypothesis that teacher quality is important in the production of eighth grade math. The eighth grade math model result combined with a t value greater than one for the MSD variable in the eleventh grade math models, suggest that teacher quality is more important in the later years of schooling and in the production of math skills, rather than reading skills.

The evidence for the importance of teacher quantity is stronger than for teacher quality. The teacher quantity variable is significant at the .15 level with the hypothesized negative sign in the eighth grade reading model and the eleventh grade reading and math models. While the significance level of the coefficient is weak, the results suggest a decrease in the pupil/teacher ratio, within the 11.8 to 18.1 range of the ratios for Virginia schools, is an important factor in the education production process at the eighth and eleventh grades. Shifts in the pupil/teacher ratio for the fourth grade level, however, are not associated with changes in education output. These results can be interpreted as an indication that the quantity of teacher input becomes more important as the students advance in the education production process.

In summary, the regression results indicate that the school inputs are related to education quality output as measured by the standardized achievement test scores. The expenditure measures indicate a higher relative return from education investment at the fourth and eighth grade levels than the twelveth grade level. The MDS and PTR variables are significantly associated with the eighth and eleventh grade achievement test scores. Again, the teacher quality and quantity measures are school division averages rather than averages for a specific school or grade.

The household input variables, which are closely associated with the socioeconomic status of a school district's population, clearly indicate the importance of household inputs in the education production process. The resource allocations of the household, the attitudes, preferences and other factors represented by the education level and the racial composition of the community have strong implications for the education production process. Decisions regarding the education production process must take into account the effects of household allocations and local attitudes, tastes and preferences on education. The measures used for household inputs, however, suffer from the same weakness as the use of such variables in earlier studies. That is, they do not provide insight into specific resource allocations of time or of purchased goods that are positively associated with changes in school output as measured by the achievement test scores. The results also fail to clarify why different levels of achievement are associated with the white community than the non-white community.

The statistical results for the volunteer input measure do not support the hypothesis that volunteer inputs have a positive impact on education. This is assumed to be a measurement problem rather than an actual reflection of the ineffectiveness of volunteer inputs in the education production process.

The significance of the dummy variable for the city/county code 1, the urban counties, indicates that factors associated with these localities are positively associated with education output. For instance, the urban location provides easier access to activities and resources that stimulate or motivate students to increase their production of education output as measured by standardized achievement test scores. The coefficients on the other dummy variables were insignificant.

The results of the quantity variable in the quality models does not indicate a strong relationship between standardized achievement test scores and the school continuation rate (HOLD). While there is some association between fourth and eighth grade reading scores and the HOLD variable, the general results of the models do not indicate a strong relationship between achievement scores and school continuation.

In summary, the influence of household inputs and socioeconomic factors of the community are important to the education production process. School inputs also make a significant contribution to education production as measured by the standardized achievement test scores. The variables specified as measures of the volunteer inputs do not support the hypothesized relationship between volunteers and output. The student- and peer-input measure, ATTEND, provides weak support for the hypothesis that student and peer inputs are positively associated with education output. Presumably, this is because the operational measures chosen for the conceptual variables do not provide a good measure of the inputs that they are intended to represent.

Comparison of the results of the quality models provides useful insight into the appropriateness of a standardized achievement test score as a representative measure for education quality output. While the high pairwise correlation between the achievement test score measures and the intuitively close relationship between each of the cognitive skills measured by the SRA scores would suggest that any of the scores would provide a good representative measure for education output, the results of the six models indicate that different policy directions may be implied depending on the dependent variable selected as the education output measure. The use of a fourth grade model would indicate the importance of the expenditure variables, but not of the teacher input measures. On the other hand, specifying the eleventh grade reading score as the dependent variable to be a representative measure of education quality output would provide results that would not show the significance of the expenditure measure associated with the fourth and eighth grade models, but would indicate that the PTR was an important factor. Caution regarding the interpretation and generalization of the education production models is clearly necessary.

EDUCATION QUANTITY MODELS

Output measures for the quantity dimension of education, often considered as a representative measure for education socialization output, are generally related to the time of schooling that a student completes. The quantity dimension of education is most often specified as years of schooling that a pupil has completed. Prior economic research has commonly associated years of schooling with the measure of total education output assuming no variation in the value of, or quality of, a year of schooling in one school versus another. Edwards and Barichello, for example, both use a years of schooling variable as the measure of school output in demand for education studies. Edwards does not use a variable to control for education quality. Barichello used the percentage of teachers with a college degree, a production-input measure, as an independent variable to control for quality variation. Estimation of returns to education have frequently used years of schooling as the measure against which expenditures are evaluated, for example see Wiess, Link and Ratledge. Ben-Porath used years of schooling as a measure of human capital in a model for optimal human capital accumulation.

While years of schooling might be a convenient variable for measuring the quantity of schooling that a student has completed, the measure poses some conceptual questions when applied as a representative measure for education output. Production studies that have used the variable as an output measure (Burkhead, Katzman) have indicated that the variable is a representative measure for the socialization output of the school. Clearly, there is a link between the student's ability to conform to the school system and the development of socialization skills that schools are charged with producing. Research (Gintis, Bowles and Gintis) has indicated that this socialization process is a valuable contribution of education to the future earnings of the student. The difficulty with the use of a years of schooling measure as an education quantity output measure, however, is the identification of theoretical linkages between years-of-schooling and specific education socialization skill outputs. Specification of variables as input measures that are conceptually linked to the production of education quantity as measured by the school continuation rate, HOLD, also is difficult. Household tastes and preferences and the socioeconomic character of the community seem the logical factors in determining student decisions regarding years of schooling. Socioeconomic variables, however, do not identify explicit factors that can be manipulated to influence local education production, if there are any that actually can influence education production.

The education quantity measure in this research, one minus the school dropout rate, is a representative measure of the amount of schooling that is produced in one school division compared to the amount produced in another. The output measure is assumed to be positively correlated with the socialization outputs, i.e. citizenship, motivation, productivity, attitude.

The education quantity models are included in the study for two primary reasons. First, they are included to allow tests for hypotheses about the relationship of school, household and volunteer inputs to education quantity production. Second, the models allows for the examination of the hypothesis about the jointness of production between education quantity and quality.

The results of the estimation of the education quantity production models are presented and discussed in this section. The regression results are then analyzed and interpreted in relationship to the research hypotheses discussed in Chapter I.

GENERAL DISCUSSION

The education quantity models were specified with the same independent variables for school, household, student and peer, and volunteer input measures as were the quality models discussed in the preceeding section. Six quantity models were estimated. Each model included a different standardized achievement test score specified as an independent variable to represent education quality output. The variables used as education quality measures were the fourth, eighth and eleventh grade achievement test scores that were specified as dependent variables in the education quality models. These variables were included to examine the relationship between the quality output measures and quantity output as measured by the education continuation measure, HOLD. The high pairwise correlation coefficients among the achievement test scores prevented entering all of the variables in a single equation.

The per pupil expenditure measure, TPP83, LPP83, and NLPP83, were specified as a polynomial lagged variable in the initial estimations of the quantity equations. The results for second order and third order polynomial lag structures were insignificant. The model, therefore, was specified with the current year values of the local and nonlocal per pupil expenditure, LPP83 and NLPP83, as independent variables.

Statistical tests were conducted to examine the data for multicollinearity. The variance inflation factors, condition indices and variance decomposition factor showed no indication of multicollinearity.

EDUCATION QUANTITY PRODUCTION MODELS

The regression results for the estimation of the education quantity production models are presented in Table 19. The models, each estimated with a different quality measure as independent variables, also include independent variables for: teacher quality, MSD; for teacher quantity, PTR; for local school expenditures, LPP83; for nonlocal school expenditures, NLPP83; for student- and peer-time inputs, ATTEND; for parents' time in support of the school system, PTOR; for the household's level of human capital, GRADS80; for the effect of cultural differences, PCRACE; and three dummy variables for the city/county codes, R1, R2, and R3.

The regression results for estimation of the quantity model indicate statistically significant relationships between several of the variables used as education inputs and education quantity output as measured by the HOLD variable. Two variables, PTR and ATTEND, are significant at the .01 level in all six of the quantity models. ATTEND has the hypothesized positive sign in each model. The PTR variable, however, has a positive sign in each model contrary to hypothesis. The R3 variable is significant at the .05 level of confidence in each of the six models. The sign on the variable was positive, contrary to expectation.

Two other variables, GRADS80 and PCRACE, are significant in five of the six models. They are not significant in the quantity model that has the eighth grade reading achievement test score specified as an independent variable. The GRADS80 variable has the hypothesized positive sign in each of the models and the PCRACE variable has the hypothesized negative sign in each model.

The three other school input variables, LPP83, NLPP83 and MSD, were not statistically significant in any of the models. PTOR, the parent-teacher organization participation rate measure, also was not significant in any of the models. The remaining two variables, R1 and R2, the dummy variables for urban counties and cities and counties of lesser urban influence, were not statistically significant. Both variables had positive signs.

Two of the standardized achievement test score variables used as quality measures in the quantity models, R4 and R8, are significant at the .15 and .05 levels respectively. The variables both had positive signs. The test score measures used as quality measures in the other models, M4, M8, R11, and M11, were not statistically significant.

TABLE 19: OLS REGRESSION RESULTS FOR QUANTITY MODEL.

Variable	QUANTITY MODEL					
R4	.05222*** (1.753)					
M4		-.04384 (-2.259)				
R4			.07519** (2.262)			
M4				-.03899 (-1.210)		
R11					-.035487 (-.810)	
M11						-.0007237 (-.014)
CONSTANT	6.4792 (.470)	2.4961 (.180)	6.0923 (.449)	4.5980 (.329)	3.3686 (.263)	3.5931 (.260)
GRADS80	.0273*** (1.604)	.0425** (2.579)	.0181 (1.006)	.0347** (1.955)	.0380** (2.114)	.0403** (2.316)
PCRACE	-.0131*** (-1.574)	-.0174** (2.193)	-.0081 (-.967)	-.0164** (-2.019)	-.0169*** (-1.789)	-.01778** (-2.109)
MSD	.00019 (.101)	.00503 (.264)	.00099 (.053)	.00198 (.097)	.00366 (.192)	.00445 (.231)
PTR	.4181* (3.484)	.4369* (3.543)	.4222* (3.556)	.4165* (3.423)	.4215* (3.447)	.4187* (3.440)
ATTEND	.8178* (5.728)	.8832* (6.206)	.8193* (5.876)	.8534* (5.937)	.8662* (6.152)	.8706* (6.137)
*PTOR	-.0384 (-.042)	-.2605 (-.206)	-.2194 (-.245)	-.1656 (-.181)	-.1768 (-.193)	-.1652 (-.316)
LPP83	.0002 (.673)	.0004 (.521)	.0003 (.844)	.0002 (.542)	.0019 (.492)	.0017 (.539)
NLPP83	.0011 (1.202)	.0004 (.450)	.0011 (1.224)	.0007 (.718)	.0006 (.613)	.0005 (.539)
R1	.3981 (.700)	.6016 (1.064)	.4038 (.724)	.5727 (1.014)	.5632 (.995)	.5727 (1.014)

R2	**.6041**	**.6462**	**.5424**	**.6321**	**.6375**	**.6321**
	(1.132)	**(1.200)**	**(1.024)**	**(1.171)**	**(1.182)**	**(1.171)**
R3	**1.2650****	**1.3123****	**1.2682****	**1.3123****	**1.3273****	**1.3123****
	(2.194)	**(2.260)**	**(2.225)**	**(2.245)**	**(2.276)**	**(2.245)**
R Square	**.4353**	**.4253**	**.4471**	**.4227**	**.4225**	**.4227**

*** Significant at the .01 level**
**** Significant at the .05 level**
***** Significant at the .15 level**

GENERAL INTERPRETATION OF THE QUANTITY MODEL

While the models for education quantity exhibit some strong positive associations between the dependent and independent variables, the relationships do not clearly link education inputs to education quantity production as measured by HOLD, the school continuation rate. First, the models do not support the hypothesis that school input variables that have a positive impact on school quantity production can be identified. Secònd, the model presents weak results in support of the hypothesis of joint production of the quality and quantity dimensions of education. Third, the estimation of the quantity models provides no support for the hypothesis that there is a lagged relationship between school inputs to education and education output as measured by HOLD.

The results for the six equations are quite similar. The model with the eighth grade reading score specified as an independent variable is the only model that does not have the same five significant variables as the other models. Because the estimated quantity models are quite similar, their results will be discussed in general terms with differences in models pointed out.

SCHOOL INPUT MEASURES

The education quantity models do not provide support for the hypothesis that school inputs that have a positive impact on the production of education quantity can be identified. Only one of the school input measures, PTR, is significant. As discussed earlier, the variable provides a measure of the quantity of the teacher input into the education production process and has strong theoretical justification for inclusion in the model. It is hypothesized that decreasing the pupil/teather ratio will have a positive relationship to education output. This would be indicated by a negative sign. The variable, however, has a positive sign contrary to the hypothesized relationship. The estimated relationship therefore indicates that increases in the pupil/teacher ratio within the 11.8 to 18.1 range for Virginia school divisions (i.e., decreases in the teacher quantity) are associated with increases in the holding power of the school division as measured by HOLD, the student retention rate. In other words, this suggests that reducing the number of teachers in the school system either will increase the HOLD rate or improve the school divisions success at holding students. This contradicts the hypothesized positive relationship between the quantity of teachers as a school input and education output. A clearer theoretical understanding of education quantity production and the relationship of school input factors to education production is necessary, therefore, to improve specification of school and teacher input measures and to explain the relationship between the inputs and education quantity production.

The percent of teachers with a professional teacher's certificate, MSD, is included in the model as a measure of teacher quality. This variable is theoretically well grounded as a factor of production, and the MSD measure provides a conceptually strong measure for teacher quality. The fact that MSD is not significant in any of the models could be interpreted to mean that either the MSD variable is not a good measure for teacher quality or that teacher quality is not related to the production of education quantity as measured by HOLD. Another possible explanation is that MSD, while a good measure of teacher quality attributes associated with human capital investments through education, does not effectively measure the teacher quality factors that are associated with keeping students in school. Again, a better understanding of the technical relationships between inputs and education quantity output would aid in the specification of variables for the empirical models. It also would aid the interpretation of the results. Economic theory provides strong conceptual support for the inclusion of PTR and MSD as teacher input measures. The direct relationship of PTR to HOLD and the insignificance of MSD raise questions related to the appropriateness of these variables as input measures and the value of school inputs in the production of education quantity.

The two other school input variables in the model, LPP83 and NLPP83, are not statistically significant. Both, however, have the hypothesized positive sign. These measures were included in the model for the school material input measure. The measure is the per pupil dollar value of school inputs for school operations and represents the value of the school inputs into education production. The insignificance of the coefficients on the school expenditure input variables do not support the hypothesis that school expenditures influence a school's holding power as measured by the quantity measure, HOLD. The initial models estimated with the lagged expenditure variables did not indicate that expenditures had a lagged association with the school division retention rate. The results suggest that school expenditures do not influence education quantity production. Measurement of school output and school inputs, however, is difficult as there is limited guidance from the education literature for identifying or measuring either.

In summary, the results of the estimation of the six quantity regression models do not provide support for the hypothesis that school inputs as measured by per pupil expenditures, the percent of teachers with professional teacher certification, and the pupil/teacher ratio are effective inputs in education production. On the contrary, the results of the PTR variable suggest that one school resource actually has a negative impact on education quantity production as measured by HOLD. A limited understanding of the factors that are involved in the production of education quantity and uncertainty as to the effectiveness of the selected variables for school inputs measuring these factors make interpretation of the results difficult. Clearly, however, these results do not support any hypothesis that school inputs influence education quantity production.

HOUSEHOLD INPUT MEASURES

The results of the signs and coefficients on the household input variables show a strong relationship between GRADS80, the percent of the adult population that holds a high school diploma, and the production of education quantity as measured by one minus the dropout rate. GRADS80 is included in the model as a measure of the community's human capital for an aggregate measure of the value of parental time spent in educational activities. As discussed earlier, parental education measures have been positively associated with education attainment in earlier research (Liebowitz, Murnane, Maynard and Ohls). The GRADS80 measure also provides a measure of the level of human capital the community has to transfer to youth. The GRADS80 variable is significant in five of the six models and has the hypothesized positive sign in all six models. The significance of the variable in the quantity models supports the hypothesis that household factors are important inputs into the education production process. While the GRADS80 variable was included as a measure for the value of the household input as an education input, as a socioeconomic measure the variable reflects a broader range of factors that relate to the tastes, preferences, and attitudes toward education that are reflected in the schooling decisions of the students in the community. These factors are critical in student decisions to continue schooling, a decision which may be made independent of the school itself, but has a major impact on school quantity production.

The other household variable used in the study, PCRACE, is the percent of the population that is nonwhite. This variable also demonstrated a strong association with the quantity measure, HOLD. The variable was included in the model to examine the effect that racial differences have on the communities' levels of education output or to test for differences between the two communities' contribution to education production. It was hypothesized that the PCRACE variable would have a negative association with education quantity production because of the historic denial of access to the nonwhite community throughout Virginia. It is recognized, as mentioned above, that the PCRACE variable may be reflecting any number of cultural factors that relate to education production or schooling decisions. The significance of the variable supports the hypothesis that factors related to differences between the white and nonwhite comunitities result in differences in the production of education quantity in a school district.

The two household variables, GRADS80 and PCRACE, indicate the importance of household factors in determining the quantity of education produced in a school district. The HOLD measure is affected by household decisions to allocate resources to the education process as well as the household tastes and preferences regarding children's participation in the education system.

STUDENT AND PEER INPUT MEASURE

The student- and peer-time input variable, ATTEND, is statistically significant with the hypothesized positive sign. ATTEND is the average daily attendance rate for the school district. The variable was included in the model as a measure of the student and peer input into the education process. The results indicate that the school attendance rate is strongly associated with the schools' production of education quantity. This supports the hypothesis that student inputs into the production process that have a positive influence on education outputs can be identified. However, it should be recognized that the ATTEND measure might be interrelated with socioeconomic factors that influence school-attendance rates. Clearly, the variable is associated with student attitude and motivation that are also student inputs into the education process.

School attendance has a strong positive association with HOLD. It also provides a measure that parents, teachers and school administrators can monitor as an indicator for quantity production. School and household actions to increase school attendance could provide an effective strategy for increasing school quantity output.

VOLUNTEER INPUT MEASURE

The parent-teacher organization participation rate, PTOR, was not statistically significant. The result, therefore, did not support the hypothesis that parents' participation in organizations that promote the school and provide volunteer labor resources and purchased goods for the school have a positive impact on education output as measured by one minus the dropout rate. The results of the PTOR variable in the models could be due to the variable not providing a good measure of the level of activity that the parent-teacher organizations are involved in. It also is possible tha parents' decisions to be involved in PTOR activities are closely associated with socioeconomic factors that the GRADS80 variable is measuring. The lack of a systematic evaluation of the extent of volunteer time or purchased goods input into the school system and lack of data on the amount of nonschool resources used by the school system hindered the specification of a measure for the volunteer contribution. The weak measure for volunteer inputs does not provide insight into the relationship between volunteer inputs as production inputs and education output.

QUALITY OUTPUT MEASURES

The sign and significance of the standardized achievement test scores used as independent variables in the quantity production model present conflicting results. Two of the variables are significant, R4 and R8. These are the fourth grade reading score and the eighth grade reading score. R4 is significant at the .15 level and BR at the .05 level. Both measures have positive signs, indicating a direct relationship to the education quantity measure. These results suggest that an emphasis on reading production in the early years of schooling has implications for the schools' current student retention rate. As the students advance in school, however, the association between the achievement test scores, the quality output measures, and the school's ability to retain students in the school system diminishes.

LOCATION MEASURES

The R3 variable, the dummy variable for the most rural counties, is significant and has a positive sign. This indicates that rural residence is associated with a greater high school holding rate than the other classifications. There are a few possible interpretations for the significance of the dummy variable for the most rural counties. Rural communities might be associated with a more traditional value system that puts a stronger emphasis on staying in school. The significance of the R3 measure also could be associated with an emphasis on completing a greater quantity of education because of the need for human capital to enhance opportunity to migrate out of the rural area to seek employment.

SUMMARY OF EDUCATION QUANTITY PRODUCTION MODELS

The empirical results of the education quantity models indicate strong relationships between HOLD, one minus the dropout rate, and some of the variables specified as independent variables. The results, however, do not provide support for each of the hypotheses presented in Chapter I.

The estimated relationships between the school input measures, MSD, LPP83 and NLPP83, do not show the variables to be related to quantity output production as measured by HOLD, one minus the dropout rate. Further, the PTR variable indicates a strong inverse relationship between the pupil/teacher ratio and HOLD.

The household variables, GRADS80 and PCRACE, indicate a strong relationship between the percent of the adult population that has completed high school (positive), the percent of the population that is nonwhite (negative) and the number of students who stay in school. While the household variables do not identify specific household allocations or actions that affect education production, the results of the variables in the regression models indicate the importance of household factors in the education production process.

COMPARISON OF QUANTITY AND QUALITY MODELS

The estimation results of the education quantity and quality models discussed above indicate significant differences in the importance of various inputs in the production of education quantity and quality. The results also indicate a weak relationship between the production of quality and quantity as measured by standardized achievement test scores and one minus the dropout rate.

HOUSEHOLD INPUT MEASURES

The results of the household input variables in both of the models indicate that production of both the quantity and quality dimensions of education are strongly associated with household factors. The two variables used as household input measures in this research, GRADS80 and PCRACE, represent the percent of adults in the population with a high school diploma and the percent of the population that is nonwhite. The measures were included in the study as variables for the parents' level of education and the racial balance of the community. Both variables are signifcant with the hypothesized signs in quantity and quality equations. The interpretation of the results requires caution, however, because the household input measures are associated with a range of socioeconomic factors in the community that may be related to the allocation of household resources to the production of both quantity and quality of education.

The empirical results from both the quantity and quality models clearly support the hypothesis that household factors are important inputs into the production of education quantity and quality. Education policy makers clearly must recognize the importance of households in the education production process. Resesarch is needed to identify the specific household factors that influence education output so that decision makers can consider them in decisions related to the education system.

SCHOOL INPUT MEASURES

The results of the quality and quantity regression models present contrasting results regarding the relationship of school inputs to education and education output. The three variables used as school input measures in the quality models, MSD, PTR, and TPP83, each demonstrated the hypothesized relationship with education output in one or more of the education quality production models. The results provide support for the hypothesis that school inputs that influence education outcomes could be identified. The significance of the polynomial lagged expenditure measure in five of the six models provides strong evidence that school inputs make a difference in the production of education output as measured by standardized achievement test scores.

The results of the four school measures, MSD, PTR, LPP83 and NLPP83, in the quantity models, on the other hand, do not provide support for the hypothesis that school inputs are important factors in the production of education quantity output. As mentioned above, the lack of technical knowledge of the relationship between inputs and ouptuts in education quantity production present difficulties in the specification of an empirical model to estimate the relationship between school, household and student inputs and education quantity outputs. So, while it appears that the teacher quantity and quality variables and the per-pupil-expenditure variable are not positively related to the school retention rate, other teacher and school input factors could well be effective determinants of education quantity production. The results show a strong association between ATTEND and HOLD, while the ATTEND variable was only significant in one of the quality models. This indicates that student-time input and factors associated with school attendance are important factors in determining the level of education quantity production.

JOINT PRODUCTION MEASURES

The results of the quantity variables specified as independent variables in the quality models do not indicate a strong relationship between the quantity and quality measures in the production process. There appears to be some relationship between the quantity measure and the quality measure at the eighth grade level. Generally, the models do not demonstrate a relationship between the standardized achievement test scores and HOLD, the school continuation rate.

The quantity and quality models were estimated simultaneously in pairs to examine further the issue of joint production. The three stage least squares procedure (3SLS) was used. The results of the 3SLS estimation did not support the joint production hypothesis. The output measures, achievement and school continuation, were not statistically significant with the exception of the eighth grade math score which in the quantity model.

A review of the variables that were significant in either a quality or a quantity model is presented in Table 20. In general, most of the variables that were significant in one of the quality models were significant in one of the quantity models. The per-pupil-expenditure measure and the percent of teachers with professional teacher certification are the two exceptions. These measures were significant in the quality models but not in the quantity models Also, the PTR variable, pupil/teacter ratio, is significant in both models, but has the hypothesized negative sign in the quality models and a positive sign in the quantity models (i.e., not as hypothesized).

TABLE 20: QUALITY AND QUANTITY MODEL SUMMARY
SIGNIFICANCE AND SIGNS OF VARIABLES

Variable	QUALITY MODELS	QUANTITY MODELS
HOLD	* +	
SRA		* +
PTR	* -	* +
MSD	* +	
ATTEND	* +	* +
PTOR		
GRADS80	* +	* +
PCRACE	* -	* -
S1	* +	
S2	* +	
S3	* +	
LPP83		
NLPP83		
R1	* +	
R2		
R3		* +

* Variable significant in one or more model
+ Variable had a positive sign
- Variable had a negative sign

COMPARISON OF QUALITY MODELS TO EARLIER STUDIES

The results of the six quality models are similar to the results of earlier studies in that the models show some relationship between the variables specified as input measures and the standardized achievement test scores used as output measures. The results of this study, however, offer insight into several issues that the earlier studies did not address or in which conflicting results were found.

Three studies found weak associations between school output as measured by standardized achievement test scores and variables used as measures of school inputs. The Coleman study concluded that schools had little impact on cognitive learning after socioeconomic factors for the pupils were taken into account. Kiesling's study also found socioeconomic factors to be the main determinants of education outputs as measured by school achievement test scores. Burkhead's study of urban and rural school divisions indicated that the school input variables were not asssociated with achievement test scores in the urban schools and only weakly associated with the scores in the rural schools.

While the current study found two socioeconomic measures to be strongly associated with school output as measured by standardized reading and math test scores at the fourth, eighth and eleventh grades, the results also indicate that school input measures are strongly associated with the achievement test scores. The lag weights of the per pupil expenditure measure were strongly associated with the output measure in five of the six models. The teacher quantity and quality measures also were associated with the achievement test scores.

The results of this study also seem to clarify the relationship between per pupil expenditures and the output measure. Katzman found no significant relationship between school expenditure measures and school output as measured by achievement test scores. Kiesling's study found weak and sometimes negative associations between expenditures and output as measured by achievement. Perl found per-pupil-expenditures to be postively associated with achievement test scores.

The conflicting and inconsistent results of past research (Katzman, Kiesley, Perl) on the relationship betweeen expenditures and education output as measured by standardized achievement test scores confused the issue of the general inpact of public spending on education. Specifying the expenditure measure as a lagged variable as in this research helps sort out the relationship between expenditures and education output. The results of the quality models in this research clearly indicate that increases in per pupil expenditures for education are positively associated with increases in standardized achievement test scores. A two-year lag occurs, however, before the changes in expenditures are associated with changes in the education output measures.

In summary, while earlier studies that used a standardized achievement test score as a measure for education output found some school inputs to be associated with the scores, this research found per pupil expenditures to be strongly associated with achievement test scores in five of the six quality models. PTR and MSD, the other school input measures specified in the quality models, were also significant in some of the quality models. Household input measures, GRADS80 and PCRACE, were also significant in the quality models, as were similar variables when used in earlier studies.

COMPARISON OF QUANTITY MODEL RESULTS WITH EARLIER STUDIES

Earlier education production function studies have focused on the relationship between achievement test scores and school inputs. Two studies, however, included empirical models that examined the relationship between school inputs and the school's holding power. These studies (Burkhead, Katzman) both used a measure related to the dropout rate to represent the school's holding power.

Burkhead's study used the dropout rate as a dependent variable for school holding power. The empirical results indicated that per capita income, per pupil expenditures for materials and supplies, and school building age were all inversely related to the dropout rate.

The other study (Katzman) used one minus the dropout rate as the dependent variable for school holding power. Average daily pupil membership (the annual average of the percent of enrolled students in attendance) and the percent of the work force that held white collar jobs, were significant and directly related to the dependent variable in the regression model. The pupil/teacher ratio was significant and inversely related to the dependent variable, indicating the hypothesized relationship between one minus the dropout rate and teacher quantity.

So, unlike the current study, the empirical results from the two earlier models indicate that school inputs are associated with school quantity production as measured by one minus the dropout rate. Burkhead found school building age and per pupil expenditures for materials and supplies to be positively associated with education quantity while measures for teacher quantity and quality were not significant. Katzman, on the other hand, found pupil/teacher ratio and average daily membership to be significant with measures for specific school inputs and expenditures insignificant.

Three of the school input measures in this study were not significant. The other, PRT, was significant, but had a sign the opposite of the hypothesized relationship. The model included socioeconomic variables, GRADS80 and PCRACE, which were both significant with the hypothesized sign. Another variable, ATTEND, the average daily attendance rate, was also significant and directly related to HOLD.

In summary, the results of the education quantity models provides no support for the hypothesis that school inputs influence quantity production, as the earlier models suggest. The other studies used other input measures (number of books per pupil, school building age) that were significant. The quantity models in this study do, however, suggest that household and student input factors as measured by GRADS80, PCRACE and ATTEND, are important determinants of education quantity production. Earlier reseach did not use these measures in the quantity models.

CHAPTER V

SUMMARY AND CONCLUSIONS

INTRODUCTION

The theoretical model for education production developed in this dissertation addresses several conceptual issues concerning the education production process that have not been addressed in prior studies. First, the model incorporates both community and household resource allocations into the education production model. The median voter model is utilized as the decision model which provides an appropriate theoretical basis for determining the level of education services that will be provided as a public service. Household production theory presents the theoretical basis for the allocation of household resources to the education production process. The education production models also include a volunteer-input sector to explicitly recognize the input contribution of nonschool resources allocated by parents and other members of the community to the education system.

Second, the conceptual model presented in Chapter II recognizes the multiproduct nature of education production. The model incorporates production functions for both the quality and the quantity dimensions of education output and explicitly recognizes the possibility of joint production of education outputs.

Third, the empirical model is specified with input measures chosen because of their appropriateness as measures for education production inputs, a characteristic that Hanushek suggests is missing in the variable selection process of prior education production research. In other words, variables specified in the empirical models discussed above were chosen to represented variables that are based on a theoretical model of education production. Also, the model incorporates a polynomial lag structure for the total per pupil expenditure variable to examine the relationship between school inputs and education output as measured by standardized achievement test scores and one minus the dropout rate. Some prior research used a current output measure for education achievement with current year's expenditures as input measures. The empirical model in this study included the lagged expenditure measure to test the hypothesis that a lag period is required before the output changes associated with, and most likely caused by, changes in the input can be effectively realized.

The empirical model developed in this research included education production inputs from the school, household, student and peer, and volunteer sectors. The input measures for several variables were only available at the school district level (school expenditures, pupil/teacher ratio, teacher educational level, population's education level). The study interest in the impact of public inputs, as well as household, student and volunteer inputs, also required a focus on aggregate input and output measures because of the public interest in average rather than individual output. The results, however, do not relate inputs to specific schools, classes, or students. The conclusions, therefore, provide more insight for general education policy, rather than for individual, grade level or school level issues.

SUMMARY OF RESULTS

The results from estimation of the quality and quantity models discussed above provide several findings that have important implications for education policy both for public policy makers and for household decision makers. The results indicate the association of specific variables with achievement test scores and the school retention rate. While the model does not show causality, the relationships identified in the research are interpreted as suggesting causality for policy implications. The results are:

1. Expenditures on education have an impact on education quality outcomes, or cognitive learning skills. The results indicate that increases in spending on education are associated with a lagged positive impact on education production. For example, over a four-year period a 10 percent increase in per pupil expenditures, an average amount of $260 per student, is associated with an achievement test score increases ranging from 9.269 points for fourth grade reading achievement to a 2.826 point increase for eleventh grade math achievement. The elasticities presented in Chapter IV provide measures that school administrators and community members can use to consider the effects of marginal changes in per pupil expenditures for education on standardized achievement test score results. Additional research using school-specific increases is needed to corroborate these findings and provide decisionmakers with more insight into the relationship. Decisions to increase or decrease education funding, therefore, can be made with some understanding of the implications that the funding changes will have on education outcomes. For instance, school administrators can expect a one percent funding cut to result in a .808% decline in fourth grade reading scores after a two year period.

2. Increases in per pupil expenditures for education are associated with a greater impact for pupils in the fourth and eighth grades than for students in the eleventh grade. The increases in fourth and eighth grade test scores associated with a ten percent increase in per pupil expenditures range from 4.341 to 9.269 points over a four year period. The changes in eleventh grade scores

are .011 and 2.826 for reading and math respectively. It appears that increased spending for education has the greatest impact on younger students.

3. Teacher quality and quantity are important factors in the production of cognitive skills. The results of the quality production models indicate that the educational level of the teaching staff and the number of teachers per pupil are positively associated with education achievement at the eighth and eleventh grades. Changes in either variable within the range of the variables for Virginia school districts, however, do not have a significant impact on achievement test results of fourth grade students. These results suggest that efforts to improve the education achievement of students in the upper grades of school should consider using funds to increase the formal education level of the teaching staff as well as hiring more teachers to reduce the pupil/teacher ratio. Surprisingly, changes in the quantity or quality of teachers at the fourth grade level is not associated with changes in either achievement test scores or student retention over the range of teacher resources observed in the study.

4. The results of this study suggest that increasing achievement test scores by increasing the level of school inputs requires a time lag. The empirical results of the polynomial lag for the per pupil expenditure variable clearly indicate that a lag period is needed before the impacts of the increased spending are realized through increased output. Decisions to improve the education system through hiring better educated teachers and a greater number of teachers also requires time to have an impact. Improving the quality of the teaching staff would require that either existing staff receive further training or new staff who have completed more years of education be hired. In either case a period of a minimum of a few years is likely to be required before the education attainment level of the teaching staff can be significantly increased.

5. Household factors clearly are important in the production of both the quality and quantity dimensions of education. Both sets of empirical models indicate a direct association between education output and the household input variables. Adult education level is positively associated with both achievement test scores and the student retention rate. The percent of

nonwhite population is negatively associated with both school output measures. These results indicate the importance of socioeconomic factors in the education production process. Additional research is needed to determine which factors associated with an educated population and a lower nonwhite population are associated with achievement test scores, student retention rates or other school outcomes.

6. The school input measures used in the empirical model are not associated with changes in the school retention rate. This research, therefore, does not support policies to increase school retention through increasing formal teacher training, decreasing the pupil/teacher ratio or increasing per pupil expenditures over the range of inputs observed in this study. School policies to change household behavior in order to involve households in the education of their children could be emphasized as a means of increasing education quantity production. Further research to identify school input factors that influence school retention rates is needed and would assist school administrators in the design of policies to improve pupil retention.

7. Pupil attendance is positively associated with education quantity output as measured by one minus the dropout rate. Both household and school decision makers can monitor school attendance rates to gauge the potential effects this may have on the ultimate level of student retention. Household and school efforts to interest students in school and decrease absenteeism, if successful, would appear to be an effective method of increasing education quantity output. The positive association between education quantity production and pupil attendance provides additional evidence of the importance of nonschool inputs in the education production process.

8. There are inconsistent results between variables used as school input measures and the achievement test scores for different grade levels and for different achievement test scores, indicating that the empirical results of the education quality models are sensitive to the measure being used as a dependent variable. The use of an achievement test score as a representative measure for cognitive learning, therefore, should be interpreted with caution. Comparison of

the empirical results from the quality models in this research indicate that different policies for increasing school achievement test scores may be appropriate, depending on grade level or cognitive skill being examined. Policies that are appropriate for increasing education production at one grade level might not be the most effective method for increasing output at another level. For instance, the fourth grade models suggest that increasing funding levels would have a positive impact on achievement test scores. Increasing funding, however, is not associated with increases in scores for eleventh grade pupils. On the other hand, the eleventh grade model suggests that hiring additional teachers would improve achievement test results. Increasing the number of teachers, however, is not associated with changes in achievement scores for fourth grade students over the range of inputs in the study.

The results of the empirical models discussed in this dissertation indicate the importance of both school and household inputs in education production. Clearly, community policies to increase the level of education output in a community should consider the education system as a production process that utilizes both public and household resources to produce education output.

The results of the estimated models discussed above were inconclusive in two areas. First, the results do not support the hypothesis of joint production between the quality and quantity dimensions of education as measured by the output variables used in the study.

The weak relationships between the quantity and quality measures, achievement test scores and student retention, in the OLS models suggest that education quality and quantity are not joint products. The quality and quantity models also were jointly estimated using the three stage least squares procedure. The results did not support the hypothesis that achievement scores and the retention rate were related to each other in the production process. There was, however, a positive association between the fourth and eighth grade reading scores and the student retention rate. While the results do not indicate simultaneous production between the achievement test scores and student retention, it does appear that there is a relationship between reading scores in the lower grades and the quantity output measure. Since Virginia law requires that students stay in school until they reach their 16th birthday, the students associated with the fourth and eighth grade reading scores most likely are not the students dropping out of school, as these students are generally under 15 years of age. Further research is needed to examine the relationship between quality and quantity in the production process.

The volunteer input measures used in this research were not statistically significant in either the education quality or quantity production models. The measure, the ratio of parent-teacher association members to school district pupils, was hypothesized to be positively associated with school outputs. Volunteer time was hypothesized to have an effect similar to school teacher time and school purchased inputs. The insignificance of the volunteer measures draws attention to the limited data available on volunteerism in the schools. There is a need to systematically identify volunteer education inputs that can be incorporated into education production research to examine relationships between volunteer inputs and school outcomes. Local parent-teacher organization membership data are the only statewide data available directly or indirectly related to volunteer involvement with the education system. The lack of significance of the volunteer input measure in this study is very likely due to measurement problems. Although the volunteer inputs used in this analysis were not statistically significant, the value of volunteer inputs into the education process remains a critical question. A clear understanding of the relationship between volunteer inputs and education outcomes would provide school administrators and household members the knowledge to develop strategies that utilize volunteer inputs in the education system as complements to the inputs supplied by other input sectors.

LIMITATIONS OF RESEARCH APPROACH

Modeling the education process in a production function framework presents several conceptual and operational problems for the specification and estimation of an empirical model. First, standard production theory is generally applied to production processes that have a homogenous output or outputs that can be easily aggregated by converting outputs to a dollar value. Inputs also are usually homogenous or convert to a dollar value. Schools, on the other hand, are more easily described as heterogeneous institutions with considerable variation in the quality and quantity of inputs and production objectives across schools. The variation in outputs (ie., cognitive learning, citizenship, years of schooling) and inputs (ie., teacher skills, family attitude), difficulty in assigning dollar values to education outputs and inputs, and limited understanding of the technical relationships between education inputs and outputs make the transfer of production theory to the education production process difficult.

Second, there is a divergence of the theoretical and empirical models due to the statistical problem of collinearity. The theoretical model describes the education production process as one that utilizes a set of inputs from discrete input sectors (school, household, student and peer) to produce a vector of education outputs. Specification of an empirical model, however, is hampered by uncertainty regarding the definition and measurement of education outputs and inputs, as well as interaction between measures selected as input variables for each of the discrete input sectors. For instance, the parent-teacher organization participation rate and the pupil attendance rate measures, PTOR and ATTEND, were positively associated with standardized achievement test scores in regression models that did not include the two household measures, GRADS80 and PCRACE. When the household input measures were introduced into the model, the PTOR and ATTEND variables became insignificant. The strength of the household measures and their interaction with measures of variables for inputs from other sectors overshadows the impact the other variables have on education output.

Third, the level of aggregation, or the unit of observation, restricts the insights that can be obtained from the research. The results indicate average relationships rather than input/output relationships of specific students, class rooms or grade levels. The results do not identify specific factors associated with increases in the output of specific students. Evaluation of the impact that public inputs to education have on education outputs is done at the aggregate level to examine the association between public resources and aggregate or average school output. Public decision makers see this issue as their most pressing problem concerning the allocation of public resources to the education process. For instance, the above models indicate that per pupil expenditures are positively associated with fourth, eighth and eleventh grade standardized achievement test scores. Estimating the production relationships for a specific class level with input measures that reflect the actual level of resources allocated to the class level would provide better estimates of the relationship of education inputs to outputs. Data that actually reflected the level of resources that were allocated to a particular class or school would provide better estimates of the impact that resoure allocations have on the achievement levels of specific class levels.

The household measures also are aggregated, resulting in household input measures that are closely linked to socioeconomic characteristics of the community rather than to specific measures for household resource contributions to education production. While community and household resources are utilized in the same production process, community and household decision makers view the education production process differently. Community decision makers are interested in the impact that public resources allocated to education have on aggregate school outcomes. Households, on the other hand, are interested in the impact that specific school and household resources have on the education production of specific students. As mentioned above, specification of a model to examine the relationships between aggregate school inputs and education output does not allow for detailed examination of the relationships between either school or household inputs and the performance of a specific school, grade level or student because the input and output measures are average values. This model, therefore, results in a model in which the household/output relationships that are estimated are strongly linked to socioeconomic characteristics rather than precise indicators of household time or purchased goods allocations that are associated with education outcomes.

FURTHER RESEARCH NEEDS

The theoretical education production model developed in Chapter II recognizes the education process as a production process that draws resources from both the public and household sectors to achieve the goal of educating students. The empirical test of the model indicates that both school and household factors are positively associated with education production. Of particular note is the finding that lagged per pupil expenditures are directly associated with education quality output as measured by standardized achievement test scores.

The conceptual models for education production suggests several issues for further research. First, a clearer understanding of the relationship between the production of different education outputs is needed to provide decision makers with an understanding of the implications of increasing the production of one type of education output on other desired education outcomes.

Second, research is needed to examine the relationship of specific household resource allocations to the education production process. This result would provide guidance to education policy makers and households for improving the production of education output through the allocation of nonschool resources to the education production process. Of particular importance is gaining an understanding of specific household time and purchased goods allocations that influence the education outcomes.

Third, identification of the cumulative effect of resource allocation to education on education output is needed. The lagged effect of the per pupil expenditure variable discussed above indicates the importance of viewing the education production process as a multiple period process. Understanding the effect of greater resource allocation to education production in the early years of students training on the students ability to utilize resources later in the production process would greatly aid local decision makers and households in developing plans for education investments over time. This study suggests that various resources have different impacts on education outcomes at different levels (years) of schooling. For instance, the results of the polynomial lag in the six quality models discussed above suggest that there are greater returns to investments in students in the earlier years of schooling. A clearer understanding of this issue as well as an understanding of the impact that other inputs have on education outcomes over time would greatly aid both local decision makers and households as they attempt to allocate resources over a twelve year education production process. While this issue is directly related to education planning, it is also of critical importance to public service sector planning and to a locality's potential for economic and social development.

Fourth, research, also, is needed to identify the value of volunteer inputs in the education production process. A first step to achieving this is a systematic approach to documenting the nonschool contributions to the education production process. Knowledge of the impact that volunteer inputs have on education outcomes would greatly enhance a school districts potential for expanding its resource base through the recruitment of volunteer resources for the education system.

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APPENDIX A. MATRIX OF CORRELATION COEFFICIENTS.

	R4	M4	R8	M8	R11	M11	HOLD	TPP83	LPP83	NLPP83	INC83	PCRACE	GRADS	PTR	MSD	ATT	PTOR
R4	1.00																
	.01																
M4	.79	1.00															
	.01	.01															
R8	.81	.66	1.00														
	.01	.01	.01														
M8	.72	.60	.85	1.00													
	.01	.01	.01	.01													
R11	.76	.59	.85	.76	1.00												
	.01	.01	.01	.01	.01												
M11	.74	.58	.82	.84	.94	1.00											
	.01	.01	.01	.01	.01	.01											
HOLD	.43	.23	.32	.26	.31	.26	1.00										
	.01	.01	.01	.01	.01.	01	.01										
TPP83	.22	.26	.20	.23	.15	.28	-.07	1.00									
	.01	.01	.03	.01	.08	.01	.01	.01									
LPP83	.38	.37	.33	.33	.31	.42	.01	.95	1.00								
	.01	.01	.01	.01	.01	.01	.90	.01	.01								
NLPP83	-.60	-.45	-.51	-.43	-.57	-.56	-.18	-.30	-.58	1.00							
	.01	.01	.01	.01	.01	.01	.04	.01	.01	.01							
INC	.54	.55	.50	.52	.46	.56	.11	.75	.81	-.53	1.00						
	.01	.01	.01	.01	.01	.01	.20	.01	.01	.01	.01						
PCRACE	-.54	-.36	.58	-.45	-.65	-.52	-.34	.07	-.06	.37	-.12	1.00					
	01	.01	.01	.01	.01	.01	.01	.43	.51	.01	.18	.01					
GRADS	.66	.62	.70	.67	.68	.72	.23	.54	.61	-.48	.79	-.30	1.00				
	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01	.01				
PTR	-.05	.01	.03	.07	-.01	-.04	.13	-.51	-.50	.20	-.19	-.11	-.08	1.00			
	.52	.88	.74	.41	.90	.68	.16	.01	.01	.02	.04	.19	.32	.01			
MSD	.13	.19	.20	.34	.25	.32	-.07	.32	-.28	.01	.30	-.19	.28	.08	1.00		
	.11	.03	.03	.01	.01	.01	.44	.01	.01	.97	.01	.03	.01	.38	.01		
ATT	.25	.18	.25	.26	.21	.23	.47	-.07	-.01	-.15	.08	-.18	.05	-.12	-.07	1.00	
	.39	.04	.01	.01	.02	.01	.01	.44	.90	.09	.84	.04	.54	.19	.43	.01	
PTOR	.30	.27	.37	.34	.35	.41	.13	.30	.33	-.25	.48	-.15	.48	.01	.24	.09	1.00
	.01	.01	.01	.01	.01	.01	.17	.01	.01	.01	.01	.11	.01	.88	.01	.36	.01

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