Understanding School Productivity Study Through Time-Related Policy Analysis

by

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Abstract

This study used time series analysis of 21 years (1970-1990) of school productivity data from Virginia to demonstrate the usefulness of time series models in describing variations in school input (primarily expenditures) and output (primarily student attainment and achievement) variables. In the study, a series of trend-removed, ARIMA(1,0,0) autoregressive time series models for school input variables were developed to describe long-term trends in school expenditures, instructional salaries and pupil/teacher ratios and to account for year to year variation in levels of school inputs. Residuals from these models for school inputs were correlated with student attainment scores and achievement score residuals with student ability removed to identify those school productivity inputs having the strongest association with school outputs.

The scores of input variables having strong associations with school outputs were then plotted over the 1970-90 time period and descriptively related to historical records of legislative and administrative policy decisions thought to have had statewide effects on school productivity in Virginia. The association of school productivity relationship changes with actual policy events was then described.

All school input variables could be described with time series accounting for 90+% of the year to year variance in inputs. Time series residuals from expenditures, instructional salaries and pupil/teacher ratio inputs were moderately to strongly associated with two output measures: 1) the percent of Virginia school graduates attending

college; and 2) the percent of dropouts, in most Virginia (30 < _N_ < 100) school districts .

These inputs shared 20 to 40% of their variance in common with school attainment outputs. School input residuals for local expenditures and pupil/teacher ratio were also strongly associated with reading, math, and language arts achievement residuals in a small number (_N_=2-31) of Virginia school districts. Stronger relationships between inputs and achievement scores in greater numbers of Virginia school districts may be revealed when more years of data are available for future analysis.

Plots of significant school input variables concurrently with school outputs and historical policy change events suggested that at least three policy change events may have had positive long term effects on school productivity in Virginia from 1970-90. Legislative commitment to a reduction in pupil/teacher ratio in the early 1980's seems to be associated with a long term decrease in dropout rates and increases in college attendance among students in most Virginia school districts. Commitment to higher teacher salaries in the same time period also seems to be associated with positive changes in college attendance and reductions in dropout rates. Finally, the long term expansion of total educational expenditures in Virginia, primarily through adoption of special education, health education, and dropout prevention curriculum initiatives, seems to be associated with rising levels of student promotion rates, percent of ninth grade students graduating and percent of students attending college from 1970-90.

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To those named above; to all students who have done well with less; to those who walk the path that guides the past through the present into the future: the gratitude of the author is offered, along with any merit that this work is due.

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Chapter I
INTRODUCTION TO THE STUDY

Since the initial policy decision to implement universal public education for people ages five to 18 in the United States during the late 1800's, means have been sought to allocate portions of total public resources to the effort. This search initiated and continues to promulgate discussion and policy analysis of public school finance (e.g., Verstegen and Salmon, 1991), as no perfectly satisfactory optimization of the allocation process has yet been found.

Release of new national goals for education (Department of Education, 1990) has renewed the analysis of school finance issues, since the goals call for significant new resources for public education or, at least, significant re-allocation of existing resources. The federal government has reduced its proportional allocation of national dollars to public education so the public policy burden of meeting these goals must fall to either state or local educational authorities.

In particular, attainment of several of the national goals will require a positive relationship between resource increase or re-distribution and student/school achievements (D.O.E., 1990, goals 2,3, and 4). Concomitantly, attainment of the new national goals would require the re-distribution of educational resource wealth from economically advantaged regions to areas containing significant proportions of dropout, drug addicted, or undisciplined students (D.O.E., 1990, goals 1,2 and 6).

It would appear that determination of the success of efforts to reach these new goals would require analysis of resource allocation to schools (inputs) and resulting student achievements (outputs) before, during, and after policy changes have taken effect, in essence, analysis of school productivity. Such an analysis would appear to require a focus on measurement of achievement and attainment-related output variables, given the historical and current emphasis of the National Assessment of Educational Progress (Mullis, Owen & Phillips, 1990).

The Problem

There is a continuing call for increased educational expenditures and an expectation that increased resources for schooling will result in increases in student achievement and attainments. There is also a need for research and policy analysis to produce a quantitative relationship between school expenditures, achievements and attainments.

However, current research on the relation of school inputs to school outputs has failed to produce a policy-relevant analytical model (See Fuller, 1987; Hanushek, 1986 for recent reviews). Most of the study of school productivity which has been done has been limited to cross-sectional samples at single points in time. Most of these studies have focused on easily measured input-output variables only indirectly related to actual policy decisions. Most policies affecting school productivity extend over much longer periods of time than are available for typical analyses (e.g., Picus, 1991).

What is needed is an approach to school productivity study which analyzes the effects of changes in inputs and outputs over long periods of time (at least more than one budget cycle) and relates these changes to actual policy decisions made by authorized legislative and administrative organizations.

Time series analysis offers the policy analyst a research method which removes the effects of long term trends, like simple inflation in the economy, and the effects of routine incremental changes in policies (e.g., year to year expenditure changes) before examining the effects of policies themselves on possible outcomes. It offers a perspective which is longitudinal in nature, allowing the analysts to avoid the short-comings of viewing policy only in the short term.

Purpose of the Study

The challenge of this study is to demonstrate and describe an analytic model for school productivity which incorporates the effects of changes in school productivity inputs and outputs over long periods of time and relates these changes to actual policy decisions. This model was constructed using Virginia school district data in the years 1970-1990 and records of statewide legislative and administrative policy decisions made in the same period.

A time-related model for the analysis of policy decisions, school inputs and outputs may overcome the limitations of simply looking at expenditure-achievement relationships for brief episodes of time. After all, a student of the public schools typically spends at least 10-12 consecutive years experiencing education. Any examination of the relationship of school inputs to outputs might at least include this minimal time period. Perhaps taking a longer view of the investment return from education could also free researchers of the tendency to respond to this topic only when policymakers push the panic button in response to some real or imagined need to account for educational expenditures.

Research Questions and Issues

The primary question addressed in this study is whether or not time series analysis is appropriate for examining changes in school inputs and outputs that are defined by potentially significant variable relationships reported in previous studies of school productivity.

If time series analysis was found appropriate for any input or output variable, a following question addressed what associations school input variables shared with school outputs, once autocorrelation between consecutive time periods and any long term trends were described and removed from measurement scores.

For the residual effects of school input variables that were significantly related to raw scores or residuals of school output variables, the study then addressed whether these effects were associated with reported legislative and administrative policy events presumably affecting schools in Virginia from 1970-90.

Rationale of the Study

The Commonwealth of Virginia has committed public resources to the public education of its youngest citizens since 1870 (Buck,1952). Like most states which adopted this policy in the middle to late 1800's, financing of public education centered on the local levy of property taxes and local allocation of resources for education, under the direction of state-authorized superintendents and boards of education (Furno & Magers, 1981).

Since property values were (and still are) used to assess school-supporting taxes, and since these values vary tremendously over time in response to localized, regional and national economic development, expected discrepancies in educational resources from one locality to another appeared shortly after the policy was implemented. Those citizens living in communities at the lower end of the educational resource base spectrum generally feel deprived by comparison to those living in economically more fortunate localities.

This fundamental economic disparity triggered intense debate in educational finance, beginning in the early 1900's with E.P. Cubberly's (1905, cited in Furno & Magers, 1981) study of local funding disparities. The disparity argument still rages today. Commitment to state equalization of local disparities did not arise from Cubberlys' efforts but the notions of subsidy to poorer districts and reward for districts exceeding state-mandated minimum educational programs did.

More recent efforts to equalize the playing field in Virginia, as in many other states, have focused on state-mandated "equalization" formulas which attempt to account for local "ability to pay" (local economic and property tax valuation), establish state minimum educational programs (Standards of Quality in Virginia), and equalize state funding at a minimum level. These formulas still allow considerable local variation in additional volunteer funding for education (Rickman, Cale, Verstegen & Salmon, 1988).

The Standards of Quality (SOQ) established a floor level of educational funding of approximately $2,044 (1988) per pupil (Average Daily Membership-ADM) in all Virginia school districts. Variation in the actual amount of resources available to local education authorities was made possible by conditional state and federal aid programs. These programs required local authorities to contribute portions of local resources that exceed the basic standards of quality to participate in programs for specially defined groups of students (special, vocational, adult education) in their schools.

Additional variance in locally-allocated resources arises from state pupil transportation payments, text rental payments, school food funds, employee benefits and discretionary programs. The Commonwealth also provides locally-initiated capital funding assistance for districts through sliding-rate loans from the Virginia Literary Fund and through local bonds issued by the Virginia Public School Authority (Rickman, Cale, Verstegen and Salmon, 1988).

Given the historical pattern of development of educational resources, it was expected that sufficient year to year variation in school inputs (primarily expenditures) and outputs (achievement and attainment) existed in Virginia from 1970-90 to relate them in an analytical model accounting for change in school productivity over time and associated with reported policy decisions affecting schools.

Development of such an analytical model may allow future researchers and policymakers to broaden their perspective on the support for, and results of, public education beyond their own limited tenure in decision-making organizations. Perhaps such a perspective could also reduce the short-term political stridency of arguments for and against additional educational funding today. This time-related policy analysis view may also support those arguing for a long-term and substantive public commitment to educating all citizens of the Commonwealth regardless of who they were, and when they lived.

Definition of School Productivity in Virginia or Any Statewide Educational System

Most of the published literature on school productivity refers to school outcome study, school effectiveness study, and school input-output analysis as synonymous. This study referred to any analysis of inputs to a school system (e.g., district and statewide expenditures, teacher salaries, etc.), in relation to outputs like average student achievement scores or graduation rates as the study of school productivity.

School productivity in this study refers to the responsiveness (productivity) of schools organized in a statewide system (districts in Virginia) to policy initiatives promulgated by authorized legislative and administrative organizations. It also refers to the theoretically correlated responsiveness of schools to inputs (primarily expenditures) directed at districts by policy-implementing authorities (School boards and administrators in Virginia).

In most studies of school productivity, responses to policy enactment and implementation and school inputs are measured as average student outputs upon completion of some time period of schooling (e.g., graduation, promotion to next grade, achievement of basic math skills).

There may be limitations in viewing schooling as a "production" process which examines only quantitative inputs and outputs, but the study of school productivity offers the potential for informing education policy makers about the relationships between their actions and resulting outputs from state school systems. It may indeed be one of the few useful ways educational policy can be analyzed in broad statewide contexts.

This study viewed school productivity in this specific way. First, policy initiatives are promulgated in authorized governmental bodies by members of the statewide education constituency. These policies are duly enacted and implemented through legislation and administrative action. Funds are appropriated to carry out school programs and locally authorized boards and administrators expend the funds in school districts, after adding in local contributions.

The state requires local boards of education to account for expenditures and report on measures of school process (e.g., teacher salaries, pupil/teacher ratio et al.). The state also requires reporting of selected school outputs (graduation rates, achievement scores). Information provided in accountability reports establishes the framework for studying school productivity in Virginia's statewide educational system. Theoretically, policies will be amended or propagated anew after policy makers consider the results of the current school productivity system.

Key to the study of school productivity is the identification and definition of school input and school output variables. This study used Virginia school district accountability information filed in two historical documents. These were "Facing Up : Statistical Data on Virginia's Public Schools " and the "Annual Report of the Superintendent of Instruction" , both published annually by the Department of Education until 1990, when they were combined into one report.

School Productivity Outputs in Virginia

The only set of school outputs for which comprehensive data existed in the Commonwealth of Virginia data base were standardized achievement scores for reading, math and science and educational attainment ratings of enrolled youth. Given: 1) the historical focus of school productivity study on achievement scores, beginning with Coleman's 1966 study and subsequent follow-up analyses (See Coleman, 1987); 2) the Commonwealth's policy focus on achievement scores, beginning with the 1970 adoption (Wirth, 1983) of management by objectives (MBO) and; 3) the new focus of the federal Department of Education on achievement outputs, this study will use reading, math and science achievement scores, along with educational attainment as school output variables. The policy-relevant output variables selected from the Virginia state data base for this study of school productivity are listed in Table 1.

Output Variable Definitions.

For the purposes of this study, definitions of all variables included in analysis follow those described in "Facing Up : Statistical Data on Virginia's Public Schools", the "Annual Report of the Superintendent of Instruction" and Shotwell, Lee, Ridgway, Hoke, Woodson and Hancock (1982).

Science Research Associates Assessment Series (SRA) and Iowa Test of Basic Skills (ITBS) achievement scores are average school district percentile equivalent scores normed to a national sample of students.

The per cent promoted in all grades is the number of students in all grades in a school district promoted to the next grade and divided by the end-of year membership times 100.

Table 1.

School Output Variables Selected for Analysis of School Productivity in Virginia 1970-90

Variable	Source	Dates Available	Variable Acronym
Grade 4,8,11 SRA achievement reading, math, language arts	Facing Up	1986-1978 (t*=9)	Read4,8,11 Math4,8,11 Langart4,8,11
Grade 4,8,11 ITBS achievement reading,math, language arts	Facing Up	1989-87 (t=3)	Read4,8,11 Math4,8,11 Langart4,8,11
Per cent promoted in all grades	Facing Up	1990-1979 (t=11)	Percent promoted
Per cent of 9th graders who graduated	Facing Up Supt. Reports	1990-1970 (t=21)	Percent ninth graders graduating
Per cent continuing their education in other than college	Facing Up Supt. Reports	1990-70 (t=20)	Percent attending education other than college
Per cent continuing their education at any college	Facing Up Supt. Reports	1990-70 (t=21)	Percent attending any college
Per cent dropouts at end of year	Facing Up Supt. Reports	1990-1970 (t=21)	Percent Dropouts

t* = years of data record

The per cent of 9th graders who graduated four years later is the number of total high school graduates (including summer) in a given year divided by the end of year ninth grade membership four years previous * 100. No adjustments are made for mobility of the population or retention of students.

The per cent continuing their education at any college is a pre-graduation estimate by high school graduates (including summer) of their attendance at two year community and four-year colleges after graduation.

The per cent continuing their education in other than college is a pre-graduation estimate by high school graduates (including summer) of their attendance at business schools, trade/technical schools or apprenticeship programs after graduation.

The per cent dropouts at end of year was computed as the number of students in grades 8-12 and ungraded students 12 and older who withdrew from school for reasons other than promotion, transfer, death or graduation and who did not enter another Virginia school during a school year, divided by the end-of-year membership (grades 8-12) times 100 from 1970-1988. After 1988, this figure included students grades 7-12, plus those who were in attendance at the end of the previous school year but failed to show up for the ensuing year.

School Productivity Inputs in Virginia

Benson (1978) prioritized inputs to educational production functions in three categories adopted in this study. The first category includes a set of background characteristics describing the community in which schooling takes place. This study examined statewide policy correspondence with average school district characteristics and did not examine the background features of each school district. Each district was also treated independently of all others in this analysis of school productivity.

The second of Bensons' categories were student school population characteristics. Measures of these typically involve cognitive ability composition. In most studies, student ability is controlled for before analysis of achievement scores is undertaken. The third category was a set of school or district level inputs to schooling. These measures are typically composed of administratively collected data on expenditures for instruction and other important budget allocation components, in addition to measures of teacher quality, like average salary. Table 2 summarizes school productivity input variables selected for this study.

Input Variable Definition.

The Cognitive Abilities Test (CogAT), Educational Ability Series (EAS -ability) and Short Test of Educational Abilities (STEA) student ability measures are a percentile equivalent verbal ability score averaged for an entire school district and normed to a national sample.

Pupil/teacher ratio 8-12 is the number of total teaching positions in a school district divided by the end-of-year membership in grades 8-12 * 100.

The average instructional salary is computed as the total funds expended for instructional salaries in a school district , regardless of source, divided by the number of instructional personnel positions at end-of-year (paid with state and local funds only). From 1970 to 1986, this included principals, assistant principals, guidance counselors, instructional supervisors, visiting teachers and librarians, as well as classroom teachers. After 1986, instructional supervisors and visiting teachers were excluded from the computation of average instructional salaries.

Total per pupil expenditures are calculated by taking the amount expended for all school district operations (day school, food services, adult education and other education programs), but not including capital outlay, debt service and refunds in a school district in one year and dividing by the average daily membership in the district.

State, local and federal expenditures per pupil are computed the same way, except the source of funding varies. Transportation expenditures per pupil are calculated from total expenditures for transportation costs in a district, divided by the March 31 average daily membership.

Instructional expenditures per pupil were not measured directly but were computed as the difference between state expenditures per pupil and transportation expenditures per pupil.

Average daily membership is defined as the average number of students belonging each day in a room, school or school system for the year. It is determined by dividing the sum of days present and absent for all pupils when school is in session in a district by the number of school days school is in session. March 31 ADM is simply the same figure for the first seven months of a school year.

Prior to 1973, per pupil expenditures were based upon the average daily attendance, rather than average daily membership. At that time, average daily attendance was defined by dividing the sum of days school was attended for all pupils when school was in session in a district by the number of school days school was in session.

Table 2

School Input Variables Selected for Analysis of School Productivity in Virginia 1970-90

Variable	Source	Dates Available
Student Ability Measures		
Cognitive Abilities Test (CogAT)	Facing Up	1989-87 (t=3)
Educational Ability Series (EAS - ability)	Facing Up	1986-81 (t=7)
Short Test of Educational Abilities (STEA)	Facing Up	1980-78 (t=3)
School Quality Inputs		
Pupil/teacher ratio 8-12	Facing Up Supt. Reports	1990-1970 (t=21)
Average Instructional salary	Facing Up Supt. Reports	1990-1970 (t=21)
School Expenditure Inputs		
Total expenditure per pupil	Facing Up Supt. Reports	1990-1970 (t=21)
Instructional expenditure per pupil	Facing Up Supt. Reports	1990-1970 (t=21)
Transportation expenditure per pupil	Facing Up Supt. Reports	1990-1970 (t=21)
Local expenditure per pupil	Facing up (<1981 calc)	1990-1970 (t=21)
State expenditure per pupil	Facing up (<1981 calc)	1990-1970 (t=21)
Federal expenditure per pupil	Facing up (<1981 calc)	1990-1970 (t=21)

The definitions preceding this section set the stage for school productivity analysis in Virginia from 1970-1990. The exact use of the terms above has varied somewhat over time so the definitions given before serve only as general guides to variable definition for this particular study.

A General Model for School Productivity Analysis in Virginia

Given the types of measurement variables previously discussed, school productivity in Virginia, or in any other statewide educational system, can be conceptualized in the following manner.

First, policy makers interested in changing the productivity of Virginia schools identify, promote, pass, and implement policies through authorized governmental bodies. Next, funds are appropriated and expended to meet policy goals in school districts organized throughout the state. Public school student cohorts experience education in schools and are exposed to varying levels of expenditure and school quality over the course of many years.

During this long time period, data are collected on achievements and attainments of students in all Virginia school districts. At some point in time, policy makers look back, relate school inputs to outputs, and then derive some correspondence between policies, inputs and outputs. When relationships are established, policy makers are able to decide and act upon future educational policy.

This study viewed school productivity in this way, using 21 years of school district data from Virginia, time series analysis methods, and historical records of educational policy making.

Delimitations

All measures used in this study were extant and systematically collected from pre-existing school populations and legislative records. Inferences drawn from tests of analytical hypotheses are limited to the time periods used in each analytical model and to the school populations which existed during the 1970-90 period used in analysis.

This study was also delimited by the final level of aggregation of data to statewide averages. Although useful for statewide policy makers, this level of aggregation necessarily masks many important differences between school districts and characteristics of the populations and geographic areas served by schools. Future study may better focus this form of policy analysis to a local school district level where interpretations of specific school conditions may better direct local policy making.

This study was also delimited by reliance upon the validity and consistency of administratively reported school inputs. There was no practical way to verify reported expenditures, student attainments or achievements, beyond standard statewide accounting practices. It was assumed that any figures published by the Department of Education had been verified through accounting procedures.

The study was also delimited by the relatively small amount of time series data available for achievement scores. The 9-12 years of data available for analysis are barely above the minimum of 5 years before and after policy intervention found necessary for significance testing by Gottman (1981).

Finally, the study was delimited by the identification of meaningful statewide educational policies. No text was found that recorded the complete history of educational policy development in Virginia. This study relied upon the experience of school superintendents and records of the state legislature for identification of significant policy events. These can represent only a sample of the policies actually affecting schools in 1970-90.

Organization of the Study

This study is organized in five chapters. First, the study of school productivity is introduced and defined in the state of Virginia. Next, a review of literature in the fields of school outcome assessment, school effectiveness and school input-output analysis is presented to identify and describe potentially significant variable relationships between previously defined school inputs and outputs. The literature review also discusses the basic use of time series analysis to extend the study of school productivity beyond a few years.

Chapter III presents a review of methods used to analyze school inputs and outputs using time series analysis. Methods used to identify educational policies in Virginia and to relate policy events to school productivity are also described.

Chapter IV presents the results of time series analysis of school inputs and outputs for 21 years in Virginia from 1970-90. Data on correlation relationships between school inputs and outputs is also presented. Then, associations are described between educational policy events and changes in school productivity over time in Virginia.

Chapter V presents a discussion of conclusions drawn from the analysis of school productivity in Virginia over time and recommendations for extending this type of analysis into future years and across geographic categories.

Chapter II
REVIEW OF THE LITERATURE

A Brief History of School Productivity Analysis

Research into the link between schooling inputs and schooling outputs began in Virginia in the 1920's with State Superintendent of Instruction reports relating expenditures to literacy rates and measures of school plant efficiency (Buck, 1952). Serious efforts to quantify the relationship of educational inputs and outputs commenced in the 1920's and 30's with the advent of "scientific" management in government. It was further stimulated by several government commissions looking into the ability of states to support public education on a national basis (e.g., Chism, 1936).

Research into expenditure/output measure relationships remained purely descriptive into the 1950's when the push for additional science and math education in public schools led to more national commission studies of educational finance and related achievement measures (e.g., Hirsch, 1959).

A number of descriptive, bivariate and multivariate associational studies of the relationship of educational expenditures to school achievement and attainment measures were done in the 1960's during reviews of intrastate funding disparities in several states (See Cohn, E., S.D. Millman & I-K Chew, (1975); Levin, 1970; MacDougall, 1963; Coleman, et al., (1966); Burkhead, et al., 1967). These led to the development of linear multiple regression models relating schooling expenditures to district-level outputs in a number of studies in the 1970's, focused on specific urban school districts, rural/urban comparative studies and regional variation in the ability of communities to support schools (e.g., Mandel, 1975; Davis, 1970).

Interest in funding disparities between school districts, states and regions, plus the expansion of interest in the enduring effects of education on personal and social development, kept research activity on educational input/output relationships going into the 1980's. The analytical effort expanded into multivariate regression modeling and structural equation models incorporating changes in the relationship over short periods of time (e.g., Furno & Magers, 1981; Fuller, 1987; Glasman & Biniaminov, 1981; Hanushek, 1986; Hanushek and Taylor, 1989; Hokanson, 1984).

A number of studies and a couple of syntheses of literature have recently focused on problems of interpretation in simple regression models of the relationship, primarily arguing that intercorrelated expenditure measures confounded the interpretation of effects on achievement output measures. Hanushek (1986) and Glasman and Biniaminov (1981) also argued for longitudinal studies which would incorporate the changes in relationship of inputs and outputs over time.

Refinement of the multivariate, regression-based and structural equation based models of the relationship between expenditures and school outputs continues to the present time with value-added and gain score approaches (Fox & Taylor, 1991; Picus, 1991); refined regression models (Lopus, 1990; McNamara, 1986); and intrastate structural equation modeling (Hereford & Keith, 1991; Hokanson, 1984).

The review of literature for this study concentrated on specific relationships between district-level expenditures for public schooling, measures of school quality such as teacher salaries, school outputs like achievement scores and simple graduation rates, and statewide policy changes in Virginia largely reported in the period 1970-1990 when quantification of the relationship was attempted. Time series modeling of the relationship was also examined to refine analytical procedures in the study.

Issues in School Productivity Analysis

Early attempts to relate educational expenditures and school outputs like efficiency and achievement were limited by factors initially identified by Powell (1933). First, defining the expected return on educational expenditure is problematic. Achievement measures represent only a small portion of the expected outcomes from education, which Powell defined as the composite of all educational changes resulting from educational activities purchased by a local educational authority.

Powell (1933) also identified the revolving nature of educational expenditures, whereby resources allocated today may yield outcomes in the year of expenditure or in future years. He also felt that community type (socioeconomic), geographic location, type of school supervision, and student ability could account for spatial variation in expenditures and achievement and "happiness" outcomes.

To account for these variables, Powell statistically controlled for location, supervision and student ability, then averaged expenditures and achievement over three years' time. He found teacher salaries, experience, condition of physical plant and enrollment all positively correlated with increasing school achievement and happiness.

The 1960's - Correlational and Regression Search for Relationships

When nationwide studies of school productivity commenced in the 1960's, the same types of variables first identified by Powell (1933), along with several new variables, were being used in expenditure /achievement relationship studies. The advent of national education surveys, like Project Talent in the early 1960's, stimulated the latest lines of new research into the relationship of schooling expenditures and achievement and added consideration of socio-economic status and racial classification to the relationship.

For example, Crandall (1961) used analysis of variance across school district expenditure groups and discovered high expenditure districts with average student IQ scores higher than low expenditure districts and subsequently higher related achievement on standardized examinations (California Achievement Test (CAT)) in California schools.

To compensate for this pre-existing difference between districts, Crandall grouped the students into similar IQ groups across low, moderate and high expenditure districts and then re-analyzed achievement data, discovering that achievement scores in high expenditure districts still exceeded low expenditure districts. He concluded that extra dollars for education yielded achievement gains over the advantages of high pre-existing student abilities.

In addition to these general results, Crandall (1961) also found that expenditures for teachers, administration, clerks (aides), audio-visuals, workbooks and health services each affected the difference in achievement scores between high and low expenditure districts, thus suggesting productive areas on which to focus increased educational expenditures.

Of these and other variables potentially related to student and school ability and achievement in school-production studies to the time of Crandall's study, student and community socio-economic background (primarily parent education, per capita income, ethnicity and characteristic possessions) had been found to have the greatest effect across school districts, continuing with the Coleman, et al., (1966) study. Apparently confounded with these observations were the additional effects of geographic location. Geographic location varies with, and is probably collinear with socioeconomic characteristics.

Coleman, et al., (1966) found facilities and curricula of schools to have little relationship to school achievement, once student socio-economic background was accounted for in a linear regression model. This relationship varied across ethnic groups, being strongest for nonwhite (principally black) minorities and least for whites. Measures important in relating school features to ability/achievement were total expenditures and its correlates, number of science labs and extracurricular activities.

Coleman, et al., (1966) also discovered a strong relationship between teacher qualities like verbal ability and educational level and student/school achievement. This relationship also varied across ethnic groups, being strongest for nonwhite (principally black) minorities and least for whites. Educational background and aspirations (attitudes toward schooling) of student peer groups also strongly affected the achievement of public school pupils, particularly for those minority students historically disadvantaged in socioeconomic background and school quality.

Burkhead, et al., (1967) examined data from the Chicago and Atlanta school systems using multiple regression and value-added analysis with ability gain scores from 8th-9th to 10-11th grades to identify important community and school variables affecting school achievement. They used census data for "status" variables and school district average test scores to derive input and output measures for analysis. Community socioeconomic status was estimated from median family income, adult educational attainment, percentage nonwhite, percentage white-collar workers, percentage substandard housing and percentage nonpublic schools (Chicago) and median family income (Atlanta), since all these had been found significant in previous studies of achievement effects.

Burkhead, et al., (1967) estimated student background cognitive ability from 9th grade (Chicago) and 8th grade (Atlanta) I.Q. measures. School expenditures were represented by textbook expenditures, materials and supplies, and teacher, administrative and auxiliary man-years per pupil (Chicago) and expenditure per pupil, building age, library expenditures, average faculty salary, and enrollment/faculty ratio (Atlanta). School qualities were represented by age of buildings, teacher experience and proportion of teachers with post-baccalaureate degrees (Chicago) and teacher turnover (Atlanta).

Output measures in the Burkhead, et al., (1967) study were 11th grade I.Q., 11th grade reading scores on standardized tests, percentage dropouts and intent to attend college (Chicago) and 10th grade verbal scores with dropouts (Atlanta). The results of this study suggested that achievement is primarily dependent on background socioeconomic characteristics of the communities in which students reside. School inputs and processes had little effect on output measures, with the exception of teacher experience on reading scores and building age on dropouts. The authors concluded that the small variation in school expenditure measures within the large city school systems they studied limited the potential explanatory power of these variables.

Burkhead, et al., (1967) did find the value-added method of regression analysis worthwhile in identifying the degree to which school process variables affected dependent measures, albeit the influence was small. By analyzing the residuals from regressing 10th and 11th grade verbal ability measures on 8th and 9th grade ability measures, they found the influence of family income reduced below that of school process variables. In this manner, the overpowering influence of student background characteristics was statistically controlled while examining the effects of school expenditure variables on achievement and other outputs of schooling.

A study by Miles (1968) attempted to relate several school quality measures to expenditures in Arkansas school districts and found a negative correlation with the number of high school credits units offered, suggesting reduced efficiency in schools with higher expenditures. Miles did not find increasing teacher qualifications significantly related to expenditure efforts.

The 1970's - Regression to the Rescue?

The Burkhead, et al., (1967) study, and other education production function studies came under increasingly critical scrutiny by researchers in the early 1970's. The 1970 National Education Finance Project (Johns, Goffman, Alexander & Stollar, Eds., 1970) produced several studies of additional economic factors affecting public education funding that suggested potential independent and dependent variables for future study. Davis (pp. 59-81 in, Johns, Goffman, Alexander & Stollar, Eds., 1970) described the benefits of education and distinguished between internal rewards to the individual and immediate family of the educated and external rewards to families outside of the educated person's immediate influence, i.e., in society as a whole.

Jencks, et al., (1972) summarized studies of expenditure and achievement inequality up to the early nineteen-seventies. They found that variances in expenditures between states generally exceeded those between districts due to state equalization policies for expenditures. Variances between schools in a district have been found to be even lower, although many districts and schools still differ significantly from average expenditures for district and school units of analysis in a given state.

Jencks, et al., (1972) concluded that school district expenditures in general have little long-term effect on student achievement or attainment, although they probably greatly affect short-term attitudes toward school environments.

Jencks' et al., (1972) also studied the relative effects of student family background (socioeconomic status and IQ-related to genetics) and found both to have strong effects on student achievement over the course of 12 or more years' of schooling. School effects of teacher quality, expenditures and other quality measures generally accounted for a few percent of variance in achievement test scores. Jencks, et al., also looked at trends in equalization of school expenditures and educational attainment over time. They found that variance in attainment between gender and race groups had declined over time as social equalization policies had been introduced. Jencks, et al., also found educational attainment to have a greater long term effect on individual occupational status and earnings than either school district expenditures or student average achievement.

Another comprehensive review of school productivity analysis studies, focused on re-analysis of the 1966 Coleman survey data and was synthesized by Mosteller and Moynihan (1972). Jencks, (pp. 437-512), in Mosteller and Moynihan (1972) discussed general problems with analysis of survey data measuring relationships between school expenditure and achievement components of school production functions. Jencks' arguments centered on invalidity and nonresponse hypotheses concerning the manner in which data on school expenditures and achievements are gathered.

Jencks showed that about 4% of principals' responses to survey items about their schools were inconsistent with other responses they gave about their schools. Jencks' estimates of the reliability of various measures ranged from .28 to .88. In addition, teacher responses about the same school quality variables seemed to correlate poorly with principal's perceptions in Jencks' analysis of Coleman survey data.

Jencks, in Mosteller and Moynihan (1972) also questioned the reliability and validity of achievement tests used in relating school expenditures with achievement, finding the reliability of tests used in the Coleman study to vary by grade and to be most valid in predicting a single general ability factor. Jencks' suggested the use of more valid tests which measure student abilities and achievements that are directly related to school instructional expenditures to better represent school productivity functions.

Nonresponse bias in the Coleman survey was another issue raised by Jencks, in Mosteller and Moynihan (1972). Although there seemed to be considerable selective participation in the Equal Educational Opportunity Survey (EEOS), Jencks' suggested that errors introduced by this process were not large enough to affect policy implications drawn from the survey.

Mandel (1975) attempted to add to the literature on school productivity analysis by examining the distribution of school inputs within, as well as across school districts. Mandel drew a model of exogenous and endogenous effect variables leading to multiple educational outputs. This model suggested a complex interaction between local property values and state product per student and state school financing, all partially determined by economic and social processes of previous and current time periods (Mandel, 1975).

Citing unpublished remarks by Henry Levin, Mandel then identified the deficiencies of previous educational production studies as poor operational formulation (model misspecification), use of single output measures, specification of input measures based only on available data, rather than theoretical models and analysis of "average" schools, rather than identifiably more efficient ones.

With this said, Mandel analyzed a regression model to investigate variation in school funding within districts, citing evidence of previous studies that such differences existed, primarily in discretionary funding available to superintendents.

Using data from Michigan school districts collected in 1970-71, Mandel attempted to relate school inputs per pupil to socioeconomic status (SES), percentage of white students in school, number of full-time equivalent students per school (SIZE) and proportion of students in fourth and 12th grades.

Mandel found significant variation in per pupil expenditure between school districts, with higher discretionary expenditures directly related to increasing SES and percentage white. When compensatory (non-discretionary) funding was included in the production function equation, effects of the independent variables differed between high and low SES schools with high and low percentages of white students. Mandel added to these results with a comparison of inter-district and intra-district funding variation, concluding that there was as much variation in expenditure for teacher salaries inside districts as between them.

This suggests that district-level aggregates may adequately represent intra-district school to school variation in expenditures. These results may ease the concern of some researchers over aggregation of school district input and output variables. Perhaps it is most important that all input and output aggregates be compiled to the same level before analysis of school productivity.

Concurrent with Mandel's 1975 study, research into input/output analysis of expenditure/achievement relationships had expanded (Cohn, Millman & Chew, 1975), to draw upon four different methodologies described in Table 3 (Adapted from Cohn, et al., Table 4-2: Pg. 32).

Table 3

Analytical Approaches to School Production Function Study to 1975.

Ordinary Least Squares Regression	Two Stage Least Squares Regression	Simple and Multiple Correlation	Factor Analysis and Commonality Analysis
Thomas (1962)	Fox (1969)	Mollenkopf and Melville (1956)	Keisling (1969, 1970)
Benson, et al (1965)	Levin (1970)	Guthrie, et al (1971)	Mayeske, et al (1972, 1973a, 1973b)
Burkhead, et al (1967) (Some value-added analysis)	Michelson (1970)	Coleman, et al (1966)	
Hanushek, (1968; 1970)	Boardman, et al (1973)	Miles (1968)	
Cohn (1968)			
Katzman (1968)			
Raymond (1968)			
Bowles (1969)			
Tuckman (1971)			
Summers and Wolfe (1975)			
Mandel (1975)			

Cohn, Millman and Chew (1975) suggested that many of the prior studies undertaken in input-output analysis of schooling had suffered from inadequately specified outcome measures. They believed that school output measures should account for basic skills, vocational (applied) skills, creativity, and attitudes in students, as well as school-level outputs like dropout rate and welfare services offered.

Cohn, Millman and Chew (1975) were also among the first reviewers of educational input-output analysis to point out the disparate levels of aggregation being used in 23 studies of expenditure/achievement relationships. They identified four studies which used the school district level, six which used the individual school as unit of analysis and eleven others that had used mixed level measures, a practice of questionable validity.

Methods of analysis typically used in studies of educational input-output were ordinary least-squares regression (N=11 studies), Two stage least squares regression (simultaneous equations) (N=4), simple correlation(N=2), and a mixture of correlation and factor analysis (N=6) (Cohn, Millman and Chew, 1975).

Of the total of 23 studies they reviewed, Cohn, Millman and Chew found the majority using achievement as the sole output measure (N=13), with verbal ability measures in seven studies and individual studies incorporating school retention rates and student attitudes as additional output measures.

Contrasting sharply with this simplicity in output measure specification was the far greater range in input measures specified in studies reviewed by Cohn, Millman and Chew (1975). Almost every study used an index of teacher quality, instructional expenditure and school quality. Likewise, almost every study used a unique proxy of these variables and added at least one unique dimension of input. This probably resulted from the relative abundance of input measures routinely collected by state educational agencies and made available to researchers, contrasted with the sparsity of output measures collected in most states.

Noteworthy also in Cohn, Millman and Chews' (1975) review of input-output analyses in education was the growing use of modern techniques in the field, specifically the use of value-added gain scores for output measures. Value-added analysis uses the change in achievement or ability scores over some time span (usually one or two years as a dependent measure and relates this "value-added" to independent predictors of the value gained.

Despite these advances, Cohn, et al, concluded that the decades of the 1960's and 1970's had not produced consistent and unambiguous methods of identifying and relating school inputs to outputs. They then went on to develop their own set of goal-programming simultaneous equations relating Pennsylvania school system inputs to specified outputs being measured longitudinally in that state.

Despite a host of simultaneous equation-solving, Cohn, Millman and Chew (1975) concluded that their output indices (achievement, attitude) were not very sensitive to changes in school district policy inputs(teacher quality, expenditure, etc..), despite their controlling for prior student ability and socio-economic status.

Like other researchers before them, Cohn and his colleagues lamented their failure to produce an analytical result which would enable Pennsylvania administrators to account for school input changes and predict school outcomes on a cross-sectional basis.

In an attempt to address some of the weaknesses identified by Coleman (1966), Jencks (1972), Cohn (1975) and others, in the use of survey data to derive school production function relationships, Summers and Wolfe (1976) used student-level data to develop a series of descriptive regression equations linking student characteristics, (family income, race, gender, et al) with school inputs (expenditures) and student/school outputs (change in ITBS achievement scores over two to three years). Summers and Wolfe found significant interactions of grade level, gender, race and family income in their tests of regression relationships. They also found differences in regression relationships between low and high-achieving student groups.

As in previous research of school production functions, Summers and Wolfe found that class size, school size, and teacher experience all significantly influenced student ITBS achievement. They also found that quality ratings of teacher undergraduate institutions had a significant effect on student achievement. Expenditure measures of other teacher and principal characteristics like salaries had little effect on average achievement, nor did the quality of physical facilities in schools.

Summers and Wolfe (1976) added to the variable list in derivation of school production functions by also finding school climate measures (number of disruptive incidents) to be significantly related to student achievement. They concluded their study by observing that qualitative measures of school inputs were more effective than quantitative measures of expenditure in explaining variance in change of student ITBS achievement over 2-3 years, suggesting once more that doing some things well in schools may do more for student achievement than simply doing more of the same thing.

Despite the improvements in analytical design introduced by Summers and Wolfe, most studies of school production functions remained limited by aggregation of data and the unavailability of school quality data when Benson

(1978) reviewed and summarized educational production function studies to that time. Benson said that results of education production studies were often conflicting and ambiguous, citing the arguments which raged over the Coleman 1966 report and later re-analyses of the same data using multiple regression modeling. He also noted the low (25 per cent) explanatory power of most production functions.

Benson pointed out that, of those individual independent variables most effective in explaining school outputs, family background is the strongest and least amenable to policy impact. Of the various other background and expenditure process variables also found significant in affecting school outputs, only a few in each study are usually significant and these few vary from study to study.

Benson (1978) also suggested that multicollinearity among the independent variables limited inferences drawn upon any single variable effect on outputs and that the feedback effect of some process variables (expenditures) on another process or output variables (e.g., attitude on achievement and vice versa) could bias estimates of production function parameters in ordinary regression analysis. Thirdly, he criticized education production function studies for being "fishing expeditions" and searching extant data sets for relationships, rather than conducting experimental or quasi-experimental studies within policy manipulable educational contexts.

Finally, Benson (1978) discussed the serious quality control problem with educational expenditure data, since most of such information is provided under mandated administrative practice and may not relate to policy-relevant educational practices. Furthermore, such data are ordinarily aggregated to school or district level and may limit interpretations of education production functions to these artificial and less policy-relevant contexts.

The 1980's - Structural Equations and Value-Added Analysis

Little had changed or improved in research attempts to relate school inputs to outputs by the time Murnane (1981) reviewed the history of what had become known as "school effectiveness" studies. By 1981, we had learned that the individual student served as the best unit of observation of achievement, that children's progress (over time) seemed a preferred mode of assessing effect, and that identifying school resources that actually reached individual students was a more appropriate way of measuring expenditure than gross estimates of school district expenditure per average daily membership or attendance.

Progress in addressing analytical issues facing policy analysts who seek a link between school expenditures and changes in schooling outputs seems to have occurred with the onset of linear structural relation models in the 1970's and 1980's. Linear structural equation models (LISREL) attempt to account for measurement error in exogenous independent variables and covariance between endogenous independent variables as effect paths leading to achievement or schooling outputs are identified.

One generalized structural equation model was proposed by Glasman and Bianiaminov in a 1981 review of school input-output analysis. They reviewed school production function studies conducted from 1959 onward and tabulated significant relationships between student background and school-related input variables, school condition and resource input variables; and cognitive and noncognitive output variables.

They found that most studies had utilized cognitive output variables (Standardized achievement tests) to relate a divergent set of student and school inputs.

Glasman and Bianiaminov (1981) found community socioeconomic (SES) status, racial composition (percent black), and percent attendance student school-related inputs; and pupil/teacher ratio, expenditures and salary school inputs significant in relation to achievement score outputs, along with a number of other independent variables. They found simple and partial correlation, ordinary least squares regression, two-stage least-squares regression, stepwise regression, path analysis, and variance-partitioning to be the analytical methods used in school input-output analysis to 1981 (See Table 3 for examples).

Glasman and Bianiaminov (1981) also found several major analytical problems with school input-output analyses in their review. First, different measures of identical independent variables were used by various researchers; second, samples used in the studies varied greatly in quality and quantity; third, data were aggregated to different levels within most studies; and fourth, the causation linkage used to test relationships between inputs and outputs was most often only one-way or unclear. They ended their synthesis of school input-output studies by proposing a structural equation model consisting of the most consistently significant variables found in previous research.

Hokanson (1984) used a modified version of the Glasman and Bianiaminov (1981) proposal to describe a causal model of the direct and indirect effects of expenditure variables on achievement scores in Florida. Hokanson used background variables of race, parental income and occupation with intervening general and special fund expenditures leading to mean school achievement for Florida districts. Hokanson found that expenditures directly targeted to instruction (salary, materials) had greater positive effect on achievement over several year's of time than indirectly targeted expenditures (administrative overhead).

Hokansons' study, albeit not a purely time series model, illustrated a temporal relationship of expenditure to achievement and suggested that measurement of the allocation of expenditures aids in identifying the targeted effects of expenditure on achievement.

Hanushek, (1986) reviewed the contributions of structural equation analysis and other recent analytical strategies to educational production study. He cited continuing inconsistencies in the findings of studies relating various measures of schooling expenditures to aggregate output measures like achievement but pointed out the single consistent finding that there appears to be no strong or systematic relationship between school inputs and outputs, once family background is accounted for.

Hanushek (1986) further argued that the public educational system is specially constrained by the longevity of teacher employment and a slow rate of expenditure response to changes in salary levels due to existing state salary schedules.

Aitkin and Longford (1986) found similar limitations of school productivity analysis in studies of school effectiveness in Greta Britain. Their critical review focused on appropriate levels of analysis, variation in demographic characterisitics of school populations, and the reliability and validity of output measurment instruments.

Aitkin and Longford (1986) developed five analytical models for the study of school effectiveness in one school distict in Great Britain. They tried three ordinary least squares regression models, one weighted least squares model and one maximum likelihood model. They found that ordinary least squares regression of output score residuals (ability-removed) on school parameter variables (their model 2) and maximum likelihood estimation of regression parameters when pupil-level variables are introduced (their model 5) provided the least biased methods of analyzing school effectiveness.

Aitkin and Longford (1986) concluded by suggesting that the successful analysis of school effectiveness would require researchers to utilize pupil-level data on outputs, inputs and background variables, complete modelling of the multiple-level structure of schools (pupil, school, district) and analysis of interactions between levels. Unfortunately, most of the data available about school districts in the United States is not able to be analyzed in this way.

Fuller (1987) summarized the situation from a global review of the topic. He highlighted weaknesses in the production-function metaphor of school effectiveness and criticized the tendency of policy analysts to utilize nationwide sample designs, based on single surveys and cross-sectional analysis, rather than more regionally-focused analyses. He particularly questioned the role of purported causal factors relating to expenditures in nationwide studies, given the spatial variance of socio-economic conditions. Fuller also argued that the lack of consistency in expenditure/achievement effects observed may be more related to the variation in study context (place and time) than to direct effects of exogenous variables.

Contemporaneous with these school production modelling efforts had come renewed emphasis on effective schools research, much of which has focused on expenditure and achievement relationships between states. Hanushek and Taylor (1989) proposed value-added analysis of state-level aggregated data to overcome the limitations of missing family data, time variant school inputs, measurement error in school inputs, and nonrandom test taking.

Using several different estimation models to account for variance in achievement scores relating to state expenditures for education, Hanushek and Taylor (1989) found that accounting for background demography (race, sex, income), the <u>history</u> of inputs (prior expenditures), and student ability (pretest), they could produce minimally biased estimates of achievement effects. They concluded that the best information for estimating school quality differences came from value-added measurement of growth in achievement over time.

A multivariate analysis of school expenditure variation between Virginia school districts (Hereford & Keith ,1990) corroborated the greater direct linkage of expenditure to instructional expenditures found by Hokanson (1984) and also demonstrated variation in school district achievement over four "regions" formed by cluster analysis of social and economic demographic information. The authors used this information to suggest statewide policy changes in funding schools, since local property tax policies could hardly be expected to overcome the identified expenditure-achievement disparities between districts and "regions".

A further refinement of school productivity and effectiveness research has recently been attempted through the greater development of value-added models (Fox & Taylor, 1991). Achievement was measured in grade school and related to later achievement in high school while accounting for the covariance of enrollments and expenditures in different schools within a school district.

Fox and Taylor (1991) used standardized achievement tests which measured achievement in all students (not just college-bound persons) and found expenditures to be uncorrelated with achievement changes in school districts. More importantly, Fox and Taylor did not find a relationship between grade school achievement and achievement in high school and implied that this indicated changes over time in student achievement, independent of school district enrollments and expenditures.

A Possible Linkage of Inputs and Outputs to Historical Policy

With an eye toward policy analysis of the school productivity function, Picus (1991) studied changes in expenditure policy over time (five years) in California school districts when the state legislature authorized incentive funding programs targeted at getting districts to spend a greater proportion of their available funds on instruction. Picus described the way school districts modified their short term expenditure policies to match state incentive goals but reverted back to former patterns as the incentive programs' initial impact faded and the majority of districts' had qualified for incentive funds.

This finding suggests that expenditure policies have a fluctuating temporal component, related to, as yet, undiscovered and underlying local and regional economic influences affecting the decision-making of school district policymakers during implementation of policy. Later, these same local expenditure influences affect statewide policymakers considering future changes in expenditure policy and potential impacts on school outputs.

The Long-Term Output of Schooling

Most recently, Husen and Tuijnman (1991) studied changes in IQ from age 10 to age 20 in Swedish males, as they related to educational attainment. Using linear structural relations, they constructed and tested a model relating home background, childhood cognitive ability, and educational attainment in youth to adult cognitive ability.

Unlike Fox and Taylors' (1991) result for achievement score change, Husen and Tuijnman found that schooling had a moderate and significant effect on adult cognitive ability above and beyond the effects of background and childhood IQ. The authors concluded that formal schooling contributed to increases in the intellectual capital of Sweden.

Of note from Husen and Tuijnman's work (1991) is their observation that intellectual gains from schooling bridge the gap from childhood to adulthood. That is, society's "real" gain from education is indeed far more than cross-sectional analysis of achievement scores would or could suggest.

These and other study findings suggest that changes in expenditure policy and schooling achievement over time could be a potent discriminator of the long term effect of schooling. Research models accounting for the effects of time on school performance might indeed alter the way current policy makers think about investments in public education.

Today's policy analyst interested in school production study is thus challenged to find some analytical stratagem incorporating time as a variable and accounting for variation in school inputs and outputs over geographic and other categorical boundaries while relating policy-relevant expenditures to policy-relevant outcomes.

A summary of the major analytical problems identified during the last decade of research on school production in public schools are summarized in Table 4 following.

Possible Solutions to Analytical Issues in School Productivity Analysis

Analysis of Variance and Covariance

Powell (1933), Crandall (1961) and others have suggested analyzing school productivity across a variety of categorical groups, including level of expenditure, socioeconomic status, ethnicity, prior ability, teacher quality, physical plant quality, and other discriminating variables using conventional analysis of variance or analysis of covariance.

Multiple Correlation, Linear Regression and Value-added Analysis

Burkhead, et al (1967), Coleman, et al, (1966) and others have suggested using multiple regression models which include covarying and categorical variables in a single analytical strategy. Burkhead, et al (1967) used regression to analyze gain score residuals over a two year period of hypothesized and measured ability change.

Table 4

Compilation of 1980-1991 Studies on School Productivity Analysis.

Author, date (analysis)	Primary Input(s)	Primary Output(s)	Issue(s)
Glasman and Biniaminov, 1981 (Synthesis of other studies)	Student background school expenditures	achievement test scores, attitudes	Sample size variance, poor measurement, poor directional models of relationships, no longitudinal studies
Murnane, 1981 (synthesis of other studies)	Expenditures per pupil	Pupil mean achievement	interaction of student & teacher behavior response
Hokanson, 1984 (Structural Equations)	Instructional Exp./pupil	School achievement	More time added to model-greater relationship
Hanushek, 1986 (synthesis of other studies)	Exp./pupil	Pupil mean achievement	Weak relationship; lag effect of exp. change due to long teacher tenure
Aitkin and Longford (1986) Multiple Regression	Exp./ school and per pupil	Pupil and school achievement	Relationship affected by level of analysis and way in which variance is partitioned
Fuller, 1987 (Synthesis of studies)	Exp./ school and per pupil	School achievement	Cross-sectional samples; over-aggregation of variables; time and place context; use of single outputs.
Hanushek and Taylor, 1989	Exp./pupil	Change in school achievement	Missing family level data; lag effects over time; measurement error of in puts; nonrandom test taking

Author, date (analysis)	Primary Input(s)	Primary Output(s)	Issue(s)
Hereford & Keith, 1990 (Structural Equations)	Exp./pupil	School district achievement	Spatial variation of local effort, expenditure and achievement; over-aggregation of variables
Fox and Taylor, 1991	Exp./pupil	Grade school & High school achievement /pupil	Change in achievement relationship from grade to high school; limited test taking sample.
Picus, 1991	Special ed. Exp./pupil	Local exp. effort	Change in school board policy over time
Husen & Tuijnman, 1991	High school IQ	Adult IQ	Basic ability measures vary over time; increase after schooling

Simultaneous Equation Analysis

Benson (1978) suggested that two-stage least-squares regression could overcome the problems of simultaneity and multi-collinearity in education production function analysis with careful, contextualized model-building. Focusing study in a single school district, or closely related districts (geographically, economically) was also suggested to make such studies more policy-relevant.

Multivariate Analysis of Variance and Repeated Measures ANOVA

Fuller (1987) concluded that an analytical design which would incorporate longitudinal measures of expenditure and achievement and that could account for spatial variation in the background characteristics of communities, families, students, teachers, schools, school districts, states and countries in a multivariate output design might better help policy makers assess a valid relationship between efforts to fund education and the results of schooling.

Linear Structural Equations (LISREL)

Hokanson (1984) and Hereford and Keith (1990) used linear structural equations (LISREL) to construct models accounting for measurement error and covariance between independent variables within their models, and to test their models over two-year periods, looking for changes in relationships related to expenditure policy changes in Virginia school districts.

Time Series-like Analysis

Finally, studies like Fox and Taylor (1991) and Husen and Tuijnman (1991) explicitly incorporated a measure of time in their models of achievement and ability change, while relating these changes to expenditure and school process-related independent variables.

Summary of the Published Literature on School Productivity Analysis

This review of school productivity literature has identified the growth in analytical procedures through time from the beginning of such policy study in the 1930's to the present day. The analytical trend has been away from simple categorical studies of group differences toward long-term multivariate models of relationships between school inputs and outputs. No single analytical method has been found satisfactory by synthesizers of study effects. Only one study was found that dealt explicitly with school productivity and educational policy implications (Picus, 1991).

The major challenges to researchers continuing the study of school productivity, that this literature review has identified, seem to center on the use of consistent levels of aggregation, measurement and analysis of change in school inputs and outputs over time, and identification of appropriate output variables.

Among all the possible school input variables which have been analyzed, measures of student background ability, school expenditure measures and school quality estimators like teacher salaries seem potentially significant in accounting for school outputs like achievement and attainment. Student achievement (school district average) and attainment are the school output measures of choice by state policy makers. Other potential measures of school output (attitudes, behavior change, etc.) may prove more appropriate in the future but are simply not widely reported at this time.

The district level of aggregation is the default used by most state educational authorities since disbursement and accounting of funding goes through local school district educational authorities in all but one state (Hawaii).

Measurement and analysis of school inputs and outputs over long periods of time would appear to be most useful in developing an understanding of the policy implications for school productivity analysis. Virginia stands out from most states in having compiled and published a fairly long record of consistently reported school output variables.

Chapter III

METHODOLOGY

Research Design

The research design used in this study was a description of the association between average time series models of school input variables for 139 Virginia school districts from 1970-90, school output variables and historical legislative and administrative expenditure policy change events. All measures used in analysis were extant and systematically collected from pre-existing school populations and legislative records. Inferences drawn from tests of analytical hypotheses are limited to the 1970-1990 time period used in each analytical model and to those historical school populations. Tables 1 and 2 presented in Chapter 1 detail the names of variables used in the study.

Measurement Issues

The school input variables of this study were derived from annual school census reports delivered to the State Department of Education in Richmond, Virginia by school division superintendents. The reports are assumed to consist of accurate and reliable measurements mandated by the agencies involved.

The output variables consisted of some measures reported by school division superintendents (drop-outs and graduates) and some standardized and norm-equivalent achievement test scores. Table 5 follows and details the types of standardized tests used and salient measurement characteristics of each reported in The Mental Measurements Yearbook (Rutgers University, various years).

Table 5

Measurement Characteristics of Standardized Achievement Tests Used in Analysis

Test	Reliabilities	Validities and Comments
Science Research Associates Assessment Series (SRA)	.90 + (KR-20 and alternate forms)	Content validated Criterion validated with course grades, correlated .7-.9 with ITBS and MAT
Iowa Test of Basic Skills (ITBS)	.7-.9 (test re-test)	Content validated Construct validated with factor analysis Criterion validated with CogAT
Educational Ability Series (EAS)	.70-.80+ (KR-20)	Criterion validated by score correlation with SRA
Cognitive Abilities Test (CogAT)	.90+ (KR-20) and .7-.8 (test re-test)	Criterion validated by score correlation with ITBS and TAPS
Short Test of Educational Ability (STEA)	.82-.84	Criterion validated by score correlation with PMA of .53-.78
Tests of Achievement and Proficiency (TAPS)	.82-.9 (KR-20)	Content validated Construct validated by relationship to basic math and verbal skills

The SRA test series was re-normed in 1978 and anchored to the original 1968 norming sample to enable longitudinal comparison of normal curve equivalent scores (Robertson, 1985). The CogAT and ITBS tests were re-normed on the same sample as the TAPS test when it was marketed in 1985 (Keene, 1985; Cannell, 1989). No evidence was discovered that suggested that re-norming of these standardized tests would affect the comparability of normal curve equivalent scores from 1978 to 1990.

Although different standardized tests were utilized by the Department of Education during the years being analyzed, they were assumed to be measuring the same latent ability and achievement variables and their correlations were expected to be similar with each other and all school input variables.

Changes in Variable Measurements Over Time

The types and measurement of variables collected in the Commonwealth of Virginia to describe school inputs and outputs varied somewhat from 1970 to 1990. Table 6 follows and describes each year of data collection and changes in measurements made.

Table 6

Reported changes in Virginia school productivity variable measurements from 1970-90.

Date	Variables affected	Measurement change from 1990 standard	Potential analysis effects
1969 - 1970	Expend- itures; achievement attainment	Average daily attendance used instead of ADM; No standardized tests scores; attainment based upon 1st grade attendance; federal & state exp. reported in % of total costs; three unconsolidated towns (Saltville, Abingdon, Poquoson) and one county (Nansemond)	Initial Baseline for study
1970 - 1971	Attainment	% of Ninth grade class graduating added to data set	% 9th GRADS

Table 6 continues..

Date	Variables affected	Measurement change from 1990 standard	Potential analysis effects
1971 - 1972	NO CHANGES		NONE
1972 - 1973	All variables	Change in per pupil calculations from ADA basis to ADM; Nansemond county became a city and Saltville merged with Smyth county.	ALL VARIABLES probably reduced in total population effect
1973 - 1974	Attainment	Dropout percentages based upon end-of year membership rather than March 31 ADM	NONE
1974 - 1978	NO CHANGES	Saltville merged with Smyth county	NONE
1978 - 1979	Teacher Salary Ability and achievement scores Transport expend-itures	Standards of Quality (SOQ) changed to add instructional salary averages in lieu of teacher salary averages; STEA ability measures and SRA assessment program started; SOQ partitioning of expenditures began	Average teacher Salary = Average Instructional salary; Ability, Reading, Math, Language Arts added; Transport-ation expenditure added.
1979 - 1980	All state Expend-itures	Sales and use tax income shifted partially to state school expenses	TOTEXP; STATEXP; LOCEXP; SALESEXP; TRANSEXP.
1980 - 1987	NO CHANGES		NONE

Table 6 continues..

Date	Variables affected	Measurement change from 1990 standard	Potential analysis effects
1987 - 1988	Ability, Achievement and state level expend- itures	EAS 4th, 8th and 11th grade ability tests replaced with 1st grade only CogAt. SRA tests replaced with ITBS (4th & 8th) and TAPS (11th). Langarts=written expression on TAPS. State expenditures included monies sent to hospitals and clinics.	ABIL READ4,8,11 MATH4,8,11 LANGARTS 4,8,11 STATEEXP
1988 - 1989	NO CHANGES		NONE
1989 - 1990	School quality, attainment	Pupil/teacher ratio total no longer reported. Substituted k-7 ratio instead. Dropout rates probably increased by adding summer dropouts to total. Comparison with rates before 1989 not recommended.	TOTAL P/T RATIO %DROPOUT.

None of the changes in school productivity variables in Virginia from 1970-90 were of enough importance to alter the analytical design of this study. The main effect of reported changes was to reduce the number of districts being analyzed over time from over 140 in 1970 to 136 in 1990 while increasing the number of output variables available for analysis. However, interpreters of changes in school outputs derived from analytical results which follow should keep the changes reported here in mind before alluding substantive effects to school input variables.

Choice of Time Frame

The starting point of data utilized in this study commenced around 1970 after the Coleman study initiated federal nationwide investigation of the effects of schooling on all segments of the American population Coleman, et al., 1966). Two policy initiatives seemed to coincide in starting large scale school productivity studies like the Coleman "Equality of Educational Opportunity" report. First was the Kennedy administrations' concern that schools respond to the needs of historically disadvantaged minorities. Second was the introduction of Planning, Programming and Budgeting (PPBS) systems in the Department of Health, Education and Welfare (HEW),(Wirth, 1983).

Each of these separate policy initiatives required the government to obtain systematically organized information on school conditions (expenditures, segregation, facilities, etc.), procedures (administration, instruction, transportation, etc.) and outcomes (graduation, college-bound, achievement on standardized tests) in order to determine relationships between policy-amenable variables and schooling outcomes under various school productivity models.

Both of these federal initiatives appeared to have had a potent impact upon schooling in Virginia, first triggering the complete desegregation of public schools and the redistribution of resources for schooling, then introducing systematic "scientific" management and evaluation of schooling processes and outcomes. Virginia adopted management by objectives (MBO) in 1971, the same year standardized achievement testing began across all districts in the Commonwealth (Wirth, 1983).

For these reasons, and due to the limited availability of longitudinal expenditure and achievement data in Virginia, analysis of school production relationships in this study of the Commonwealth began in 1970 and ended with 1990, the latest year of publication of data. State education policy events in the Commonwealth are reported from Acts of the General Assembly and Annual Reports of the State Superintendent of Instruction.

Analytical methods

This study utilized a time series and correlation analysis plan, following methods suggested by Gottman (1981), Harvey (1981), McDowall, et al. (1980), McCleary, et al.(1980), Cook and Campbell (1979), and Kendall (1976), for social science data. One hypothetical example school district will be used to discuss analytical procedures in three stages: 1) time series description; 2) correlation of school inputs to outputs; and 3) description of the correspondence between statewide educational policy events and statewide average time series of significantly correlated school input and output variables.

All dollar amounts for school expenditure and salary variables were converted to constant 1984 dollars using implicit price deflators for 1970-1990 government goods and services before analysis of the time series.

Standardized percentile equivalent achievement test scores were regressed on student ability scores at grades 4, 8 and 11 to obtain achievement score residuals used in final analysis of time series relationships between school input and achievement output variables.

Time Series Model Description

Time series data were decomposed for each school input and output variable described before in Tables 1 and 2 in each of 139 Virginia school districts having data available from 1970-90. Time series models for each district and each variable were developed using an autoregressive (AR), integrated moving average (MA) model (ARIMA) to describe trend, stationarity (AR), invertibility (MA), cyclicity and autocorrelation in the series.

Trend is the linear relationship of year to year values for a variable from the beginning of a time series (e.g., 1970) to the end of a time series (e.g., 1990). It is computed by simple least squares regression of the values from a variable, for example, total expenditures on time in the 21 year period from 1990 through 1970.

Stationarity is a characteristic of time series which is necessary to fulfill analytical assumptions for developing ARIMA models. Stationarity implies an unchanging mean and variance in the distribution of variable values over time. It is most critical for development of autoregressive (AR) models (Gottman, 1981).

Invertibility of parameters is a similar condition necessary for the development of moving average models. Fundamentally, this condition assumes that each moving average parameter (called theta) is less than 1.00 for the simplest time series models. The assumptions of stationarity for autoregressive models and invertibility for the parameters of moving average models place constraints on the values of parameters. For simple first order models, these assumptions mean that $theta_1$ (MA) and phi_1 (AR) should not be => 1.00 (Harvey, 1981).

Cyclicity is a term which describes an episodic, up and down variation in the time series for a variable. It implies that the values vary around a stationary mean with equal variance over time. Cyclicity can be described in trigonometric terms (e.g., sines and cosine relationships).

Autocorrelation refers to the correlation of one year's observation with another year's observation. If 1970 total expenditures were correlated with 1971 expenditures, the observations were said to be autocorrelated.

ARIMA (autoregressive, integrated moving average) time series models were used to describe trend, cyclicity (if any) and autocorrelation in time series. Stationarity was evaluated by examination of residuals from ARIMA models of significantly autocorrelated time series for a variable. Non-random residuals from a modelled time series implied nonstationarity in the data. Invertibility was evaluated by examination of parameter values for moving average models and comparison with published guidelines (e.g., Gottman, 1981).

The Number Cruncher Statistical System (Hintze, 1989) was used to compute time series models. Time series models were described in terms of three parameters: P (autoregressive phi), D (degree of differencing, usually 0 if trend is removed and data are stationary), and Q (moving average theta). An ARIMA model is typically described in terms of (P,D,Q) for any time series. A simple example of an autoregressive model would be ARIMA(1,0,0). An example of a moving average model would be ARIMA(0,0,1). A mixed model might be (1,0,1). The analysis consisted of several discrete steps discussed below for one hypothetical school district.

Step 1: Detect and remove long term trend, and check assumptions at the school district aggregate level.

First, autocorrelations and partial autocorrelations were computed for a school district for each input and output variable. Long term trend was removed from the time series by ordinary least-squares linear regression of variable values over time. This also helped to establish stationarity in each series and ensure that the assumptions of autoregressive (AR) models for homogeneity of variance about the long term mean and invertibility of parameters for moving average(MA) models were met.

Step 2: Detect and account for deterministic cycles.

Plots of autocorrelation and partial autocorrelation values from year one (1970) to year twenty-one (1990) were examined to identify appropriate ARIMA models for further testing (either autoregressive, moving average or a mixed model). In general, the most simple ARIMA time series model that could describe a variable in a school district was selected for further testing, regardless of whether it was autoregressive, moving average or a mixed model.

Autocorrelations and partial autocorrelations for the entire 21 year time series (12 years for some achievement variables) were tested for statistical significance at the .05 probability level (null hypothesis rho=0, df= t-2 at every lag interval) to aid in model identification.

Plots of the autocorrelations and partial autocorrelations at lag periods from two to ten years (about 1/2 of the total time series) were examined to identify significant lag cycles in the time series for a variable. These lag periods were then used to establish ARIMA model parameters, based on the rate at which autocorrelation and partial autocorrelations declined from 1970 to 1990.

For example, total expenditures for one school district were found to have significant autocorrelations every two year period. The partial autocorrelations of lag periods two to ten died off rapidly after the two year lag value. This would suggest an autoregressive (AR) (2,0,0) model for this district for this one variable.

However, if the same lag period had been apparent in the time series but the partial autocorrelations had died off gradually, a moving average (MA) (0,0,2) model would have been suggested. If neither model (AR or MA) alone could describe the time series, various mixtures could be tested (1,0,1), (2,0,1) etc. until an appropriate ARIMA model could be found. (See Gottman, 1981; Harvey, 1981 for additional examples).

<u>Step 3: Check model residuals</u>.

Residuals were then computed from the ARIMA time series models for each variable in every school district and were observed for randomness. Time series models were modified for each school district and each variable until randomness of residuals was observed. It was expected that nothing more complex than a second order ARIMA model would be necessary to describe the time series of the social science measures used in this study, as suggested by Gottman, (1981).

Step 4: Description of variables without significant autocorrelation of values over time.

Variables which could not be modelled with time series (e.g., output variable values which exhibited apparently random distributions over time) in a majority of Virginia school districts were described and simply correlated with other variables in the analysis of input-output variable relationships.

Tests of the Relationship of School Expenditures to School-level Student Achievement and Attainment Over Time

Once ARIMA models had been developed for school input variables in the study, values for all school districts which could be modeled with the identical time series were averaged together to form statewide time series model aggregates for each input variable. The averaged time series were then "prewhitened" (mean, trend and autocorrelations relationships removed) using the ARIMA time series model appropriate for the variable.

Residuals from this process were then analyzed simultaneously in a multiple correlation (all input variable time series models and all school districts) model for each output variable. This analysis described cross-correlation and coherence (variance shared) over time among the residual unexplained variance of the input variables and raw (attainment variables) and residualized (achievement variables) scores of output variables in all 139 school districts. A similar correlation analysis was computed using statewide averages of both input and output variable scores.

Significant (*P* < .05 on a test of 0 correlation, *df* range 7-19) correlations for each input/output model tested in each district were further aggregated across districts and averaged as a description of potential statewide effect size for each input variable time series model.

Association of Statewide Policy Initiatives and Time Series Model Relationships of Virginia School Productivity from 1970-90

Time series models that had significant cross-correlation relationships between input variable model residuals and output variables in at least 25% (approximately 30) of all school districts analyzed in the study were averaged for all school districts statewide and then plotted concurrently with the annual dates of major statewide school policy initiatives identified by experienced school superintendents (N=7) in a survey of their recollections from 1970-1990. Additional policy events were identified from the reported Virginia Acts of Assembly.

Input-output relationships that significantly affected more than 30 districts (about 25% of all districts) in the state were noted and later examined for association with policy events. This limit was arbitrarily established as a lower limit since the researcher believed that any policy which did not affect at least one-quarter of the state's school districts could not have substantial statewide impact and would not be of interest to the state educational policy constituency.

However, any time series variable model whose residuals were significantly correlated with statewide average output variable scores was also plotted with statewide school policy events as a check on the frequency count procedure discussed above.

Each plot of time series was examined for corresponding changes in significantly correlated school input variables and school output variables. These changes were matched with dates of major educational policy events before and after changes appeared to have occurred. Hypothetical policy explanations for changes in school productivity over time were then described.

Chapter IV

RESULTS

Identification and Estimation of Simple Descriptive Time Series Models

Time series data from 1970-1990 were decomposed for each school input and output variable in every Virginia school district using an autoregressive, integrated moving average model (ARIMA) to describe trend, stationarity, cyclicity and autocorrelation in the series. Autocorrelations and partial autocorrelations were examined to identify appropriate ARIMA models for testing. Linear trend was removed from all variable distributions over time before models were developed to establish stationarity of all series. Residuals from the ARIMA models were examined for randomness and the results of observations were used to modify proposed models until randomness of residuals was observed. Tables 7 to 34 below display the results of identifying prospective ARIMA models for all 139 1970-90 Virginia school districts.

Productivity Inputs: School Quality Variables

Average teacher instructional salaries.

Few differences existed in the time series patterns of average teacher salaries among Virginia school districts over the 1970-1990 time period, except for the relative level of salaries. It is possible to describe all districts with a simple autoregressive (AR), trend-removed model (P,D,Q = 1,0,0) with evidence of a consistent two-year cycle and one nearly significant 10-year cycle. The Box-Jenkins autoregressive trend-removed ARIMA(1,0,0) model of the teacher salary time series for all districts averaged together is described in Table 7 following.

Table 7

ARIMA (1,0,0) Model of Teacher Salaries over time for all Virginia School Districts 1970-1990

Label	Estimate	Std Err	t	Prob
AR(1)	0.9786	0.0464	21.09	0.0000

Number Observations	21	Residual Sum Sqrs	8441900
Pseudo R-Squared	99.03437	Root Mean Square	649.6884
Trend Equation	(2949.774)+(1026.742)x(timeperiod)		

This model suggests that average teacher instructional salaries (X_t) in Virginia school districts may be estimated each year by simply looking at the previous year's salary at (t-1) and adding or deleting a few dollars ((1-.9786) times X_{t-1}) to it, sometimes less than the rate of inflation in the economy. This model can account for 99% of the variance in salaries from 1970-1990.

Pupil/teacher ratio.

Most of the school districts (108/139) in Virginia had the same time series model (Autoregressive 1,0,0) accounting for 96.5% of the variance in pupil/teacher ratios from 1970-1990. Table 8 describes the Box-Jenkins trend-removed ARIMA model for these districts. As in teacher salaries, one year of change in pupil/teacher ratios is significantly associated with the next year, but no further in time. This suggests that the major determinant of this variable and instructional salaries is associated with the biennial budgeting cycle in Virginia.

Table 8

ARIMA model for Pupil/Teacher ratio 1970-1990 in 108 Virginia School Districts

Label	Estimate	Std Err	t	Prob
AR(1)	0.9170	0.1706	5.38	0.0000

Number Observations 21 Residual Sum Sqrs 4.830502

Pseudo R-Squared 96.4794 Root Mean Square .491452

Trend Equation (21.01926)+(-.4035729)x(timeperiod)

Although an ARIMA(1,0,0) model accounts for most Virginia school district change over time in pupil/teacher ratios, there appeared to be more variety in the models of this school quality measure than in teacher salaries. For example, 27 of the 137 districts with sufficient data for time series modelling had non-significant autocorrelations across time and were not modeled with a time series (See Table 53 in appendix). The changes in pupil/teacher ratio over time in these districts could be modeled with a simple linear regression model showing consistent decrease in the ratio over the 1970-1990 period with no significant association between pupil/teacher ratios in each year.

In addition to these non-significant models for 27 of the school districts, two districts had more complex autoregressive time series models (2,0,0) than the average district in Virginia. The ARIMA(2,0,0) models for Grayson county and Lynchburg city are described in Tables 9 and 10 following. These account for 97 and 95% of the variance over time in pupil/teacher ratios in these two counties and suggest that the overall trend in decreasing ratios over time is related for one and two years at a time. This may reflect the before and after effect of a change in biennial budgeting at the state level or a local response to such change.

Table 9

ARIMA model for Pupil/teacher ratio 1970-1990 in Grayson Co. School District

Label	Estimate	Std Err	t	Prob
AR(1)	1.1130	0.1938	5.74	0.0000
AR(2)	-0.5476	0.1873	-2.92	0.0035
Number Observations 21			Residual Sum Sqrs 4.92223	
Pseudo R-Squared 97.8582			Root Mean Square .508984	
Trend Equation (24.97857)+(-.5297403)x(timeperiod)				

Both of the school quality variables included in this study are well represented in most Virginia school districts by simple trend-removed, autoregressive(1,0,0) time series models suggesting that changes in these variables are highly correlated from year to year, as might be expected in a state where teacher salaries and pupil/teacher ratios are directly affected by a biennial legislative and executive budgeting process. What remains (1-5%) of the variance in these variables after long term trend and autocorrelation are removed is all that may be expected to impact school output variables.

Table 10

ARIMA model for Pupil/teacher ratio 1970-1990 in Lynchburg School District

Label	Estimate	Std Err	t	Prob
AR(1)	1.2795	0.1571	8.14	0.0000
AR(2)	-0.6583	0.1622	-4.06	0.0000

Number Observations 21   Residual Sum Sqrs 3.514514

Pseudo R-Squared 95.148   Root Mean Square .4300866

Trend Equation (18.97448)+(-.2765974)x(timeperiod)

Productivity Inputs: School Expenditure Variables

Total expenditures per pupil.

This variable may be accounted for in 135/139 of the Virginia school districts with a simple ARIMA(1,0,0) trend-removed model reflecting a consistent increasing trend from 1970-90 in Virginia; a 10 year cycle and consistent correlations in two-year periods. This variable strongly follows the state biennial budgeting cycle, as might be expected when total expenditures follow limits set by the legislature. Table 11 follows and describes the time series model accounting for more than 99% of the year to year variation in total expenditures.

Table 11

ARIMA model for total expenditures per pupil in most Virginia school districts

Label	Estimate	Std Err	t	Prob
AR(1)	0.9861	0.0416	23.71	0.0000

Number Observations	21	Residual Sum Sqrs	254200.8
Pseudo R-Squared	99.14	Root Mean Square	112.7388
Trend Equation	(-167.8864)+(189.6014)x(timeperiod)		

Two Virginia school districts (Prince Edward County and the City of Staunton) were not accounted for by significant autocorrelation of yearly total expenditures. They are represented by a more simple regression trend model increasing yearly from 1970-90. Three small towns (Cape Charles, Fries and Abingdon) did not have sufficient data for the time period to model.

Local expenditures per pupil.

The majority (111/139) of Virginia school district local expenditures per pupil may be accounted for with a simple ARIMA(1,0,0) trend-removed model exhibiting a consistent annual increase from 1970-90 and accounting for more than 96% of the variance in local expenditures per pupil. A 9-10 year cycle is apparent in many of the districts and all 111 time series models exhibit a biennial pattern of autocorrelation probably resulting from the state budget cycle. The ARIMA model for all 111 districts averaged together is described in Table 12 following. Most Virginia districts varied from one another in the amount of local expenditures per pupil, but not in their pattern of expenditure over time.

Table 12

ARIMA model for local expenditures per pupil in most Virginia school districts

Label	Estimate	Std Err	t	Prob
AR(1)	1.0056	0.0879	11.44	0.0000

Number Observations	21	Residual Sum Sqrs	206131
Pseudo R-Squared	96.4298	Root Mean Square	101.5212
Trend Equation	(105.2138)+(82.14178)x(timeperiod)		

The model for local expenditures contains a phi component of approximately 1. This violates the assumption of stationarity in the time series and limits interpretations of the model to the time period 1970-90. This results from the dependence of the phi parameter on the time when starting values are chosen (Harvey, 1981). No other time series model tested in this analysis could be found that described the time series as well as this AR(1,0,0) model. Interpretations of local expenditure relationships should be limited specifically to the time period analyzed here, 1970 to 1990.

The Prince Edward County school district was described by an ARIMA(2,0,0) model accounting for 83% of the variance in local expenditures per pupil. Table 13 follows and describes the time series model for Prince Edward. It appears as if local expenditures in Prince Edward are correlated for one and two year periods and vary up, then down repeatedly for the 1970-90 time period while generally increasing over time.

Twenty-six of the districts did not exhibit significant autocorrelation in their local expenditures and could not be modelled with a time series (See Table 53 in appendix). These all exhibited the same general linear trend of increasing expenditures over the 1970-90 time period, but their time series varied around the long term trend line in a random fashion from year to year.

Table 13

ARIMA model for local expenditures per pupil in Prince Edward County

Label	Estimate	Std Err	t	Prob
AR(1)	0.4245	0.2074	2.05	0.0407
AR(2)	-0.6114	0.2059	-2.97	0.0030

Number Observations	21	Residual Sum Sqrs	171141.5
Pseudo R-Squared	82.6986	Root Mean Square	94.90756
Trend Equation	(234.8762)+(30.78182)x(timeperiod)		

State expenditures per pupil.

The majority (128/139) of Virginia school district state expenditures per pupil may be accounted for with a simple ARIMA(1,0,0) trend-removed model exhibiting a consistent annual increase from 1970-90 and accounting for more than 97% of the variance in local expenditures per pupil. A 10 year cycle is apparent in many of the districts and all 128 time series models exhibit a biennial pattern of autocorrelation probably resulting from the state budget cycle. The ARIMA model for all 128 districts averaged together is described in Table 14 following.

Table 14

ARIMA model for state expenditures per pupil in most Virginia school districts

Label	Estimate	Std Err	t	Prob
AR(1)	0.9391	0.0730	12.87	0.0000

Number Observations	21	Residual Sum Sqrs	104685.1
Pseudo R-Squared	97.8117	Root Mean Square	72.34817
Trend Equation	(-116.4952)+(75.60563)x(timeperiod)		

Most Virginia districts varied in the level of state expenditures per pupil, but not in their pattern of expenditure over time.

Four Virginia school district state expenditures per pupil were not modelled with time series since the autocorrelation between consecutive years of expenditure was not significant. These are listed in Table 53 in appendix.

Nansemond, Clifton Forge, Manassas, Manassas Park, Salem, Abingdon and Saltville were not modelled at all since there was insufficient data available for this variable in the 1970-90 time period in these localities.

Federal expenditures per pupil.

A substantial number (54/139) of Virginia school district federal expenditures per pupil could be modelled with time series. The ARIMA model for 50 of these districts is an autoregressive trend-removed(1,0,0) series which increases over time (See Table 15 following).

Table 15

ARIMA model for federal expenditures per pupil in 50 Virginia school districts

Label	Estimate	Std Err	t	Prob
AR(1)	0.6149	0.1799	3.42	0.0006

Number Observations	21	Residual Sum Sqrs	1837.368
Pseudo R-Squared	97.8626	Root Mean Square	9.584801
Trend Equation	(62.36903)+(10.38625)x(timeperiod)		

Four of the districts (Accomack, Prince George, Wise and Waynesboro) were modelled with an autoregressive, trend-removed (2,0,0) model which increases, then decreases, then increases again over time (See Table 16 following). Both models exhibit a 9-10 year cycle and describe a biennial and triennial pattern of change in federal expenditures per pupil.

The majority (77/139) of Virginia school district federal expenditures per pupil were not modelled with time series since the year to year autocorrelations were non-significant. These are noted in Table 53 in appendix. The pattern of federal expenditures in these districts from 1970-90 was more or less random each year, but with an overall increasing trend. Eight additional school district federal expenditures per pupil were not analyzed (Nansemond, Clifton Forge, Manassas, Manassas Park, Salem, Fries, Abingdon and Saltville), since they had too few cases for computation of autocorrelations.

Table 16

ARIMA model for federal expenditures per pupil in 4 Virginia school districts

Label	Estimate	Std Err	t	Prob
AR(1)	0.6619	0.1623	4.08	0.0000
AR(2)	-0.7211	0.1615	-4.47	0.0000

Number Observations 21 Residual Sum Sqrs 2106.685

Pseudo R-Squared 98.68829 Root Mean Square 10.52987

Trend Equation (65.79143)+(14.22448)x(timeperiod)

Transportation expenditures per pupil.

This variable seemed to be the most difficult to adequately model with simple time series descriptions. A significant change in this expenditure variable in the 1980-81 time period dramatically lowered the level of transportation funding and re-set the previous series of rising expenditures to a new series of rising expenditures. Both series (before and after 1980) peaked and then fell, suggesting a moving average phenomena. Moreover, the direction of trend in most Virginia districts was gently falling from 1970-90, despite the opposing trend in national energy and transportation costs. It looks as if Virginia spent less per pupil on transportation during a time when costs were going up.

However, almost half of the city school districts exhibited the expected steadily increasing trend, opposite that of most other districts. Due to this variation in the pattern of transportation expenditures per pupil, one autoregressive, trend-removed time series model ARIMA(1,0,0) was developed for 67 (48% of all 139) school districts with significant autocorrelations between each year from 1970-90. Transportation expenditures followed the same biennial correlation pattern as most other expenditure variables in these districts.

The model developed for this majority of Virginia districts is shown in Table 17 following. The model accounts for only 33% of the variance in transportation expenditures but the residuals from the model were randomly distributed through time so it is presumed to account for changes in expenditures over time. Other unanalyzed phenomena are presumed to account for the remaining variance in transportation expenditures.

A more complex ARIMA(0,0,2) moving average model was used to describe the 1970-90 transportation expenditures per pupil of 14 additional school districts listed in Table 18 following. This model suggests that two waves of expenditure increases and decreases occurred in the 1970-90 time period, which matches the apparent distribution of raw scores fairly well.

Table 17

ARIMA model for transportation expenditures per pupil in 67 Virginia school districts

Label	Estimate	Std Err	t	Prob
AR(1)	0.5530	0.1873	2.95	0.0032

Number Observations 21 Residual Sum Sqrs 1125.5

Pseudo R-Squared 33.91143 Root Mean Square 7.501665

Trend Equation (35.8182)+(-.3523384)x(timeperiod)

Table 18

School districts modeled with a moving average time series for transportation expenditures

Amelia	Bland
Carroll	Craig
Franklin	Hanover
Northhampton	Prince George
Spotsylvania	Stafford
Washington	Norfolk
Roanoke City	West Point

This model (See Table 19 following) accounts for 56% of the variance in transportation expenditures but seems to conflict with the known steadily increasing cost of transportation in the state and nation during this time period. These school districts were experiencing something very different than expected with national transportation expenditures in this time period.

Table 19

Transportation expenditures per pupil modeled with a moving average time series for 14 Virginia school districts

MOVING AVERAGE PARAMETERS

Label	Estimate	Std Err	t	Prob
MA(1)	-0.4902	0.1284	-3.82	0.0001
MA(2)	-0.8910	0.1140	-7.82	0.0000

Number Observations 21 Residual Sum Sqrs 1019.719

Pseudo R-Squared 56.385 Root Mean Square 7.325943

Trend Equation (41.91404)+(-.5663157)x(timeperiod)

Approximately 1/3 of the school districts (46/139) did not exhibit significant autocorrelation between transportation expenditure years and were not modeled with any time series. Another 12 Virginia school districts had insufficient transportation expenditure data for time series models to be developed. These are all noted in Table 53 in appendix.

Instructional expenditures per pupil (state minus transportation).

This variable represents the difference between state expenditures per pupil and transportation expenditures and was assumed to represent expenditures primarily directed at instruction and therefore expected to affect school outputs, like achievement, most directly. Instructional expenditures per pupil may be accounted for in 123 of the 139 Virginia school districts with a simple ARIMA(1,0,0) trend-removed model reflecting a consistent increasing trend from 1970-90 in Virginia; a 10 year cycle and consistent correlations in two-year periods. This variable strongly follows the state biennial budgeting cycle. Table 20 follows and describes the time series model accounting for more than 97% of the year to year variation in instructional expenditures.

Table 20

ARIMA model for instructional expenditures per pupil in 123 Virginia school districts

Label	Estimate	Std Err	t	Prob
AR(1)	0.9468	0.0771	12.27	0.0000

Number Observations	21	Residual Sum Sqrs	115634.7
Pseudo R-Squared	97.658	Root Mean Square	76.03773
Trend Equation	(-117.6987)+(76.37833)x(timeperiod)		

Four Virginia school district instructional expenditures exhibited non-significant autocorrelation patterns from year to year in 1970-90 (Arlington, Bath, Surry, and Williamsburg) and were not modeled with time series. Another 12 districts had insufficient instructional expenditure data to compute time series from and were excluded from analysis. These are listed in Table 53 in appendix.

School Productivity Input Variable Summary.

All school productivity input variables analyzed in this study could be modeled with time series. Most school districts exhibited an ARIMA (1,0,0) model with an increasing linear trend, a 2 year cycle of autoregression, and a background 10 year cycle of less significance. For every input variable analyzed, at least a few districts did not have significant time series models. Federal expenditures per pupil and transportation expenditures per pupil were least able to be modeled with simple time series.

School Productivity Outputs: Attainment Variables

Percent of all grades promoted.

The vast majority (122/139) of Virginia school district promotion data exhibited more or less random patterns over time and could not be modeled with time series. Another six districts had too little data for modeling and were excluded from analysis (Nansemond, Clifton Forge, Salem, Cape Charles, Fries, Abingdon, and Saltville).

Only 11 school district promotion variable patterns could be modeled with time series (Albemarle, Arlington, Essex, Greensville, Isle of Wight, King and Queen, Loudon, Page, Patrick, Pulaski, Chesterfield, and Fredericksburg).

These exhibited an ARIMA(2,0,1) pattern with increasing, then decreasing patterns with average peaks and troughs every couple of years. Table 21 follows and describes the time series model for these districts accounting for only 41% of the variance in this variable.

Percent of ninth grade class graduating.

The majority of school district percent of ninth grade students graduating scores (104/139) could not be modeled with time series because the autocorrelation of year to year measures was not significant. Another 11 districts had insufficient data (*N* < 9) to compute time series and were excluded from the analysis.

Table 21

Time series model for 11 school district percent of all students promoted from 1970-90

AUTOREGRESSIVE PARAMETERS				
Label	Est.	Std Err	t	Prob
AR(1)	0.5606	0.2596	2.16	0.0308
MOVING AVERAGE PARAMETERS				
Label	Est.	Std Err	t	Prob
MA(1)	0.9335	0.1004	9.30	0.0000
Number Observations 15		Residual Sum Sqrs 21.5874		
Pseudo R-Squared 41.7		Root Mean Square 1.288631		
Trend Equation	(90.49522)+(.2014446)x(timeperiod)			

Nineteen Virginia school district ninth grade graduating percentage scores could be modeled with time series. Models varied from ARIMA(1,0,0) for 18 districts to ARIMA(3,0,0) for Chesterfield County. Most of the modeled patterns from 1970-90 seemed to vary up and down with periodic peaks and troughs over several years. Tables 22 to 24 follow and describe each model and the districts associated with them.

Table 22

Virginia school districts (N=18) with ARIMA(1,0,0) model for percent of ninth grade graduating from 1970-90

Campbell	Caroline	Fairfax
Gloucester	Henrico	Lancaster
Prince Edward	Richmond county	Rockingham
Spotsylvania	Washington	Charlottesville
Fredericksburg	Hopewell	Petersburg
Portsmouth	Radford	Suffolk

Table 23

Time series model for 18 school districts - percent of ninth grade graduating 1970-90

AUTOREGRESSIVE PARAMETERS

Label	Estimate	Std Err	t	Prob
AR(1)	0.7009	0.1639	4.28	0.0000

Number Observations 20 Residual Sum Sqrs 70.45315

Pseudo R-Squared 56.358 Root Mean Square 1.925632

Trend Equation (74.41239)+(-.196842)x(timeperiod)

The ARIMA(1,0,0) model for these 18 districts accounted for 56% of the variance in percent of ninth graders graduating each year from 1970-90. The long-term trend seems to be decreasing over this period (See Table 23). Chesterfield County was the single school district with an ARIMA(3,0,0) model for the percent of ninth graders graduating in 1970-90. This model accounted for 63% of the variance from 1970-90 (See Table 24).

Percent attending any college.

The majority of Virginia school district percent attending any college scores (106/139) could not be modeled with time series because the autocorrelation of year to year measures was not significant. Another 8 districts had insufficient data ($N < 9$) to compute time series and were excluded from the analysis.

Table 24

Time series model for Chesterfield - percent of ninth grade graduating 1970-90

AUTOREGRESSIVE PARAMETERS						
Label	Estimate	Std Err	t	Prob		
AR(1)	0.4971	0.1648	3.02	0.0026		
AR(2)	0.5556	0.1456	3.82	0.0001		
AR(3)	-0.6909	0.1515	-4.56	0.0000		
Number Observations		20			Residual Sum Sqrs	537.4619
Pseudo R-Squared		63.91			Root Mean Square	5.622757
Trend Equation	(73.91315)+(.6911278)x(timeperiod)					

Twenty-five Virginia school district percent attending any college variables could be modeled with time series. Models varied from ARIMA(1,0,0) for 20 districts to ARIMA(0,0,1) for five districts (Caroline, Isle of Wight, New Kent, Smyth, and Sussex). Most of the modelled patterns from 1970-90 seemed to vary randomly up and down with periodic peaks and troughs over several years. Tables 25 to 27 follow and describe each model and the districts associated with them.

Table 25

Virginia school districts (N=20) with an ARIMA(1,0,0) model for percent of students attending any college after graduation from 1970-90

Amherst	Botetourt	Buchanan
Dickenson	Dinwiddie	Fairfax
Franklin	Giles	King George
Lancaster	Loudon	Nelson
Rockbridge	Russell	Shenendoah
Wise	Norfolk	Suffolk
Colonial Beach	Fries	

The ARIMA(1,0,0) model for these 20 districts accounted for 88% of the variance in percent of graduates attending college each year from 1970-90. The long-term trend seems to be slightly decreasing over this period (See Table 26).

The second time series model (ARIMA 0,0,1) for percent of graduates attending college from 1970-90 applied to five districts (Caroline, Isle of Wight, New Kent, Smyth, and

Sussex) and accounted for only 29% of the variance from 1970-90 (See Table 27).

Table 26

Time series model for 20 school districts - percent of graduates attending any college 1970-90

AUTOREGRESSIVE PARAMETERS

Label	Estimate	Std Err	t	Prob
AR(1)	0.9617	0.0496	19.39	0.0000

Number Observations 21 Residual Sum Sqrs 103.1938

Pseudo R-Squared 88.27995 Root Mean Square 2.271495

Trend Equation (36.54903)+(.6328204)x(timeperiod)

Table 27

Time series model for 5 school districts - percent of graduates attending any college 1970-90

MOVING AVERAGE PARAMETERS

Label	Estimate	Std Err	t	Prob
MA(1)	-0.4494	0.2023	-2.22	0.0263

Number Observations 21 Residual Sum Sqrs 180.2704

Pseudo R-Squared 29.44902 Root Mean Square 3.002252

Trend Equation (35.68971)+(.2066495)x(timeperiod)

Percent continuing education in institutions other than colleges.

The majority of school district percent attending post high school education other than college scores (118/139) could not be modeled with time series because the autocorrelation of year to year measures was not significant. Another 6 districts had insufficient data ($N < 9$) to compute time series and were excluded from the analysis.

Fifteen Virginia school district percent attending post high school education other than college scores could be modeled with time series. Models varied from ARIMA(1,0,0) for 14 districts to ARIMA(1,0,1) for Bedford county. Most of the modeled patterns from 1970-90 seemed to vary randomly up and down with periodic peaks and troughs over several years. Tables 28 to 30 below describe each model and the districts associated with them.

Table 28

Virginia school districts (N=14) with an ARIMA(1,0,0) model for percent of students attending post high school education other than college after graduation from 1970-90

Amelia	Dickenson	Essex
Fauquier	Mathews	Northhampton
Spotsylvania	Sussex	Wise
York	Norfolk	Portsmouth
Roanoke City	Colonial Beach	

The ARIMA(1,0,0) model for these 14 districts accounted for 48% of the variance in percent of graduates attending post high school education other than college each year from 1970-90. The long-term trend seems to be slightly decreasing over this period (See Table 29).

The second time series model (ARIMA 1,0,1) for percent of graduates attending post high school education other than college from 1970-90 applied only to Bedford county and accounted for only 26% of the variance from 1970-90 (See Table 30).

Table 29

Time series model for 14 school districts - percent of graduates attending post high school education other than college 1970-90

AUTOREGRESSIVE PARAMETERS

Label	Estimate	Std Err	t	Prob
AR(1)	0.7284	0.1440	5.06	0.0000

Number Observations 21 Residual Sum Sqrs 36.7727

Pseudo R-Squared 48.33868 Root Mean Square 1.355963

Trend Equation (10.40315)+(-8.316328E-02)x(timeperiod)

Percent of all students who are classified as dropouts.

The majority of Virginia school district percent classified as dropouts scores (98/139) could not be modeled with time series because the autocorrelation of year to year measures was not significant. Another 5 districts had insufficient data (N < 9) to compute time series and were excluded from the analysis.

Thirty-four Virginia school district percent classified as dropouts variables could be modeled with an autoregressive, trend-removed ARIMA(1,0,0) model. Greensville county was modeled with an ARIMA(2,0,1) mixed model and Pulaski county was modeled with an ARIMA(2,0,0) model. Most of the modeled patterns from 1970-90 seemed to vary randomly up and down with periodic peaks and troughs over several years and a generally decreasing trend. Tables 31 to 34 follow and describe each model and the districts associated with them.

Table 30

Time series model for Bedford county - percent of graduates attending post high school education other than college 1970-90

AUTOREGRESSIVE PARAMETERS

Label	Estimate	Std Err	t	Prob
AR(1)	-0.9996	0.0333	-30.01	0.0000

MOVING AVERAGE PARAMETERS

Label	Estimate	Std Err	t	Prob
MA(1)	-0.9348	0.1068	-8.75	0.0000

Number Observations	21	Residual Sum Sqrs	56.12768
Pseudo R-Squared	26.75086	Root Mean Square	1.718746

Trend Equation (5.487143)+(2.974026E-02)x(timeperiod)

The ARIMA(1,0,0) model for these 34 districts accounted for 72% of the variance in percent of graduates classified as dropouts each year from 1970-90. The long-term trend seems to be slightly decreasing over this period (See Table 32). The second time series model (ARIMA 2,0,0) for percent of graduates classified as dropouts from 1970-90 applied only to Greensville county and accounted for only 46% of the variance from 1970-90 (See Table 33).

Table 31

Virginia school districts (N=34) with an ARIMA(1,0,0) model for percent classified as dropouts from 1970-90

Augusta	Chesterfield	Dickenson
Fauquier	Goochland	Greene
Halifax	Henrico	King George
Montgomery	Northumberland	Orange
Prince William	Rockingham	Russell
Scott	Stafford	Warren
Washington	Wise	York
Alexandria	Danville	Hopewell
Lycnhburg	Martinsville	Norfolk
Portsmouth	Radford	Roanoke city
Williamsburg	Winchester	West Point
Cape Charles		

The third time series model (ARIMA 2,0,0) for percent of graduates classified as dropouts from 1970-90 applied only to Pulaski county and accounted for only 49% of the variance from 1970-90 (See Table 34).

Table 32

Time series model for 34 school districts - percent of graduates classified as dropouts from 1970-90.

AUTOREGRESSIVE PARAMETERS

Label	Estimate	Std Err	t	Prob
AR(1)	0.9028	0.1003	9.00	0.0000

Number Observations	21	Residual Sum Sqrs	2.899962
Pseudo R-Squared	72.90996	Root Mean Square	.3802898

Trend Equation (5.629169)+(-2.543089E-02)x(timeperiod)

Table 33

Time series model for Greensville county - percent of graduates classified as dropouts 1970-90.

AUTOREGRESSIVE PARAMETERS

Label	Estimate	Std Err	t	Prob
AR(1)	0.6742	0.1987	3.39	0.0007
AR(2)	-0.5294	0.2045	-2.59	0.0096

Number Observations	21	Residual Sum Sqrs	18.49233
Pseudo R-Squared	46.22686	Root Mean Square	.9865497

Trend Equation (9.349048)+(-7.155844E-02)x(timeperiod)

Table 34

Time series model for Pulaski county - percent of graduates classified as dropouts 1970-90

AUTOREGRESSIVE PARAMETERS

Label	Estimate	Std Err	t	Prob
AR(1)	0.7198	0.1991	3.61	0.0003
AR(2)	-0.5023	0.1932	-2.60	0.0093

Number Observations 21 Residual Sum Sqrs 13.87378

Pseudo R-Squared 49.78122 Root Mean Square .8543758

Trend Equation (6.467619)+(-7.584416E-02)x(timeperiod)

School Productivity Outputs: Achievement Variables.

Before achievement variables were analyzed with time series, the effects of average student ability in each school district were removed from the achievement variables. The proportion of variance shared between student ability and achievement scores varied for each district in each grade level analyzed. Fourth grade proportions varied from a low of .04 % shared between reading scores and ability in one district to a high of 89% shared between language arts scores and ability in another district. Eighth grade proportions shared varied from a low of 6% shared between language arts scores and ability in one district to a high of 99.3% shared between language arts scores and ability in another. Eleventh grade proportions shared varied from a low of 6% shared between reading scores and ability in one district to a high of 99.5% shared between language arts scores and ability in another.

Although student ability accounted for most of the variance in achievement scores in most Virginia school districts, as expected, the very low (near zero) correlation between ability and achievement in some districts was an unexpected finding. The variance of each ability and achievement variable in every Virginia school district was checked to see if very low variance in some districts might account for the resulting low correlation values.

None of the district ability or achievement variables in school districts with near zero correlation values exhibited near zero variance. The lowest variance observed in any district for any variable was four percentile equivalent score points over nine years. However, this district, and others with low variance, had relatively high correlation values.

On the other hand, some districts with variance in ability and achievement scores greater than 100 percentile equivalent points over 21 years had near zero correlation values. The computed achievement residuals were accepted as representative of student achievement with ability removed.

Time series were then run on the residuals from regressing ability out of achievement variables. Only reading, math and language arts scores residuals for fourth grade students had sufficient numbers of years ($\underline{N}$=12) to analyze for time series and none of the districts exhibited autocorrelations exceeding the critical level of significance for so few observations. As a result, no time series models were developed for achievement score residuals.

Output variable summary.

School attainment and achievement output variables varied randomly over time for most Virginia school districts from 1970 to 1990. As a result, analysis of the relationship between school inputs and outputs was continued using the residuals from time series models of school input variables, raw scores from school attainment variables and ability-residualized school achievement scores.

Relationships between Input Variable Time Series Residuals and Output Variable Raw and Residualized Scores

After linear long-term trends and time series autocorrelation were removed from school productivity input variable (K=8) scores, averaged across all districts exhibiting the same time series model, residuals from these scores were correlated with raw educational attainment school productivity output variable (K=5) scores and with residualized achievement scores (K=9) from all 139 Virginia school districts. Correlations were also computed between statewide average time series model residuals and statewide average school output variables (N=139). Any correlation found significant at the .05 probability level in any district (N <= 139) or for any statewide average input/output variable pairing (N=139) was tabulated for each output variable.

The number of districts exhibiting significant correlation between school input and output variables was counted. The number of positive and negative correlations were separately tabulated. An average variance shared and standard deviation of variance shared for all significant districts for each input variable was computed. The results of each correlation analysis for educational attainment output variables are summarized in Tables 35 to 39 below.

Only input-output relationships that significantly affected more than 30 districts (about 25% of all districts) or that were found significant between statewide average inputs and outputs in the state were noted and later examined for association with policy events. This limit was arbitrarily established as a lower limit since the researcher believed that any policy which did not affect at least one-quarter of the state's school districts or a statewide average school district could not have substantial statewide impact and would not be of interest to the state educational policy constituency.

School Outputs: Educational Attainments

Percent of graduates attending any college.

Residuals from time series models of total expenditures, local expenditures, instructional salaries, pupil/teacher ratio, instructional expenditures, and state expenditures were significantly correlated in more than 25% of all Virginia school districts (See Table 35 below).

Assuming the results of this correlation analysis represent average associations between school inputs and percent of graduates going to any college in Virginia, examination of residuals from the time series models suggests that minor positive changes (residual averages of $1.13 to $14.00 1984 dollars) in instructional salaries, total expenditures, local expenditures, and instructional expenditures are associated with the overall increase in percent of graduates going to college in Virginia from 1970 to 1990.

Table 35

Average correlation of school productivity variable time series model residuals and percent of graduates attending any college 1970-90

Output	% graduates going to any college					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD)* AVS	SAV* (r)
Pupil/Teacher ratio ARIMA(1,0,0)	45	45 (.52)		.28	.008	.57*
Pupil/Teacher ratio ARIMA(2,0,0)	10	10 (.48)		.26	.008	.41
Instructional Salaries ARIMA(1,0,0)	72	72 (.62)		.39	.13	.59*
Total expenditures ARIMA(1,0,0)	91	91 (.68)		.46	.18	.69*
Local expenditures ARIMA(2,0,0)	3	2 (.47)	1 (-.49)	.23	.003	.13
Local expenditures ARIMA(1,0,0)	85	85 (.59)		.36	.11	.66*
Federal expenditures ARIMA(1,0,0)	2	2 (.47)		.22	.004	.0004
Federal expenditures ARIMA(2,0,0)	1	1 (.46)		.22	.004	.30
State expenditures ARIMA(1,0,0)	30	30 (.48)		.23	.004	.36

Output		% graduates going to any college				
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD)* AVS	SAV* (r)
Transportation expenditures ARIMA(1,0,0)	4	1 (.44)	3 (-.48)	.22	.004	.04
Transportation expenditures ARIMA(0,0,2)	2	1 (.43)	1 (-.48)	.21	.003	-.05
Instructional Expenditures ARIMA(1,0,0)	43	43 (.53)		.29	.008	.46*

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* p < .05)

However, a minor loss (negative average residuals of -$1.13) of state expenditures is also associated with the long term increase in college-going graduates. Similarly, a trivial positive average residual (.008%) increase in pupil/teacher ratio may be associated with the increase in college-going graduates over time.

Percent of dropouts.

Residuals from time series models of total expenditures, pupil/teacher ratio, instructional salaries and local expenditures, were significantly correlated in more than 25% of all Virginia school districts (See Table 36 below).

Table 36

Average correlation of school productivity variable time series model residuals and percent of dropouts 1970-90

Output	% dropouts					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV* (r)
Pupil/Teacher ratio ARIMA(1,0,0)	46		46 (-.50)	.28	.008	-.71*
Pupil/Teacher ratio ARIMA(2,0,0)	7	1 (.45)	6 (-.48)	.23	.003	-.36
Instructional Salaries ARIMA(1,0,0)	45	4 (.59)	41 (-.56)	.33	.009	-.45*
Total expenditures ARIMA(1,0,0)	52	7 (.49)	45 (-.56)	.34	.124	-.41
Local expenditures ARIMA(2,0,0)	2	1 (.51)	1 (-.59)	.31	.006	-.19
Local expenditures ARIMA(1,0,0)	32	1 (.60)	31 (-.54)	.30	.008	-.49*
Federal expenditures ARIMA(1,0,0)	5	4 (.55)	1 (-.54)	.29	.004	.15
Federal expenditures ARIMA(2,0,0)	3		3 (-.52)	.27	.007	-.20
State expenditures ARIMA(1,0,0)	12		12 (-.48)	.27	.008	-.31
Transportation expenditures ARIMA(1,0,0)	4	1 (.88)	3 (-.51)	.41	.248	-.35

Output	% dropouts					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV* (r)
Transportation expenditures ARIMA(0,0,2)	3	2 (.45)	1 (-.47)	.21	.001	-.25
Instructional Expenditures ARIMA(1,0,0)	18	3 (.51)	15 (-.52)	.28	.008	-.28

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* p < .05)

Examination of residuals from the time series models suggests that minor positive changes in instructional salaries, total expenditures, and local expenditures are associated with the overall decrease in percent of dropouts from Virginia schools from 1970 to 1990. However, a trivial positive average residual increase in pupil/teacher ratio may also be associated with the decrease in dropouts over time.

Percent of students promoted..

Residuals from time series models of total expenditures and instructional salaries were significantly correlated in more than 25% of all Virginia school districts (See Table 37).

Table 37

Average correlation of school productivity variable time series model residuals and percent of students promoted in Virginia 1970-90

Output			% Promotion			
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	9	8 (.56)	1 (-.52)	.34	.0068	.23
Pupil/Teacher ratio ARIMA(2,0,0)	4	4 (.57)		.34	.0036	-.18
Instructional Salaries ARIMA(1,0,0)	40	40 (.6)		.39	.10	.02
Total expenditures ARIMA(1,0,0)	46	46 (.65)		.43	.11	.04
Local expenditures ARIMA(2,0,0)	4	2 (.65)	2 (-.56)	.37	.14	-.06
Local expenditures ARIMA(1,0,0)	16	14 (.63)	2 (-.54)	.38	.008	.13
Federal expenditures ARIMA(1,0,0)	2		2 (-.56)	.32	.006	.04
Federal expenditures ARIMA(2,0,0)	1	1 (.56)		.31		-.16

Output	% Promotion					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
State expenditures ARIMA(1,0,0)	5	5 (.56)		.33	.009	-.08
Transportation expenditures ARIMA(1,0,0)	4	1 (.94)	3 (-.58)	.46	.288	.07
Transportation expenditures ARIMA(0,0,2)	4		4 (-.56)	.32	.003	-.06
Instructional Expenditures ARIMA(1,0,0)	8	7 (.55)	1 (-.68)	.31	.006	-.05

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* p < .05)

Examination of residuals from the time series models suggests that minor positive changes in instructional salaries and total expenditures are associated with the overall increase in percent of students promoted in all grades in Virginia schools from 1970 to 1990.

However, a trivial positive average residual increase in pupil/teacher ratio may also be associated with the increase in promotion rates over time. Moreover, these patterns do not hold up over the state as an average, there being no significant correlation of time series model residuals with statewide average percent promoted. Perhaps the school districts where time series model residuals did correlate significantly with the percent of students promoted differ from the average statewide school district in some manner not explored here.

Percent of ninth grade graduates.

Residuals from time series models of total expenditures, instructional salaries and local expenditures were significantly correlated in more than 25% of all Virginia school districts (See Table 38 following).

Examination of residuals from the time series models suggests that minor positive changes in total expenditures, instructional salaries and local expenditures are associated with the overall increase in the percent of ninth grade students graduating from Virginia schools from 1970 to 1990. However, a trivial positive average residual increase in pupil/teacher ratio may also be associated with the increase in the percent of ninth grade graduates over time.

Table 38

Average correlation of school productivity variable time series model residuals and percent of ninth grade students graduating in Virginia 1970-90

Output	% Ninth grade graduates					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	12	10 (.52)	2 (-.50)	.27	.004	.39
Pupil/Teacher ratio ARIMA(2,0,0)	7	3 (.52)	4 (-.54)	.30	.078	.13

Output	% Ninth grade graduates					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Instructional Salaries ARIMA(1,0,0)	33	27 (.54)	6 (-.62)	.34	.116	.49*
Total expenditures ARIMA(1,0,0)	42	34 (.56)	8 (-.64)	.36	.142	.42
Local expenditures ARIMA(2,0,0)	3	1 (.53)	2 (-.51)	.26	.004	.28
Local expenditures ARIMA(1,0,0)	32	26 (.53)	6 (-.51)	.29	.006	.57*
Federal expenditures ARIMA(1,0,0)	4	1 (.54)	3 (-.48)	.26	.008	-.24
Federal expenditures ARIMA(2,0,0)	8	5 (.48)	3 (-.47)	.25	.006	-.07
State expenditures ARIMA(1,0,0)	12	8 (.52)	4 (-.51)	.28	.062	.19
Transportation expenditures ARIMA(1,0,0)	7	6 (.58)	1 (-.56)	.34	.006	.26
Transportation expenditures ARIMA(0,0,2)	6	5 (.52)	1 (-.60)	.35	.175	.30
Instructional Expenditures ARIMA(1,0,0)	16	9 (.56)	7 (-.56)	.31	.008	.05

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* p < .05)

Percent of graduates going to education other than college.

None of the residuals from time series models of school input variables were significantly correlated with the percent of graduates going to education other than college in more than 25% of all Virginia school districts (See Table 39 below). However, statewide average federal expenditure residuals were positively correlated with statewide average percent of students going to education other than college.

Table 39

Average correlation of school productivity variable time series model residuals and percent of graduates going to education other than college in Virginia 1970-90

Output	% graduates going to other than college					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	17	5 (.47)	12 (-.52)	.26	.005	-.10
Pupil/Teacher ratio ARIMA(2,0,0)	5	2 (.56)	3 (-.55)	.33	.12	-.30
Instructional Salaries ARIMA(1,0,0)	24	14 (.52)	10 (-.53)	.28	.007	-.08
Total expenditures ARIMA(1,0,0)	27	10 (.56)	17 (-.52)	.30	.01	-.03
Local expenditures ARIMA(2,0,0)	3		3 (-.49)	.24	.004	-.34

Output	% graduates going to other than college					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Local expenditures ARIMA(1,0,0)	21	7 (.54)	14 (-.51)	.28	.008	-.18
Federal expenditures ARIMA(1,0,0)	9	6 (.48)	3 (-.48)	.27	.14	.58*
Federal expenditures ARIMA(2,0,0)	5	4 (.44)	1 (-.44)	.20	.000 5	.11
State expenditures ARIMA(1,0,0)	6	6 (.54)		.27	.005	.04
Transportation expenditures ARIMA(1,0,0)	9		9 (-.47)	.26	.008	-.29
Transportation expenditures ARIMA(0,0,2)	6	3 (.48)	3 (-.48)	.25	.006	-.31
Instructional Expenditures ARIMA(1,0,0)	12	11 (.47)	1 (-.46)	.24	.006	.06

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* $p < .05$)

It appears from the correlation analysis of time series residuals and school attainment variable scores that the percent of students attending college after graduation and the percent of those dropping out of school are most often associated with positive residuals of school inputs variables in Virginia over the 1970-90 time period.

School Outputs: Educational Achievements

A similar correlation analysis relating time series input variable residuals to ability-residualized achievement scores produced no relationships significant in more than 25% of all Virginia school districts. Reading score residuals in grade 4 came closest to meeting this criterion as almost 30 school districts exhibited significant correlation between pupil/teacher ratio residual scores and achievement residuals. These results are probably due to the low number of years (12) for which achievement data were available. Tables 40 to 48 follow and describe potential school productivity relationships for achievement variables that future extended analysis may show to be significant.

Reading achievement: grades 4,8,11.

Despite the fact that only 12 years of data were available for analysis of reading achievement score residuals, relationships between most of the input variables and achievement outputs shared 40 to 60% of their variance in common. This was generally more than that shared with attainment variables.

Table 40

Average correlation of school productivity variable time series model residuals and grade 4 reading achievement score residuals in Virginia 1970-90

Output	reading grade 4					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	31	1 (.61)	30 (-.65)	.43	.009	-.66*
Pupil/Teacher ratio ARIMA(2,0,0)	3	1 (.57)	2 (-.61)	.36	.005	-.15
Instructional Salaries ARIMA(1,0,0)	No effects					
Total expenditures ARIMA(1,0,0)	7	7 (.61)		.41	.007	.24
Local expenditures ARIMA(2,0,0)	22	1 (.74)	21 (-.66)	.46	.103	-.63*
Local expenditures ARIMA(1,0,0)	3		3 (-.61)	.38	.000 6	-.24
Federal expenditures ARIMA(1,0,0)	4		4 (-.65)	.42	.07	.16
Federal expenditures ARIMA(2,0,0)	2	1 (.76)	1 (-.73)	.55	.002	.08
State expenditures ARIMA(1,0,0)	No effects					.07

Output	reading grade 4					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS	SAV (r*)
Transportation expenditures ARIMA(1,0,0)	3	2 (.64)	1 (-.62)	.40	.005	.10
Transportation expenditures ARIMA(0,0,2)	6	6 (.60)		.40	.008	.21
Instructional Expenditures ARIMA(1,0,0)	No effects					.03

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* p < .05)

Table 41

Average correlation of school productivity variable time series model residuals and grade 8 reading achievement score residuals in Virginia 1970-90

Output	Reading grade 8					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	5	2 (.81)	3 (-.75)	.60	.12	-.30
Pupil/Teacher ratio ARIMA(2,0,0)	12	5 (.79)	7 (-.72)	.60	.15	-.39
Instructional Salaries ARIMA(1,0,0)	3	1 (.70)	2 (-.71)	.50	.006	.22

Output	Reading grade 8					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Total expenditures ARIMA(1,0,0)	No effects					.14
Local expenditures ARIMA(2,0,0)	4	1 (.79)	3 (-.71)	.61	.19	-.23
Local expenditures ARIMA(1,0,0)	8	3 (.69)	5 (-.82)	.59	.11	-.20
Federal expenditures ARIMA(1,0,0)	1	1 (.68)		.47		.64
Federal expenditures ARIMA(2,0,0)	6	3 (.79)	3 (-.69)	.58	.11	-.23
State expenditures ARIMA(1,0,0)	3		3 (-.73)	.54	.009	-.06
Transportation expenditures ARIMA(1,0,0)	5	3 (.79)	2 (-.71)	.58	.10	-.33
Transportation expenditures ARIMA(0,0,2)	12	1 (.75)	11 (-.73)	.54	.005	-.48
Instructional Expenditures ARIMA(1,0,0)	5		5 (-.72)	.64	.20	.01

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* p < .05)

Table 42

Average correlation of school productivity variable time series model residuals and grade 11 reading achievement score residuals in Virginia 1970-90

Output	Reading grade 11					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	9	4 (.74)	5 (-.74)	.60	.15	-.48
Pupil/Teacher ratio ARIMA(2,0,0)	8	5 (.73)	3 (-.67)	.51	.006	-.01
Instructional Salaries ARIMA(1,0,0)	2	1 (.70)	1 (-.71)	.50	.0006	.02
Total expenditures ARIMA(1,0,0)	1	1 (.83)		.69		-.27
Local expenditures ARIMA(2,0,0)	11	7 (.71)	4 (-.67)	.50	.008	-.13
Local expenditures ARIMA(1,0,0)	14	7 (.79)	7 (-.74)	.59	.112	-.33
Federal expenditures ARIMA(1,0,0)	No effects					.36
Federal expenditures ARIMA(2,0,0)	7	4 (.72)	3 (-.83)	.58	.125	.001
State expenditures ARIMA(1,0,0)	9	1 (.74)	8 (-.80)	.61	.139	-.20

Transportation expenditures ARIMA(1,0,0)	6	4 (.76)	2 (-.70)	.54	.006	.10
Transportation expenditures ARIMA(0,0,2)	3	2 (.68)	1 (-.66)	.45	.002	.39
Instructional Expenditures ARIMA(1,0,0)	8	2 (.69)	6 (-.79)	.58	.129	-.25

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* $p < .05$)

Relationships between reading achievement score residuals and school input time series residuals are not significant in a majority of Virginia school districts for the limited number of years available for analysis. However, the results described above suggest that slight positive change in pupil/teacher ratio and local expenditures residuals may be associated with a reduction in reading score residuals.

Math achievement: grades 4,8,11.

Similar to reading achievement score residual results above, math score results suggest moderate association between math score residuals, local expenditures and pupil/teacher ratio. These variable residuals shared between 40% and 50% of their variance in common (See Tables 43 to 45 following).

Table 43

Average correlation of school productivity variable time series model residuals and grade 4 math achievement score residuals in Virginia 1970-90

Output	Math grade 4					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	12	7 (.58)	5 (-.64)	.42	.101	.30
Pupil/Teacher ratio ARIMA(2,0,0)	10	8 (.65)	2 (-.63)	.43	.006	.49
Instructional Salaries ARIMA(1,0,0)	7	6 (.62)	1 (-.62)	.40	.007	.08
Total expenditures ARIMA(1,0,0)	21	12 (.67)	9 (-.67)	.44	.008	.32
Local expenditures ARIMA(2,0,0)	9	7 (.65)	2 (-.61)	.45	.127	.56
Local expenditures ARIMA(1,0,0)	3	2 (.67)	1 (-.63)	.44	.006	.14
Federal expenditures ARIMA(1,0,0)	16	7 (.60)	9 (-.67)	.42	.009	-.38
Federal expenditures ARIMA(2,0,0)	3		3 (-.63)	.51	.236	-.28
State expenditures ARIMA(1,0,0)	2	1 (.68)	1 (-.86)	.60	.204	-.13

Output				Math grade 4		
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Transportation expenditures ARIMA(1,0,0)	4	2 (.65)	2 (-.64)	.42	.008	.15
Transportation expenditures ARIMA(0,0,2)	6	3 (.65)	3 (-.58)	.40	.005	.18
Instructional Expenditures ARIMA(1,0,0)	4	2 (.60)	2 (-.73)	.45	.172	-.13

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* p < .05)

Table 44

<u>Average correlation of school productivity variable time series model residuals and grade 8 math achievement score residuals in Virginia 1970-90</u>

Output				Math grade 8		
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	14	10 (.73)	4 (-.73)	.56	.102	.07
Pupil/Teacher ratio ARIMA(2,0,0)	11	4 (.70)	7 (-.79)	.54	.009	-.25
Instructional Salaries ARIMA(1,0,0)	1	1 (.74)		.55		.05

Output	Math grade 8					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Total expenditures ARIMA(1,0,0)	1		1 (-.79)	.62		-.15
Local expenditures ARIMA(2,0,0)	4	2 (.72)	2 (-.72)	.52	.004	.28
Local expenditures ARIMA(1,0,0)	12	6 (.78)	6 (-.77)	.62	.140	-.08
Federal expenditures ARIMA(1,0,0)	1		1 (-.67)	.44		.04
Federal expenditures ARIMA(2,0,0)	8	3 (.67)	5 (-.68)	.51	.009	-.48
State expenditures ARIMA(1,0,0)	5	3 (.75)	2 (-.73)	.56	.006	-.07
Transportation expenditures ARIMA(1,0,0)	8	3 (.76)	5 (-.70)	.56	.010	-.31
Transportation expenditures ARIMA(0,0,2)	9	3 (.68)	6 (-.72)	.51	.005	-.41
Instructional Expenditures ARIMA(1,0,0)	6	3 (.74)	3 (-.70)	.54	.107	.04

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* $p < .05$)

Table 45

Average correlation of school productivity variable time series model residuals and grade 11 math achievement score residuals in Virginia 1970-90

Output	Math grade 11					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	9	3 (.81)	6 (-.70)	.58	.168	.06
Pupil/Teacher ratio ARIMA(2,0,0)	7	5 (.76)	2 (-.80)	.59	.007	.03
Instructional Salaries ARIMA(1,0,0)	3	1 (.70)	2 (-.70)	.48	.002	-.13
Total expenditures ARIMA(1,0,0)	6		6 (-.72)	.53	.007	-.64
Local expenditures ARIMA(2,0,0)	9	7 (.76)	2 (-.73)	.56	.116	.51
Local expenditures ARIMA(1,0,0)	16	5 (.80)	11 (-.73)	.59	.114	-.17
Federal expenditures ARIMA(1,0,0)	1		1 (-.82)	.68		-.27
Federal expenditures ARIMA(2,0,0)	7		7 (-.69)	.50	.006	-.43
State expenditures ARIMA(1,0,0)	13	3 (.67)	10 (-.74)	.58	.15	-.26

Output			Math grade 11			
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Transportation expenditures ARIMA(1,0,0)	2	1 (.74)	1 (-.68)	.50	.006	-.15
Transportation expenditures ARIMA(0,0,2)	2	2 (.80)		.64	.156	.05
Instructional Expenditures ARIMA(1,0,0)	10	5 (.69)	5 (-.78)	.59	.147	-.18

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* $p < .05$)

Relationships between math achievement score residuals and school input time series residuals are also not significant in a majority of Virginia school districts for the 12 years available for analysis. However, the results described above suggest that slight positive change in pupil/teacher ratio, total expenditure and local expenditures residuals may be associated with an increase in math score residuals.

Language arts achievement: grades 4,8,11.

As with reading and math achievement score residual results above, language arts score results suggest moderate association between math score residuals, local expenditures and pupil/teacher ratio. These variable residuals shared between 35% and 60% of their variance in common (See Tables 46 to 48 below).

Table 46

Average correlation of school productivity variable time series model residuals and grade 4 language arts achievement score residuals in Virginia 1970-90

Output	Language arts grade 4					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	17	1 (.67)	16 (-.65)	.44	.009	-.29
Pupil/Teacher ratio ARIMA(2,0,0)	4	2 (.66)	2 (-.6)	.39	.007	.25
Instructional Salaries ARIMA(1,0,0)	2	1 (.58)	1 (-.65)	.38	.006	.04
Total expenditures ARIMA(1,0,0)	13	5 (.62)	8 (-.64)	.41	.007	-.21
Local expenditures ARIMA(2,0,0)	5	1 (.58)	4 (-.67)	.42	.097	-.08
Local expenditures ARIMA(1,0,0)	4		4 (-.65)	.45	.008	-.26
Federal expenditures ARIMA(1,0,0)	7	3 (.67)	4 (-.63)	.42	.007	-.28
Federal expenditures ARIMA(2,0,0)	2	1 (.71)	1 (-.74)	.52	.003	.07
State expenditures ARIMA(1,0,0)	No effect					.04

Output	Language arts grade 4					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Transportation expenditures ARIMA(1,0,0)	4	4 (.65)		.45	.125	.41
Transportation expenditures ARIMA(0,0,2)	12	12 (.65)		.45	.112	.66*
Instructional Expenditures ARIMA(1,0,0)	1	1 (.59)		.35		-.00

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* p < .05)

Table 47

<u>Average correlation of school productivity variable time series model residuals and grade 8 language arts achievement score residuals in Virginia 1970-90</u>

Output	Language arts grade 8					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	21	1 (.73)	20 (-.79)	.61	.108	-.78*
Pupil/Teacher ratio ARIMA(2,0,0)	14	1 (.69)	13 (-.73)	.55	.008	-.50
Instructional Salaries ARIMA(1,0,0)	5	3 (.72)	2 (-.74)	.52	.004	.08

Output	Language arts grade 8					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Total expenditures ARIMA(1,0,0)	1	1 (.98)		.96		-.15
Local expenditures ARIMA(2,0,0)	8		8 (-.71)	.52	.006	-.61
Local expenditures ARIMA(1,0,0)	24		27 (-.76)	.63	.129	-.73*
Federal expenditures ARIMA(1,0,0)	No effect					.34
Federal expenditures ARIMA(2,0,0)	6	4 (.76)	2 (-.67)	.56	.112	.28
State expenditures ARIMA(1,0,0)	9	4 (.71)	5 (-.81)	.61	.154	.26
Transportation expenditures ARIMA(1,0,0)	7	5 (.71)	2 (-.68)	.53	.009	.28
Transportation expenditures ARIMA(0,0,2)	6	4 (.70)	2 (-.69)	.48	.004	.39
Instructional Expenditures ARIMA(1,0,0)	8	4 (.72)	4 (-.79)	.58	.104	.18

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* $p < .05$)

Table 48

Average correlation of school productivity variable time series model residuals and grade 11 language arts achievement score residuals in Virginia 1970-90

Output	Language arts grade 11					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Pupil/Teacher ratio ARIMA(1,0,0)	7	5 (.70)	2 (-.71)	.54	.117	.13
Pupil/Teacher ratio ARIMA(2,0,0)	5	1 (.82)	4 (-.74)	.57	.009	-.06
Instructional Salaries ARIMA(1,0,0)	2	1 (.74)	1 (-.72)	.53	.02	.02
Total expenditures ARIMA(1,0,0)	5	1 (.98)	4 (-.71)	.60	.202	-.36
Local expenditures ARIMA(2,0,0)	7	7 (.78)		.60	.008	.44
Local expenditures ARIMA(1,0,0)	17	5 (.80)	12 (-.75)	.60	.105	-.05
Federal expenditures ARIMA(1,0,0)	2		2 (-.76)	.59	.185	-.08
Federal expenditures ARIMA(2,0,0)	7		7 (-.73)	.54	.006	-.46
State expenditures ARIMA(1,0,0)	9	1 (.67)	8 (-.78)	.62	.147	-.21

Output	Language arts grade 11					
Input Model residuals	N*	#pos. (r*)	#neg. (r*)	AVS*	(SD) AVS*	SAV (r*)
Transportation expenditures ARIMA(1,0,0)	9	1 (.96)	8 (-.73)	.59	.144	-.37
Transportation expenditures ARIMA(0,0,2)	3		3 (-.69)	.53	.104	-.32
Instructional Expenditures ARIMA(1,0,0)	6		6 (-.76)	.58	.133	-.09

N* Number of school districts
AVS* Average variance shared
r* Pearson correlations
(SD) Standard deviation
SAV* Statewide Average correlation (* $p < .05$)

Relationships between language arts achievement score residuals and school input time series residuals are also not significant in a majority of Virginia school districts for the few years available for analysis. However, the results described above suggest that slight positive change in pupil/teacher ratio and local expenditures residuals may be associated with a decrease in language arts score residuals.

It appears from the correlation analysis of time series residuals and school achievement variable residual scores that reading, math and language arts achievement scores may be associated with positive residuals of total expenditure, local expenditure and pupil/teacher ratio school input variables in Virginia over the 1970-90 time period. These variables share anywhere from 30 to 60% of their variance in common. Corroboration of this evidence of association waits on future collection of school achievement variable data.

Summary of Relationships between Input Variable Time Series Residuals and Output Variable Raw and Residualized Scores

The time series models of school input variables removed long term trends (increasing for expenditures and salaries and decreasing for pupil/teacher ratio) and year-to-year correlations, leaving only residual (different from year to year) changes for the 21 year period of analysis to be associated with changes in student attainment and achievement variables. On average, the time series models for each variable left only a few dollars ($1.13 to $14.00 /pupil) of expenditure and salaries and less than 1% of change in pupil/teacher ratio unaccounted for in all Virginia school districts.

However, even a few dollars change in total and local expenditure per pupil seems to be statistically significantly associated with positive changes in the percent of students attending college and with reductions in the percentage of school dropouts in Virginia. Similar small changes in instructional salaries are also associated with changes in these school outputs.

These few residual dollars per pupil were not significantly associated with student achievement variables after student ability was removed from their score variance. This result may be due to two factors. First, removal of student ability from achievement scores left, on average, less than +.001 percentile equivalent score points of change to be accounted for by school input variables.

Second, there were only 12 years of data with which to analyze achievement scores, barely above the level found by Gottman (1981) necessary to declare statistical significance of autocorrelation values in time series. Despite this limitation, at least some of the Virginia school districts exhibited significant correlations between achievement residuals, total expenditure and pupil/teacher ratio time series residuals. Future analysis of achievement scores with more years of data may substantiate these potential relationships further.

Association of Statewide Policy Initiatives and Time Series Model Relationships of Virginia School Productivity From 1970-90

Average individual school district time series models that had significant cross-correlation relationships between input variable model residuals and output variables in more than 30 school districts (about 25% of total districts) were plotted concurrently with major statewide school policy initiatives to describe how relationships between expenditure and output variables in correlated time-series models of school productivity might correspond to legislated policy events.

From the analysis of cross-correlation relationships between time series residuals of school input variables and school outputs in Virginia from 1970-90, six school input variables were found significantly correlated with four educational attainment output variables in more than 30 Virginia school districts. The school input variables were:

1. Instructional salaries;
2. Pupil/Teacher ratio;
3. Total expenditures per pupil;
4. Local expenditures per pupil;
5. State expenditures per pupil; and
6. Instructional expenditures per pupil (State - Transport).

The school output variables were:

1. Percent of graduates going to any college;
2. Percent of students dropping out of school;
3. Percent of all students promoted each year; and
4. Percent of ninth grade students graduating from high school.

To describe the correspondence between the time series of these input-output variables with actual statewide educational policy events, substantively significant policy events had to be identified. This was done in two steps. First, a sample of school superintendents in Virginia known to have 15 or more years of experience in the state were contacted by phone and asked to identify the five most substantively significant statewide policy decisions made between 1970 and 1990 that they thought might affect student educational attainment and achievement. Their responses are described next.

Substantive State Policy Events: School Superintendent Opinions

A small sample (N=7) of experienced (years in Virginia schools > 15) school superintendents were interviewed by phone and asked to list the most important 4-5 policy events they had observed with statewide effects on school operations between 1970 and 1990. Table 49 below lists their observations.

It appears as if the most experienced school superintendents believe that adoption of outcome standards for schools (SOQ and others); introduction of radical new curricular elements (e.g., Technology initiative) and alterations to statewide funding formulas are expected to have the most common statewide effects upon school productivity.

Table 49

A survey of Virginia school superintendents to determine the four or five most important statewide educational policy decisions of 1970-1990

Superintendent	Policy responses
Dr. Jim Graham Wise County Schools	1973 Funding formula change to equalize statewide school expenditures
	Special education funding policy
	Standards of Quality adoption
	Outcomes Assessment Program
	Ban on corporal punishments
Dr. Sidney Harvey & Danny Edwards Grayson / Fries Schools	Standards of Quality adoption
	JLARC* Disparity funding program 1980's
	1985 technology initiative
Dr. Bayes Wilson Roanoke Co. Schools	1972 Standards of Quality adoption
	1975 Special education policy
	1980's teacher salary mandates
	JLARC Disparity funding program 1980's
	1980's Home schooling law
	Gifted & Vocational students regulations
Dr. Edward Clymore Augusta Schools	1972 Standards of Quality adoption
	Balile's administration power shift from State Supt. to Sec. of D.O.E.
	VEA employment grievance procedure adoption
	Va. Literacy passport program

Superintendent	Policy responses
Dr. James Bradford Buena Vista Schools	Funding disparity policy Technology initiative Teacher training program changes Decentralization initiative Literacy passport program Outcomes assessment program
Dr. Kenneth Frank Staunton Schools	Standards of Quality adoption Pupil/teacher ratio change Adoption of student ability measures JLARC funding policy changes 1980's
Dr. Arthur Gosling Arlington Schools	Literacy passport program Disparity funding formula policy World class standard setting Technology initiative Accountability standards (OAP)

*JLARC - Joint Legislative Action Review Committee of the Virginia General Assembly

The second procedure used to identify substantively significant statewide educational policy events involved a review of the published Acts of Assembly. These acts contain descriptions and dates of all authorized legislation pertaining to educational policy in Virginia and cover the 1970-90 period of time. The results of this literature survey follow.

Substantive State Policy Events: Acts of the Virginia Assembly

Based upon examination of the 1970-90 Acts of Assembly which may logically be thought to directly affect variables in this study through expenditure of public monies or change in school outcomes, Table 50 follows and was constructed to describe important legislative policy events.

Table 50

Description of legislative policy events thought to affect school productivity in Virginia 1970-90

Date	Chapter/page/act	Policy	Expected Variable Effect(s)
1970	451/672 /22-275.4	Permit written excuse from school attendance of any child found not benefitting by a court	Attend-ance
1970	496/1080 /22-9,9.1,9.2, 9.2:1,22-55.1,22-228, 22-275.5, 22-275.12, 22-275.13 & 22-275.14	Provide special education for visually handicapped in public schools along with all other classes of handicapped children.	Expend-itures
1971	162/319 22-116,22-117,22-127,22-128, 22-126.1	Tax code changed to require all localities to levy a school tax in proportion to their state-apportioned school support amount and authorizing special taxes for capital funding	Local Expend-itures

Date	Chapter/page/act	Policy	Expected Variable Effect(s)
1971	102/128 22-121 and Chapter 2 Title 23	abolished this previous school segregation legislation	Expend- itures, race
1972	248/282 22-236.1	Mandated drug instruction program for all schools	Expend- itures
1972	699/949 S 553-1	State board will pay transport costs for all pupils in counties without a system per pupil basis equal to nearest city cost	Transport Expend- itures
1974	House Joint Resolution 161 pages 1498-1501	State school performance objectives (SOQ) adopted in local divisions	Achieve- ment
1975	464/798 22.10.11	Transport costs for special ed students limited to max set by state board and shared with locality 40state/60local	Transport expend- itures
1976	23/40 22.8	Abolishing mandatory graded schools	Achieve- ment
1977	SJR 116, pp.1579	Established health education curriculum in all schools	Expend- itures
1977	528/791 1976 Acts	Revised SOQ to re-focus on math, reading and language arts and to reduce class sizes to an average of 22 pupils by 1983	Achieve- ment
1980	559/679/Title 22.1 in entirety	A general re-wording of the Code of VA. educational policy to reflect changes made in statutes from 1970-80.	all variables

Date	Chapter/page/act	Policy	Expected Variable Effect(s)
1981	HJR 289	Reaffirmation of assembly commitment to education and acknowledgement of increase in achievement from 1973-79.	Achieve-ment and expend-itures
1984	713/1572 22.1-253.13	Revision of SOQ emphasizing basic skills attainment and testing, new standardized testing and two-year comparison reporting. Instituted criterion-referenced testing grades 1-6 in basic skills. New grievance procedures for teachers.	Achieve-ment and expend-itures
1985	491/796 SB 740	Reading to learn project established to train teachers to increase reading abilities in all grades	Achieve-ment
1985	SJR 1676	Bd. of Ed. asked to implement drug & alcohol education curriculum	Achieve-ment and expend-itures
1988	87/96 Title 22.1-212.2	Created electronic classrooms statewide	Achieve-ment and expend-itures
1988	644 and 682/827 and 869 Title 22.1 sections 22.1-253.13:1-13:8	Standards of quality revised to focus on basic skills and require 8 alternative ed. programs for all students to lower dropout rates	Achieve-ment, expend-itures, attain-ment

Date	Chapter/page/act	Policy	Expected Variable Effect(s)
1989	287/379 repeal 22.1-280 and add 22.1-279.1	Ban corporal punishment	Achievement, attainment
1990	797/1248 16.1-279, 18.2-371 up to 22.1-344; add 22.1-17.1, 209.1:1 and 22-279.2; repeal 22.1-279	redefine dropouts and institute prevention programs	Expenditures, attainment and achievement

Results of this review of the Acts of Assembly verified and extended the list of policy events remembered by experienced school superintendents and provided a limited history of policy events in the 1970-90 period of Virginia education. The list in Table 51 may also be categorized in terms of events that affected:

1. school funding (e.g., 1971 changes to tax code altering local expenditure requirements);
2. those that introduced new programs and curricula (e.g., 1972 drug program instruction mandate); and
3. those that re-defined school outcomes or attempted to alter outcomes (e.g., 1974 SOQ performance objectives).

Policy Expectations

It seems clear from the survey of school superintendents and review of the Acts of Assembly that policy initiatives (later, historical events) which might affect school productivity inputs or outputs are associated with some simple expectations on the part of members of the state educational constituency.

The first involves an expectation that investment of more dollars into the state educational system will lead directly to positive changes in school products, i.e., more or better students. The second involves an expectation that accrual of new instructional programs in the existing educational production system will also directly lead to positive changes in school products. The last expectation is that statewide goals for education can and ought to be defined, implemented and related to measurable school-level outcomes.

These expectations seem to drive policy making in the school productivity arena and are the focus of this study's attempt to identify school outputs which have statewide effects associated with school funding changes and associated program additions. With the survey of superintendents and review of the Acts of Assembly in mind, the next procedure adopted in this study was to individually plot the statewide average time series of the six school input variables concurrently with statewide average time series of all four significant output variables at the same scale. These plots were examined and related visually in time to the recorded policy events described before. A description of those policy events which appeared to correspond to changes in the relationship of school inputs and outputs from 1970-90 in Virginia follows.

Correspondence Between Policy Events and School Productivity in Virginia 1970-90

Figure 1 shows the distribution of average pupil/teacher ratio from 1970-90 in Virginia, concurrent with three positive output variables (going to college, promoted and ninth grade graduating) and one negative output variable (dropouts). It appears that pupil/teacher ratios stayed fairly constant from 1970-78, then underwent a major downturn around 1979-80 and declined slightly each year until around 1989. During the 1970-78 period of relative constancy in pupil/teacher ratio in Virginia, one legislative event was directed toward reducing pupil/teacher ratio statewide (1977 Standards of Quality revision). The effects of this commitment to reduced class size appeared a few years after, when pupil/teacher ratio declined, dropout rates decreased, and the percent of students being promoted, graduating and going to college increased in Virginia.

Figure 2 shows the time series distribution of statewide average instructional salaries (adjusted to constant 1984 dollars) from 1970-90, concurrent with school output variables. Instructional salaries, like pupil/teacher ratio, stayed relatively constant in the 1970-79 period. In fact, after instructional salaries were adjusted to common 1984 dollars with implicit price deflators for government services, it appeared that the rate of increase in average instructional salaries actually fell below the rate of increase needed to match inflation in the national economy during this time period. In short, teachers in the "average" school district in Virginia were probably losing income by teaching in this period than by doing most other activities.

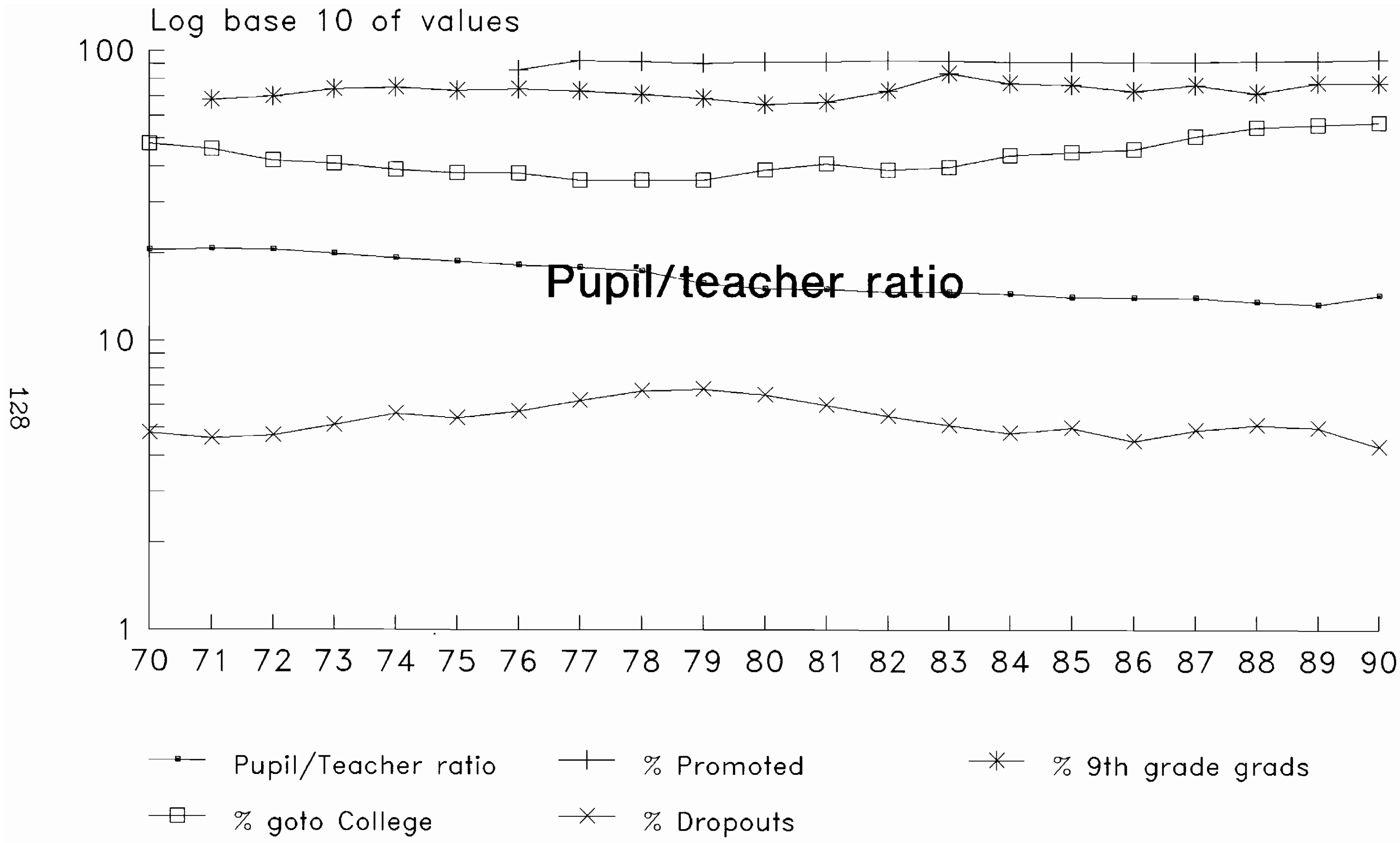

Figure 1. Average pupil/teacher ratio with educational attainments in Virginia 1970-90

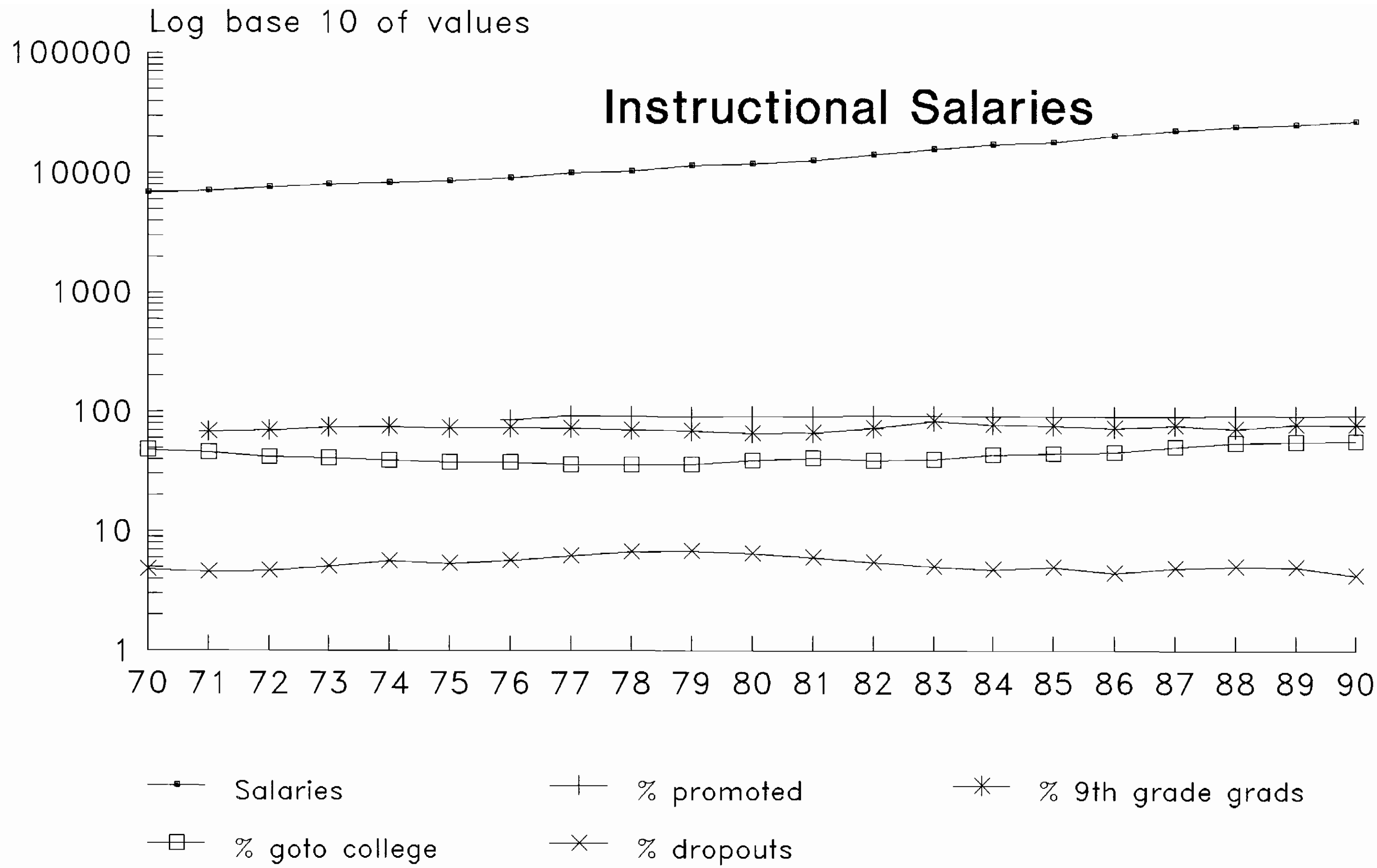

Figure 2. Average instructional salaries with educational attainments in Virginia 1970-90

Figure 2 also suggests that dropout rates had peaked by 1979, while the percent of students attending college bottomed out. The early 1980's saw a revision of the entire educational code in Virginia (1980), the institution of new grievance procedures for teachers (1984) and a series of mandated salary increases during the Robb administration (1980-84), some of which took effect during the Balile's administration (1984-88). In any case, the average salary of teachers improved dramatically in the 1980's and Figure 2 shows that dropout rates decreased, while the percent of students promoted, graduated and attending college all rose.

Figure 3 shows the time series distribution of statewide average total expenditures per pupil (adjusted to constant 1984 dollars) from 1970-90, concurrent with school output variables. This period reflects the general growth in education in Virginia during this time as new programs and curricula were adopted (1970,72,74,77,85,88), the state accepted responsibility for transporting more students (1972,75) and teacher salaries rose (1980-88).

The rate of growth in average total expenditures appears to have been slower in the first half of this time period (1970-77) than the last (1978-90). Overall, as average total expenditures have increased, dropout rates have decreased and the percentages of students being promoted, graduating and going to college have risen.

Figure 4 shows the time series distribution of statewide average local expenditures per pupil (adjusted to constant 1984 dollars) from 1970-90, concurrent with school output variables. It appears that average local expenditures per pupil rose slowly from 1970-78, dropped dramatically in 1979 and then readjusted upwards at a faster rate of increase from 1980-90. The legislative record reports a revision of the educational code in Virginia in

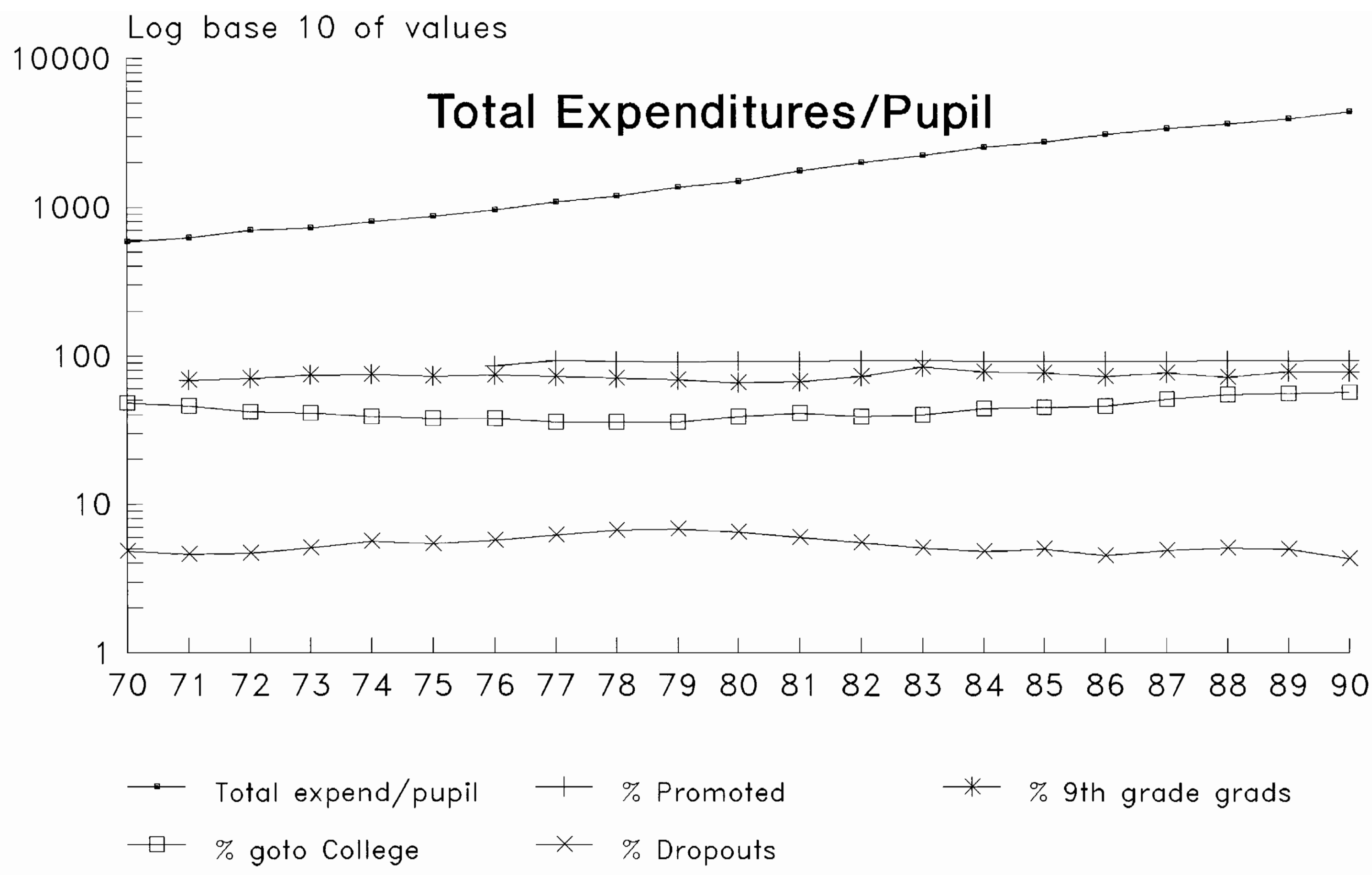

Figure 3. Average total expenditures/pupil with educational attainments in Virginia 1970-90

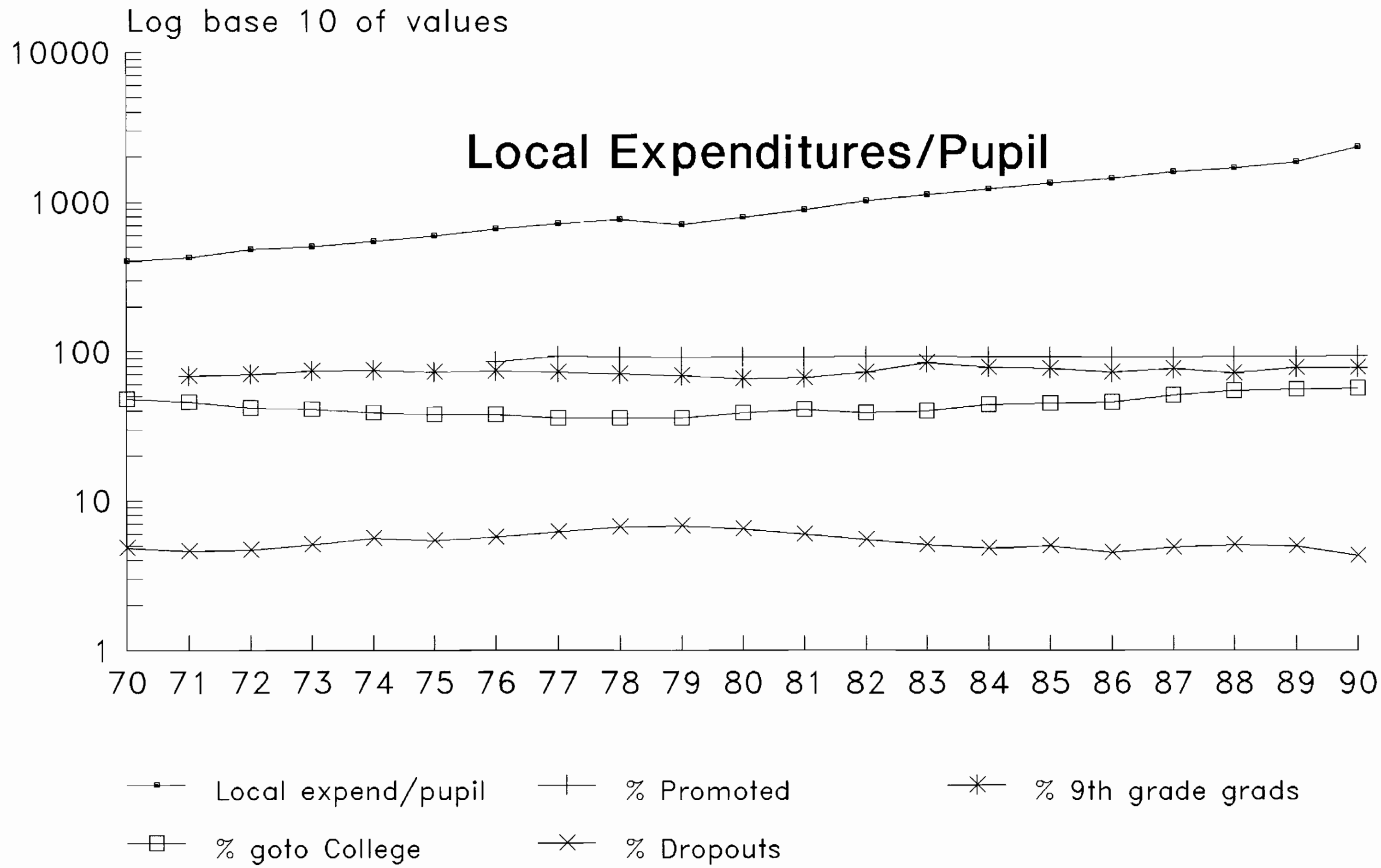

Figure 4. Average local Expenditures/pupil with educational attainments in Virginia 1970-90

1980 but give no specifics on how the changes might have altered local expenditures per pupil. At the same time (1979), average state and instructional expenditures per pupil jumped upward , before settling in to a steady increasing rate from 1980 onward.

Whatever the underlying policy reasons (if any) for these changes in the rate of local expenditures, Figure 4 shows that when they dropped, dropout rates peaked and the percentages of students graduating and going to college minimized.

Figures 5 and 6 show the time series distribution of statewide average instructional and state expenditures per pupil (adjusted to constant 1984 dollars) from 1970-90, concurrent with school output variables. With the exception of the 1979 adjustment leap, these series increase slowly in the 1970-78 period, and then more rapidly afterward, presumably in response to the same expansionary forces affecting statewide average total expenditures per pupil. Like total expenditures per pupil, as instructional and state expenditures per pupil have risen, dropout rates have decreased and the percentages of students being promoted, graduating and going to college have increased.

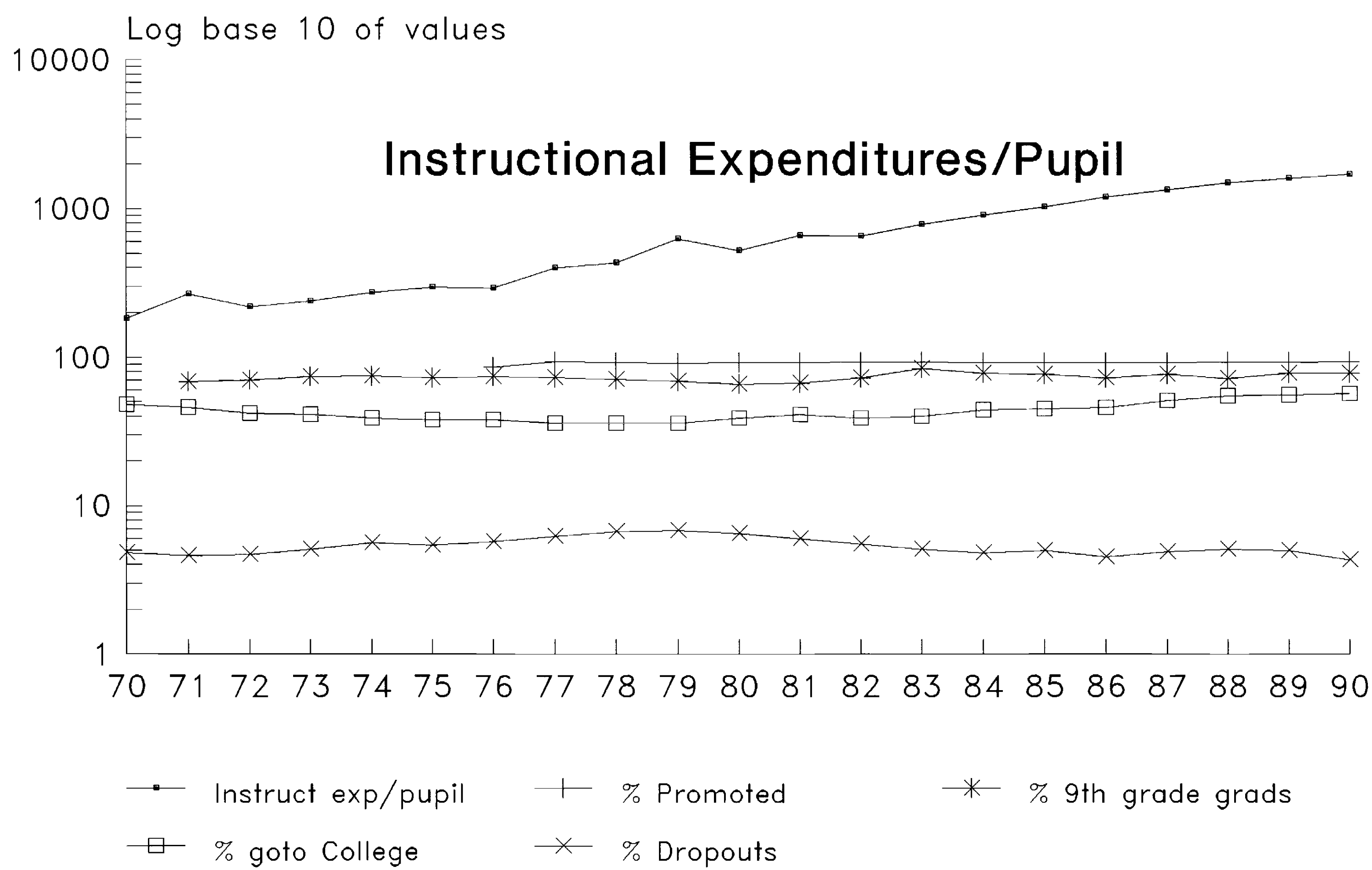

Figure 5. Average instructional exp./pupil with educational attainments in Virginia 1970-90

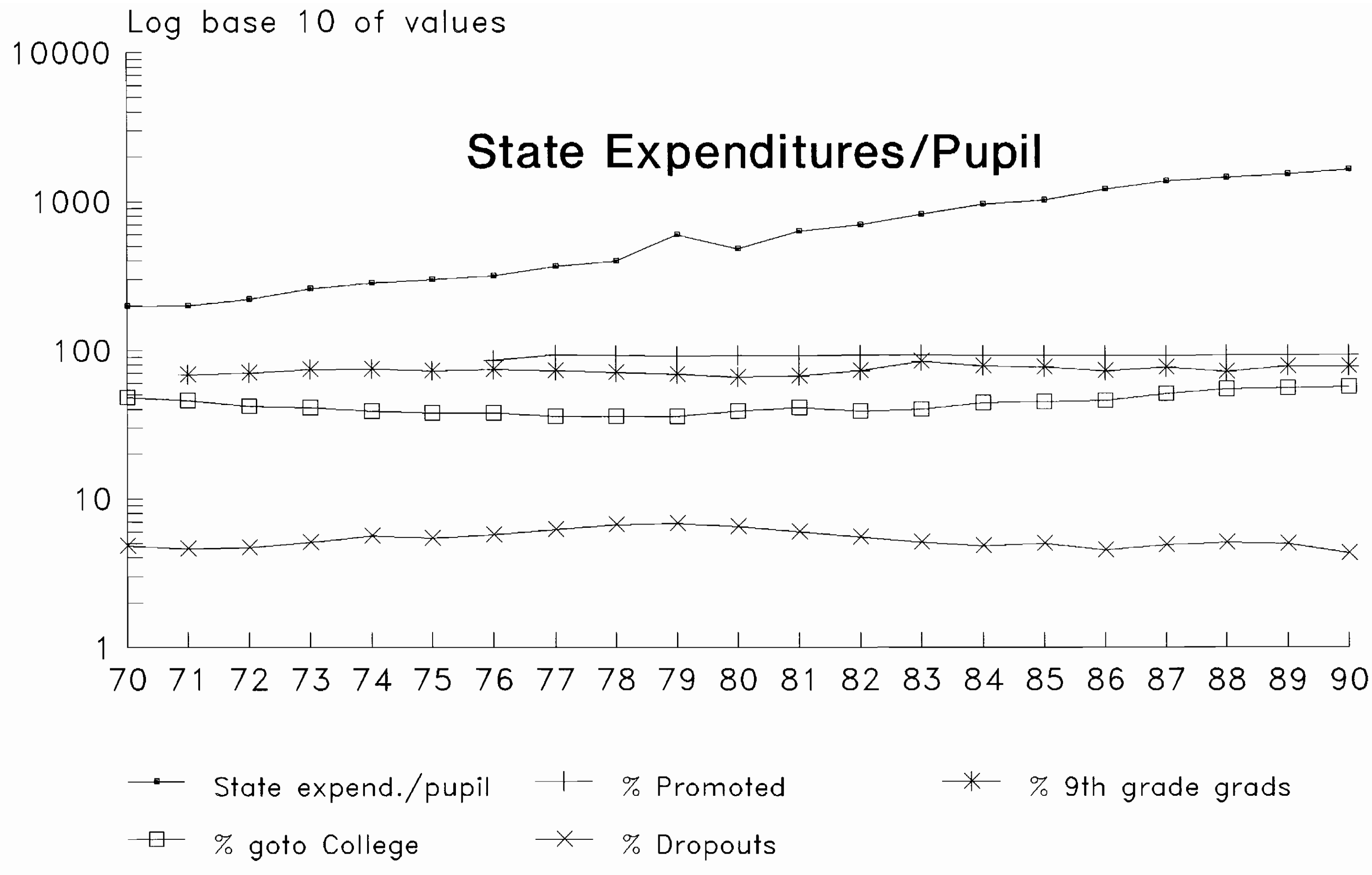

Figure 6. Average state expenditures/pupil with educational attainments in Virginia 1970-90

A Summary of the Association of Statewide Policy Initiatives and Time Series Model Relationships of Virginia School Productivity From 1970-90

A correspondence between educational policy initiatives and school productivity responses in Virginia from 1970-90 can be tentatively drawn. As efforts to improve educational opportunities for all Virginians have been made, corresponding increases in positive school outputs (e.g., promotion from grade to grade, graduating, going to college) have occurred. As more money has been spent per pupil and more programs added to school curricula, correspondingly fewer students have dropped out of school.

Chapter V

DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

Discussion

The purpose of this study was to demonstrate and describe an analytic model for school productivity which incorporated the effects of changes in school productivity inputs and outputs over long periods of time and related these changes to actual educational policy decisions. This model was constructed using Virginia school district data in the years 1970-1990 and records of statewide legislative and administrative policy decisions made in the same period.

School input and output variables were selected from a review of literature focused on school productivity analysis and from available data records in the Commonwealth of Virginia for the years of interest. Time series analysis was useful in developing descriptive models for the distribution of school input values over time, but not for the output variables. Time series models developed for eight school input variables were correlated with raw educational attainment output values for five variables and with ability-removed residuals of achievement scores from nine variables.

Significantly associated input-output relationship models were then averaged across all 139 Virginia school districts for statewide comparison of policy effects. Plots of significant input-output relationship models over the annual dates of substantively important policy events were used to identify policy changes and corresponding modifications in school productivity relationships.

The following discussion reviews the findings of each step in this study and suggests implications for policy analysts and policy makers. This is followed by a re-visit to limitations of this study and caveats for interpretation of results. Suggestions for future research directions are offered last.

Findings

Was Time Series Analysis Appropriate for Analyzing Cross-time Variance in School Input and Output Variables?

Time series analysis was appropriate for analyzing long term trends and year to year autocorrelations in time series of school input variables. All the school input variables analyzed in this study were appropriately described with simple ARIMA(1,0,0) autoregressive time series in the majority of Virginia school districts. Using these models, long term trends and autocorrelation were removed from school input variables before testing them for correlation with school output variables. This way, only those increments of expenditure, instructional salary and pupil/teacher ratio which represented exceptional policy change were left to be related to school outputs.

However, federal expenditures per pupil and transportation expenditures per pupil were difficult to fully account for from 1970-90 with simple time series models. This may be explained from the source of policy decisions for distribution of these funds.

Federal funds are distributed through the state to districts via categorical definitions of need, primarily for special education, health and nutrition program support. Since school districts may be expected to vary each year in their need for such assistance, there is unlikely to be a large amount of autocorrelation present in federal expenditures per pupil. Nonetheless, most districts could be described with an ARIMA(P,0,0) model of first or second order, suggesting that categorical needs persist with time as well.

Transportation expenditures per pupil were also difficult to model with simple time series. Perhaps this is due to the way in which such funds are distributed. The state pays a portion of transport costs and local school districts pay the remainder, based upon miles travelled and students transported. Since the number of students being transported each year may be expected to vary a bit, there should be reduced autocorrelation in transport expenditures. Nonetheless, it is possible to model transport expenditures in most districts with simple trend-removed, autoregressive ARIMA(1,0,0) time series models.

It was not possible to model school output variables with time series. This was an expected outcome of the study since measures of school outputs are taken from student cohorts which change each year of measurement. There is no reason to expect year to year values of graduation rates, dropout rates, achievement scores, et al. to be autocorrelated. They are not autocorrelated in Virginia from 1970-90. School outputs appear to vary randomly from year to year in most school districts.

<u>What Are the Relationships of School Input Variable Time Series Residual Scores with School Output Scores?</u>

The time series residuals of six school input variables were significantly correlated with four school output variables describing the educational attainments of Virginia students from 1970-90. Average statewide time series residual values of pupil/teacher ratio, instructional salaries, total expenditures per pupil, local expenditures per pupil, instructional expenditures per pupil and state expenditures per pupil were significantly correlated with raw scores of the percent of students promoted in all grades, percent of ninth grade students graduating from high school, percent of graduates going to any college and percent of students dropping out in more than 25% of all Virginia school districts.

Table 51 summarizes the significant school input variable effects for the four attainment variables strongly affected. It appeared as if the association of Total expenditures > Local expenditures > Instructional salaries > Pupil/teacher ratio > Instructional expenditures > State expenditures in the number of districts where school outputs scores were significantly associated. Total and local expenditures per pupil seemed to share the largest proportion of variance with school output measures.

These associations gain more substantive meaning when the average size of the time series residuals and the average change in school outputs from 1970-90 are considered for each school input variable. Table 52 describes the average values for school input residuals and the range of change (1970 to 1990) in school output variables found significant in this study.

Table 51

Average proportion of variance shared by school productivity input variable time series model residuals and school output attainment variables in Virginia 1970-90

Output	% graduates going to any college		% Dropouts		% Promotion		% Ninth Grade Graduating	
Input Model residuals	N*	Average Variance Shared	N	AVS	N	AVS	N	AVS
Pupil/ Teacher ratio ARIMA(1,0,0)	55	.28	53	.28	13	.34	19	.28
Instructional Salaries ARIMA(1,0,0)	72	.39	45	.33	40	.39	33	.34
Total expenditures ARIMA(1,0,0)	91	.46	52	.34	46	.43	42	.36
Local expenditures ARIMA(1,0,0)	88	.36	54	.30	20	.38	35	.29
State expenditures ARIMA(1,0,0)	30	.23	12	.27	5	.33	12	.28
Instructional Expenditures ARIMA(1,0,0)	43	.29	18	.28	8	.31	16	.31

N* Number of Virginia school districts with significant correlation results ($p < .05$)

Table 52 shows that as total, local, instructional and salary expenditures rise above the long term trend and by more than can be accounted for by the previous year's value, students seem to be doing better over the 21 years of analysis.

Table 52

Average statewide value of school input time series residuals and range of change in school output variables in Virginia 1970-90

School Input Time Series Statewide Average Residuals 1970-90					
Total Expend-itures	Local Expend-itures	Instruc-tional Salaries	Pupil/ Teacher Ratio	Instruc-tional Expend-itures	State Expend-itures
+$2.40 Range: $423	+$14.00 Range: $534	+$2.00 Range: $2175	+.008 % Range: 2.7%	+$1.13 Range: $294	-$1.18 Range: $310
School Input Variables Range of Change (1990 minus 1970)					
Percent Attending College	Percent Dropouts	Percent Promoted	Percent 9th Grade Graduating		
+7.33%	-0.5%	+7.33%	+10.66%		

This study did not find any significant correlation between school input time series residual values and achievement score residuals (ability-removed) in more than 25% of Virginia school districts from 1970-90. This may have resulted from having too few years of observational data to test for statistical significance.

Have School Productivity Outputs in Virginia Met Policy Expectations?

This study has identified six school input variables significantly related to school output variables describing the educational attainments of Virginia public school clients. This significance was found in a large number ($30 < N < 100$) of school districts, even after the effects of long term trends and year to year correlations in the values seen in figures 1-6 were removed.

It does appear that Virginia public schools produced positive outcomes in the 1970-90 period which responded to expenditure-related inputs directed to the school system by legislative and administrative policy enactment and implementation. It also appears that the policy actions of adding new programs and simply expanding the educational system are associated with rising levels of educational attainment in the state. Finally, this study has demonstrated the potential for identifying key output variables that can be used to relate policy initiatives to appropriations to implementation to school processes and qualities across the state of Virginia.

If educational policymaking in Virginia operated under the expectations discussed in Chapter 4, this study has found some reasons for policy makers to be satisfied with at least some of the efforts made to increase teacher salaries, provide expanded educational services and spend more money on the public education of Virginians.

Conclusions

Consideration of the findings from this study leads to five general conclusions. First, Virginia school district expenditure time series have strong linear trends from 1970-90. This makes predictability of future expenditures fairly easy and suggests that policy decisions regarding expenditures have an incremental quality that results largely in future expenditures looking much like past expenditures over long time periods.

Second, school expenditure measures and school quality measures appear to significantly affect school attainment and achievement measures over time. Perhaps future research could refine a general school process indicator reflecting these components of school input and explore their relationship to school output indicators more fully.

Third, this study has identified potentially important statewide education policies which seem to be associated with positive school attainments. These were: 1) increased teacher salaries, over and above general inflationary trends; 2) generally rising total and local expenditures over time, again beyond inflationary trends; and 3) the addition of new program elements (health, dropout prevention and special education) to the public school curriculum.

Fourth, time series analysis has proven to be a useful way to view the school productivity relationship in Virginia. Future use of this technique in educational policy analysis is warranted.

Finally, dollars expended on schooling and several school outcomes appear to be positively and consistently related over time, at least in Virginia. Perhaps this relationship varies somewhat over brief periods of time when researchers examine cross-sectional data on expenditures and outputs. This study has demonstrated that time series analysis can shed light on long term school effects.

Re-Visitation of Study Limitations

The findings and conclusions of this study must be considered in light of the numerous analytical and interpretive limitations of the study. First, the study is historical and associational in nature. Merely correlating the occurrence of school input variables with school outputs, and then relating them to identified policy events provides poor evidence of potential causal linkages.

Moreover, there is no way to relate the time period from 1970-90 to future educational policy conditions. There are no guarantees that policies similar to those used in the past will have similar positive results in the future. The conditions of individual school districts and the different students found in Virginia schools each year have not been accounted for in this study. These may be expected to change in the future and may confound the results discussed in this study.

Finally, there is no easy way to verify the impact of policy events identified with school productivity change in this study. Simply naming a policy act and recording a date of passage cannot guarantee the successful implementation and impact of a policy. The most this study can hope to do is describe potential associations of policies and impacts and leave the reader to ascribe greater meaning to those policies when they find stronger evidence for effects in more focused future analysis.

Suggestions for Future Research

It might be valuable for this analysis of time series relationships to be extended further into the past and future as more data is developed on school inputs and outputs. This type of analysis could also be extended to general policy analysis since it may be argued that substantive policy effects should exceed incremental advances from the immediate past, as well as long term averages, if policy makers hope to alter the direction of policy development.

The study of school productivity might also be profitably extended to the school district level, if the spectrum of acceptable input and output measures could be broadened to include local community characteristics in analysis. The Commonwealth of Virginia recently took steps in that direction by creating an Educational Performance Recognition Indicator program for school districts (Commonwealth of Virginia, 1991) .

The results of this study also suggest that policy analysts might focus more on educational attainment outputs, rather than the limited number of achievement output measures now in use, to describe long term gains from schooling inputs. This may save a bit of the increased school indicator costs referred to by Porter (1991) and others calling for new and increased measurement of school processes and outputs. Study of the reliability and validity of attainment measures is clearly in order as there does not appear to be much validation research available for these output indicators. Nonetheless, promotion, graduation and dropout rates, however crudely measured, seem to be affected over the long haul by school expenditures and other process measures.

Additional work could also be done to explore why no significant time series were found for some districts with some school input variables. Perhaps dramatic local changes in expenditures or other inputs resulted from changes in school superintendents, building losses to catastrophes or any other of a host of potential unintended intervention effects over time. Historical analysis of policy and non-policy events within a local school district might shed light on reasons for changes in school input-output relationships that cannot be explained at the state aggregate level.

It also still seems that local educational policymakers have the greatest stake in school outputs. Based upon the results of this study, local expenditure variance is significantly associated with variance in outputs over time. Moreover, the residual amount of local dollars left to potentially affect school outcomes is greater for local expenditures per pupil than for any other school input variable analyzed in this study. It appears that local policymakers can directly influence the success of their schools over the long haul.

However, reliance solely upon either local, state or federal school inputs to obtain successful school productivity may result in an inherently undemocratic educational system, as David Berliner warned in a recent address to the American Association of Colleges of Teacher Education (Berliner, 1992). This study shows that state policies to increase educational expenditures over time, particularly in the areas of increasing teacher salaries and reducing class sizes, have positive output effects. Hughes' (1991) recent analysis of outcomes from high and low expenditure districts in Virginia lends even greater urgency to the need for more statewide investment in public education in the Commonwealth. This study and others like it should encourage more generous long-term support for education in Virginia and in the nation.

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APPENDICES

Table 53

Virginia school district independent variables not significantly modeled (X) with time series and with insufficient data (N/A) for modeling

District	School Input Variables					
	Pupil/ teacher ratio	Local expenditures	State expenditures	Federal expenditures	Transportation expenditures	Instructional expenditures
Accomack						
Albemarle						
Allegany Highlands				x		
Amelia						
Amherst				x		
Appomattox				x		
Arlington				x		x
Augusta					x	
Bath			x			x
Bedford						
Bland		x				
Botetourt				x		
Brunswick		x				
Buchanan				x		
Buckingham				x		
Campbell				x	x	
Caroline				x	x	
Carroll				x		

District	School Input Variables					
	Pupil/teacher ratio	Local expenditures	State expenditures	Federal expenditures	Transportation expenditures	Instructional expenditures
Charles City				x		
Charlotte				x		
Chesterfield				x		
Clarke				x		
Craig		x		x		
Culpeper					x	
Cumberland		x				
Dickenson				x	x	
Dinwiddie						
Essex				x	x	
Fairfax				x		
Fauquier				x		
Floyd		x				
Fluvanna		x		x	x	
Franklin						
Frederick						
Giles						
Gloucester		x		x		
Goochland					x	
Grayson				x	x	
Greene				x		
Greenville						
Halifax						
Hanover				x		

District	School Input Variables					
	Pupil/ teacher ratio	Local expenditures	State expenditures	Federal expenditures	Transportation expenditures	Instructional expenditures
Henrico					x	
Henry						
Highland		x	x	x	x	
Isle of Wight						
King George	x			x		
King & Queen	x	x		x	x	
King William						
Lancaster					x	
Lee		x			x	
Loudon				x		
Louisa				x		
Lunenberg	x				x	
Madison					x	
Mathews				x	x	
Mecklenberg						
Middlesex				x	x	
Montgomery	x			x		
Nansemond				N/A	N/A	N/A
Nelson				x		
New Kent					x	
Northhampton						

District	School Input Variables					
	Pupil/teacher ratio	Local expenditures	State expenditures	Federal expenditures	Transportation expenditures	Instructional expenditures
Northumberland					x	
Nottoway		x		x		
Orange						
Page				x		
Patrick				x		
Pittsylvania		x		x		
Powhatan					x	
Prince Edward				x	x	
Prince George						
Prince William				x	x	
Pulaski	x					
Rappahannock		x		x		
Richmond Co.		x			x	
Roanoke				x	x	
Rockbridge				x		
Rockingham				x	x	
Russell	x	x		x		
Scott		x		x		
Shenandoah						
Smyth	x			x		

District	School Input Variables					
	Pupil/ teach- er ratio	Local ex- pendi- tures	State ex- pendi- tures	Fed- eral ex- pendi- tures	Trans- porta- tion ex- pendi- tures	Instruc- tional ex- pendi- tures
South- hampton				x		
Spotsyl- vania				x		
Stafford				x		
Surry					x	x
Sussex				x		
Tazewell	x	x				
Warren					x	
Washington				x		
Westmore- land	x				x	
Wise	x					
Wythe	x					
York	x	x		x		
Alexandria				x	x	
Bristol					x	
Buena Vista				x		
Charlottes ville				x	x	
Cheaspeake						
Clifton Forge	x	x		N/A		N/A
Colonial Heights				X		
Covington				X		

District	School Input Variables					
	Pupil/ teacher ratio	Local expenditures	State expenditures	Federal expenditures	Transportation expenditures	Instructional expenditures
Danville		x		X		
Falls Church	x		x	X	x	
Franklin City				X		
Fredricksburg				X		
Galax		x		X		
Hampton	x			X	x	
Harrisonburg						
Hopewell	x			X		
Lexington	x			X	N/A	N/A
Lynchburg		x			x	
Manassas				N/A	N/A	N/A
Manasass Park				N/A	N/A	N/A
Martinsville						
Newport News				X		
Norfolk						
Norton	x	x			x	
Petersburg	x				x	
Poquoson	x				x	
Portsmouth				X	x	
Radford	x			X	N/A	N/A

District	School Input Variables					
	Pupil/ teacher ratio	Local expenditures	State expenditures	Federal expenditures	Transportation expenditures	Instructional expenditures
Richmond				X	x	
Roanoke city	x					
Salem	x			N/A	N/A	N/A
South Boston		x			N/A	N/A
Staunton				X		
Suffolk	x			X	x	
Va Beach				X	x	
Waynesboro					x	
Williamsburg					x	N/A
Winchester					x	
Cape Charles		x		X	N/A	N/A
West Point						
Colonial Beach	x			X	x	
Fries	x	x	x	N/A	N/A	N/A
Abingdon			N/A	N/A	N/A	N/A
Saltville			N/A	N/A	N/A	N/A

N/A Not applicable to this county or city due to consolidation before or during the 1970-90 time period.

John M. Williams **VITA SUMMARY** Fall 1992

John M. Williams

Professional Experience

Currently: Research and Evaluation Specialist with Appalachia Educational Laboratory specializing in qualitative and quantitative data analysis and program evaluation. Contact Jack Sanders, Associate executive director, AEL, Box 1348 Charleston, WV 25325, phone (800) 624-9124 for more information.

Teaching

Position	Location	Subject matter/ grade levels	Dates
Graduate assistant	AES Division, College of Education Virginia Tech Blacksburg, VA 24061-0302 703-231-9726 (Karl Hereford)	IBM pc and mainframe computer software applications to research	10/89 - 5/92
Teacher	Orange Co. H.S. P.O. Box 349 Orange, VA 22960 703-672-5564 (Skip Edwards)	Earth Science Geography	1/87-6/87
Teacher	Albemarle H.S. 12000 Hydraulic Road Charlottesville, VA 22903 804-973-5351 (Wm. Raines)	Earth Science	11/87-12/87
Adjunct Faculty	Mary Baldwin College Adult Degree Program Staunton, VA 22401 804-977-3900 (Rod Owens)	Biology Geography	01/86-01/87 Part time
Adjunct Faculty	Piedmont Va. Community College (S&T division) Charlottesville, VA 22901 804-977-3900 (Jim Perkins or Cliff Haury)	Biology Lab Physical Geography	01/85-01/87 part time
Teaching Assistant	University of Virginia Biology Department Charlottesville, VA 22901	Biology Lab	09/85-01/85 part time

Academic Progression

Degree	Program of Study	Institution	Dates
Ph.D.	Educational Research, Evaluation & Policy Study	Virginia Tech Blacksburg, VA	1989-1992
M.Ed.	Science Education	University of Virginia Charlottesville, VA	1984-1987
M. Sc.	Biological Science	Marshall University Huntington, WV	1982-1984
B. Sc.	Earth Science	Frostburg State University Frostburg, MD	1979-1981
A.A.	Forest Technology	Allegany Community College Cumberland, MD	1977-79

Latest Publications and Presentations

Williams, J. M. & Pantili, L. (1992). A Meta-analytic model of principal assessment. Journal of School Leadership 2(3), 256-279.

Impara, J. C., Fortune, J. C., Bruce, F. A. Jr. & Williams, J. (1992). Use of a survey of local businesses to gain school district planning information. The High School Journal 75(4), 244-251.

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