THE DETERMINANTS OF OKLAHOMA SCHOOL DISTRICTS' EFFICIENCY - A FRONTIER ANALYSIS

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LIST OF SYMBOLS

CPF:	average children per family
DEGREE:	percentage of teacher with advanced degree
DIRINS:	percentage of total expenditure for direct instructions
EI	Efficiency Index
ENROL	school district enrollment
ENROL2	square of ENROL
FAX:	percentage of total revenue from federal aid (exclusive of school lunch program)
FE	fixed effects
INSEXPS	instructional expenditure per student
LN11:	natural log of school district's grade 11 TAP test score
LN3:	natural log of school district's grade 3 ITBS test score
LNDEN:	natural log of population density
LNEI	natural log of efficiency index
LNTPOP:	natural log of total population
LNTS:	natural log of test score
LRX:	percentage of total revenue from local from property tax
LUNCH:	percentage eligible for free or reduced payments lunch

LUNCH2:	square of LUNCH
MFY:	school district median family income (in natural log)
MINORITY:	percentage of non white or minority students
MINORITY2:	square of MINORITY
OEXPS:	other expenditure per student
OEXPSR:	reciprocal of other expenditure per student
RE	random effects
SALARY:	teachers' average salary
SALR:	reciprocal of teachers' average salary
TEXPS:	total expenditure per student
TEXPSR:	reciprocal of total expenditure per student
TIME	dummy variable for year
TSTU:	teacher per student ratio
TSTUR:	reciprocal of teacher per student ratio
XED:	percentage of adult with high school education or higher (in natural log)
XMIN:	percentage of minority children
XMLF:	percentage of mother in labor force
XPOV:	percentage of children in poverty
XSPF:	percentage of single parent family
YRSEXP:	teachers average years experience

YRSEXP2: square of YRSEXP

CHAPTER 1

INTRODUCTION

Introduction

The general view is that U. S. public schools are inefficient. This is based partly on the observed trends of declining student performance on standardized test scores and increasing school expenditures. Hanushek (1994, pg. 40) a leading authority in education research stated that

> - Student performance, as measured by a wide variety of standardized tests, fell across the board during the 1970's.
> - During the 1980s some measures of student performance began to improve (from the depressed levels of the 1970s), but others showed only maintenance of a dismal status quo.
> - The average minority student consistently performs less well than the typical white student, even though a modest narrowing of the gap has occurred during the past decade and a half.
> Students from the United States perform worse than those from many other countries. Although some variation occurs across tests, there is little evidence of significantly narrowing international performance gaps.

The largest declines are noted in college admission tests such as the Scholastic Aptitude Test (SAT) and American College Test (ACT). The decline in SAT, for example, began as far back as 1963. It began to improve in the early 1980s, "but the recovery has been neither consistent nor sufficient to return performance to its previous highs" (Hanushek 1994, pg. 40). There were also evidence of little overall growth in the test scores for National Assessment of Educational Progress (NAEP) proficiency exams in core subjects such as science and mathematics. For example, between the early 1970s and early 1980s, seventeen-year olds showed little improvement in reading achievement, going from an average score of 285.2 to 285.5 on a scale of 0 to 500 (NCES, 1994, pg. 113). During the same period, their mathematics achievement fell from an average score of 300.4 to 298.5 (NCES, 1994, pg. 121). The U.S. students' performance was worse than that of students from many other countries. The general findings of 1991 International Assessment of Educational Progress (IAEP) show American students generally falling behind students (ages 9 and 13 years old) from other countries especially in mathematics and science (Hanushek 1994, pg. 43).

Declining or stagnant performance is not due to resource reductions. On the contrary, the historical pattern of real public expenditure on elementary and secondary education shows an increasing trend. Spending increased from 2 billion dollars in 1890 to almost 190 billion dollars in 1990, equivalent to more than triple the growth rate in GNP during the same period. Real per pupil expenditure increased roughly 30 times from $164 in 1890 to $4622 in 1990 (Hanushek et al, 1994, p. 27).

Taylor's (1994) review of a number of studies of educational production frontier provides further evidence of school inefficiency. She concludes that these studies suggest that the United States public school systems are on average 15 percent inefficient. The economic consequences of school inefficiency are significant. By her calculations, if the schools continue at this rate of inefficiency over the next 25 years, GDP will be smaller by 6 billion to 45 billion dollars. This is equivalent to a 1 percent decrease in annual output and consumption. Bishop (1989) suggested that if student test scores had continued to rise during the 1970s, labor quality would now be at least 2.9 percent higher and GNP 86 billion dollars higher.

Although there have been some improvements in student performance in 1990s, the change has been inconsistent. There is still a serious concern about the efficiency of the public school system. Reforming education became the main goal among many analysts rather than expanding the school budget. Existing empirical evidence is not supportive of a policy of increasing resources. Frequently cited are Hanushek's (1986, 1989) surveys of close to 190 studies of input and output analyses of the educational production function. According to Hanushek, the evidence suggests no relationship between school resources and school performance, as measured by student achievement on standardized test scores. A reanalysis of Hanusheks survey by Hedges et al (1994) came to the opposite conclusion: that school resources matter. The empirical evidence remains inconclusive.

Education in Oklahoma

In a commitment to improve the quality of education in Oklahoma, an educational reform law, House Bill 1017 (HB 1017) was passed in early 1990. Despite its good intention, it is controversial. Many were against it because "the act included a significant tax increase, and a reallocation of state funds toward common education and away from other popular programs" (Moomaw and Yusof, 1995, pg. 1).

In 1994 total revenue funded for common education increased by 31 percent to approximately 2.26 billion dollars over the 1.73 billion dollars funded in 1990 (Results 1994, pg. 2). Seventy one percent of the 1994 total was state appropriated funds. From 1990 to 1994, state appropriated funds increased by 49 percent from 1.1 billion dollars to 1.61 billion dollars (Results 1994. pg. 2). Thus, there has been a large increase in resources going to common education since the passage of HB 1017.

HB 1017 incorporates extensive changes in many areas of school operation in an attempt to improve the quality of education in Oklahoma. Key provisions involve (1) new accreditation and curriculum standards for all public high schools, (2) reducing class size to no more than 20 students per class, (3) increasing teachers' salary and incentive pay plans for teachers, (4) streamlining standards for teachers employment, discharge and due process, and (5) the consolidation and annexation of small school districts. Some of these changes are already in place: for example, (1) new accreditation and curriculum standards for all public high schools, (2) class size reductions from kindergarten to grade 12, (3) a teacher salary increase plan raising the minimum beginning salary from $17,000 in 1990-1991 to $24,000 in 1994-1995, (4) streamlining standards for teachers employment, discharge and due process standards, and (5) consolidation and annexation of small school districts with financial incentives provided for consolidation involving more than two districts.

The progress reports on current status of educational performance in Oklahoma since HB 1017 took effect have been encouraging. The major indicators suggest that student achievement has increased, as reflected by composite scores on standardized tests of Iowa Tests of Basic Skills (ITBS) and Tests of Achievement Proficiency (TAP). From 1990 to 1994, it is calculated that the increase ranged from 7 percent to 14.5 percent for ITBS tests taken by grade 3, 5 and 7 students (derived from figures in Results 1994, pg. 1)). The score increases for TAP tests, range from 1.7 percent to 9.4 percent (for grade 9 and grade 11 respectively). The average composite score for American College Test (ACT) has also shown some improvement. It rose from 20 in 1990 to 20.3 in 1994.

Statement of the problem

Educational reform is the result of public concern with declining school performance. Most educators propose putting more money into the school system to increase performance. Other analysts argue against it. Their argument often based on past studies on school performance. A majority of studies found little relationship between additional money spent and school performance, where school performance is measured by student achievement in standardized test scores. Other studies suggest schools are generally inefficient, so spending more per student will not have much effect on school performance or student achievement.

Purpose of the Study

The study intends to evaluate the performance of Oklahoma school districts by computing the relative efficiencies of Oklahoma school districts with frontier methodology using school district data from 1990 to 1994. The main purposes of the study will be to examine the potential effect of increased school district resources on school district performance in standardized tests and to examine the effect of socioeconomic and other external factors on school district efficiency. School district efficiency is a measure of a school district performance relative to those school districts on the production frontier. School districts on the frontier are school districts that need the fewest resources to produce a given level of output or that produce the most output with a given level of resources (Taylor 1994, pg. 2). The frontier analysis is appropriate as it measures school district efficiency from the production frontier.

Statement of Hypotheses

The null hypotheses to be tested are :

1. There is no significant relationship between school district resources (or inputs), for example teacher characteristics and school expenditure, and school district performance on standardized tests.

2. There is no relationship between school district specific student characteristics (percentage of minority and student eligible for subsidized lunch) and school district performance.

3. There is no significant relationship between school district socioeconomic factors (e.g. parents education level and median family income) and school district efficiency.

The alternative hypotheses for 1 is that we expect more and better resources will increase school district performance on standardised tests. The alternative for 2 is that the student characteristics have a negative effect on school district outcome in standardised test as these characteristics reflect less favorable socioeconomic environment. The test will be one sided for favorable socioeconomic factors (example, higher median family income, more educated adults) as we expect them to have a positive influence on school districts' efficiency.

Significance of Study

A large amount of money has gone into Oklahoma education system from 1990 to 1994. This study presents an analysis of whether increasing resources can be expected to improve a particular educational outcome. This study examines school efficiency in two stages. This allows separate analysis of the effect of increased school resources on school district outcome, and the effect of district's socioeconomic status on their efficiency The school measures used in the study are based on data (1990 to 1994) obtained from the Oklahoma Department of Education.

Organization of Study

Chapter 1 covers the statement of problem and other background information applicable to the study. The next chapter, contains a literature review of major findings of past studies, and other related studies on school performance. The literature review is not exhaustive; its purpose is to establish the framework for this study. Chapter 3 presents the methodology and procedures used in analyzing the data and examines the variables. There are two stages to the data analysis. Chapter 4 presents the results for stage 1, and chapter 5 covers stage 2 results. The summary and concluding remarks will be given in chapter 6. The definitions and other relevant notes are given in the Appendix.

Source of data

The data for this study are obtained from a number of sources. The various measures of school district performance such as test outcomes, expenditures and teachers per student are from the reports "Results 1990" to "Results 1994" compiled by the

Oklahoma Office of Accountability. These reports are the result of the Oklahoma Education Indicators program which is one of the provisions included in House Bill 1017. The Indicators Program is developed for the purpose of assessing the performance of public schools and school districts and reporting to the general public the performance and progress during the years of education reform.

The other main source of data is the "School District Data Book (SDDB)" CD-Roms. These CD-Roms are developed by the MESA Group under the sponsorship of the U.S. Department of Education National Center for Education Statistics. The project involves cooperation of all state education agencies. Basically SDDB contains detailed 1990 Census School District Tabulation data, Administrative Data, and Census of Government School District Finances. The data can be summarized by state, or broken down by county and each school district within each state.

CHAPTER 2

REVIEW OF LITERATURE

In this chapter the focus will be on developing the methodology of the study in the context of current literature and evidence on efficiency of the educational system. We will review some of the major literature on educational production function and recent related inquiries into school performance.

Literature Review

An influential examination of school efficiency began with the Coleman Report. Hanushek (1978) states that the Coleman Report, published in 1966, was influential for a number of reasons. First, its impact was large because of its magnitude in analyzing information of nearly half a million students from over 3000 elementary and secondary schools. Second, it brought attention to the importance of the relationship between school inputs and student achievement. Last, it introduced policy makers to the statistical and analytical issues such as, production efficiency, statistical significance and multicollinearity, that are involved in such studies. Further, the Coleman Report highlighted the importance of input and output analyses to policy issues, such as school management of resources, consolidation of schools and the finance of public schools.

The Coleman Report found that student performance was more closely related to family background and students' peers, that is, characteristics of other students in the school, than to variations in schools (Hanushek, 1986, 1989). The report was controversial. Because of its relevance to policy issues, it generated a lot of interest and resulted in a significant and growing volume of analyses into school performance. These input and output studies of school performance were later referred to as the studies of the educational production function.

These studies differ in their estimation, approach, and focus. But, as Hanushek (1986), a leading scholar in this area asserted, they provide some understanding of school efficiency. These studies generally have a similar underlying notion, namely relating some output measure of the educational process to a series of inputs. A majority of the studies used student achievement on standardized tests, such as the American College Testing (ACT) as measures of output. In Hanushek's survey of 187 studies, over 70 percent of the studies used some kind of standardized test as a measure of educational output (Hanushek, 1989). Other examples of output measures used are college continuation, dropout rates, attendance rates and student attitudes.

The inputs reflect school characteristics that are believed to matter to student achievement. There are a number of factors which are consistently investigated in the studies. They include such measures as total spending per student, instructional spending per student, class size, teacher education, and teacher experience. Other inputs investigated relate to students' family background, their innate ability, and their peers.

The estimation approach also varied. Some studies have focused on school performance as related to individual student achievement, and others looked at aggregate performance across school districts. Some studies used single equation regression, and others used simultaneous equations techniques. Hanushek (1989, pg. 46) found a majority of the studies (104), close to 56 percent, focuses on individual students' achievement. The rest of the studies employed aggregate data, either at school, district or state level.

In an effort to understand and reconcile results, Hanushek (1986, 1989) reviewed results from some 187 studies of the educational production function that followed the Coleman Report. The reviews were restricted to studies of U. S. public schools. They covered different grade levels, different measures of performance, and different analytical approaches. The primary determinants of student achievement that Hanushek surveyed are expenditure per student and teacher per student ratio, teacher education, and teacher experience. The results of the studies were mixed and contradictory. However, Hanushek found that there are consistent in finding "no strong or systematic relationship between school expenditures and student performance" (Hanushek, 1989, pg. 47). They also found that family characteristics were the primary factor linked to student achievement.

As with most empirical studies, these studies on school performance have conceptual and statistical problems. Hanushek (1978, 1986) and others (Boardman and Murnane, 1979) highlighted some of the conceptual and analytical problems present in these studies, which might account for the generally mixed results. Among them are relying on standardized test scores as primary measure of educational output and the dependency of choice of inputs on data availability rather than conceptual notions. Then there is the issue of departure between the conceptual and empirical models due to ambiguous assumptions regarding omitted variables (e.g. students innate ability, and past achievements), and measurement errors that might give biased estimates of the relationship. Hanushek, Rivkin, and Taylor (1996) found evidence that the problem of omitted variable bias tends to increase with the level of data aggregation. This problem is further worsen by specification problems. These problems consistently result in a larger estimated impact of school resources on student performance, perhaps explaining why aggregate data are much more likely to find positive school resource effects on student achievement.

Hanushek's conclusion from the survey is not universally accepted. Hedges, Laine and Greenwald (1994) in their analysis argued that Hanushek's analytical method of reviewing the studies has low statistical power, making his conclusions suspect. They reanalyzed Hanushek's review of the 187 studies on school performance using a sophisticated statistical method of synthesis - meta-analysis. They found in their reanalysis that school inputs matters. In particular, they found a positive and consistent relationship between school inputs (or resources) and school outputs (as measured by student performance).

In response, Hanushek (1994, pg. 5) stated that Hedges et al set out to show that the statement "there is no strong or systematic relationship between school expenditures and student performance" is statistically incorrect. Hanushek (1994, pg. 6) stated that "they interpreted this statement as meaning that there is no evidence that the estimated relationship in any study has the expected sign and is statistically significant". They attempted to zealously prove his statement incorrect using what they referred to as the right statistical and sophisticated methods. Hanushek responded by stating that his statement meant to summarize a situation, where the majority of studies found the relationship between specific resources and student performance to be statistically insignificant. He reasserted Hedges, Laine and Greenwald's findings are nothing new and different. Their findings merely confirmed his previous findings that a vast majority of studies on the relationship implied that the estimated relationships are statistically insignificant.

Related studies try to measure the importance of school quality by relating it to earnings or other labor market outcomes. This gives a different perspective on school performance. Recent studies are by Card and Krueger (1992a, 1992b), found a positive relationship between school quality and earnings.

Card and Krueger (1992a) did an extensive analysis relating earnings and school quality. They estimated the effects of school quality (as measured by the pupil per teacher ratio, average term length and relative teacher pay) on rate of return to education, using aggregate measures of school quality by state for each group of men born between 1920 and 1949. They concluded that men from states with higher quality schools and better educated teachers generally have a higher rate of return. Teachers' education is measured by the mean years of education. They further found an individual's family background, measured by parents income and education, had no impact on returns to education, holding school quality constant. In a related study Card and Krueger (1992b) examined the relationship between school quality and the wage gap between southern born black and white men. Using similar measures of school quality as their earlier study, Card and Krueger found that school quality had an affect on narrowing the wage gap between black and white men.

One problem with such earning - school quality studies is the degree of correlation between student achievement and earnings (Card and Krueger, 1992a). Student achievement and earnings are correlated but not identical. The results of these studies may be confounded by other factors that may affect earnings but have smaller or no impact on test scores. An examination by Heckman et al (1995) found the estimated impacts of school quality on earnings are sensitive to the assumptions and specifications of the quality - earnings relationship. They also found that quality affects the return to education differently across different labor markets. Betts (1996) provided a detailed review of the literature on the relationship between school resources and students' outcome as measured by their earnings and educational attainment. His review casts doubt on the existence of a strong school quality - earnings relationship, and hence on the benefit of investments in the public schools. Betts (1996) found that results of such studies are dependent on whether the school inputs used are measured at school level or state level, the period of schooling, and the age of the workers for whom the earnings are observed. Studies that find a strong relationship between school inputs and earnings generally measure school resources at the state level, and workers schooled before the 1960s. Studies of the relationship between earnings of more recently educated workers and school quality find no significant effect.

Other recent investigations consider other determinants of school performance. Among those recently investigated are school choice, i.e. allowing parents to choose which public schools they want their children to attend. These studies infer that the arguments for school choice came from the hypotheses that competition between schools improves the quality of education and attempt to test it. Hoxby (1994a, 1994b) did two separate studies looking at effect of school choice on school performance. One is in the context of private and public schools, and the other is among public schools only. Hoxby estimated several models using instrumental variables and least squares. In her first study (Hoxby, 1994a) looks at 1) the effect of private school enrollment on public school outcomes (e.g. public school students' educational attainment, their wages, and test scores) holding variations in public school spending constant, and 2) the effect of private school enrollment on public school characteristics such as teachers salaries, per pupil spending, and variation in per pupil spending. Hoxby (1994a) found that increased competition between private and public school increased public school productivity. She added that this increase in public school productivity is mostly by means that do not require higher spending. There is also evidence that public schools react to private school competition by paying higher teacher salaries. Her second study (Hoxby, 1994b) used similar methodology and measures of public school outcome as her first study, with an additional school outcome of teacher per student ratio. In this study, she examines the effect of easier choice of public schools on public schools' outcomes. To capture ease of choice among public schools, the Herfindahl index of enrollment shares are used as measure of concentration of public school districts. The evidence suggests competition among public schools leads to greater productivity. Public schools facing choice are generally in areas of lower per pupil spending, lower teacher salaries, and larger class sizes. Nevertheless these schools tend to have better than average student performance, as measured by educational attainment, wages and test scores. These findings are consistent with the idea that school expenditures have no or even a negative relationship with student performance. The findings also reject the hypothesis that smaller classes benefit student performance. These findings support prior evidence of no relationship between school resources and student achievement.

A different approach to analyzing school efficiency uses frontier methodology. Generally studies on school efficiency use multivariate regression analysis that examines the effect of school inputs on average school performance. The frontier approach measures inefficiency (or technical inefficiency) from the "best practice" production frontier. This frontier describes the boundary of maximum outputs that can be achieved given the inputs. This is the main difference between frontier analysis and the usual regression techniques.

There are two frontier methods used to measure technical efficiency, the linear programming method (DEA) and the econometric method. Bessent et al (1982) favor the DEA approach as it overcomes most of the problems associated with the econometric approach. Bessent states that in contrast to the econometric approach, DEA does not require the production function to be in parametric form, allows multiple outputs, which can be related linearly or non linearly with the multiple inputs, and uses extremal methods to locate sources of inefficiency (Bessent, 1982, pg. 1350). These are some of the reasons a majority of the published studies on school efficiency have used linear programming (DEA) to examine school efficiency or technical efficiency (for example, Bessent et al 1982, Bessent et al 1980, Fare et al 1989, Jesson et al 1987, McCarty et al 1992, and Ray 1991). Some examples of DEA studies using multiple outputs are Bessent et al (1982), and Fare et al (1989). DEA studies generate efficiency ratings for the schools in the sample, given the set of school and non school variables under consideration. Generally the results will show low achieving schools which are efficient, and high achieving schools which are inefficient. DEA then provides a means for a comparative analysis of school efficiency among schools in the sample. This is achieved by calculating the expected input and output values for an inefficient schools as if it were efficient, and measuring the extent to which inputs are underutilized if the schools were inefficient (Bessent et al, 1980, pg. 73). The results are unique to each school in the sample. DEA however, does not provide the means to test hypotheses about, for example, increased resources on school outcome.

Other frontier studies, such as McCarty et al (1992) and Ray (1991), employ the two stage method of frontier analysis. The two stage method differs from the one stage method in that it provides the possibility of separating the effect of different sources of inefficiency, school and non school inputs. School inputs are those school resources under the control of the school district decision maker. Non school inputs are those variables the decision maker has no control over, such as variables that reflect socioeconomic and demographic characteristics. The two stage method involves using either the DEA approach or the statistical approach in stage 1 to estimate the relationship between school outputs and inputs, and obtain the relative school efficiencies. Both Ray and McCarty used DEA to compute the relative school inefficiencies. Then stage 2 regresses the efficiencies on socioeconomic characteristics that were omitted from stage 1. McCarty et al (1992) found similar results with the one stage or two stage method. That is, there is no major difference in the efficiency rankings of the 27 poor and urban school districts in New Jersey between the two methods. Ray (1991) asserted in his efficiency of school districts in Connecticut, that the two stage method is most appropriate if the focus is to isolate the source of inefficiency, whether due to school management or socioeconomic factors. The evidence from Ray (1991) and McCarty (1992), suggest that to a large extent school districts' inefficiency can be explained by their socioeconomic conditions. However, the evidence also indicate that there are school districts whose achievement levels can be improved with more effective use of its resources.

Only a few of the studies have used econometric methods of frontier estimation to study education production function and to measure school efficiency (for example, Barrow 1991, and Deller et al 1993). Deller et al (1993), examines the production efficiency of elementary schools in Maine. Deller et al (1993) reported that Maine schools did show some level of production inefficiency. The results also show parent's education, community income, school size and expenditures on instructional related activities are important determinants of student achievement. Lovell (1992) points out the DEA and the econometric frontier approach differ essentially in their treatment of noise and inefficiency. The econometric approach has the advantage of separating the effect of noise and inefficiency and the disadvantage of being susceptible to specification errors. In his study, Barrow (1991) illustrates the sensitivity of cost frontier analysis to the different statistical estimation techniques; cross sectional and panel data. The dependent variable is the average cost per pupil of 57 local education authorities (LEA) in England. The determinants are a number of school outputs and socioeconomic background variables. He concluded that the estimated efficiency is sensitive to the method of estimation used and that the panel data estimation gives a much higher estimate of cost inefficiency. Besides evidence of cost inefficiency, Barrow found some evidence of economies of scale, i.e., larger LEAs have lower average cost per pupil. He also found that LEAs with higher percentage of students with low socioeconomic status face higher cost per pupil.

The general consensus of the frontier studies is obtained from Taylor (1994) who reviewed at least 10 studies on educational frontier production of schools in United States. The results of these frontier studies implied on the average, U. S. public schools inefficiency range from less than 5 to 15 percent (Taylor 1994, pg. 3). A majority of the frontier studies reviewed used DEA approach.

Conclusion

There must be a continual process of evaluating school performance because of its importance and the wide usage of its findings academically and economically. It is even more important because of the wave of school reforms directing more resources to schools and the expectation of future tightening of school financing. This study intends to continue the investigation into school efficiency, addressing some of the empirical issues such as omitted variables by using panel data. Generally most studies on school efficiency have been "cross sectional and include only contemporaneous measures of inputs" (Hanushek, 1978, pg. 364). A panel data study of school efficiency may reduce the bias due to effect of omitted variables on the estimated relationship. (Other advantages of panel data will be discussed in future chapters.) This study intends to use the statistical frontier approach because it provides the possibility of estimating and testing the relationship between inputs and outputs of the educational production. This study will assume the two stage method of analysis to focus on the differing impacts between inputs under policy makers control and beyond their control.

CHAPTER 3

METHODOLOGY

This chapter discuss the theory and methodology used in the study. There are various sections covering model specification and other formulations for the different stages in the study. The last section will present a discussion of the variables and their correlation.

Methodology

The objectives of this study are 1) to evaluate the performance of Oklahoma school districts by quantifying their relative efficiency, 2) to investigate if variations in school district resources have any effect on Oklahoma school districts' performance, and 3) to examine the difference sources of school district efficiency. The school districts are assumed to have the basic input output educational production function. Their performance is measured by their students' outcome on standardized tests such as the Iowa Tests of Basic Skills (ITBS) and the Test of Achievement Proficiency (TAP). Student achievement is assumed to be a function of inputs from family, peers, schools and teachers.

These analyses of school district performance will be carried out in two stages as in McCarty et al (1992) and Ray (1991). With the two-stage method, the inputs can be separated into school and non school inputs. School inputs are inputs or resources under policy makers' control, such as school expenditure and teachers. Non school inputs refer to external factor or inputs over which the school districts have little or no control such as students' family, and socioeconomic background. The first stage involves using school inputs to estimate the education production function and to compute the relative efficiency. The second stage involves estimating the effect of non school factors such as socioeconomic variables on school districts' efficiency.

Instead of using a linear programming approach in stage one, as in McCarty (1992) and Ray (1991), the stochastic frontier approach will be used to estimate the education production function and compute the school districts' relative efficiency. The stochastic frontier is appropriate as it allows us to meet the objectives specified earlier. Furthermore, the frontier approach is more in line with the economic concept of a production function than is the average production function, which most econometric studies of education production have used. The frontier approach traces out the maximum or "best practice" frontier given the set of school inputs. The school district performance or efficiency is then measured relative to this maximum frontier, not the average frontier. Taylor (1994, pg. 2) describes schools on the frontier as "the schools that either need the fewest resources to produce a given level of output or that produce the most output with a given level of resources". Further, schools are inefficient if "they use more resources or produce less output" than comparable schools on the frontier.

For stage one this study will use panel data from Oklahoma school districts from 1990 to 1994. According to Lovell (1992, pg. 25) the principal advantage of panel data is the ability to observe each school district more than once. This ability should translate into "better" estimates of efficiency for each school district than can be obtained from a single cross section. Another advantage of panel data involves the flexibility to introduce group and time specific effects into the model to control for omitted variables. This is one of the empirical issues associated with cross sectional or time series studies on school performance (Hanushek 1978, 1986 and Boardman et al 1979). Omitting an important variable can introduce bias in the estimates of the model's parameters; i.e. effect of school resources on school performance (Hanushek

1986). It is reasonable to assume that using panel data models in stage 1 will lessen the effect of this bias. The omitted variables may consist of other less relevant school district specific inputs or other unmeasured characteristics of non-school district inputs relevant to performance. The other main advantage of using panel data involves relaxation of strong assumptions such as the distributional assumptions of error terms often required by cross sectional data (Lovell 1992, pg. 25).

<u>The Stochastic Frontier model</u>

Schmidt and Sickles (1984, pg 368) state the frontier model for panel data can be written as

$$y_{it} = \alpha + X'_{it}\,\beta + v_{it} - \mu_i \qquad (2.1)$$

where

$i = 1, .., N$ refers to the school district,

$t = 1, ..., T$ refers to the time period,

y_{it} is the output of school district i at time t, and

X'_{it} is the 1xK vector of production inputs

The frontier model assumes two types of disturbance terms; 1) v_{it} - a two sided disturbance that represents other unobserved and or unmeasured influence on output y_{it}, and 2) μ_i - a one sided disturbance term representing the technical inefficiency of the school district. It is assumed that v_{it} is uncorrelated with the regressors, and $\mu_i \geq 0$ (for all i) and identically and independently distributed (iid) with mean μ and variance σ^2 and is independent of v_{it}.

The model can be rewritten in two ways (Schmidt and Sickles 1984, pg 368); First, let $E(\mu_i) = \mu > 0$ and define

$$\alpha^* = \alpha - \mu, \qquad \mu_i^* = \mu_i - \mu \qquad (2.2)$$

so that μ_i^* are iid with mean 0. The model then becomes

$$y_{it} = \alpha^* + X'_{it}\beta + v_{it} - \mu_i^*, \qquad (2.3)$$

and the error terms v_{it} and μ_i^* will have zero mean.

The second way defines

$$\alpha_i = \alpha - \mu_i = \alpha^* - \mu_i^* \qquad (2.4)$$

and the model becomes

$$y_{it} = \alpha_i + X'_{it}\beta + v_{it}. \qquad (2.5)$$

The frontier production function describes the maximum output obtainable from a given set of inputs. The technical inefficiency is computed as the distance of school district output from the maximum frontier.

There are several ways to estimate the frontier model for panel data. We consider two ways. The frontier model can be estimated as a Fixed Effects (FE) model (Least Square Dummy Variables) or as a Random Effects (RE) model (Generalized Least Squares). Discussions of panel data models can be found in Judge et al (1988), and Greene (1993). Schmidt and Sickles (1984), Beeson and Husted (1989), and Greene (1992) present panel data analysis in the context of frontier models.

1) Fixed Effects

The Fixed Effects (FE) estimator is also referred to as LSDV (Least Square Dummy Variables) or the within estimator in panel data literature. If the μ_i, which represents technical inefficiency, is assumed fixed over time, then the frontier model can be estimated by the FE model. This will give a model with N different intercepts ($\alpha_i = \alpha - \mu_i$) where $i = 1, \ldots, N$ and "α" is the overall constant term. These intercepts are then used to estimate the technical inefficiency, μ_i of the frontier models. The consistency of FE estimator does not depend on μ_i being uncorrelated with the regressors. The Least Squares parameter estimator of the slopes in the FE model is consistent as either N (number of school districts) or T (number of years) approaches infinity. The consistency of the OLS estimator of the fixed effects (α_i) requires T to approach infinity. Schmidt and Sickles (1984, pg. 368) used the assumption that μ_i is greater than or equal to zero to define the estimate of μ_i as $\max(\alpha_i)- \alpha_i$ for the N different intercepts. This definition amounts to treating the most efficient firm (in our case the school district) in the sample as 100 percent efficient. The estimated μ_i and $\max(\alpha_i)$ are consistent as N and T approaches infinity.

2) Random Effects

If the technical inefficiency, μ_i, is assumed random and independent of the regressors, then the frontier models can be estimated by the generalized least squares (or GLS). Beeson and Husted (1989, pg. 18) describe the GLS estimator as essentially a weighted average of the FE and a cross section estimator (or between estimator). The cross section estimator is derived from a regression on means over time of the regressors for each cross section unit. The GLS weights are derived from the components of the covariance matrix, which is a function of var(μ_i) and var(ν_{it}). Var(μ_i) is the variance of the individual effects, and var(ν_{it}) is the variance of the random error term. As in the panel data literature, if the disturbance variances, var(μ_i) and var(ν_{it}) are not known then the GLS estimators are based on the consistent estimates of the variances. The GLS estimator of α^* and β is consistent as either T approaches infinity or N approaches infinity. In general, it will be more efficient than the FE estimator, especially as the number of individual units, N, grows. As T approaches infinity the efficiency improvement of GLS relative to the FE estimator diminishes. Hence, the best circumstance for GLS is when T is small and N large - exactly the situation in the Oklahoma school district sample.

In our case, since the variances of disturbances are unknown, the best linear unbiased predictor of the individual effects (Schmidt and Sickles, 1984, Judge et al

1988) is a function of the var(μ_i) and var(ν_{it}), and this equation is given later in the chapter (see efficiency equations).

An important consideration in choosing between the two models (FE or RE) relate to the assumptions about the correlation of the individual effects μ_i and the regressors. The RE (or GLS) estimator assumes the effects and the regressors to be uncorrelated. The FE (or LSDV) estimator does not. The Hausman test can be used to test the hypotheses of correlation between the individual effects and the regressors, and so distinguish between the two estimators (Schmidt and Sickles, 1984, pg. 370).

Another important distinction between the FE and RE models relates to the inferences that can be made. The RE model assumes the sample is randomly drawn from a large population and their inferences can be generalized to units outside the sample (Judge et al, 1988) The FE model assumes they are not randomly drawn; therefore any inference is confined to the units in the sample only.

In stage 1, for comparison and analytical purpose, we will estimate the frontier models as FE and RE models.

Model Specification (Stage 1)

In stage one, we use school district results on standardized tests for grade 3 and grade 11 as measures of school district performance. Grade 3 test results are school districts' outcomes on the Iowa Tests of Basic Skills (ITBS) and grade 11 test results are district outcome on Tests of Achievement and Proficiency (TAP).

One of the issues regarding estimating school quality differences is the use of contemporaneous input and output measures. Hanushek (1989, pg. 183) states that contemporaneous measures do not reflect the effects of historical inputs on student achievement. Learning is a cumulative experience that occurs over time. This study uses a third-grade performance measure which reduces the problem of omitting past school inputs, past family inputs, and past peer influence. It is reasonable to assume that the lower grade output is a more precise measure of students' performance as related to contemporaneous inputs. The effects of historical inputs may be more important with higher grade levels. With the panel data models, however, group effects may capture the effects of these historical inputs. From this perspective, panel data models are similar in concept to using the value-added approach to estimating school quality differences. The difference is the value-added approach uses prior output measures as proxies for past determinants of school performance, while the panel data models uses the group effects. It has been shown (Hanushek, 1989) that the value-added approach of estimating school quality differences yields reasonable and less biased parameter estimates.

The functional form for the school production function in our empirical model is a variation on the logarithmic reciprocal model. It is assumed that for some of the inputs, test scores increase at an increasing rate at first then at a decreasing rate to an asymptotic limit. That is, for example beyond a certain level of expenditure, the marginal effect of total expenditure per student on test scores will diminish and eventually become zero. Assuming this functional form allows us to capture this relationship. (Effects of other variables are explained later in this chapter). We will estimate several versions of FE models and the RE models. This allows us to evaluate the consistency of results across the different models. In addition to the individual specific effects, time specific dummy variables are included to capture effect of structural or institutional changes. The models are based on the following specific equations:

<u>Model</u> <u>Equation</u>

T(1): $$LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 TEXPSR_{it} + \beta_4 TIME_{it} + v_{it} - \mu_i \quad (2.6)$$

$$\text{TSAL(1)}: \quad LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 TEXPSR_{it} - \beta_4 SALR_{it} + \beta_5 TIME_{it} + \nu_{it} - \mu_i \tag{2.7}$$

$$\text{OSAL(1)}: \quad LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 OEXPSR_{it} - \beta_4 TSTUR_{it} - \beta_5 SALR_{it} + \beta_6 TIME_{it} + \nu_{it} - \mu_i \tag{2.8}$$

$$\text{OTM(1)}: \quad LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 OEXPSR_{it} - \beta_4 TSTUR_{it} + \beta_5 DEGREE_{it} + \beta_6 YRSEXP_{it} + \beta_7 YRSEXP2_{it} + \beta_8 TIME_{it} + \nu_{it} - \mu_i \tag{2.9}$$

where

$i = 1,\ldots,N$ represents the school district

$t = 1,\ldots.,T$ represents time

LNTS = natural log of school district's average test scores

ENROL, ENROL2 = enrollment, and square of enrollment

TEXPSR = 1/total expenditure per student

SALR = 1/average teacher salary

OEXPSR = 1/other expenditure per student

TSTUR = 1/teacher per student ratio

DEGREE = teachers' degree

YRSEXP = teachers' experience, and square of YRSEXP

TIME = dummy variables for year

β_i = parameters to be estimated

ν_{it} and μ_i represents the two types of disturbance terms assumed by the frontier models.

Model T(1) assumes that total spending per student (TEXPS) is the primary determinant of school district educational outcome in standardized tests. The second model, TSAL(1), adds average teacher salary. Holding TEXPS constant, an increase in salary reduces the number of teachers and perhaps increasing the quality. TEXPS is basically instructional expenditure per student (INSEXPS) and other expenditure per student (OEXPS);

(TEXPS = f(OEXPS, INSEXPS)).

Instructional expenditure per student is total expenditure devoted to instruction. Other expenditure per student is total expenditure per student less instructional expenditure per student. INSEXPS is generally a function of teachers average salary (SALARY) and teachers per student (TSTU);

(INSEXPS = f(SALARY, TSTU)).

Therefore TEXPS is then a function of OEXPS, TSTU and SALARY, which give the basis for model OSAL(1). Teachers' salary is normally determined by teachers' degree and years experience;

SALARY = f(DEGREE, YRSEXP)

This relationship provides the basis for model OTM(1).

Efficiency Equations

The Fixed Effect model assumes the individual effects, μ_i to be fixed over time. Therefore it estimates a separate intercept for each of the N school districts in the sample. The intercepts will then be used to calculate the efficiency index. Given the logarithmic specification of the model, the efficiency index (EI) is calculated as:

$$EI = 100\exp(-u_i) = 100\exp(-(a-a_i))\ i=1,\ldots,N \qquad (2.10)$$

where u_i is the estimate of technical inefficiency (μ_i), a_i is intercept (α_i) estimate for the ith school district, and a is maximum of the a_i (from Beeson and Husted, 1989). This implies that the most efficient school district in the sample is 100% efficient. The estimates of μ_i and α_i are consistent as N and T approaches infinity.

The Random Effects model assumes that individual school district effects are random. The best linear unbiased predictor of these individual effects (from Schmidt and Sickles (1984, pg. 369) and Judge et al (1988, pg. 486)) can be estimated as:

$$u_i^* = (vu/v1)(j'_T(y_{it} - X_{it}'b_{it})) \qquad (2.11)$$

where vu and v1 are the variance components of the GLS covariance matrix, y_{it} is the vector of dependent variables, X_{it} is a matrix of independent variables, j_T is a (Tx1) vector of ones, and b_{it} is the vector containing the GLS parameter estimates. Variance v1 is a function of variances of disturbance terms, var(u_i) and var(ν_{it}). Judge (1988, pg. 486) states that this predictor "can be viewed as a proportion of the generalized least squares residual allocation to u_i^*, the precise proportion depending on the relative variances var(u_i) and var(ν_{it})". Estimates of these variances are obtained from LIMDEP (statistical software) from their estimates of the RE models. From this we then calculated the efficiency index for the RE models as:

$$EI = 100\exp(-(u-u_i^*)) \qquad i=1,\ldots N \qquad (2.12)$$

where u is the maximum of the individual effects. (Equation (2.12) is based on Beeson and Husted (1989) with regards to the logarithmic specification of the models).

Model specification (Stage 2)

In stage two we regress the efficiency index (EI) obtained from stage one on variables that are assumed to be the primary factors of students' and school districts' socioeconomic environment (example, family income, poverty level, and adult education). Most of these variables have been used in previous studies of school quality. In this study, the variables are categorized into two groups; the socioeconomic variables (example, family background such as family income and education), and the financial variables (example, local and federal source of revenue). To control for differing density and population sizes among the school districts, density and population variables are included. The models are specified as:

<u>Model</u> <u>Equation</u>

A: $$LNEI_i = \gamma_0 + \gamma_1 MFY_i + \gamma_2 XED_i + \gamma_3 XMLF_i + \gamma_4 XMIN_i + \gamma_5 XSPF_i + \gamma_6 XPOV_i + \gamma_7 CPF_i + \gamma_8 LNDEN_i + \gamma_9 LNTPOP_i + w_i \qquad (2.13)$$

B: $$LNEI_i = \gamma_0 + \gamma_1 MFY_i + \gamma_2 XED_i + \gamma_3 XMLF_i + \gamma_4 XMIN_i + \gamma_5 XSPF_i + \gamma_6 XPOV_i + \gamma_7 CPF_i + \gamma_8 LNDEN_i + \gamma_9 LNTPOP_i + \gamma_{10} LRX_i + \gamma_{11} FAX_i + \gamma_{12} DIRINS_i + w_i \qquad (2.14)$$

C: $$LNEI_i = \gamma_0 + \gamma_1 MFY_i + \gamma_2 XED_i + \gamma_3 XMLF_i + \gamma_4 XMIN_i + \gamma_5 LNDEN_i + \gamma_6 LNTPOP_i + \gamma_7 LRX_i + w_i \qquad (2.15)$$

D: $$LNEI_i = \gamma_0 + \gamma_1 MFY_i + \gamma_2 XED_i + \gamma_3 XMLF_i + \gamma_4 XMIN_i + \gamma_5 LNDEN_i + \gamma_6 LNTPOP_i + \gamma_7 LRX_i + \gamma_8 FAX_i + \gamma_9 DIRINS_i + w_i \qquad (2.16)$$

where

$i = 1,\ldots,N$ is the school district

w_i the error term is assumed normally distributed with mean zero and constant variance σ^2,

γ_j are the parameters to be estimated,

LNEI = log of efficiency index,

MFY = log of median family income,

XED = log of percent of adults with high school degree or higher,

XMLF = percent of mother in labor force,

XMIN = percent of minority children,

XSPF = percent of single parent family,

XPOV = percent of children in poverty,

CPF = average children per family,

LNDEN = log of population density,

LNTPOP = log of total population,

LRX = percent of total revenue from local property tax,

FAX = percent of total revenue from federal aid, and

DIRINS = percent of total expenditure on direct instruction.

These models will be referred to as the efficiency models. (For easier commentary, models evaluating efficiency index obtained from FE (or RE) models in stage 1 will be referred to as the FE (or RE) efficiency models). The group A models examine the effect of the socioeconomic differences on school district efficiency. The group B models examines the influence of socioeconomic and financial variables on school district efficiency. The group C and D models are similar to models A and B but restrict the coefficients of XSPF, XPOV and CPF to be zero. Estimating these different models allows us to evaluate the consistency in results and their sensitivity.

<u>Other Models (Stage 1)</u>

We also intend to add other variables to the basic models in stage one. The variables reflect the characteristics of the school district student body such as the percentage eligible for school lunch (LUNCH) and percentage of nonwhite minority students (MINORITY). LUNCH is used to measure the family income of the students. These student measures are non school inputs. This exercise allows us to test the sensitivity of the models to the inclusion and exclusion of these variables in stage one. The models are specified below:

Model	Equation	
T(2):	$LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 TEXPSR_{it} + \beta_4 TIME_{it} + \beta_5 LUNCH_{it} + \beta_6 LUNCH2_{it} + \beta_7 MINORITY_{it} + \beta_8 MINORITY2_{it} + \nu_{it} - \mu_i$	(2.17)
TSAL(2):	$LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 TEXPSR_{it} - \beta_4 SALR_{it} + \beta_5 TIME_{it} + \beta_6 LUNCH_{it} + \beta_7 LUNCH2_{it} + \beta_8 MINORITY_{it} + \beta_9 MINORITY2_{it} + \nu_{it} - \mu_i$	(2.18)
OSAL(2):	$LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 OEXPSR_{it} - \beta_4 TSTUR_{it} - \beta_5 SALR_{it} + \beta_6 TIME_{it} + \beta_7 LUNCH_{it} + \beta_8 LUNCH2_{it} + \beta_9 MINORITY_{it} + \beta_{10} MINORITY2_{it} + \nu_{it} - \mu_i$	(2.19)
OTM(2):	$LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 OEXPSR_{it} - \beta_4 TSTUR_{it} + \beta_5 DEGREE_{it} + \beta_6 YRSEXP_{it} + \beta_7 YRSEXP2_{it} + \beta_8 TIME_{it} + \beta_9 LUNCH_{it} + \beta_{10} LUNCH2_{it} + \beta_{11} MINORITY_{it} + \beta_{12} MINORITY2_{it} + \nu_{it} - \mu_i$	(2.20)

where LUNCH2 and MINORITY2 are LUNCH squared and MINORITY squared.

Variables and their Correlation

Stage One Variables

Data for stage one are obtained from the annual report "Results" from 1990 to 1994. These reports are published as part of the Oklahoma Education Reform Act of 1990. This report is issued to inform the public of the progress that has been made by the educational reform bill of 1990. The report contains various measurements of educational performance relating to school districts' test results, student information, and teacher information.

All the models include enrollment (ENROL) as a measure of school district size. Prior studies find no consistent relationship between enrollment and student achievement (Bridge (1979) et al, Dynarski (1989)). Andrews (1991) found that as school size increases, performance decreases. This study permits discussions of school district scale; the size variable, enrollment enter as a quadratic (ENROL, ENROL2). We expect test scores to increase with enrollment, but to do so at a decreasing rate. That is, we expect the a positive coefficient for ENROL and a negative one for ENROL2.

Total expenditure per student (TEXPS) is a measure of spending on instruction, support services, and other operations. Other expenditure per student is total expenditure per student less instructional expenditure per student. Total expenditure is a common gross measure of school inputs used in most school input and output studies. Hanushek's survey (1989) of studies with expenditure per student, found no consistent evidence to suggest it is positively related to educational outcome.

Because there is no exact data for other expenditures per student, we approximate it as being equal to total expenditure per student less instructional expenditure per student. Thus, other expenditures per student consists of school district spending on non instructional items such as administration, support services and building upkeep.

Salary, degree, and years experience reflects different measures of teacher quality. Salary reflects differences in teacher quality in terms of teachers educational qualification and teaching experience. However, average salary can also reflect the financial wealth of the school district. It is reasonable to assume that wealthier school districts pay a higher salary, and thus are able to attract better or more qualified teachers. We control for this, however, with the district dummy variable. Therefore, salary captures the effect of teacher quality and it is not confounded with other things including wealth of the school district. Hanushek's (1989) survey summarizes 69 studies with teacher salary. Of the 69, only 15 find salary to be significant, with 11 of them having the expected positive sign (Hanushek, 1989, pg. 47).

Teacher experience and degree are more direct proxies for teacher quality. It is assumed that relationship between teaching experience and student achievement increases to a point and then decreases. This occurs because experienced teachers may have less incentive to be more productive in the classroom. Hanushek's (1989) summary of the results on teacher quality found experience to most relevant. Of the 140 studies with teachers experience, approximately 37 percent of the estimates are statistically significant. Of those significant, 80 percent have the expected positive sign. Findings on teachers' education are less hopeful; only 12 percent of the estimates are significant, and 8 of the 13 significant have the expected positive sign.

The teacher per student ratio is a proxy for class size. It is argued by some that class size is a significant factor for higher test scores as smaller class size implies more attention given by teachers to individual students. This presumably translates to higher test scores. According to Hanushek's (1989) survey, there is no strong evidence to support the benefits of small classes, with 0.09 percent of the estimates having the expected relationship.

This study expects expenditure per student (total or other), teacher per student ratio, and salary to result in increased test scores at an increasing rate at first, then at a decreasing rate to an asymptotic limit. Thus, these variables are entered as reciprocals (see section on models specification). We expect a negative sign for the coefficient estimates of the variables' reciprocals. This implies a positive relationship between these inputs and school district expected test scores.

In some variations of the models, we include non school inputs in addition to school inputs in stage 1. This is to test the sensitivity of the models to inclusion and exclusion of these inputs. The non school inputs are student measures lunch (LUNCH and minority (MINORITY).

The variable lunch (LUNCH) is the percentage of students eligible for federally funded or subsidized lunch in school. LUNCH is a proxy for students socioeconomic status. Reviews by both Bridge et al (1979) and Hanushek (1986), find consistently that students' whose family are financially well off tend to perform better on average.

The variable MINORITY is the percentage of nonwhite students in the school district. MINORITY aggregated at district level also reflects differences in school district students' family background. Evidence on the effect of MINORITY are mixed. Dynarski et al (1989) conclude from their study of California elementary school districts that percentage of black is negatively associated with school districts' test scores. Andrews et al (1991) found a negative relationship between percentage of nonwhite students for upper grades, but not the lower grade.

In our models we presumed school district test outcome to vary with student measures; they are entered as quadratic. Low socioeconomic status is usually associated with LUNCH and MINORITY. This suggest an adverse effect on school district's expected outcome. However, we expect test scores to decrease with LUNCH and MINORITY, at an increasing rate. This imply a negative sign for coefficients of LUNCH and MINORITY, and a positive one for their squares, LUNCH2 and MINORITY2.

Stage Two Variables

Data for stage two is taken from the School District Data Book (SDDB) CD-ROMS. The SDDB is developed by The MESA Group using data from the Census Bureau and the National Center for Education Statistics (NCES), U.S. Department of Education. It contains social, economic and administrative data from the 1989 to 1990 census for nearly 15000 public school districts in the United States. The data extracted from the SDDB can be categorized as 1) socioeconomic data and 2) financial data. The socioeconomic data describe the socioeconomic and family background of students in the school district. The financial data reflect the local community effort and control of the school districts' management. Data are as relevant as possible for the 3rd and 11th grade population. Basically data are obtained for two age groups: ages 5 to 13 years which is relevant to grade 3 output, and ages 14 to 17 years which is relevant for grade 11 output. If not feasible, then the data applies to all children in the school district, 3 to 19 years of age who are not high school graduates.

The Coleman Report indicates that family background and characteristic of other students in the school has a more pronounced effect on performance than differences in school (Hanushek, 1986, pg. 1150). Hanushek (1986) and Bridge et al (1979) consistently found that family background is important in explaining differences in achievement. Districts with socioeconomic characteristics that make it difficult for students to achieve will show up in stage 1 as inefficient districts. This study assumes the following variables reflect the students socioeconomic background:

1. median family income (MFY),

2. percentage of adults with high school diploma or higher (XED),
3. percentage of mother in labor force (XMLF),
4. percentage nonwhite or minority (XMIN),
5. percentage of single parent family (XSPF),
6. percentage of children in poverty (XPOV), and
7. average children per family (CPF).

Note that data for variable XED, XSPF and CPF are from households with children enrolled in public schools. The data for XMLF, XMIN and XPOV are from the children's own characteristics. The XED represents the education of the head of household. The XMLF represents the percentage of working mothers for children living with both parents. The XSPF represents the percent of single parent family from family households. The district's financial variables representing community effort are:

1) percentage total revenue from local property taxes (LRX),

2) percentage total revenue from federal aid exclusive of payments for school lunch (FAX), and

3) percentage spending on direct instruction.

Also included are variables that describe urbanization differences. They are total population (LNTPOP) of school district, and the population density (LNDEN). The population represents the number of people per square kilometers of the school district. (Detailed definitions are in the appendix).

The assumption is that variables that reflects favorable family and social environment have a positive effect on school district efficiency. The variables are MFY, XED, and XMLF. While variables XMIN and XSPF that reflects the opposite environment have a negative effect on school district efficiency.

There is a large literature on the effect of socioeconomic variables on student achievement. Generally, the results are mixed. Following are some of the findings with respect to the effect of socioeconomic status on student's achievement.

Milne et al (1986) in their review of the literature on effect of working mothers, conclude that working mother have a negative effect on a white middle class school boys' achievement. The evidence is stronger for elementary school boys and marginal for high school boys. However, for lower class and black children, the evidence suggest that working mothers may contribute to their achievement.

Andrews et al (1991) in their study of school districts in Louisiana find that having both parents present is an important influence on student performance for grades 2, 7, and 10. Mulkey et al (1992) found single parent family has a negative effect on students' test scores, but the effect lessens once other socioeconomic variables relating to family background (example, parents' education, race, income) are controlled for. In their study, Milne et al (1986) found having two parents benefit the elementary school students more than the high school students.

According to the findings of Mulkey et al (1992), race has a stronger effect on lowering test scores than single parent family. Andrews et al (1991), however, find that percentage minority has a negative influence on upper grades (grade 7 and 10), but no influence on the lower grade (grade 2).

<u>Stage 1 Variables Summary and their Correlation</u>

The study uses a balanced panel of school data from 1990 to 1994 of all independent public school districts which offer both grade 3 and grade 11. School districts with missing school data are eliminated from the sample. There are 405 school districts for grade 3, and 400 school districts for grade 11. The summary statistics and correlation analysis between the sample data sets are similar. Since there are only slight differences in number of observations between the two grades, only grade 3 data summary statistics and correlation analysis are presented.

Table 3-1 gives summary statistics of variables used in stage one. The variables are grouped into district measures, teacher measures and student measures for easier analysis. The district measures are enrollment (ENROL), total expenditure per student (TEXPS), other expenditure per student (OEXPS), and teacher per student ratio (TSTU). The student characteristics are given by lunch (LUNCH) and minority (MINORITY). The characteristics of teachers are given by degree (DEGREE), years experience (YRSEXP) and salary (SALARY). The standard deviation and the range suggest that there is sufficient variation in the school district data for an informative evaluation of its relationship.

Table 3-2 to 3-4 give the correlation analysis of the variables. Correlation is the degree of linear association between pairs of variables. Correlation of greater than or equal to 0.8 indicates a strong linear association and suggests a potential problem of multicollinearity (Griffiths, 1993, pg. 435). The correlation analysis does not seem to indicate a significant collinearity problem among stage one variables.

Among district measures (table 3-2) used in stage one, all measures are significantly correlated with the correlation ranging from -0.28 to 0.89. The highest correlation 0.89 is between total expenditure per student (TEXPS), and other expenditure per student (OEXPS). The lowest correlation -0.28 is between enrollment (ENROL), and teacher per student (TSTU). Enrollment is negatively correlated with expenditure per student and teacher per student ratio. Expenditure per student measures is positively correlated with each other and teacher per student ratio.

The correlation indicates that low expenditures per student is associated with high enrollment and small teacher per student ratio i.e. large class sizes. That is, large school districts have lower expenditures per student and bigger class sizes. The

Table 3-1 :

Summary Statistics
Stage 1 Variables

VAR.	YEAR	MEAN	STD	MIN	MAX
Test Scores					
Grade 3 Test	1990-1994	58.08	11.08	7	94
Grade 11 Test	1990-1994	52.90	9.83	13	83
District Measures (Grade 3)					
ENROL	1990-1994	1376.31	3493.34	107	41831
TEXPS	1990-1994	3607.42	767.61	2160	9847
OEXPS	1990-1994	1354.63	408.28	573	5598
TSTU	1990-1994	0.07	0.01	0.04	0.15
Teacher Measures (Grade 3)					
DEGREE	1990-1994	35.93	14.09	2	89
YRSEXP	1990-1994	12.12	2.51	5	27
SALARY	1990-1994	25806.52	2516.09	19314	33474
Student Measures (Grade 3)					
LUNCH	1990-1994	46.27	17.56	5	100
MINORITY	1990-1994	23.61	16.87	0	100

Table 3-2:

Correlation Analysis
District Measures

	ENROL	TEXPS	INSEXPS	OEXPS	TSTU
Grade 3 Test Score	0.05	0.12	0.16	0.05	0.04
	(0.0251)	(0.0001)	(0.0001)	(0.0212)	(0.0443)
Grade 11 Test Score	0.12	0.04	0.10	-0.03	0.002
	(0.0001)	(0.0728)	(0.0001)	(0.1352)	(0.9341)
ENROL		-0.17	-0.14	-0.16	-0.28
		(0.0001)	(0.0001)	(0.0001)	(0.0001)
TEXPS			0.91	0.89	0.68
			(0.0001)	(0.0001)	(0.0001)
INSEXPS				0.61	0.68
				(0.0001)	(0.0001)
OEXPS					0.54
					(0.0001)

The number in parentheses is the probability value.

Table 3-3:

Correlation Analysis
District Measures vs Teacher and Student Measures

	DEGREE	YRSEXP	SALARY	LUNCH	MINORITY
Grade 3 Test Score	0.10	0.05	0.24	-0.23	-0.22
	(0.0001)	(0.0184)	(0.0001)	(0.0001)	(0.0001)
Grade 11 Test Score	0.08	0.12	0.24	-0.45	-0.31
	(0.0002)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ENROL	0.11	0.02	0.24	-0.19	0.07
	(0.0001)	(0.2614)	(0.0001)	(0.0001)	(0.0015)
TEXPS	0.02	0.01	0.25	0.39	0.13
	(0.4238)	(0.5063)	(0.0001)	(0.0001)	(0.0001)
INSEXPS	0.05	0.04	0.35	0.33	0.09
	(0.0179)	(0.0419)	(0.0001)	(0.0001)	(0.0001)
OEXPS	-0.02	-0.02	0.08	0.38	0.14
	(0.2762)	(0.3275)	(0.0001)	(0.0001)	(0.0001)
TSTU	-0.03	-0.05	-0.25	0.36	-0.06
	(0.1438)	(0.0223)	(0.0001)	(0.0001)	(0.0054)

The number in parentheses is the probability value.

Table 3-4:

Correlation Analysis
Teacher Measures and Student Measures

	YRSEXP	SALARY	LUNCH	MINORITY
DEGREE	0.39	0.17	0.01	0.03
	(0.0001)	(0.0001)	(0.6763)	(0.1546)
YRSEXP		0.23	-0.06	-0.002
		(0.0001)	(0.0047)	(0.9328)
SALARY			-0.11	0.09
			(0.0001)	(0.0001)
LUNCH				0.53
				(0.0001)

The number in parentheses is the probability value.

correlation also suggest that school districts with large expenditures per student have smaller class sizes.

Among the teacher measures correlation (table 3-4) all measures are significantly and positively correlated with correlation ranging from 0.17 (between SALARY and YRSEXP) to 0.39 (between DEGREE and YRSEXP). Salary is more correlated with teachers experience (YRSEXP) than percentage of teachers with advanced degree (DEGREE).

The student measures LUNCH and MINORITY are positively and significantly correlated, with correlation of 0.53. School districts with large percentage of students eligible for free or subsidized lunch also have a large percentage of minority students.

Stage 2 Variable Summary and their Correlation

There are two socioeconomic data sets used for analysis in stage 2: one for grade 3 and the other for grade 11. These data sets are obtained from the School District Data Base (SDDB) from the 1990 census on school districts. The socioeconomic data for grade 3 is applicable for children ages 5 to 13 years enrolled in public schools and who are not high school graduates. The socioeconomic data for grade 11 is applicable for children age 14 to 17 years enrolled in public schools who are not high school graduates. School districts with missing socioeconomic data are eliminated from the sample. This reduces the number of school districts for the stage 2 analysis.

Table 3-5 gives the summary statistics of variables use in stage 2 for grade 3 and grade 11. Table 3-6 to 3-8 give the correlation analysis for the two data sets.

Note that the favorable socioeconomic variables (MFY, XMLF, and XED) are all positively and significantly correlated. The favorable variables are negatively and significantly correlated with XMIN.

Table 3-5:

Summary Statistics
Stage 2 - Socio Economic Variables

	VARS.	MEAN	STD	MIN	MAX
Grade 3	MFY	25685.68	6612.95	9637.00	50340
	XED	79.36	9.88	46.91	100.00
	XMLF	64.49	11.67	27.47	100.00
	XMIN	20.51	14.89	0	98.04
	LRX	23.07	11.63	1.46	66.61
	FAX	6.62	5.05	0.00	32.04
	DIRINS	55.22	6.41	15.86	70.02
	TPOP	7167.36	22444.39	553.00	288872
	DENSITY	40.36	106.54	0.49	1053.60
Grade 11	MFY	26443.63	6432.24	11953	51187
	XED	78.33	11.55	25.00	100.00
	XMLF	70.68	13.54	26.80	100.00
	XMIN	18.80	15.28	0.0	96.98
	LRX	22.79	11.24	1.46	66.66
	FAX	6.43	4.76	0	32.04
	DIRINS	55.27	6.46	15.86	70.02
	TPOP	7559.45	23119.35	572.00	288872
	DENSITY	42.60	109.60	0.87	1053.60

Note: Statistics for variable LRX, FAX, DIRINS, TPOP, and DENSITY apply to the school districts in the data set. The other variables are relevant to each grade in the school district.

Table 3-6:

Correlation Analysis - Grade 3
Stage 2 - Socio Economic Variables

VARS.	MFY	XED	XMLF	XMIN
MFY		0.58	0.14	-0.36
		(0.0001)	(0.0029)	(0.0001)
XED			0.15	-0.35
			(0.0019)	(0.0001)
XMLF				-0.09
				(0.0676)
LRX	0.33	0.35	0.08	-0.37
	(0.0001)	(0.0001)	(0.0953)	(0.0001)
FAX	-0.44	-0.28	-0.09	0.54
	(0.0001)	(0.0001)	(0.0541)	(0.0001)
DIRINS	-0.05	-0.08	0.02	-0.07
	(0.2815)	(0.1128)	(0.7283)	(0.1898)
DENSITY	0.21	0.11	0.05	0.08
	(0.0001)	(0.0186)	(0.3074)	(0.1022)
TPOP	0.13	0.08	0.05	0.10
	(0.0094)	(0.1112)	(0.3513)	(0.0481)
LAND	-0.04	0.02	0.07	-0.18
	(0.3942)	(0.6340)	(0.1490)	(0.0002)

The number in parentheses is the probability value.

Table 3-7:

Correlation Analysis - Grade 11
Stage 2 - Socio Economic Variables

VARS.	MFY	XED	XMLF	XMIN
MFY	1.000	0.53	0.18	-0.35
		(0.0001)	(0.0001)	(0.0001)
XED		1.000	0.13	-0.31
			(0.0073)	(0.0008)
XMLF				-0.08
				(0.1003)
LRX	0.33	0.30	0.08	-0.30
	(0.0001)	(0.0001)	(0.1321)	(0.0001)
FAX	-0.44	-0.26	-0.16	0.48
	(0.0001)	(0.0001)	(0.0012)	(0.0001)
DIRINS	-0.05	-0.06	0.09	-0.07
	(0.3028)	(0.2372)	(0.0426)	(0.1898)
DENSITY	0.24	0.12	0.07	0.09
	(0.0001)	(0.0108)	(0.1530)	(0.0633)
TPOP	0.15	0.9	0.16	0.11
	(0.0019)	(0.0760)	(0.0006)	(0.0269)

The number in parentheses is the probability value.

Table 3-8:

Correlation Analysis
Stage 2 Financial and Other Variables

VARS.	FAX	DIRINS	TPOP	DENSITY
LRX	-0.49 (0.0001)	-0.20 (0.0001)	0.11 (0.0173)	0.47 (0.0006)
FAX		-0.03 (0.5834)	-0.05 (0.2922)	-0.08 (0.5839)
DIRINS			-0.02 (0.6141)	-0.31 (0.0266)
TPOP				0.72 (0.0001)

The number in parentheses is the probability value.

Among the financial variables, school districts with higher percentage of local property tax (LRX) tend to have lower federal support and lower expenditure on direct instructions as percentage of total expenditure. School districts with favorable socioeconomic condition (especially, MFY and XED) tend to have higher percentage of revenue from local sources (LRX). School districts with high XMIN tend to have higher percentage of their revenue from the federal sources.

Conclusions

From stage 1, the choice of frontier models depends on the assumptions we make about the effects, random or fixed. For comparison and analytical purposes we estimate both fixed and random effects model. This allows us to evaluate the consistency in results, and its sensitivity to the different assumptions.

In summary we expect stage 1 results to show that school resources, regardless of how they are measured, will affect school district's performance on standardized tests. We expect stage 2 results to confirm that some of the variability in school district inefficiency can be explained by factors beyond the school district's control. These for example, are the socioeconomic factors and demographic factors. Also some of the differences in school district inefficiency can be explained by the extent of local community and federal agencies support for their school districts, and the focus of the school district's on instructional activities.

CHAPTER 4

RESULTS STAGE 1

Overview

The regression results for the stage 1 models are presented in this chapter. In stage 1 the panel data models (the Random Effects (RE) Model and Fixed Effect (FE) Model) are used to compute the relative efficiencies of the school districts. They are also used to test the hypotheses that school resources have no effect on school districts' expected outcome on grade 3 Iowa Tests of Basic Skills (ITBS) and grade 11 Test of Achievement Proficiency (TAP). The RE models estimated are categorized under models (1) and (2). They are:

A. Models 1	Explanatory Variables
1. RT(1)	enrollment (ENROL, ENROL2), and total expenditure per student (TEXPS)
2. RTSAL(1)	enrollment (ENROL, ENROL2), total expenditure per student (TEXPS), and average teachers' salary (SALARY)
3. ROSAL(1)	enrollment, other expenditure per student (OEXPS), teacher per student (TSTU), and teachers' average salary (SALARY)
4. ROTM (1)	enrollment, other expenditure per student, teacher per student, percentage of teachers with advanced degree (DEGREE), and teachers' average years experience (YRSEXP, YRSEXP2)

The FE models 1 are labeled as: FT(1), FTSAL(1), FOSAL(1), and FOTM(1).

B. Models 2

Models 2 are models 1 with student measures: percentage of students eligible for subsidized lunch (LUNCH), and percentage of minority students (MINORITY).

Note TEXPS, OEXPS, SALARY and TSTU appear as reciprocals in the models. We assume that school district's expected test scores will first increase at an increasing rate then at a decreasing rate until a certain level, beyond which the marginal effect of these variables on district's test scores will be zero. Therefore, we expect a negative sign for the variables' reciprocal. This implies the variables have a positive effect on school district test outcome. The analysis will focus around models (1). All hypothesis tests are at a 0.05 significance level unless specified otherwise. Elasticities are calculated based on the variables' sample mean. Note the unit of analysis is the school district. The results then relate to school districts' expected performance in grade 3 ITBS or in grade 11 TAP. For example, in model RT(1) TEXPS is significant with elasticity of 0.086 for grade 3 (table 4-2, 4-4). This implies a one percent increase in TEXPS will increase school district expected grade 3 test score by 0.086 percent, holding other variables constant. Note in interpreting the effect of the variables on each grade level, we assumed that the variables are relevant to the school district's outcome for the grade level analyzed. In actuality, the same set of data are applied to the different output. This assumption is necessary if we are to infer anything from the results.

General Results

The analysis emphasize results from the RE models. A preliminary analysis of the models indicates compelling evidence favoring the RE models over the FE models. The Lagrange multiplier test for whether group effects (or individual effects) are fixed or random (Ho: $u_i = 0$ or variance $u_i = 0$) was conducted. Large values of this test statistic cause us to reject the hypothesis that group effects are fixed, and is evidence in favor of the RE model (Greene, 1992, Greene, 1993, Judge et al, 1988). In table 4-1 it can be seen that FE are rejected at 5% level. The existence of RE means that efficiency gains are possible using a GLS estimator. However, if the random effects are correlated with the regressors, the GLS estimator is inconsistent. A Hausman test is conducted to determine whether the u_i and X_i are correlated. The Hausman test statistics are very small at 0.00010 with p values equal to 1 (see table 4-1). There is little evidence that the individual effects are correlated with the X_i. This means the RE estimators are asymptotically more efficient than the FE estimators (Greene, 1992, Greene, 1993, Judge et al, 1988).

The models estimated include fixed time effects. The joint F tests indicate the group effects for grade 3 and 11 models are jointly significant; so are the time effects. Evidence on group effects implies that differences among school districts, besides those reflected by the explanatory variables, have an effect on school districts' expected outcome on the tests. The time effects suggest that structural or institutional changes between the period 1990 to 1994 are responsible for some of the variation in school districts' expected test scores.

In the RE models, the time dummy for 1990 is omitted to prevent perfect collinearity. The result in table 4-2 and 4-3 show that school districts' outcome vary significantly across the years. The evidence is stronger, after controlling for the socioeconomic status (models (2)). The t values and the coefficient estimates for the time effects are higher compared to those in models (1).

<u>Stage 1 Results for RE models (RT, RTSAL, ROSAL, ROTM)</u>

<u>(i) RE models (1) (without LUNCH, and MINORITY)</u>

Table 4-2 and 4-3 gives the results for the Random Effects (RE) models, (1) and (2) for grade 3 and 11. Table 4-4 gives the elasticities. We found the results to be

Table 4-1:

Lagrange Multiplier Test Statistics

and Hausman Test Statistics

Models (1)	Grade 3 Lagrange Multiplier Test	Hausman Test	Grade 11 Lagrange Multiplier Test	Hausman Test
RT(1)	650.21 (0.0000)	0.00010 (1.0000)	701.58 (0.0000)	0.00010 (1.0000)
RTSAL(1)	631.46 (0.0000)	0.00010 (1.0000)	655.99 (0.0000)	0.00010 (1.0000)
ROSAL(1)	614.50 (0.0000)	0.00010 (1.0000)	629.41 (0.0000)	0.00010 (1.0000)
ROTM(1)	604.97 (0.0000)	0.00010 (1.0000)	633.71 (0.0000)	0.00010 (1.0000)
RT(2)	371.84 (0.0000)	0.00010 (1.0000)	231.70 (0.0000)	0.00010 (1.0000)
RTSAL(2)	368.75 (0.0000)	0.00010 (1.0000)	226.33 (0.0000)	0.00010 (1.0000)
ROSAL(2)	369.06 (0.0000)	0.00010 (1.0000)	234.65 (0.0000)	0.00010 (1.0000)
ROTM(2)	338.22 (0.0000)	0.00010 (1.0000)	206.78 (0.0000)	0.00010 (1.0000)

Note: Test statistics given by Limdep statistical sofware.
The number in parentheses is the probability values.

Table 4-2: Random Effects Model
Dependent Variable :Ln3

VARS.	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
ENROL	0.017E-3 (3.293)	0.013E-3 (2.400)	0.014E-3 (2.591)	0.017E-3 (3.120)	0.144E-5 (0.284)	-0.029E-5 (-0.056)	0.113E-5 (0.212)	0.130E-5 (0.251)
ENROL2	-0.045E-8 (-2.757)	-0.035E-8 (-2.132)	-0.038E-8 (-2.271)	-0.044E-8 (-2.659)	0.660E-11 (0.044)	0.446E-10 (0.289)	0.175E-10 (0.112)	0.159E-10 (0.104)
1/TEXPS	-310.55 (-2.222)	-300.82 (-2.158)			-686.54 (-5.001)	-672.18 (-4.880)		
1/OEXPS			3.060 (0.095)	6.375 (0.199)			-48.805 (-1.558)	-48.048 (-1.540)
1/TSTU			-0.007 (-2.268)	-0.006 (-1.765)			-0.013 (-3.705)	-0.012 (-3.434)
1/SALARY		-5706.3 (-2.321)	-6895.5 (-2.763)			-3011.7 (-1.275)	-5321.3 (-2.238)	
DEGREE				0.107E-2 (2.114)				0.153E-2 (3.330)
YRSEXP				-0.101E-1 (-0.904)				-0.044E-1 (-0.410)
YRSEXP2				0.309E-3 (0.774)				0.111E-3 (0.288)
LUNCH					-0.859E-2 (-5.204)	-0.848E-2 (-5.136)	-0.849E-2 (-5.126)	-0.894E-2 (-5.425)
LUNCH2					0.541E-4 (3.376)	0.544E-4 (3.391)	0.532E-4 (3.307)	0.552E-4 (3.451)
MIN					0.157E-2 (1.507)	0.141E-2 (1.342)	0.186E-2 (1.741)	0.194E-2 (1.833)
MIN2					-0.492E-4 (-3.444)	-0.477E-4 (-3.323)	-0.504E-4 (-3.489)	-0.507E-4 (-3.551)
INTERCPT	4.056 (88.953)	4.304 (36.861)	4.368 (34.362)	4.074 (48.694)	4.452 (70.558)	4.577 (39.241)	4.677 (36.958)	4.421 (49.313)
T(91-90)	0.010 (0.920)	-0.001 (-0.152)	-0.002 (-0.170)	0.016 (1.393)	0.006 (0.492)	-0.074E-2 (-0.060)	-0.245E-2 (-0.195)	0.012 (1.054)
T(92-90)	0.072 (5.693)	0.048 (2.924)	0.052 (3.228)	0.087 (6.921)	0.071 (5.732)	0.059 (3.696)	0.065 (4.171)	0.095 (7.611)
T(93-90)	0.100 (6.859)	0.064 (3.022)	0.073 (3.556)	0.121 (9.504)	0.089 (6.230)	0.070 (3.485)	0.085 (4.272)	0.123 (9.776)
T(94-90)	0.098 (6.425)	0.050 (2.004)	0.061 (2.481)	0.123 (9.727)	0.099 (6.715)	0.074 (3.069)	0.091 (3.851)	0.143 (11.267)
ADJ R2	0.066	0.073	0.077	0.076	0.188	0.190	0.189	0.198

The numbers in parentheses are the t values.

Table 4-3: Random Effects Model
Dependent Variable :Ln11

VARS.	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
ENROL	0.282E-4 (5.670)	0.227E-4 (4.407)	0.263E-4 (5.008)	0.309E-4 (5.980)	0.100E-4 (2.390)	0.071E-4 (1.631)	0.097E-4 (2.173)	0.111E-4 (2.572)
ENROL2	-0.073E-8 (-4.795)	-0.060E-8 (-3.932)	-0.069E-8 (-4.438)	-0.079E-8 (-5.141)	-0.021E-8 (-1.719)	-0.015E-8 (-1.180)	-0.020E-8 (-1.558)	-0.023E-8 (-1.863)
1/TEXPS	85.628 (0.658)	102.39 (0.792)			-476.03 (-3.290)	-446.89 (-3.667)		
1/OEXPS			55.568 (1.902)	59.336 (2.032)			-19.469 (-0.702)	-21.478 (-0.780)
1/TSTU			-0.740E-2 (-2.260)	-0.626E-2 (-1.921)			-0.127E-1 (-4.232)	-0.119E-1 (-4.031)
1/SALARY		-7604.3 (-3.380)	-8097.1 (-3.566)			-5104.1 (-2.481)	-6999.2 (-3.391)	
DEGREE				0.362E-3 (-0.775)				0.577E-3 (1.487)
YRSEXP				0.191E-1 (1.860)				0.242E-1 (2.558)
YRSEXP2				-0.560E-3 (-1.528)				-0.741E-3 (-2.148)
LUNCH					-0.917E-2 (-6.382)	-0.904E-2 (-6.304)	-0.909E-2 (-6.320)	-0.985E-2 (-6.896)
LUNCH2					0.468E-4 (3.346)	0.478E-4 (3.421)	0.463E-4 (3.303)	0.511E-4 (3.674)
MIN					-0.137E-2 (-1.553)	-0.168E-2 (-1.887)	-0.114E-2 (-1.250)	-0.078E-2 (-0.879)
MIN2					-0.250E-5 (-0.209)	0.484E-5 (0.040)	-0.337E-5 (-0.278)	-0.764E-5 (-0.640)
INTERCPT	3.840 (90.159)	4.170 (39.098)	4.278 (36.876)	3.773 (48.398)	4.368 (78.606)	4.580 (45.151)	4.711 (42.808)	4.216 (53.529)
T(91-90)	0.020 (2.002)	0.004 (0.377)	0.003 (0.263)	0.016 (1.531)	0.014 (1.420)	0.004 (0.368)	0.001 (0.151)	0.012 (1.188)
T(92-90)	0.073 (6.306)	0.041 (2.733)	0.037 (2.554)	0.066 (5.840)	0.070 (6.170)	0.048 (3.436)	0.005 (3.646)	0.077 (6.874)
T(93-90)	0.097 (7.281)	0.050 (2.589)	0.047 (2.526)	0.099 (8.626)	0.079 (6.154)	0.049 (2.739)	0.005 (3.213)	0.102 (9.003)
T(94-90)	0.090 (6.469)	0.028 (1.235)	0.024 (1.092)	0.090 (7.832)	0.089 (6.707)	0.048 (2.269)	0.005 (2.754)	0.117 (10.228)
ADJ R2	0.084	0.099	0.104	0.094	0.285	0.288	0.292	0.291

The numbers in parentheses are the t values.

Table 4-4:

Elasticity for Grade 3 and Grade 11

for Random Effects (RE) Models (1)

Vars.	Sample Mean	Grade 3 RT (1)	Grade 3 RTSAL (1)	Grade 3 ROSAL (1)	Grade 3 ROTM (1)	Sample Mean	Grade 11 RT (1)	Grade 11 RTSAL (1)	Grade 11 ROSAL (1)	Grade 11 ROTM (1)
ENROL	1376.31	0.022	0.017	0.018	0.022	1391.18	0.036	0.029	0.034	0.040
TEXPS	3607.42	0.086	0.083	x	x	3591.28	x	x	x	x
OEXPS	1354.63	x	x	x	x	1348.91	x	x	-0.041	-0.044
TSTU	0.073	x	x	0.097	0.083	0.072	x	x	0.103	0.087
SALARY	25806.52	x	0.221	0.267	x	25823.09	x	0.294	0.314	x
DEGREE	35.93	x	x	x	0.038	36.03	x	x	x	x
YRSEXP	12.12	x	x	x	x	12.15	x	x	x	2.155

consistent within the group of RE models (1); that is, RT(1), RTSAL(1), ROSAL(1), and ROTM(1). The results are consistent in the direction and significance of the estimates. The variables when significant have the expected sign.

The evidence is consistent that larger school districts perform better, but at a decreasing rate. In model RT(1) for grade 3, the coefficients of ENROL and ENROL2 are individually, and jointly significant with an elasticity of 0.022. ENROL has a positive sign with a t value equal to 3.293. The estimate for ENROL2 is negative, and has a t value equal to -2.757. These results imply that the net effect of 1 percent increase in enrollment will increase school districts expected grade 3 test scores by 0.022 percent, holding other variables constant. The quadratic relationship suggests that school district performance peaks when enrollment is approximately 19,000 students per school district. The other RE models (RTSAL(1), ROSAL(1), and ROTM(1)) show similar results with elasticity of 0.017 to 0.022, and peak performance when enrollment is about 19,000 students. In the models with the student measures (models (2)), enrollment is not significant. The evidence for economies of scale is stronger for grade 11; t values of ENROL and ENROL2 are higher and the elasticity larger. For example, in model RT(1) the t value for ENROL is 5.670 and ENROL2 is -4.795, with enrollment having elasticity of 0.036. In addition the results persist when student measures are added. The reason for this result may be the higher degree of specialization that exists in the higher grades. For a given expenditure per student, larger districts can provide more specialized classes. Thus it is not suprising that the effect of enrollment is greater in the higher grades. In the lower grades, the emphasis is more on basic skills like reading and arithmetic (Hanushek, 1978, pg. 362). Bridge et al (1979) review of a number of studies, using aggregated input and output at school level, found no relationship between enrollment and student achievement. Dynarski (1989) also found no relationship in his study on elementary schools with input and output aggregated at school district level.

The results also indicate that total expenditure per student (TEXPS) has a positive effect on school districts expected performance on grade 3 standardized tests. Model RT(1) estimate of its reciprocal (1/TEXPS) has the expected negative sign and is significant for grade 3 (t value = 2.222). Its elasticity implies that a 1 percent increase in total expenditure per student will tend to increase school districts' average test score by 0.086 percent (see table 4-4). Although, grade 11 model RT(1) estimate shows no significant effect of total spending on school districts' expected test outcome, the results with student measures are strong. The estimate of 1/TEXPS in model RT(1) for grade 11 is not significant (t value = 0.658) and has the wrong sign (positive). When student measures are included in the models, we obtain a positive relationship between TEXPS and school district expected outcome for grade 3 and grade 11 (see models RT(2) and RTSAL(2)). The t values are higher for grade 3 than grade 11. For example, in model RT(2), the t values for 1/TEXPS is close to - 5 for grade 3 and - 3.3 for grade 11 in model RT(2).

With the inclusion of the group effects, SALARY is assumed to reflect differences in teacher quality, not socioeconomic conditions. Model RTSAL(1) estimates that a 1 percent increase in SALARY will increase school districts' grade 3 test score by 0.22 percent holding other variables constant. SALARY has the expected sign and is significant (t value = -2.321). For grade 11, the evidence for SALARY is stronger; SALARY is more significant with a larger t value (= -3.380). In their review, Bridge et al (1979) found that when significant, teachers salary are positively related to student achievement (Some of the studies are Cohn, 1968, Perl, 1973, and Burkhead et al, 1967). Hanushek's (1989) survey reports no consistent evidence; he found estimates of SALARY when significant to be both positive and negative. In our study the evidence for SALARY weakens after controlling for LUNCH and MINORITY. The t values are slightly lower. For grade 3, SALARY became insignificant in 1 of the models estimated (model RTSAL(2)). The evidence is strong for grade 11 (models RTSAL(2), ROSAL(2)), and almost as strong for grade 3 (model ROSAL(2)) that higher salaries are associated with high performance on tests. To the extent that higher salaries reflect high quality teachers, this is evidence that the quality of teachers is important to the school districts' performance.

Model ROSAL(1) reflects school district's variations in TEXPS by its primary determinants; OEXPS, TSTU and SALARY. This has resulted in a higher t values for estimates of enrollment (ENROL, ENROL2) for model ROSAL(1) compared to those of model RTSAL(1).

Results of model ROSAL(1) suggest that the teacher per student ratio has a positive effect on school districts' expected outcome for grade 3 and grade 11. The t values are approximately -2.3 for both grades. Model ROSAL(1) finds that holding other variables constant, a 1 percent increase in the teacher per student ratio will increase expected test scores by 0.097 percent for grade 3 and 0.103 for grade 11. The evidence for TSTU is stronger after controlling for socioeconomic status of school district. From model ROSAL(2) the estimates for TSTU became more precise with higher t values for both grade 3 and grade 11 (t values close to -4 for grade 11, and -3.7 for grade 3). TSTU is used to measure the effect of class size. Earlier evidence on effect of smaller class sizes on student performance is weak (Hanushek, 1989, Bridge et al, 1979). The evidence show that even when significant, the signs are mixed. Some example of studies that uses data at school district level that favor smaller class sizes are Bidwell, 1975, and Andrews et al, 1991. Again our results for the two grades strongly support the proposition that resources matter.

Model ROTM(1) replaces teachers' average salary (SALARY) with teachers' education (DEGREE) and years experience (YRSEXP) to reflect differences in teacher quality. This change cause TSTU to be significant only at 0.10 confidence level for grade 3. Its t value decreases to -1.765 for grade 3, and -1.921 for grade 11. TSTU has an elasticity of 0.083 percent for grade 3, and 0.087 for grade 11 in model

ROTM(1). We further note that t values for TSTU increases after accounting for school districts socioeconomic status (model ROTM(2) for both grades). The evidence in favor of smaller classes is stronger after controlling for school district's socioeconomic status for model ROTM(2).

The intent is that OEXPS reflects school district's expenditures on activities indirectly related to students learning, that is, those that concern management and operations of the school districts. For models (1) the evidence appears that increasing OEXPS has an adverse effect on school districts performance for grade 11 but not grade 3. The t values are close to 2 with an unexpected positive sign for OEXPS for grade 11. After controlling for student measures, OEXPS became insignificant for grade 11, but t values increase for grade 3. However, OEXPS is still not significant for grade 3. Though not significant, OEXPS has the expected sign implying a positive effect on school district expected outcome. From this analysis it appears that OEXPS is sensitive to student measures.

DEGREE and YRSEXP are assumed to reflect teachers' quality. The evidence for DEGREE is stronger for grade 3. DEGREE is significant for school districts' outcome on grade 3 ITBS, but not grade 11 TAP. The evidence is even stronger after controlling for differences in socioeconomic status (t values are higher in models (2) for both grades). However, for grade 11, DEGREE remains insignificant. This results are consistent with the idea that teachers with advanced degree in education are more proficient at elementary levels. If most advanced degrees are education degrees rather than subject matter degrees, it is not surprising that a greater proportion of such degrees does not have as large an effect on grade 11 achievement as on grade 3 achievement.

In models (1) the evidence is teacher experience has a quadratic effect on school district test outcome for grade 11, not for grade 3. That is school districts' performance increases with teacher's experience for about 17 years, before it starts to decrease. The coefficients of YRSEXP and YRSEXP2 are jointly significant for grade 11, but not grade 3. YRSEXP has the expected positive sign and is significant at 0.10 for grade 11 (t value = 1.860), not grade 3. YRSEXP2 is negative for grade 11, but not significant for both grades. From this result, it appears grade 11 students are more dependent on teachers' experience than lower grade students. Our result contradicts Andrew's et al (1991) findings that experience is a more important variable for the lower grades. They believed that "lower grade students are much more dependent on the specific skills teacher has acquired with experience than for high school students" (Andrew's et al, 1991, pg. 32). In their study, Andrew et al used three measures of output, school district's outcome on grade 2, 7 and 10. Dynarski et al (1989) consistently found experience to have a positive influence on school district's outcome for grade 3 (in all 3 of the models estimated).

Further evidence, that school districts performance in the higher grade is dependent more on teachers' experience is provided by models (2). It appears that the effect is stronger for grade 11, but weaker for grade 3 after controlling for socioeconomic differences. The t values increase for grade 11, and decrease for grade 3 (see models (2)).

(ii) RE Models (2) (with LUNCH, and MINORITY)

Student measures LUNCH and MINORITY reflect the socioeconomic background of the students. We have already discussed the effects of having these socioeconomic variables on school districts' variables. In summary, some of the variables are sensitive to the student measures for grade 3. For example, ENROL has sign changes (see model RTSAL(2)) and enrollment becomes insignificant in all models (2). OEXPS is also sensitive to these student measures; it now has the expected sign (model ROSAL(2) and ROTM(2)). Average teachers' salary (SALARY) also become less significant, such that in model RTSAL(2) it is insignificant. However, results for variables TEXPS, TSTU, DEGREE, and YRSEXP are generally consistent. TEXPS, TSTU and DEGREE become more significant (higher t values), while YRSEXP has lower t values.

For grade 11, ENROL, TEXPS, and OEXPS are generally more sensitive to the student measures. Their t values are lower, and some ENROL estimates become insignificant. TEXPS, on the other hand becomes significant with the expected signs. OEXPS now has the expected sign. The evidence for DEGREE and YRSEXP are stronger (the t values increased). However DEGREE remains insignificant, but YRSEXP and YRSEXP2 become more significant at 0.05 significant level.

We also observe a stronger relationship between TEXPS and socioeconomic status of school districts to achievement for grade 3 and grade 11. This result contradicts earlier evidence. Hanushek (1986, pg. 1162) indicated that in most studies it is observed that the relationship between school expenditures and achievement disappears when differences in family background are controlled for.

LUNCH is generally a proxy for family income of students in the school districts. For grade 3, the coefficient for LUNCH and LUNCH2 have the expected negative and positive sign (in all models (2)). They are also individually and jointly significant, with quite large t values. Furthermore, the coefficient estimates for LUNCH and LUNCH2 are not significantly different from one another for the various models. The results of model RT(2) for example, indicate that school districts' outcome decreases as LUNCH increases. When LUNCH is about 78 percent, then the test score will increase with LUNCH. The other models also indicated that expected test score are at a minimum when LUNCH is about 80 percent. The grade 11 models have similar results; LUNCH and LUNCH2 are individually and jointly significant, with the expected signs. The grade 11 models estimate a threshold level of 94.4 to 98.2 percent before a positive relationship is observed between LUNCH and school district's outcome on TAP. This evidence supports the view that unfavorable socioeconomic conditions have a negative influence on school districts' performance. A majority of Oklahoma school districts in the sample are below the minimum threshold level for LUNCH. In 1994 approximately 96 percent of the sample school districts have less than 77 percent of students eligible for subsidized lunch for grade 3. For grade 11, close to 99 percent of the sample school districts have less than 90 percent of the students eligible for subsidized lunch.

MINORITY is included to test the hypothesis that minority background has no effect on school district outcome. MINORITY, aggregated at district level, may reflect the students' social environment. The evidence differs between grade 3 and grade 11. We found for grade 3 that school districts' outcome varies with percentage of minority students, at a decreasing rate. Here the sign of MINORITY and MINORITY2 is unexpected; positive and negative. Model RT(2) predicts that test scores peak at about 16 percent. Districts with smaller and larger percentages of minority students do not do as well. The estimates for the other models are in the range of 15 to 19 percent.

For grade 11, the coefficient of MINORITY and MINORITY2 are jointly significant at 0.10 significant level. Individually the coefficients are generally not significant. MINORITY has the expected negative sign. However, the signs are unexpected for some estimates of MINORITY2; MINORITY2 has an unexpected negative sign for all models (2) except model RTSAL(2). The results indicates that school district outcome on grade 11 TAP decreases as MINORITY increases. However, three of the four models suggest the outcome decreases with MINORITY, at a declining rate. One model (model RTSAL(2)) implies outcome decreases at an increasing rate. Regardless, the evidence is that school districts' performance in grade 11 TAP decreases as MINORITY increases at all positive range of MINORITY. Our findings are similar to Andrews et al (1991) for the upper grades who found the percentage minority has an adverse effect in the upper grades but not the lower grade.

Stage 1 Results for FE models (FT, FTSAL, FOSAL, FOTM)

Judge et al (1988, pg. 490) state that even if the effects are random, the FE estimators are consistent but not efficient. Also under these assumptions, asymptotically the FE and the RE estimators differ only through the sampling error. Further, the FE estimators are more conservative estimators, as they ignore the randomness of the individual effects.

Table 4-5 to 4-6 give the results for the FE models - models (1) and (2). The results are generally consistent in the direction and significance of estimates. The variables when significant have the expected sign. The evidence is stronger for grade 3 that increasing resources has a positive effect on school district test outcome. The results find total expenditure per student (TEXPS) and teacher per student ratio (TSTU) to be significant for grade 3. However, there is weaker evidence for TEXPS for grade 11. The evidence for TSTU is weak for grade 11 (t values are lower compared to grade 3, and estimates significant at 0.10).

There is no evidence to support teacher quality measures; SALARY, DEGREE and YRSEXP for grade 3. Only DEGREE is significant in grade 11, but with an unexpected negative sign.

Including student measures, LUNCH and MINORITY have no effect on the sign and significance of the coefficients of the other variables. Estimates for LUNCH and LUNCH2 are individually and jointly significant with the expected signs for both grades. However, there is insufficient evidence for MINORITY. MINORITY and MINORITY2 are not jointly significant. There is evidence of relationship between socioeconomic status and school district test outcome, but not percentage minority.

Efficiency Summary and Correlation

Table 4-7 summarizes the efficiencies derived from the RE models (models 1 and models 2). On average, the efficiency indices derived from models with school

Table 4-5: Fixed Effects Model
Dependent Variable :Ln3

VARS.	FT (1)	FTSAL (1)	FOSAL (1)	FOTM (1)	FT (2)	FTSAL (2)	FOSAL (2)	FOTM (2)
ENROL	-0.111E-3 (-1.372)	-0.107E-3 (-1.295)	-0.099E-3 (-1.178)	-0.113E-3 (-1.368)	-0.087E-3 (-1.067)	-0.085E-3 (-1.018)	-0.078E-3 (-0.922)	-0.089E-3 (-1.084)
ENROL2	0.148E-8 (0.647)	0.142E-8 (0.615)	0.118E-8 (0.508)	0.143E-8 (0.617)	0.107E-8 (0.467)	0.103E-8 (0.448)	0.081E-8 (0.347)	0.102E-8 (0.441)
1/TEXPS	-640.12 (-3.372)	-637.57 (-3.352)			-621.04 (-3.279)	-619.56 (-3.265)		
1/OEXPS			-44.129 (-1.174)	-44.332 (-1.180)			-43.086 (-1.145)	-42.973 (-1.142)
1/TSTU			-0.010 (-1.927)	-0.009 (-1.757)			-0.105E-2 (-1.969)	-0.972E-2 (-1.819)
1/SALARY		-783.56 (-0.238)	-2083.6 (-0.631)			-445.25 (-0.135)	-1689.0 (-0.512)	
DEGREE				-0.061E-2 (-0.677)				-0.066E-3 (-0.739)
YRSEXP				-0.092E-1 (-0.696)				-0.072E-1 (-0.545)
YRSEXP2				0.209E-3 (0.459)				0.154E-3 (0.339)
LUNCH					-0.662E-2 (-2.110)	-0.659E-2 (-2.092)	-0.684E-2 (-2.165)	-0.663E-2 (-2.098)
LUNCH2					0.568E-4 (2.053)	0.565E-4 (2.039)	0.552E-4 (1.987)	0.535E-4 (1.922)
MIN					0.254E-2 (1.152)	0.255E-2 (1.152)	0.276E-2 (1.245)	0.267E-2 (1.202)
MIN2					0.151E-4 (0.469)	0.151E-4 (0.470)	0.132E-4 (0.410)	0.147E-4 (0.455)
INTERCPT	4.357 (43.074)	4.383 (29.870)	4.421 (27.826)	4.445 (31.857)	4.419 (33.479)	4.432 (26.821)	4.490 (25.105)	4.510 (27.447)
T90	-0.047 (-4.512)	-0.044 (-2.490)	-0.055 (-3.254)	-0.066 (-7.580)	-0.045 (-4.073)	-0.043 (-2.369)	-0.054 (-3.130)	-0.063 (-6.792)
T91	-0.039 (-4.465)	-0.037 (-3.395)	-0.047 (-4.616)	-0.050 (-6.489)	-0.041 (-4.403)	-0.040 (-3.446)	-0.051 (-4.651)	-0.052 (-6.261)
T92	0.015 (2.125)	0.015 (2.120)	0.015 (2.076)	0.018 (2.325)	0.017 (2.419)	0.017 (2.414)	0.017 (2.404)	0.020 (2.562)
T93	0.037 (4.124)	0.035 (3.099)	0.044 (4.070)	0.046 (5.760)	0.035 (3.871)	0.034 (2.961)	0.042 (3.890)	0.044 (5.438)
T94	0.034 (3.425)	0.031 (1.816)	0.044 (2.696)	0.051 (6.456)	0.033 (3.011)	0.031 (1.764)	0.046 (2.649)	0.051 (5.440)
ADJ R2	0.443	0.443	0.441	0.441	0.448	0.448	0.446	0.446

The numbers in parentheses are the t values.

Table 4-6: Fixed Effects Model
Dependent Variable : Ln11

VARS.	FT (1)	FTSAL (1)	FOSAL (1)	FOTM (1)	FT (2)	FTSAL (2)	FOSAL (2)	FOTM (2)
ENROL	-0.961E-4 (-1.307)	-0.868E-4 (-1.157)	-0.685E-4 (-0.901)	-0.858E-4 (-1.156)	-0.825E-4 (-1.114)	-0.760E-4 (-1.007)	-0.570E-4 (-0.747)	-0.716E-4 (-0.958)
ENROL2	0.153E-8 (0.735)	0.138E-8 (0.661)	0.093E-8 (0.440)	0.126E-8 (0.602)	0.126E-8 (0.607)	0.116E-8 (0.555)	0.067E-8 (0.320)	0.096E-8 (0.458)
1/TEXPS	-44.794 (-0.259)	-39.361 (-0.228)			-45.467 (-0.263)	-41.449 (-0.239)		
1/OEXPS			9.477 (0.278)	13.611 (0.400)			10.834 (0.316)	14.652 (0.429)
1/TSTU			-0.008 (-1.727)	-0.008 (-1.617)			-0.928E-2 (-1.919)	-0.894E-2 (-1.840)
1/SALARY		-1861.9 (-0.627)	-2239.3 (-0.753)			-1317.0 (-0.442)	-1684.8 (-0.565)	
DEGREE				-0.229E-2 (-2.825)				-0.226E-2 (-2.783)
YRSEXP				0.181E-1 (1.479)				0.194E-1 (1.588)
YRSEXP2				-0.656E-3 (-1.573)				-0.690E-3 (-1.652)
LUNCH					-0.659E-2 (-2.226)	-0.649E-2 (-2.225)	-0.668E-2 (-2.290)	-0.668E-2 (-2.292)
LUNCH2					0.502E-4 (1.985)	0.495E-4 (1.954)	0.485E-2 (1.914)	0.484E-4 (1.916)
MIN					-0.178E-2 (-0.899)	-0.179E-2 (-0.902)	-0.178E-2 (-0.896)	-0.166E-2 (-0.837)
MIN2					0.274E-4 (0.939)	0.276E-4 (0.944)	0.278E-4 (0.950)	0.257E-4 (0.877)
INTERCPT	4.074 (44.189)	4.135 (31.013)	4.229 (29.343)	4.114 (32.642)	4.260 (35.044)	4.300 (28.413)	4.418 (27.055)	4.310 (28.941)
T90	-0.055 (-5.766)	-0.046 (-2.941)	-0.045 (-2.938)	-0.052 (-6.613)	-0.060 (-6.067)	-0.055 (-3.346)	-0.054 (-3.397)	-0.058 (-6.863)
T91	-0.034 (-4.250)	-0.030 (-3.002)	-0.030 (-3.201)	-0.034 (-4.886)	-0.040 (-4.717)	-0.037 (-3.512)	-0.038 (-3.795)	-0.041 (-5.386)
T92	0.016 (2.495)	0.016 (2.477)	0.015 (2.298)	0.015 (2.071)	0.018 (2.762)	0.018 (2.743)	0.017 (2.578)	0.016 (2.269)
T93	0.039 (4.831)	0.035 (3.429)	0.034 (3.540)	0.039 (5.398)	0.040 (4.941)	0.038 (3.628)	0.037 (3.749)	0.041 (5.530)
T94	0.033 (3.645)	0.025 (1.655)	0.025 (1.719)	0.032 (4.437)	0.042 (4.137)	0.036 (2.230)	0.037 (2.390)	0.042 (4.869)
ADJ R2	0.467	0.467	0.468	0.470	0.468	0.468	0.469	0.471

The numbers in parentheses are the t values.

Table 4-7:

Summary Statistics
Efficiency Index
Random Effects Model

GRADE 3 EFFICIENCY SUMMARY								
	MODELS 1 WITHOUT STUDENT MEASURES				MODELS 2 WITH STUDENT MEASURES			
MODELS	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
MEAN	75.18	76.63	76.60	76.46	75.41	75.33	74.43	74.08
STD	8.69	8.38	8.28	8.24	6.69	6.67	6.60	6.37
MIN	26.32	28.57	28.65	28.68	39.15	39.11	38.60	39.17
MAX	100	100	100	100	100	100	100	100

GRADE 11 EFFICIENCY SUMMARY								
MODELS	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
MEAN	76.24	77.43	77.47	76.86	86.23	85.63	85.62	84.32
STD	8.25	8.21	8.18	8.28	5.70	5.60	5.64	5.37
MIN	49.75	51.18	51.09	49.84	61.90	61.76	61.79	61.21
MAX	100	100	100	100	100	100	100	100

The student measures are LUNCH and MINORITY.

input measures only (i.e., models 1) differ from those obtained from models which include students' measures that reflects their family income and racial background (models 2). The efficiency averages from models 2 are slightly higher than those obtained from models 1 for grade 11. The efficiency averages are however, lower for grade 3. On average, school districts in the sample are 25 (=100 - 75.41) percent inefficient when grade 3 test results are used as output measures (model RT(2)). However, when grade 11 test scores are used as school districts' performance measure, the school districts' are on average 13.8 (=100 - 86.23) percent inefficient (model RT(2)). The other models (models 2) average estimates are slightly higher by 1 to 2 percent for both grade 3 and grade 11. Our inefficiency estimates are comparable to those surveyed by Taylor (1994). Taylor (1994, pg. 3) states that most educational frontier studies suggest that primary and secondary schools are less than 15 percent, on average.

Table 4-8 and 4-9 give the correlations and rank correlations analysis among the efficiency indices from various models. The correlation analysis indicate the efficiency index are highly correlated (greater than 0.9) within the group of models (example, among models 1). However, between models 1 and models 2 the correlations is not as high. The correlation is between 0.78 and 0.80 for grade 11 models, and between 0.80 to 0.90 for grade 3 models. The rank correlation analysis in table 4-9 gives similar results. This analysis indicates that a school district's efficiency index and rank especially within the same group of models (example, models 1) are similar. That is, if a school district is highly efficient in model RT(1), for example, than it is also highly efficient in the other models within the same group (RTSAL(1), ROSAL(1), and ROTM(1)). Across group of models, if a school district is highly efficient in model RT(1), it is not as likely to be highly efficient or ranked as high in model RT(2).

Table 4-8:
Correlation Analysis of Efficiency Index
Random Effects Model

GRADE 3 EFFICIENCY INDEX								
	MODELS 1 WITHOUT STUDENT MEASURES				MODELS 2 WITH STUDENT MEASURES			
MODELS	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
RT	1.000	0.997	0.996	0.994	0.886	0.884	0.880	0.870
(1)		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
RTSAL		1.000	0.998	0.991	0.888	0.891	0.885	0.873
(1)			(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ROSAL			1.000	0.993	0.892	0.893	0.892	0.881
(1)				(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ROTM				1.000	0.879	0.878	0.877	0.881
(1)					(0.0001)	(0.0001)	(0.0001)	(0.0001)
RT					1.000	0.999	0.996	0.986
(2)						(0.0001)	(0.0001)	(0.0001)
RTSAL						1.000	0.996	0.985
(2)							(0.0001)	(0.0001)
ROSAL							1.000	0.989
(2)								(0.0001)

GRADE 11 EFFICIENCY INDEX								
MODELS	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
RT	1.000	0.994	0.992	0.994	0.795	0.791	0.781	0.772
(1)		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
RTSAL			0.996	0.990	0.795	0.800	0.788	0.777
(1)			(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ROSAL				0.995	0.794	0.798	0.794	0.784
(1)				(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ROTM				1.000	0.792	0.789	0.786	0.783
(1)					(0.0001)	(0.0001)	(0.0001)	(0.0001)
RT					1.000	0.996	0.992	0.983
(2)						(0.0001)	(0.0001)	(0.0001)
RTSAL						1.000	0.994	0.983
(2)							(0.0001)	(0.0001)
ROSAL								0.991
(2)								(0.0001)

The numbers in parentheses are the probability values.
The student measures are LUNCH and MINORITY.

Table 4-9:
Spearman Rank Correlation Analysis
Rank of Efficiency Index
Random Effects Model

GRADE 3 RANK OF EFFICIENCY INDEX								
	MODELS 1 WITHOUT STUDENT MEASURES				MODELS 2 WITH STUDENT MEASURES			
MODELS	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
RT	1.000	0.996	0.995	0.994	0.881	0.882	0.886	0.871
(1)		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
RTSAL		1.000	0.998	0.989	0.878	0.883	0.886	0.868
(1)			(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ROSAL			1.000	0.991	0.875	0.879	0.887	0.868
(1)				(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ROTM				1.000	0.867	0.868	0.876	0.875
(1)					(0.0001)	(0.0001)	(0.0001)	(0.0001)
RT					1.000	0.999	0.995	0.983
(2)						(0.0001)	(0.0001)	(0.0001)
RTSAL						1.000	0.996	0.982
(2)							(0.0001)	(0.0001)
ROSAL							1.000	0.986
(2)								(0.0001)

GRADE 11 RANK OF EFFICIENCY INDEX								
MODELS	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
RT	1.000	0.992	0.990	0.993	0.763	0.757	0.749	0.740
(1)		(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
RTSAL			0.995	0.987	0.764	0.769	0.758	0.746
(1)			(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ROSAL				0.993	0.763	0.765	0.763	0.753
(1)				(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
ROTM				1.000	0.761	0.756	0.754	0.752
(1)					(0.0001)	(0.0001)	(0.0001)	(0.0001)
RT					1.000	0.995	0.991	0.982
(2)						(0.0001)	(0.0001)	(0.0001)
RTSAL						1.000	0.993	0.981
(2)							(0.0001)	(0.0001)
ROSAL								0.989
(2)								(0.0001)

The numbers in parentheses are the probability values.
The student measures are LUNCH and MINORITY.

Summary and Conclusion

In conclusion there is evidence that increased school resources have a positive effect on school district's educational outcome. The evidence appears stronger after controlling for socioeconomic status of school districts.

To summarize, the results of RE models imply school districts with higher expenditure per student perform better on grade 3 ITBS on average. They also find school districts with smaller class sizes tend to do better on average for both lower (grade 3) and upper (grade 11) grades. There is evidence average teacher salary has a positive effect on school districts performances for both grades; evidence is stronger for the upper grade. The RE models find school districts with a higher percentage of teachers with advanced degree tend to do better on average for the lower grades. For the higher grade, average years experience is an important factor in school district performance.

The RE models consistently find evidence that larger school districts tend to have better test outcomes for both lower and upper grades. However, the evidence that their performances decline with increasing size is not as strong after accounting for socioeconomic differences for the lower grades.

The evidence suggests that students characteristics are important to school districts performance. Family income seems to be an important factor (as reflected by LUNCH) in explaining differences in school district's educational outcome. The result is consistent for both upper and lower grades. Other differences in family background (reflected by MINORITY) is also an important determinant to school district's performance.

CHAPTER 5

RESULTS STAGE 2

This chapter presents the regression results for stage 2. The first section begins with the correlation analysis of the variables and continues with an analysis of the effect of the different group of variables on school district efficiency, as estimated by the various models. The second section compares and analyzes school district efficiency (derived from stage 1) and their predicted efficiency. The chapter ends with a summary and conclusion.

Overview

In this stage we focus on the Random Effects (RE) models. The discussion will emphasize the efficiency levels derived from the four basic RE models (RT, RTSAL, ROSAL, and ROTM) from stage 1. The efficiency index obtained from these models are regressed on various socio economic variables and financial variables. School districts population density (LNDEN) and total population (LNTPOP) are also included in the models to account for the urbanization of school districts and their size. The socio economic variables are median family income (MFY), percentage of adults with high school diploma or higher (XED), percentage mother in the labor force (XMLF), percentage of minority children (XMIN), percentage of single parent family (XSPF), percentage of children in poverty (XPOV) and average number of children per family (CPF). The financial variables are percentage of total revenue from local property tax (LRX), percentage of total revenue from federal aid exclusive of payments for school lunch (FAX), and percent of total expenditure on direct instruction (DIRINS). To differentiate from stage 1 models, the stage 2 models will be referred to as the efficiency models.

Stage 2 Models

For comparison and analytical purposes, we estimated several efficiency models. They are:

1. Efficiency models A with variables:
   MFY, XED, XMLF, XMIN, XSPF, XPOV, CPF, LNDEN and LNTPOP
2. Efficiency models B with variables (Full Model):
   MFY, XED, XMLF, XMIN, XSPF, XPOV, CPF, LRX, FAX, DIRINS, LNDEN and LNTPOP
3. Efficiency models C with variables:
   MFY, XED, XMLF, XMIN, LRX, LNDEN and LNTPOP
4. Efficiency models D with variables:
   MFY, XED, XMLF, XMIN, LRX, FAX, DIRINS, LNDEN and LNTPOP

The dependent variables are the natural logarithm of the school district efficiency index obtained from stage 1. Note variables MFY, XED, LNDEN and LNTPOP are in natural logs.

Models B have financial variables (LRX, FAX, DIRINS) as explanatory variables, models A do not. Models C and D are similar to models A and B but without variables XSPF, XPOV, and CPF. We found when estimating full model B, the coefficients of the variables XSPF, XPOV and CPF are not jointly significantly different from zero. The choice of models is also based on the results of the RESET test (see appendix C for details). Failure to pass the RESET test is indicative of some kind of specification error such as omitted variables or incorrect functional form

(Griffiths, 1993, pg. 344). From the reset test (see appendix C), we found efficiency models A and C are well specified for grade 3. Efficiency models B, C and D are well specified for grade 11.

The focus of the following analysis will be on the effect of the socioeconomic and financial variables on school districts efficiency.

Correlation Analysis

Table 5-1 shows the correlation between the school districts' efficiency index and stage 2 variables (the socio economic, and the financial variables). The general analysis is that the more efficient school districts tend to have more favorable socio economic characteristics. They have higher median family income (MFY), higher percentage of educated adults (XED), and generally higher percentage of mother in the labor force (XMLF). However, the relationship between school district efficiency and the percentage of working mother is not as strong as the other favorable socio economic characteristics. Their correlation ranges from 0.07 to 0.13. The other favorable socio economic variables (MFY, and XED) have a correlation of 0.30 to 0.40 (for the different models). These school districts also tend to have a smaller percentage of minority children (XMIN), children in poverty (XPOV), and percentage of single parent family (XSPF). Of the 3 variables, XMIN has a higher correlation with efficiency than XPOV or XSPF, and their correlations range from -0.19 to -0.41. In summary, the correlation analysis supports the idea that a favorable socio economic environment is related to school district performance on standardized tests. However, the correlations do not suggest any significant linear relationship between population density, or population and school districts' efficiency.

There are 3 major source of revenue for Oklahoma school districts; local, state and federal. At the local level, the major source of income is the local property tax (Olson and Gade, 1990, pg. 30). However, the data show the percentage of total

Table 5-1:
Correlation Analysis
Stage 2 variables vs Efficiency Indexes

	Grade 3 Efficiency Index				Grade 11 Efficiency Index			
	RT	RTSAL	ROSAL	ROTM	RT	RTSAL	ROSAL	ROTM
MFY	0.2961	0.2978	0.2993	0.3009	0.3763	0.3779	0.3941	0.3942
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
XED	0.3282	0.3259	0.3247	0.3282	0.3051	0.3066	0.3091	0.3102
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
XMLF	0.1270	0.1227	0.1193	0.1170	0.0855	0.0704	0.0772	0.0897
	(0.0106)	(0.0136)	(0.0165)	(0.0187)	(0.0881)	(0.1606)	(0.1239)	(0.0734)
XMIN	-0.3913	-0.3979	-0.3818	-0.3834	-0.3929	-0.4084	-0.4051	-0.3974
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
XSPF	-0.1872	-0.1936	-0.1902	-0.1910	-0.2187	-0.2301	-0.2309	-0.2202
	(0.0002)	((0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
XPOV	-0.2479	-0.2457	-0.2436	-0.2535	-0.3429	-0.3411	-0.3479	-0.3515
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
CPF	0.0294	0.0353	0.0309	0.0296	0.0185	0.0246	0.0183	0.0109
	(0.5545)	(0.4790)	(0.5358)	(0.5535)	(0.7120)	(0.6236)	(0.7151)	(0.8277)
LRX	0.3544	0.3476	0.3394	0.3502	0.5333	0.5279	0.5084	0.5158
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
FAX	-0.3943	-0.3947	-0.3973	-0.3938	-0.3943	-0.3947	-0.3973	-0.3938
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
DIRINS	0.1023	0.0954	0.0857	0.0949	-0.0171	-0.0307	-0.0357	-0.0327
	(0.0402)	(0.0556)	(0.0858)	(0.0569)	(0.7346)	(0.5412)	(0.477)	(0.514)
LNDEN	-0.007	-0.006	-0.006	-0.003	-0.016	-0.016	-0.015	-0.021
	(0.8870)	(0.9085)	(0.9085)	(0.9568)	(0.7451)	(0.7525)	(0.7608)	(0.6793)
LNTPOP	0.0003	-0.0005	-0.0005	-0.0003	0.0082	0.0058	0.0066	0.0089
	(0.994)	(0.992)	(0.991)	(0.9949)	(0.8705)	(0.9087)	(0.8959)	(0.8590)

The number in parentheses is the probability value.

revenue from local property varies significantly among school districts, from 1.5 percent to 67 percent (see table 3-5). The correlations indicate efficient school districts tend to have a higher percentage of total revenue from local property tax (correlation range from 0.33 to 0.53). We use FAX (federal aid exclusive of school lunch program as percentage of total revenue) as a measure of federal assistance to the local schools districts. The school district efficiency are negatively associated with FAX . These correlation analysis support the assumptions; the greater the effort of the local community to support their schools, the more efficient is its school district.

The correlation analysis suggest a weak support for percentage of expenditure on direct instructions (DIRINS); its correlation with school district efficiency are positive and significant for grade 3 efficiency level only. The correlations do not suggest any linear relationship between school districts' efficiency and their population density or total population.

The correlation analysis among the stage 2 variables does not suggest significant problem of multicollinearity as the highest correlation values are generally between 0.4 and 0.5. The highest correlation is 0.53 between XED and MFY (see table 3-6 to 3-8.)

Stage 2 Results for Efficiency Models

Table 5-2 present the regression results for grade 3. Table 5-3 give the regression results for grade 11. The results for most of the variables are generally consistent across the different versions of the four basic models (example, models RT(A), RTSAL(A), ROSAL(A), and ROTM (A)). They are also consistent within each group of the different models (example, models RT(A), RT(B), RT(C) and RT(D)). Their parameter estimates generally have the same signs and significance. For example, the estimates for median family income (MFY) are positive, but insignificant for all models that include it (grade 3 efficiency models). When significant, most of the variables generally have the expected signs.

Table 5-2: Stage 2 Regression Results - Grade 3 Efficiency Models
Dependent Var : Log of Efficiency Index (from Random Effects Models)

Var.	RT (A)	RTSAL (A)	ROSAL (A)	ROTM (A)	RT (B)	RTSAL (B)	ROSAL (B)	ROTM (B)	RT (C)	RTSAL (C)	ROSAL (C)	ROTM (C)	RT (D)	RTSAL (D)	ROSAL (D)	ROTM (D)
MFY	0.043	0.047	0.048	0.042	0.040	0.044	0.047	0.041	0.014	0.017	0.019	0.019	0.025	0.027	0.030	0.031
	(1.168)	(1.350)	(1.396)	(1.228)	(1.091)	(1.282)	(1.364)	(1.208)	(0.505)	(0.648)	(0.748)	(0.736)	(0.890)	(1.023)	(1.168)	(1.188)
XED	0.147	0.136	0.137	0.137	0.131	0.121	0.121	0.121	0.127	0.117	0.119	0.120	0.127	0.117	0.117	0.118
	(2.799)	(2.741)	(2.777)	(2.793)	(2.526)	(2.471)	(2.477)	(2.485)	(2.445)	(2.385)	(2.431)	(2.470)	(2.479)	(2.409)	(2.419)	(2.463)
XMLF	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0005	0.001	0.001	0.001	0.0005	0.001	0.001	0.001	0.0005
	(1.482)	(1.431)	(1.358)	(1.22)	(1.323)	(1.277)	(1.216)	(1.074)	(1.357)	(1.292)	(1.224)	(1.114)	(1.270)	(1.208)	(1.153)	(1.038)
XMIN	-0.003	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002	-0.002
	(-5.802)	(-5.909)	(-5.521)	(-5.466)	(-5.196)	(-5.307)	(-5.038)	(-5.021)	(-5.283)	(-5.369)	(-5.000)	(-4.994)	(-5.254)	(-5.330)	(-5.067)	(-5.101)
XSPF	0.0001	0.0001	0.0001	0.0001	0.00005	0.0001	0.0001	0.0001								
	(0.113)	(0.158)	(0.101)	(0.124)	(0.058)	(0.110)	(0.077)	(0.108)								
XPOV	0.001	0.001	0.001	0.0004	0.0005	0.001	0.001	0.0003								
	(0.660)	(0.780)	(0.777)	(0.506)	(0:628)	(0.746)	(0.716)	(0.428)								
CPF	0.005	0.007	0.004	0.005	0.004	0.006	0.004	0.004								
	(0.133)	(0.201)	(0.130)	(0.134)	(0.108)	(0.180)	(0.117)	(0.124)								
LRX					0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002
					(3.575)	(3.414)	(3.351)	(3.527)	(2.381)	(2.263)	(2.181)	(2.275)	(3.586)	(3.424)	(3.360)	(3.543)
FAX					0.002	0.002	0.002	0.003					0.002	0.002	0.003	0.003
					(1.652)	(1.610)	(1.795)	(1.953)					(1.729)	(1.694)	(1.881)	(2.011)
DIRINS					0.004	0.003	0.003	0.003					0.004	0.003	0.003	0.003
					(4.289)	(4.098)	(3.839)	(4.100)					(4.314)	(4.123)	(3.863)	(4.122)
LNDEN	-0.027	-0.024	-0.023	-0.026	0.020	-0.018	-0.017	-0.020	-0.020	-0.019	-0.018	-0.020	-0.020	-0.018	-0.018	-0.020
	(-3.395)	(-3.284)	(-3.166)	(-3.547)	(-2.438)	(-2.363)	(-2.257)	(-2.604)	(-2.525)	(-2.460)	(-2.373)	(-2.694)	(-2.526)	(-2.455)	(-2.346)	(-2.676)
LNTPOP	0.032	0.027	0.026	0.031	0.024	0.019	0.019	0.023	0.026	0.022	0.021	0.025	0.025	0.021	0.020	0.024
	(3.238)	(2.886)	(2.803)	(3.281)	(2.383)	(2.068)	(2.014)	(2.465)	(2.578)	(2.282)	(2.212)	(2.637)	(2.490)	(2.190)	(2.128)	(2.560)
INTERCPT	3.029	3.092	3.079	3.117	2.922	2.922	2.980	3.006	3.432	3.503	3.473	3.45	3.104	3.204	3.177	3.132
	(7.927)	(8.591)	(8.577)	(8.712)	(7.611)	(8.255)	(8.223)	(8.352)	(12.561)	(13.598)	(13.510)	(13.466)	(11.120)	(12.153)	(12.055)	(11.975)
ADJ R2	0.2111	0.2118	0.1996	0.2059	0.2550	0.2516	0.2365	0.2477	0.2251	0.2242	0.2116	0.2194	0.2597	0.2558	0.2411	0.2529

The number in parentheses is the t-statistic.

Table 5-3: Stage 2 Regression Results - Grade 11 Efficiency Models
Dependent Var : Log of Efficiency Index (from Random Effects Models)

Var.	RT (A)	RTSAL (A)	ROSAL (A)	ROTM (A)	RT (B)	RTSAL (B)	ROSAL (B)	ROTM (B)	RT (C)	RTSAL (C)	ROSAL (C)	ROTM (C)	RT (D)	RTSAL (D)	ROSAL (D)	ROTM (D)
MFY	0.098	0.102	0.108	0.106	0.059	0.064	0.072	0.069	0.074	0.077	0.085	0.082	0.074	0.077	0.084	0.083
	(3.264)	(3.463)	(3.662)	(3.502)	(1.986)	(2.173)	(2.429)	(2.275)	(3.029)	(3.228)	(3.540)	(3.347)	(2.987)	(3.138)	(3.395)	(3.271)
XED	0.064	0.063	0.061	0.065	0.036	0.037	0.038	0.039	0.032	0.033	0.033	0.345	0.033	0.034	0.035	0.035
	(1.818)	(1.834)	(1.776)	(1.835)	(1.071)	(1.109)	(1.116)	(1.131)	(0.961)	(1.008)	(0.996)	(1.014)	(0.988)	(1.039)	(1.034)	(1.032)
XMLF	0.0001	-0.0000	-0.0000	0.00003	0.0000	-0.0001	-0.0001	-0.0000	0.0001	-0.0000	-0.0000	0.0001	0.00003	-0.0001	-0.0001	0.00003
	(0.146)	(-0.093)	(-0.081)	(0.089)	(0.002)	(-0.244)	(-0.231)	(-0.019)	(0.267)	(-0.021)	(-0.007)	(0.212)	(0.076)	(-0.194)	(-0.174)	(0.075)
XMIN	-0.002	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	(-4.143)	(-4.225)	(-4.336)	(-4.203)	(-2.891)	(-3.165)	(-3.111)	(-3.051)	(-3.965)	(-4.221)	(-4.166)	(-4.057)	(-3.370)	(-3.604)	(-3.541)	(-3.527)
XSPF	0.001	0.001	0.001	0.001	0.0001	0.00005	0.0001	0.0001								
	(1.361)	(1.256)	(1.176)	(1.334)	(0.134)	(0.081)	(0.120)	(0.232)								
XPOV	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001								
	(-1.453)	(-1.245)	(-1.183)	(-1.386)	(-1.306)	(-1.112)	(-1.062)	(-1.284)								
CPF	-0.032	-0.028	-0.031	-0.035	-0.033	-0.029	-0.032	-0.036								
	(-0.942)	(-0.851)	(-0.953)	(-1.038)	(-1.026)	(-0.921)	(-1.010)	(-1.104)								
LRX					0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003
					(5.677)	(5.454)	(4.862)	(5.174)	(6.135)	(6.007)	(5.476)	(5.710)	(5.797)	(5.568)	(4.974)	(5.305)
FAX					-0.0001	-0.0002	-0.0004	-0.0001					-0.0002	-0.0003	-0.001	-0.0002
					(-0.048)	(-0.182)	(-0.333)	(-0.050)					(-0.135)	(-0.259)	(-0.407)	(-0.133)
DIRINS					0.001	0.001	0.001	0.001					0.001	0.001	0.001	0.001
					(1.481)	(1.185)	(0.897)	(0.956)					(1.619)	(1.301)	(1.008)	(1.097)
LNDEN	-0.042	-0.040	-0.038	-0.038	-0.027	-0.026	-0.024	-0.024	-0.026	-0.025	-0.024	-0.023	-0.026	-0.025	-0.024	-0.023
	(-6.494)	(-6.336)	(-5.944)	(-5.874)	(-3.987)	(-3.880)	(-3.672)	(-3.520)	(-3.986)	(-3.889)	(-3.652)	(-3.488)	(-3.980)	(-3.888)	(-3.660)	(-3.479)
LNTPOP	0.041	0.037	0.035	0.037	0.026	0.023	0.022	0.023	0.027	0.024	0.023	0.024	0.027	0.023	0.023	0.024
	(4.866)	(4.457)	(4.287)	(4.359)	(3.097)	(2.728)	(2.690)	(2.704)	(3.273)	(2.874)	(2.818)	(2.858)	(3.173)	(2.793)	(2.756)	(2.785)
INTERCPT	2.909	2.920	2.876	2.867	3.387	3.399	3.333	3.337	3.239	3.258	3.178	3.175	3.170	3.212	3.154	3.130
	(9.938)	(10.203)	(10.024)	(9.753)	(11.196)	(11.457)	(11.116)	(10.897)	(14.111)	(14.506)	(14.009)	(13.689)	(13.089)	(3.138)	(13.153)	(12.767)
ADJ R2	0.2825	0.2879	0.2841	0.2802	0.3450	0.3463	0.3321	0.3325	0.3434	0.3477	0.3344	0.3331	0.3446	0.3474	0.3330	0.3318

The number in parentheses is the t-statistic.

The adjusted R squares suggest that the models with both the financial variables, and the socio economic variables, explains a higher proportion of variability in the school districts efficiency. This is true for grade 3 and grade 11 efficiency models. The F-test suggest that all the regression equations are statistically significant for grade 3 and grade 11 (see row 7 in appendix C). That is, the data supports all the models.

The coefficient estimates are generally quite consistent, with small differences among the models. This consistency can be seen also from the estimates of elasticities (table 5-4).

The following sections examine the influence of the various socio economic variables and related variables, on school district efficiency. There are a limited number of frontier studies on school efficiency using the two stage method. McCarty et al (1992) and Ray (1991) are good examples. Most of the supporting evidence in this study reflects the relationship between school resources and socio economic characteristics on student achievement (some at individual level, some aggregated at school or school district level). It is reasonable to assume that inputs that affects student achievement also indirectly affects school efficiency, if the efficiency measure is based on the same output measure, that is test performance.

1. <u>Effect of socio economic variables on school district's efficiency</u>

The results indicate that the coefficients of median family income have the expected positive sign. They are significant for grade 11 but not grade 3. Model RT(A) for grade 11 estimates that a one percent increase in median family income will lead to a 0.098 percent increase in school districts' efficiency, holding other variables constant. MFY is less significant with financial variables (LRX, FAX and DIRINS) in the model; the t value is lower in model RT(B). This pattern is the same in all the other models (from models A to B, and models C to D). The elasticity for MFY is smaller with financial variables in the model (see models (B)). For example, MFY has

Table 5-4
Elasticities of Significant Variables
for Stage 2 Efficiency Models
Grade 3 and Grade 11

(Grade 3) Vars.	RT (A)	RTSAL (A)	ROSAL (A)	ROTM (A)	RT (B)	RTSAL (B)	ROSAL (B)	ROTM (B)	RT (C)	RTSAL (C)	ROSAL (C)	ROTM (C)	RT (D)	RTSAL (D)	ROSAL (D)	ROTM (D)
MFY																
XED	0.147	0.136	0.137	0.137	0.131	0.121	0.121	0.121	0.127	0.117	0.119	0.120	0.127	0.117	0.117	0.118
XMIN	-0.062	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041	-0.041
LRX					0.046	0.046	0.046	0.046	0.023	0.023	0.023	0.023	0.046	0.046	0.046	0.046
FAX					0.013	0.013	0.013	0.020					0.013	0.013	0.013	0.013
DIRINS					0.221	0.166	0.166	0.166					0.221	0.166	0.166	0.166
LNDEN	-0.027	-0.024	-0.023	-0.026	-0.020	-0.018	-0.017	-0.020	-0.020	-0.019	-0.018	-0.020	-0.020	-0.018	-0.018	-0.020
LNTPOP	0.032	0.027	0.026	0.031	0.024	0.019	0.019	0.023	0.026	0.022	0.021	0.025	0.025	0.021	0.020	0.024
(Grade 11)	RT (A)	RTSAL (A)	ROSAL (A)	ROTM (A)	RT (B)	RTSAL (B)	ROSAL (B)	ROTM (B)	RT (C)	RTSAL (C)	ROSAL (C)	ROTM (C)	RT (D)	RTSAL (D)	ROSAL (D)	ROTM (D)
MFY	0.098	0.102	0.108	0.106	0.059	0.064	0.072	0.069	0.074	0.077	0.085	0.082	0.074	0.077	0.084	0.083
XED	0.064	0.063	0.061	0.065												
XMIN	-0.038	-0.038	-0.038	-0.038	-0.019	-0.019	-0.019	-0.019	-0.019	-0.019	-0.019	-0.019	-0.019	-0.019	-0.019	-0.019
LRX					0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.068
FAX																
DIRINS																
LNDEN	-0.042	-0.040	-0.038	-0.038	-0.027	-0.026	-0.024	-0.024	-0.026	-0.025	-0.024	-0.023	-0.026	-0.025	-0.024	-0.023
LNTPOP	0.041	0.037	0.035	0.037	0.026	0.023	0.022	0.023	0.027	0.024	0.023	0.024	0.027	0.023	0.023	0.024

The elasticites are calculated based on sample averages.

an elasticity of 0.059 in model RT(B) compared to 0.098 in model RT(A). In general MFY has elasticity ranging from 0.06 to 0.11. Bridge et al (1979) review of educational production studies generally found family income to be a positive factor in student achievement. A majority of the studies they reviewed used student achievement in grade 11 and grade 12 standardized tests (Bridge et al 1979, pg. 222). In their study of California elementary school districts, Dynarski et al (1989) found some evidence that median income is significant for school district outcome for grade 3 (in 2 of the 3 models estimated). Our results found family income to be important for efficiency in the higher grade but not in the lower grade.

The evidence for the percentage of educated adults on school district efficiency is stronger for grade 3. The coefficient of XED is significant in all the models for grade 3 (A, B, C and D), and has the expected positive sign. For grade 11, the coefficient XED has the expected sign but is only significant (at 0.10) for models A. When financial variables are included in the model, XED became insignificant (see models B for grade 11). Model RT(A) estimates that a 1 percent increase in adult with high school or higher degree will increase expected school district efficiency for grade 3 by 0.15 percent. When significant, XED has a smaller elasticity with financial variables in the model. For example, the elasticity of XED in model RT(B) is 0.04 compared to 0.15 in model RT(A). For grade 3, XED has an elasticity ranging from 0.12 to 0.13 with financial variables in the model (models B, C and D). Otherwise XED has an elasticity of 0.14 to 0.15 (models A). Generally educational production studies have found a positive relationship between parents education and student achievement (Bridge et al, 1979, Bidwell et al 1975, Fuchs et al 1994). A similar frontier study by Ray (1991) of school districts in Connecticut, support our findings. He found a positive relationship between adult education and school district's efficiency, on average. In his study Ray used school districts average outcome of 9th grade students in state proficiency tests as their output.

Ray's frontier study (1991) also found the percentage of minority students has a negative effect on school districts efficiency. Our results confirm his findings. The coefficients of MINORITY are negative and significant in all the models (A, B, C and D), for grade 3 and grade 11. The evidence is stronger for grade 3; the t values are higher. Holding other variables constant, model RT(A) estimates that a 1 percent increase in minority children will decrease school district's expected efficiency by 0.04 percent for grade 3, and 0.02 percent for grade 11. XMIN has elasticities close to 0.04 for grade 3 and 0.02 for grade 11 in models with financial variables (models B and D).

The general findings on the other socioeconomic characteristics, family structure (XSPF - single parent family), family size (CPF - children per family), employment status of mother (XMLF - percentage of mother in labor force), and children's poverty level (XPOV) are that they have some influence on student's achievement (Andrews et al, 1991, Milne et. al, 1986, Winkler, 1975, Fuchs et al 1994). In our study, the estimates for these socioeconomic variables are not significant determinant of school district efficiency for grade 3 and grade 11. Ray (1991) found family structure has a negative effect on school districts efficiency. Ray defines the variable as percentage of children from single parent family. In our study it represents percentage of single parent from households with children enrolled in the school districts.

We did a joint test to test for the significance of all the socioeconomic variables. The joint test indicates that the coefficients of the socioeconomic variables in models A and B are jointly significant at 0.05 significance level (row 1 in appendix C). In all the models, we reject the hypothesis that the coefficients of MFY, XED, XMLF and XMIN are jointly equal to zero except for grade 11 model B (row 3 appendix C). However, the F test do not reject the hypothesis that the the coefficients of XSPF, XPOV and CPF jointly zero (row 2 appendix C). These results suggest that at least the socioeconomic variables of median family income, percentage of educated adults, percentage of mother in labor force, and percentage of minority together influence school districts' efficiency.

2. Effect of financial variables on school district's efficiency

The results support the hypothesis that the level of local community effort has a positive influence on school district's efficiency. The coefficients of percentage of total revenue from local property tax (LRX) are positive and highly significant in all the grade 3 and 11 models (efficiency models B, C and D). The evidence is stronger for grade 11, as indicated by the higher t values. Holding other variables constant, model RT(A) estimates that a 1 percent increase in percent revenue from local property tax will lead to a 0.02 percent increase in school district's expected efficiency for grade 3. The elasticity estimate is slightly higher for grade 11, at 0.07 percent. These results on LRX support the argument that emphasizing local control of the school system is desirable for its efficiency, because it can better meet the demands and needs of the local parents and their children (Selakovich, 1984).

FAX represents federal aid received through state and direct aid from federal agencies exclusive of lunch payments. The evidence for FAX on school district's efficiency are inconsistent. The coefficient of FAX has a positive sign for grade 3 and negative for grade 11. The coefficients are generally significant at 0.10 confidence level for grade 3, and are not significant for grade 11. It has an elasticity of 0.01 to 0.02 for grade 3.

The coefficients for percentage of total expenditure on direct instruction (DIRINS) have the expected positive sign. They are significant for the grade 3 efficiency models, but not for grade 11. Model RT(B) imply that a 1 percent increase in expenditure of instructional related activities will lead to 0.22 percent increase in school district expected efficiency for grade 3, holding other variables constant. DIRINS represents school district's percentage total expenditure on direct instructions.

It does not differentiate between expenditure for grade 3 or grade 11. If the results are consistent, then its reasonable to assume that variability in school district efficiency is partly due to differences in their spending on direct instruction.

For grade 3 models, the F test finds the financial variables jointly affect school districts' efficiency (row 4 appendix C). There is evidence that both expenditure on direct instructions and percentage of revenue from federal sources explains a significant portion of school districts' efficiency in grade 3 (jointly the coefficient of these variables are significant - see row 5 appendix C).

3. Effect of population variables on school district's efficiency

The coefficient estimates for population density (LNDEN) have the expected negative sign, and are significant for grade 3 and grade 11 efficiency models. For grade 3, model RT(A) predicts that a 1 percent increase in population density will lower school district efficiency by 0.03 percent, holding total population and other variables constant. The other models have elasticities close to 0.02 for grade 3, and the grade 11 have elasticities within the range of 0.02 to 0.03. These results are supportive of the claim that urban school districts tend to be less efficient (Levin, 1971).

The estimates for total population (LNTPOP) suggest large school districts (in terms of population and land area) tend to be more efficient than smaller school districts on average, holding density and other variables constant. Their elasticities range from 0.02 to 0.03 for grade 3, and from 0.02 to 0.04 for grade 11. The estimates for total population have the expected positive sign and are significant in all the models (grade 3 and grade 11).

The data supports the hypothesis that school districts' efficiency is to some extent due to the urbanization and of size of the school districts. Jointly the F statistics for these LNDEN and LNTPOP are greater than the tabulated F at 0.05 significance level (row 6 appendix C).

Summary and Conclusions

In summary, the analysis confirm findings from similar frontier studies (McCarty et al, 1992, and Ray (1991)), that differences in school district efficiency is to some extent due to differences in socioeconomic background. This is indicated by both the joint F test and individual test of the coefficients. Favorable socio economic background tend to lead to higher efficiency level for the school district, on average. These factors are student related (median family income, and percentage of educated adults), and some reflect district differences (percentage of revenue from local property tax, total population and population density). The strength of the evidence also appear differently for the different grade level. For example, percentage of educated adult is more important to school district efficiency for grade 3. For the higher grade, there appears to be more supporting evidence for median family income. The school districts' efficiency is also highly affected by percentage of students with a minority background and level of support from the local community.

CHAPTER 6

SUMMARY AND CONCLUSIONS

Summary

In general the purpose of the study is examine the determinants of school districts' efficiency and performance on standardized test. To achieve this objective we use frontier techniques to compute the school districts relative efficiency and panel data models to estimate the school production frontier. We did the analysis in two stages. This allows separate consideration of the different group of inputs that affect school district efficiency and performance. The two main categories of inputs are inputs school administrators have control over in achieving their outcome, and inputs that are beyond their influence, for example, inputs related to socioeconomic status. In stage 1, we compute the relative efficiencies of the school districts, and examine the relationship between school resources and their test performance. In stage 2, we examine the effect of socioeconomic factors and policy related factors on school districts efficiency.

We used two measures of school district performance, test scores for grade 3 ITBS and grade 11 TAP. This allows us to test the effect of the different determinants on the school district outcome at the elementary and high school level. We examine several determinants of school district performance using different specifications. These relationships are based on the idea that total expenditure per student is the primary determinant of school district performance. There are approximately 400 school districts used in the study and using school district data from 1990 to 1994, and school district census data for 1989.

Conclusions

The results of the study are consistent with the expectations that school resources do matter to school districts' outcome on standardized tests. The evidence appears stronger after controlling for students family background and socioeconomic status for some school variables. For example total expenditure per student is significant after controlling for family background and socioeconomic status for grade 11. The effect of smaller class sizes on school district performance is more significant in both lower and upper grades.

There are similarities and differences between the results for the upper and lower grades. For example, in the lower grade teachers education is an important determinant to school district performance. In the upper grade, teachers' experience, not level of education, is the significant factor to school district performance. However, the results of both grades find teachers' average salary to be an important determinant of school district test outcome. Regardless how school resources are measured, the evidence suggest that they are significant to school districts test performance

In summary, the results of these analyses suggest that school districts with smaller classes on average perform better. The results also reveal that school districts with better quality teachers have better test outcomes on average. Therefore educational reform in Oklahoma seems to be moving in the right direction with its focus on implementing smaller class sizes, and focusing on improving the quality of teachers through certification, training and their education.

Another significant result pertains to school district size. Evidence of economies of size is stronger for the upper grades. This suggest policies toward achieving size efficiency are beneficial to school districts performance especially in the upper grades.

The results are consistent with past evidence that family background and socioeconomic status are important determinants to students achievement, i.e. school district performance. Unfortunately school districts administrators have no control over these areas.

The analysis of school districts relative efficiency seems to indicate that there is evidence of inefficiency in Oklahoma school districts. This evidence is consistent with findings of other studies that there are a certain level of inefficiency in the public school systems. Further examination of Oklahoma school districts efficiency suggest that to a certain extent school district inefficiency is the consequences of their socioeconomic status. Low socioeconomic status suggest a less enriching learning environment. Thus its not suprising that school districts with low socioeconomic status are generally less efficient. Regardless how socioeconomic status is measured (family income, or percentage of educated adults) the result is consistent that school inefficiency is to a certain extent consequences of their socioeconomic conditions.

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APPENDIX A

List Of Definitions

Stage 1 Variables

A. Test Scores

Grade 3 Test Scores

- are results in percentiles of the Iowa Test of Basic Skills (ITBS) of Oklahoma School Testing Program for grade 3. ITBS is a part of a series of standardized norm achievement tests given to grades 3, 5 and 7.

Grade 11 Test Scores

- are results in percentiles of Test of Achievement and Proficiency (TAP) of Oklahoma School Testing Program for grade 9 and 11. TAP is a series of standardized norm achievement tests that measure students accumulated knowledge and skills in a variety of subjects.

B. District Measures

ENROL (District Enrollment)

- is the average daily membership (ADM) in the school district for the year rounded to nearest whole number. ADM is calculated by dividing the total days of membership throughout the school year by the number of days taught.

ADM = total days of membership/ # of days taught

TEXPS (Total Expenditure per Student)

- is the amount in dollars spent per student. Average daily membership (ADM) is used to calculate "per pupil" amounts.

INEXPS (Instructional Expenditure per Student)

- is the total expenditure per student devoted to instruction.

OEXPS (Administrative Expenditure per Student)

- is the expenditure per student devoted to administrative and other school operations. This value is calculated as follows:

Oexps = Texps - Inexps.

TSTU (Teacher per Student)

- is the ratio of full time equivalency (FTE) teachers per student based on ADM throughout the school year rounded to the nearest whole number. This value is calculated as follows:

Tstu = # FTE teachers/ Enrol (ADM)

C. Teacher Measures

TEACH (Teachers)

- is the number of full time equivalency teachers (FTE) among instructional staff throughout the school year.

SALARY (Teachers Salary)

- is the average teacher salary computed by dividing the gross salaries and fringe benefits of by the number FTE teachers for the school year :

Salary = Gross salaries and fringe benefits / # FTE teachers

YRSEXP (Teachers Experience)

- is the average years of experience among the teaching staff. The value is calculated as follows:

Yrsexp = Total years experience / # FTE teachers

DEGREE (Teachers Degree)

- is the percentage of teaching staff with an advanced degree (masters and above) which is computed as :

Deg = # FTE teachers with advanced degree/ # FTE teachers

D. Student Measures

LUNCH (Free Lunch)

- is the percentage of Oklahoma students who are eligible for federally funded or reduced payments lunch in school.

MINORITY (Minority)

- is the percentage enrollment of "nonwhite" students i.e. the American Indians, Blacks, Hispanics and Asian students.

Stage 2 Variables

A. Socio economic Variables

CPF (Average Children per Family)

- defined to be the total number of children ages 3 to 19 years, and not high school graduate over the total number of families.

MFY (Median Family Income)

- Median family income.

XED (Percentage of Adult with High School Diploma or Higher)

- derived from the percent of householder with high school diploma or equivalent, or some college, or bachelor's degree or a higher degree. The relevant population is householders from household with children. A household implies all persons who occupy a housing unit. A householder is normally the person who owns, or rents the housing unit, or heads the household.

XMLF (Percentage of Mother in Labor Force)

- derived from employment status of parents. The relevant population is children living with both parents. XMLF is the percentage of children whose mother is in the labor force.

XMIN (Percentage Nonwhite or Minority)

- Percentage of children who are minority or non-white, i.e., Black, American Indian, Eskimo, Aleutian, Asian, Pacific Islander, or other race.

XPOV (Percentage of Children Below the Poverty Line)

- derived from children for whom the poverty status is determined according to the income poverty level in 1989.

XSPF (Percentage of Single Parent Family)

- defined to be the total number of male family households with no wife present, and number of female family households with no husband present over the total number of family households.

B. Financial and Other Relevant Variables

DIRINS

- percent of total expenditure on direct instructions. From Financial Accounting for Local and State School System, 1990, this expenditures is mainly a result from activities dealing directly between teachers and students.

FAX

- Percentage total revenue of school district from federal aid (all other and direct federal aid) but exclusive of payments for school lunch.

LRX

- is the Percentage total revenue of school district from local property taxes.

C. Other Variables

LNDEN

- Population per square kilometers of school district.

LNTPOP

- Total population of school district.

APPENDIX B

RESET TEST

The RESET test

The RESET test is one of a number of criteria that are used for selection of regressors, and assessing model adequacy. In the RESET test, the squares and possibly the cubes of the predictions from a model are included in that model as additional explanatory variables. The model is then reestimated. The coefficients of the prediction variables are singly, or collectively, tested using either a t-test or an F test. If the coefficients are significantly different from zero, then this is intended to be indicative of some kind of specification error such as omitted variables or incorrect functional form (Griffiths et. al., 1993). The following is an example of the RESET test applied to model T(1):

$$LNTS_{it} = \beta_1 ENROL_{it} + \beta_2 ENROL2_{it} - \beta_3 TEXPSR_{it} + \beta_4 TIME_{it} + \beta_5 LNTShat2_{it}$$

where LnTShat2 is the additional explanatory variable added to the original equation of model T(1), and it is the square of predicted value of LNTS, the dependent variable. The coefficient b_5 is the parameter to be estimated and tested for its significance.

From the RESET test, we observed the following t values for the coefficients of the squares of the predicted value for stage 1 and stage 2 models :

Stage 1 Models (dependent variable is the log of test score):

The t values for the coefficients of the squares of the predicted value (stage 1 models) are:

	RT (1)	RTSAL (1)	ROSAL (1)	ROTM (1)	RT (2)	RTSAL (2)	ROSAL (2)	ROTM (2)
Grade 3 Models	-1.956	-1.902	-2.303	-2.065	-5.057	-4.884	-4.746	-5.191
Grade 11 Models	-1.966	-0.774	-1.885	-2.486	-1.732	-0.934	-1.139	-2.057

The RESET test indicates that model RT(1) and RTSAL(1) for grade 3, and models RT(1), RT(2), RTSAL(2), and ROSAL(2) for grade 11 are well specified at 0.05 confidence level (i.e. the t values for the coefficients of the square of predicted values are less than the tabulated values at 0.05 significance level). Note models 2 are models 1 with student measures, LUNCH and MINORITY included as explanatory variables (see appendix B for model specification).

<u>Stage 2 Models (dependent variables are the log of efficiency index)</u>

The t values for the coefficients of the squares of the predicted value (stage 2 models) are:

	RT (A)	RT (B)	RT (C)	RT (D)
Grade 3 Models	-1.266	-5.210	-1.003	-5.089
Grade 11 Models	2.455	1.565	1.674	1.670

The RESET test is applied to stage 2 efficiency models RT only. The dependent variables of these models are the log of efficiency index derived from models RT in stage 1 (see chapter 3 for model specification). We assume that if the RESET test is applied to the other stage 2 efficiency models (example, ROSAL (A to D), ROTM (A to D)) the results will be similar to that of models RT(A) to RT(D). This is because the correlation analysis of the efficiency indices of the various stage 1 models show these indices derived from these models are highly correlated (greater than 0.99) for both grade 3 and grade 11. The RESET test indicate that models A and C seems well specified for grade 3, while models B, C, and D are well specified for grade 11 (the t values are less than tabulated t at 0.05 confidence level).

APPENDIX C

The F statistics for joint test (stage 2)

The following tabulates the F statistics for the joint test of models RT in stage 2. The results for the other models (RTSAL, ROSAL, and ROTM) are believed to be similar to model RT as the efficiency indices from these models are highly correlated with model RT at 0.99.

	Grade 3				Grade 11			
Null hypotheses	Model RT(A)	Model RT(B)	Model RT(C)	Model RT(D)	Model RT(A)	Model RT(B)	Model RT(C)	Model RT(D)
1. Ho: the coefficients of MFY, XED, XMLF, XMIN, XSPF, XPOV, and CPF are zero.	13.29*	8.20*	X	X	15.63*	5.73*	X	X
2. Ho: the coefficients of XSPF, XPOV, and CPF are zero.	0.227	0.166	X	X	1.79	1.07	X	X
3. Ho: the coefficients of MFY, XED, XMIN, and XMLF are zero.	14.32*	11.10*	14.76*	14.31*	12.51*	1.63	12.77*	9.22*
4. Ho: the coefficients of LRX, FAX, and DIRINS are zero	X	8.71*	XX	8.84*	X	12.71*	XX	10.20*

Continue from previous page:

	Grade 3				Grade 11			
Null hypotheses	Model RT(A)	Model RT(B)	Model RT(C)	Model RT(D)	Model RT(A)	Model RT(B)	Model RT(C)	Model RT(D)
5. Ho: the coefficients of DIRINS and FAX are zero.	X	10.02*	X	10.23*	X	1.11	X	1.34
6. Ho: the coefficients of LNDEN and LNTPOP are zero.	6.17*	3.22*	3.54*	3.43*	17.45*	3.25*	3.16*	-
7. Ho: all the coefficients of the socioeconomic and financial are zero.	12.95*	12.46*	17.68*	16.67*	17.49*	17.55*	29.17*	23.03*

XX - the t value for LRX is significant for all the models.
X - not applicable.
* - significant at 0.05 significance level.

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