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AN EFFICIENCY AND PRODUCTIVITY STUDY IN THE PRESENCE OF THE "NO CHILD LEFT BEHIND ACT" IN PENNSYLVANIA SCHOOL DISTRICTS

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ABSTRACT

This study investigated the efficiency and variation of 492 Pennsylvania school districts. Currently, under the *No Child Left Behind Law*, school districts and schools have to conform to strict regulations such as meeting adequate yearly progress and hiring highly qualified teachers, even though they may have difficulty in funding their programs because of the not-fully-funded financial constraints. Consequently, this will serve as a means of providing the Pennsylvania Department of Education (school districts) with a resource to evaluate their efficiency. As a result, five questions were addressed in this study: (1) What are the levels of efficiency measures in school districts? (2) How widely do efficiency measures vary across school districts? (3) What are the common factors presented by efficient school districts? (4) Has the efficiency of school districts improved since the 2001-02 school year? What explains the efficiency change of school districts? (5) Has the productivity of school districts improved since the 2001-02 school year?

The school district was the unit of analysis. The data was from 492 Pennsylvania school districts and the Department of Education for five fiscal years: 2001-02, 2002-03, 2003-04, 2004-05, and 2005-06. Simply, On the one hand, the efficiency is the observed output value over the maximum potential output, given a combination of inputs. On the other hand, the productivity is the ratio of output over input, that is, average product.

First, using the stochastic frontier analysis, the efficiency measures of districts were calculated from the Battese & Coelli model. Furthermore, efficiency measures of this basic model were compared with other variants of stochastic frontier analysis in order to deal with the unobserved heterogeneity problem and, in doing so, obtain reliable efficiency measures. Therefore, other panel data variants included the pooled data model,

the time-invariant inefficiency random effects model (Pitt & Lee, 1982), and the true random effects model (Greene, 2005). Furthermore, rank correlation among these panel data estimators were explored for model performance. The reason for this is that the ranking of school district efficiency measures was of much more interest rather than their absolute values. The stochastic frontier models represent that the average efficiency of school districts ranged from 77.48 percent to 82.98 percent in math proficiency rate and from 85.10 percent to 87.40 percent in reading proficiency rate. That is to say, on average, school districts had an average inefficiency of 22.52 percent to 17.12 percent in math and 14.90 percent to 12.60 percent in reading. The Battese & Coelli model was an effective method of efficiency analysis of Pennsylvania school districts. That is why efficient school districts of the Battese & Coelli model had a mutual consistency with other models, making it more effective, than the true random effects model.

Next, this study estimated the education production frontier and its relationship with input variables. Most importantly, the correlation between institutional factors and inefficiency was furthermore explored in order to explain the monitoring and competition effects on inefficiency. Moreover, the efficiency of 492 districts was descriptively analyzed according to geographic location, locale type, and AYP status component of the NCLB Act.

Environmental variables (NIEP and NECO) had a greater impact on the educational production than traditional inputs (INST and SUP), which is consistent with a theoretical background. Additionally, teachers' salary (SALARY) was positively associated with the proficiency rate.

In the case of inefficiency model estimation, SIZE (population per square mile) had a positive impact on school district inefficiency. As a monitoring factor, the aid ratio factor (MV/PI AR) had a positive impact on the school district inefficiency statistically significant at the five percent level.

In the case of competition factors, the Herfindahl index (HERF) had a negative association with district inefficiency, generally. As a school district dominates the county education system in terms of enrollment shares, district inefficiency will be reduced. On the other hand, generally, a lagged value of private school enrollments (LagPRIV) showed a positive impact on district inefficiency.

Third, to answer *RQ 3*, this study identified the similarities of the most efficient school districts. The efficient districts came from the highest group (5 percent) of all school districts. Furthermore, these efficient school districts were compared with the results of Pennsylvania's costing out study.

The efficient school districts of this study presented more diversity in differences rather than evident similarities under the stochastic frontier analysis. This is similar to the result of the Kansas school district efficiency study by Standard & Poor's, using the data envelopment analysis. However, eight and ten of the efficient school districts were located in southwest region in math and reading, respectively. Also, 15 and 12 of the efficient school districts were located in *large suburb* in both math and reading proficiency rates, respectively.

Based on the costing out study, there was no clear relationship between school district needs and efficiency measures. However, school districts of higher needs had better efficiency measures. Therefore, overall, adequate funding for higher needs school districts obtained the rationality of their adequate funding under the framework of efficiency. However, nine of the 25 highest needs school districts were ranked below 400. Accordingly, it is reasonable that the state government require school districts to make a plan of action in order to get the adequate funding for productive efficiency and adequacy.

Fourth, in the case of *RQ 4*, average efficiency measures of each school district from the 2001-02 to 2005-06 school years were obtained in order to explore the relationship between the efficiency change and four determinants. The efficiency changes were regressed on regressors such as the status of warning, improvement, and corrective action of school districts, the percentage of state aid (school district's dependence on the state), equalized mills (school district's tax effort), and the percentage of expenditures dedicated to salaries and benefits spending (fixed cost) in order to obtain the critical determinants of the school district efficiency change.

State share had a positive impact on the efficiency change statistically significant at the five percent level. School district tax effort, equalized mills, was positively related to the efficiency change. On the other hand, salary share had a negative association with the efficiency change.

Most importantly, there has been a critical expectation that school districts have to transform inputs into outputs efficiently under the NCLB accountability regime. The positive relationship between the AYP status and the efficiency change of this study provided a positive evidence of the AYP status component in the NCLB Act.

Last, answering RQ 5, following Coelli et al. (2005) and Orea (2002), the total factor productivity index of this study was decomposed into a technical efficiency change, technical change, and scale change of school districts.

In considering the cumulative percentage change over a five-year period, the total factor productivity increased by 14.2 percent and 16.9 percent, due to the 8.6 percent and 8.6 percent upward shift in educational technology, the 3.1 percent and 4.8 percent increase in technical efficiency, and the 2.6 percent and 3.5 percent increase in productivity due to scale effects in math and reading, respectively. In both proficiency rates, technical change improvement over a five-year period made a major contribution to the total factor productivity change of Pennsylvania school districts.

Positive technical change could result from the impact of skilled and trained personnel for the state government or school districts causing an outward shift of the school district educational production frontier initiated by professional development and highly qualified teachers of the NCLB Act accountability system. That is to say, this change would be capacity building and improvement of the state government and school districts in Pennsylvania as one of the policy instruments. Conclusively, the technical change of Pennsylvania school districts could come from three sources: professional development, curriculum improvements, and other improvements not specified. Next studies need to analyze the effects of the three factors on productivity change separately.

However, this study has three major limitations: 1) the linkage of the AYP status of the No Child Left behind Act with the efficiency change; 2) an indicator of student performance; and 3) an efficiency concept as an education goal. Therefore, prior to interpreting and applying any possible policy implications of this study, it is important and prudent for educational stakeholders to note the weaknesses of this study.

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CHAPTER 1: INTRODUCTION

1.1. Background

Educators have to optimize their days under strict circumstances. They have to maximize student learning, while being subjected to constraints:

> Educators share the common objective of maximizing student learning (the outputs) and working with limited resources (the inputs). Further, educators try to maximize learning for all students' learning while working with the core challenge that each student is not equally prepared to learn (the constraints). (*Standard and Poor's*, Kansas School District Efficiency Study, 2007, p4)

As the demand side of education, that is, parents and business leaders, has questioned the education system, educational efficiency has been a hot issue since *A Nation at Risk: The Imperative for Educational Reform* (1983) publication. However, generally, the education community of school finance focuses on equity and adequacy rather than efficiency and productivity. Currently, under the No Child Left Behind Act (thereafter, NCLB), school districts and schools have to conform to strict regulations, such as meeting adequate yearly progress (thereafter, AYP) and hiring highly qualified teachers, even though they have difficulty in funding their programs because of the not-fully-funded financial constraints. They should achieve their goals under the not-fully-funded demand of the NCLB Act. Also, Pennsylvania state takeover of Philadelphia school district pushes Pennsylvania (thereafter, PA) education into productivity and efficiency. Therefore, the productivity and efficiency of classrooms, schools, and school districts in Pennsylvania has been a reality to most educators, being afraid of sanctions of the American accountability system.

Has the efficiency of Pennsylvania school districts improved since the No Child Left Behind Law? Are wealthy or large school districts in Pennsylvania efficient? Overall, has the efficiency of Pennsylvania school districts improved since the 2001-02 school year? This study investigated these questions. Furthermore, educational productivity of Pennsylvania school districts was also explored as one of key educational performance concepts as well as efficiency. In general, economic performance of producers has been investigated from efficiency and productivity concepts.

The educational policy-making process is a source of struggle among contradictory objectives of diverse groups in terms of different values (Boyd, 1997). The education community has struggled in order to obtain the educational legitimacy in the areas of equity, adequacy, efficiency, productivity, and so on. This originates from questions about the productivity of public education. Therefore, education policy makers and researchers have given different approaches and solutions to education reforms based on different educational values. According to Boyd (1997), most studies seem to take into consideration two categories of values: democratic values and economic values. Democratic values are liberty and equality, while economic values are efficiency and excellence. For example, there are values associated with the main arguments for and against school choice (Boyd, 1997). On the one hand, values that support school choice are liberty and efficiency. On the other hand, values against school choice are equality and destruction of the public good.

According to McDonnell (2005), the NCLB Act is not a radical “revolution” but an “evolutionary” change of the federal role since the 1980s from the viewpoint of the policy regimes. There has been “a punctuated equilibrium shift” in American education politics (Baumgartner, 2008). In this context, the passage of the NCLB Act is a critical change from the input and process regime to the accountability regime of school performance (McGuinn, 2006). This important regime change signifies more accountable responsibility of schools and school districts, transforming inputs to outputs and so focusing on student performance. Most importantly, in Pennsylvania, theories about how to reform urban school districts such as Philadelphia have been systemic standards-based reform; testing and accountability (e.g., Pennsylvania System of School Assessment); state takeovers replacing school boards and often placing the schools under the mayor; choice; privatization; diverse providers (e.g., Educational Management Organizations and non-profits) and so on (Boyd, 2008). Diverse provider models were implemented in order to improve the performance of the Philadelphia school district as a result of state takeover. Simultaneously, adhering to the same philosophy, the passage of the NCLB Act offers the chance to confirm whether this critical change from the input and process regime to the accountability regime of school performance is positive or negative.

1.2. Purpose of the Study & Research Questions

The purposes of this study were to investigate the theory, systematic comparison, and actual conditions focusing on the efficiency of 492 school districts in Pennsylvania. Three critical themes of this study were efficiency and productivity concepts, Pennsylvania school district, and the No Child Left Behind Act. In educational efficiency and productivity, how to define them, how to measure them, and how to increase them in Pennsylvania educational context were key themes of this study. Pennsylvania school district was the unit of analysis. The federal No Child Behind Act had a major impact on educational efficiency and productivity than any other education policies.

Equity and efficiency have been key issues of educational reforms. The demands of the NCLB Act are the new accountability for equity and efficiency. Specifically, from the view point of efficiency, the NCLB Act is aimed to increase the accountability of school districts (schools). On the other hand, this act also includes the commitment to provide educational services to disadvantaged classes from the perspective of equity. Put simply, “the implicit component of the NCLB Act in the accountability of school systems transforming resources into performance (an efficiency emphasis) is an endeavor to secure some degree of equity” (King-Rice, 2004, p147). In this context, King-Rice (2004) considered the importance of educational efficiency as one of the principles of the NCLB Act. Simultaneously, a Pennsylvania state takeover transformed the “monopolistic” and “public” school district of Philadelphia into a “diverse provider model” (Christman et al., 2007). For-profit and non-profit organizations managed public schools in order to improve urban schools in the area of accountability.

Specifically, from the viewpoint of efficiency, the NCLB Act is aimed to increase the accountability of school districts. For this reason, the objectives of this study were to: 1) estimate school district efficiency, 2) identify the common characteristics of efficient school districts, 3) explore the critical determinants of school district inefficiency, 4) assess the efficiency changes of school districts, and 5) estimate school district productivity change. Consequently, this will serve as a means of providing the Pennsylvania Department of Education (school districts) with a resource to use to evaluate their school finance and education reforms in light of efficiency and productivity. As a result, the specific research questions addressed by this study were as follows:

RQ 1: What are the levels of efficiency measures in school districts?

RQ 2: How widely do efficiency measures vary across school districts?

RQ 3: What are the common factors presented by the efficient school districts?

RQ 4: Has the efficiency of school districts improved since the 2001-02 school year? What explains school district efficiency change?

RQ 5: Has the productivity of school districts improved since the 2001-02 school year?

1.3. Rationale of the Study

This study will have many implications for theory, policy, and practice. First, in terms of theory, the findings will have the possibility of exploring the relatively uncultivated “efficiency” and “productivity” concepts in relation to equity and adequacy. Rolle & Houck (2004) suggested future directions for educational productivity such as modified quadriform analysis, data envelopment analysis, and stochastic frontier analysis. The stochastic frontier analysis is a theoretical and methodological theme of this study. Hanushek (1986) and education finance researchers have argued that money does not have a systematic correlation with student performance. Some interpret that money does not matter in education. On the contrary, others emphasize that there is inefficiency in educational organizations, transforming inputs into outputs. Also, Chubb & Moe (1990) pointed out that school organization and resources allocation are more critical factors of student performance than spending. Therefore, this study explored the relationship between the money and educational outputs in the context of the stochastic frontier.

However, up until now, Kansas has been the first and only state to analyze school district efficiency by *Standard & Poor's* in 2007, using the data envelopment analysis. Educational scholars have focused mainly on "traditional" equity and "new" adequacy measures. Specifically, adequacy studies have tended to be based on the average and fitted cost functions. However, appropriate equity and adequacy analysis is impossible without assessing the efficiency (productivity) principle.

Second, what defining factors cause inefficiency is one of the most important questions in the efficiency studies. This study investigated critical determinants of Pennsylvania school district inefficiency. Rodriguez (2004) pointed out the fact that we do not depend on "deficit model thinking theory" (p25). Deficit model thinking signifies that school failures rest on particular characteristics of the student body rather than institutional factors. This study investigated the possibility of overcoming this deficit model thinking in the Pennsylvania educational context. Educational school district technical inefficiency may be dependent on all kinds of organizational inefficiency which results from ineffective management on education production function inputs.

Consequently, in the case of primary and secondary education, questions may arise such as: Do certain kinds of school districts tend to be more inefficient than others? Do inefficient school districts rest on teachers' characteristics of a school district? Or do a student body's characteristics prevent a school district from providing the efficient education? This study investigated these questions. In economics, productivity change of firms could be decomposed into efficiency change, technical change, and scale change under the framework of the total factor productivity change. Therefore, this study further explored the total factor productivity change of Pennsylvania school districts.

Third, this study will contribute to multidisciplinary approaches to estimating the education input-output relationship. The stochastic frontier analysis technique came from economics. This will overcome classical ordinary linear regression models (thereafter, OLS). Major methodology in this study was the stochastic frontier analysis (thereafter, SFA).

In general, traditional equity measures have been the coefficient of variation, the Gini coefficient, the McLoone index, and the correlation coefficient, and so on. Moreover, multiple regression analysis generally has been used in educational production and cost functions. However, even though a multiple regression framework has mainly been used, this analysis has a great disadvantage related to average fitted values.

As a consequence, the stochastic frontier analysis will give the opportunity to estimate the best production frontier, not the average and fitted input-output relationship. The econometric approach of costing out studies is based on cost functions related to district spending for student performance, input prices, and other district-specific characteristics (Odden & Picus, 2007). However, this approach is closely related to the average and fitted input-output relationship approach (Costrell et al., 2008).

From the viewpoint of policy and practice, this study will create the first step of benchmarking for efficiency and productivity. The stochastic frontier analysis will show the efficiency index of individual school district. The Pennsylvania Department of Education and school districts can employ benchmarking as a tool for improvement when seeking better resource allocation practices for efficient school finance. Practically, this study will help educational practitioners to assess technical efficiency. Beyond school district technical efficiency, educational productivity variation of school district through the time has been attributed to differences in educational production technology, differences in the scale of operation, differences in operating efficiency, and differences in the operating environment in which educational production occurs (Färe et al., 2008). As a result, educational performance of school districts will be redefined as the product of efficiency change, technical change, and scale change of school districts.

1.4. Limitations

Two major limitations apply to this study. First, this quantitative study cannot fully describe how the inside of schools changes in terms of efficiency related to student performance (Lee, 2004). That is to say, this is a process problem of the educational production function associated with student performance. Accordingly, qualitative methodology will be needed to capture instructional best practices as a form of mixed methods.

Second, this *Ex Post Facto* design may be unable to control rival hypotheses (Krathwohl, 1998). Most importantly, as Schafft & Heller (2008) argue, this design has a comparison group rather than a control group, accordingly, the causal relationship of this design is possible, but weak. Therefore, overcoming the weak causal relationship between competition factor and efficiency, this study chose lagged value of private school enrollments rather than current value for a lagged adaptation.

CHAPTER 2: REVIEW OF THE LITERATURE

2.1. American Accountability System

Currently, the reauthorization of the No Child Left Behind Act has been a hot issue among education stakeholders. Some recommend that the growth model should be applied during the reauthorization. That is to say, the differences among school districts and schools in terms of a starting point of student performance have to be considered. Moreover, the federal government suggests that "differentiated accountability will assist those states by targeting resources and interventions to those schools most in need of intensive interventions and significant reform" (U.S. Department of Education, 2008).

The NCLB Act focuses on the alignment among curriculum, instruction, and assessment closely in order to open the pathway to school improvement. Critiques of this act come from the fact that the logic of educational accountability reforms is fundamentally at odds with the logic of loose-coupling educational organizations from the viewpoint of organizational theory. The NCLB Act's assumption is that there is a negative relationship between accountability and the achievement gap. However, some argue that this relationship comes from behaviorism. This shows the ministry perspective. In other words, if we make an education policy decision for better education, automatically will educational outputs be better. Moreover, they maintain that when implementing the NCLB Act, the capacity of school districts and schools has not been taken into account. That is, the costs of school districts and schools have not been fully funded (McDonnell, 2005).

The transformation from the Elementary and Secondary Education Act (ESEA) to the NCLB Act represents the moving from parallel programs to the instructional core

(McGuinn, 2006). Consequently, the NCLB Act pays much more attention to the core technology of education, that is, teaching and learning, than any other policies. In other words, there is a major change from the input-and-process focused education system (equity principle) to the output-focused education system (the relationship between input and student performance) from the viewpoint of accountability. In this context, this signifies the change of school finance research from an input-oriented perspective to a output-oriented perspective. Before the NCLB Act is the input-oriented-perspective of school finance. In other words, school finance researches focused on how to minimize the educational cost. A major component of the NCLB Act is to give the foundation for the output-oriented perspective connected to student performance.

As Faircloth (2004, p3) stated, the four guiding principles of the NCLB Act are: 1) increased accountability; 2) increased flexibility for states, school districts, and schools in the use of federal funds; 3) increased choices for parents of children from disadvantaged backgrounds; and 4) emphasis on scientifically-based teaching methods. Most importantly, this is to "move districts into increasing levels of school improvement based on the performance of the same group of students" (Pennsylvania Department of Education, 2007, p7). Struggling districts are experiencing difficulties with school improvement sanctions due to the regulation on so many subgroups that are to be met. "Currently, the status of a school or district is based on the performance of all subgroups" (Pennsylvania Department of Education, 2007, p7).

- If one subgroup is not performing adequately one year, the school or school district is placed on a warning.
- The following year, if the previous subgroup improves, but a different subgroup fails to meet adequately yearly progress, the school and school district will be

placed on a second year of school improvement.

"Districts and schools should only progress to increasing levels of school improvement if the same subgroup fails to make adequately yearly progress in the same subject" (Pennsylvania Department of Education, 2007, p7). As a result, fulfilling AYP requirements is a critical concern at the school, district, and state level and is on the minds of teachers, students, parents, and principals across the United States of America.

At the same time, in Pennsylvania, Philadelphia public education was transformed into a contracting regime (Bulkley, 2007). According to Boyd (2008), what impedes success in urban school districts are poverty and social problems, inadequate pedagogy and teaching, management and union problems, financial problems, and governance problems. A contracting regime refers to the "district central office's contract with a variety of private organizations to provide services" (Bulkley, 2007). This contract regime is expected to increase efficiency and improve student performance of the school system. This productive tension between centralization and autonomy symbolizes the responsibility and accountability of individual schools for student performance. As a result, Edison Schools Inc., Foundations Inc., Office of Restructuring Schools, Temple University, Universal Companies, University of Pennsylvania, and Victory Schools Inc. managed 70 schools (Research for Action, 2008; Boyd, 2008).

Most importantly, some educators criticize that the NCLB Act just focuses on increasing students' test scores. However, according to the U.S. Department of Education (2008), benefits of school wide programs in the context of the NCLB paradigm are flexibility, coordination and integration, accountability, and unified goals accordingly:

- Flexibility: combining resources, serving all students, redesigning the school and its services

- Coordination and Integration: reduction in curricular and instructional fragmentation
- Accountability: clear and coordinated; all students are responsible for achieving the same high standards
- Unified Goals: school-wide programs bring parents, the community, and the school together to redesign and improve the school

These components of the NCLB Act depict schools and school districts as combining resources in order to improve school-wide programs for achieving high standards. Consequently, in summary, the NCLB Act expects that there is a negative relationship between efficiency based on accountability and the achievement gap. The first reason for this is that school districts and schools have difficulties in financing public education. That is why the capacity and costs of school districts have not been taken into account (McDonnell, 2005). The second is that school districts and schools have to achieve adequately yearly progress despite financial problems. Accordingly, school districts and schools have to reduce the achievement gap in the fiscal stress despite difficulties of financing public education. The American Federation of Teachers estimated that total NCLB resources had fallen $40 billion short of the 2001 authorized appropriation (Pennsylvania Task Force on School Cost Reduction, 2007). Also, the Pennsylvania Department Education (2007) estimated that an additional $254.1 million from the federal government is needed for transform itself into the technical assistance resource envisioned under the law.

2.2. Competing Education Values

2.2.1. Overview

Boyd (1992) identified the shift from a social paradigm to an economic paradigm, reviewing the impact of paradigmatic shift on education policy and the search for the thrust of American education policy from the 1960s to the 1990s. However, some criticize this paradigm shift for imposing linear models on complex education systems. Also, Hartman & Boyd (1988) divided the reasons why school administrators do more to promote productivity into economic and financial, sociological, and political factors.

According to Hartman (2008), the main principles of school finance are adequacy, equity, efficiency, local control, and so on. “Adequacy” helps districts raise student performance to meet standards. “Equity” reduces disparities across districts and students. On the other hand, “efficiency” maximizes the benefits of each dollar spent. “Local control” allows districts to meet special local conditions and preferences.

The American education system is a particular one of the most decentralized education finance systems in the world. According to *Education at a Glance* (OECD, 2008), the United States of America was one of the countries with the highest annual expenditure on educational institutions per student for primary and secondary education in 2005, at 9,156 and 10,390 dollars, respectively. On the other hand, student performance on the PISA (Programme for International Student Assessment) science scale in 2006 was below the OECD average at 489. Also, there has been a significant variation across states and regions in terms of equity (King et al., 2003; Stiefel et al. 1998).

From an economic viewpoint, the American education system is inefficient considering the relatively large amount of resources currently put into education. Moreover, business leaders and economists argue that there is much room for improvement in the efficiency and productivity by changing the American school system. School choice came from this perspective. On the other hand, educational proponents maintain that the cause of an inferior educational environment is attributed to the accumulated under-investment from the viewpoint of adequacy and equity. That is to say, school finances are inequitable and inadequate for a quality education.

Which of the two principles is currently a more important criterion in the U.S.A. if there is an efficiency-equity trade-off relationship? In the educational real-world battle of equity and efficiency, each state set the realization of equity among the urban and rural regions and income levels as a major agenda. Educational disparities between the rural and urban regions have been a serious problem in the past. Specifically, there has been a tremendous concern on growing inter-district inequality (King et al., 2003). According to Hoxby (1996), there is a fundamental trade-off between promoting equitable consumption of the public good and promoting efficiency in production of the public good. In this context, until now, most educators have had a dichotomous equity and efficiency mindset in considering school finance for achieving high standards. King-Rice (2004) depicted this as the “see-saw” game between equity and efficiency (p.134). American educational policy makers have made a fluctuation trend on policy focus of equity and efficiency in the historical perspective. Although whether or not efficiency and equity are conflicting goals is still an arguable question, King et al. (2003) concluded that “schooling can not be truly equitable without also being efficient” (p.347). King-Rice (2004) stresses on “the best path that merges two sought-after goals,” explaining the “complementary nature of equity and efficiency” (p.149). Therefore, equitable and adequate school funding would be a “sand castle” without efficient and productive one.

Finally, as Guthrie (2006) puts it, even though there is no clear chronological order between modern and old thought where education finance is concerned, early-twentieth-century funding mechanisms have to be changed to modern education finance within the current performance policy paradigm. Modern education finance has to be oriented away from distributional and taxpayer equity to efficiency and productivity based on accountability (Guthrie, 2006). In this paradigm, the school district incentive is to maximize income via input manipulation and outcome maximization. The analytical orientation of this paradigm is resource and performance interaction. For this reason, to summarize, educational equity and adequacy concepts can be volatile without for educational efficiency and productivity.

2.2.2. Equity, Adequacy vs. Efficiency

King et al. (2003) divide efficiency into two types, external and internal efficiency. External efficiency is based on “rate-of-return” (King et al., 2003, p347). On the other hand, internal efficiency refers to “the allocation of resources within educational enterprises in order to maximize output from the resources committed” (King et al., 2003, p348). The major productivity research is the Coleman report (1966). This report showed that inputs to school, rather than family background, do not make a difference.

From the viewpoint of organizational theory, Niskanen budget-maximizing (1994), X-inefficiency (Leibenstein, 1978), public choice (Buchanan & Tullock, 1962), and principal-agent theories (Stiglitz, 1987) explained inefficiency of organizations.

Budget maximizing theory (Niskanen, 1994) explained the inefficiency in that bureaucrats tend to maximize their budget on a basis of increasing their domain rather than rationality. The critical determinants of inefficiency in the case of X-inefficiency theory (Leibenstein, 1978) are managers' empire building, lack of motivation from lower competition, and labor unions' pressure. From the perspective of public choice theory (Buchanan & Tullock, 1962), the rational ignorance of the voters causes the government not to maximize the wellbeing of the citizens, and so to make the public goods underprovided from the viewpoint of economic efficient point. This is called as a self-maximizing democracy. In the case of a principal-agent theory (Stiglitz, 1987), because of asymmetric information between a principal and an agent and an agent's moral hazard, the agent tries to maximize his incentives rather than on an efficiency.

Recently, economists develop efficiency analysis. The frameworks for measuring efficiency are least-squares econometric production models, total factor productivity indices, data envelopment analysis, and stochastic frontier analysis (Coelli et al., 2005). Generally, the educational community has hesitated to use parametric stochastic frontier analysis and non-parametric data envelopment analysis methods in efficiency (productivity) analysis because of environmental and discretionary factors different from fixed inputs (Duncombe et al., 1997).

Previous studies focused on whether money is fairly distributed across school districts and students in order to assess the school finance system. As Hartman (2008; 1988) puts it, school finance's major problem is its need for equalized funding. Equalized funding reduces wide differences in quality of education across districts. That is why these differences are linked to district wealth. Berne & Stiefel (1984) produced a framework for equity analysis such as equity for whom, equity for what, equity principles, and measures of equity. They also developed three equity concepts: horizontal equity, vertical equity, and equal opportunity. Horizontal equity refers to the idea that students who are alike should receive equal shares. Vertical equity recognizes the positive requirement that unequals receive appropriately unequal treatment. Equal opportunity is expressed: there are no differences according to the characteristics that are considered illegitimate like property wealth per pupil, household income, and fiscal capacity.

However, due to the times of accountability and standards of the No Child Left Behind Act, the adequacy concept dominates the main stream of school finance. The adequacy concept refers to having "enough resources to provide a proper education" (Odden & Picus, 2008). It is a very difficult task for researchers to determine what or how much is adequate, a proxy for adequacy connected with student performance (Hartman, 2008). In this context, "Costing Out" study is used to set adequate levels of Pennsylvania school finance using different methods such as the professional judgment approach, successful school districts model, economic approach, and evidence-based approach (Odden & Picus, 2008).

However, the Pennsylvania study is not connected with efficiency directly. Ruggiero et al. (2002) showed that traditional horizontal equity and equal opportunity studies using observed expenditures statistics should be analyzed in the presence of efficiency measures. As a result, costs and inefficiency differences explained the majority of the observed inequities in New York State school districts.

The Pennsylvania Costing Out study found that the commonwealth needed to provide $21.63 billion to adequately educate each student, in terms of the statewide cost.

Unfortunately, this amount was $4.38 billion short of what was provided. The study clearly highlighted the need to find a more equitable and adequate system to fund Pennsylvania's education system. The Costing Out study found that the commonwealth's districts varied greatly in the area of local revenue. The study also found that Pennsylvania's highest need districts generate the least amount of local revenues, while those with the lowest need generate the most revenue. The poorest districts have the highest tax efforts, while the wealthiest have the lowest effort. Lastly, the wealthiest districts generate more local funds with less tax effort. Building on the Costing Out study, the House Education Committee recommended changing the current system for funding public education. According to Hartman (2008), the four principal goals of the recommendations are as follows:

- State funds allocated for basic education are distributed both adequately and equitably.
- The allocation of state funding addresses and is reflective of unique characteristics among districts, including changes in demography and needs of students.
- The allocation of state funding is linked with measures of accountability.
- School districts remain accountable for meeting state academic standards and attaining student proficiency.

Conclusively, higher need districts require higher costing out estimates to equalized student success. Also, need has a negative relationship with wealth. However, while examining successful district efficiency, this analysis also identified efficient schools districts that not only outperform academically, but also do so without spending significantly higher resources than their other successful counterparts. This study does not examine real efficiency indexes. But, Pennsylvania Representative Michael Veon

(2006) in *the Morning Call* argued that Costing Out study is the first step to define "thorough and efficient" education:

> The General Assembly shall provide for the maintenance and support of a "thorough and efficient" system of public education to serve the needs of the Commonwealth. (Article III, Section 14 of the Pennsylvania Constitution)

A thorough and efficient system of public education in the Pennsylvania Constitution considers the two major concepts of adequacy and efficiency. However, Pennsylvania school finance research has focused on the equitable and adequate function for education. The current American financial crisis makes the education funding difficult for school districts and state government. Therefore, the efficiency study could have a critical momentum for better education for all.

2.3. Efficiency Estimation

2.3.1. Overview

Greene (2005b) proposed two major questions in the efficiency studies. First, which do we mean by "inefficiency" economically or mathematically in the model? Second, is the efficiency measurement a relative one or an absolute one? For this reason, an efficiency measurement framework is generally divided into two types according to the definition and measurement of the efficiency: the data envelopment analysis and the stochastic frontier analysis. On the one hand, the data envelopment approach focuses on a relative concept solved from mathematical linear programming models. On the other hand, the stochastic frontier approach deals with an absolute concept drawn from econometric statistical models.

Data envelopment analysis and stochastic frontier analysis have opposite strengths and weaknesses, as seen in Table 2.1. The data envelopment analysis came from the theoretical background of operations research. On the contrary, economists developed the stochastic frontier analysis.

We can assume that production technology is smooth or piecewise graphically. Different technologies represent different approaches to the estimation of the production frontier and efficiency (Greene, 2005). "Econometric" stochastic frontier approach estimates smooth "parametric" frontiers. On the other hand, the data envelopment approach based on linear programming models estimates piecewise linear "nonparametric" frontiers. These efficient school districts determine the piecewise linear envelopment surface. Two different approaches are converged and utilized complimentarily with each other for efficiency study empirically. That is to say, efficiency study based on one approach is not accurate for policy implications and recommendations. Therefore, a parametric methodology has been validated by non-parametric methodology for robust and reliable estimation of efficiency measures.

Table 2.1 Comparison between Data Envelopment Analysis and Stochastic Frontier Analysis

Classification	Strengths	Weaknesses
DEA	• Easy to implement • Need less information • Does not need a particular functional form	• Regard a random error as inefficiency • Cannot make statistical inference • Efficiency scores are sensitive to the number of constraints • More prone to sampling and outlier problems
SFA	• Can separate statistical noise from the inefficiency • Can make statistical inferences • Less prone to sampling outlier problem	• Need more information • Need strong distributional assumptions • Need to specify a proper functional form

Source: Choi (2002).

2.3.2. Education Production Approach and Critiques

2.3.2.1. Education Production Function

Education production function approach has been utilized for estimating the influence of some inputs on one output (Odden & Picus, 2008). Accordingly, education production function can be expressed as the following functional form (Cobb-Douglas, Translog model, etc.):

(2.1) $Q = f(RI, SC, DSC)$

in which Q = Student performance,

RI = Resource inputs,

SC = Student body characteristics,

and DSC = District and school-specific characteristics

The class size is generally chosen as an instrumental variable for resource inputs, *RI*. Practically, class size is a proper instrument of *RI*, because it plays a role as a proxy for *RI* available for students and has a high correlation to spending per pupil (Odden & Picus, 2008).

In general, education production function research was initiated by the Coleman Report (Coleman et al., 1966), that is, *Equality of Educational Opportunity*. Analyzing approximately 3,000 elementary and secondary schools, the Coleman Report showed that students' performance has a positive relationship with their socioeconomic background rather than school effects. Moreover, this report presented the significance of multicollinearity and production efficiency (Rassauli-Currier, 2002).

Hanushek (1986) argued that the critical factors of student performance are expenditures per pupil, student/teacher ratio, teacher education and experience, and family background, reviewing education production function studies. His conclusion was that there is no a systematic relationship between funding level and student outcomes. That is to say, he explained that "these results have a simple interpretation: there is no longer a consistent relationship between school resources and student performance" (p.148).

From the viewpoint of efficiency, Hanushek (2007) identified that the incentive structure change for motivating schools and teachers in a way that use resources efficiently will improve student performance. Most importantly, teacher quality is the most important force and is closely related to salaries and readily identified attributes of teachers (Hanushek, 2007). On the contrary, Hedges et al. (1994) concluded that money has a positive relationship with educational outcomes, in other words, money can make a difference, based on their calculation of a significantly positive effect size. In summary, the main theme of education production function is whether money makes a difference or not.

2.3.2.2. Cost Function Approach and Critiques

Many scholars used to choose production function to address whether money and resources matter or not. However, according to Odden & Picus (2008, p52), production function studies have the following methodological problems: 1) to determine the correct measure of outputs; 2) to control social and demographic impacts; 3) statistically to adjust for variables measured at different levels of education system such as student, classroom, school, and district levels; 4) to conduct longitudinal rather than cross-sectional analyses; and 5) correctly to specify input factors, because pupil-teacher ratios are not appropriate for actual class sizes.

As a consequence, the cost function approach has become a popular trend in education analysis. Cost functions minimize the cost of producing multiple outputs, having given constraints on inputs prices and a technological process (Schwartz et al., 2005).

Table 2.2 Comparison between Cost and Production Function Approaches

Classification	Production Function	Cost Function
Representation	• Direct representation of production possibilities	• Representing a decision making unit's technology as fully as a production function, because input minimization and output maximization has a dual relationship
Behavioral Assumption	• Output maximization • Input prices are endogenous	• Input minimization • Input prices are given as exogenous to schools.
Flexibility	• Limited to single output	• Flexibility to include multiple outputs
Efficiency	• Only technical efficiency	• Allocative efficiency, technical efficiency, and total economic efficiency

Source: Schwartz et al. (2005)

Accordingly, the cost function approach has the following advantages: 1) allowing multiple outputs in the model specification; 2) requiring information on school-level spending, outputs, and input prices; and 3) assuming that input prices rather than quantities are exogenously given (Schwartz et al., 2005). As a result, the comparison between the two approaches is seen in Table 2.2.

2.3.3. Efficiency Definition

Economists divide the definition of efficiency into three types: 1) technical efficiency; 2) allocative efficiency; and 3) total economic efficiency. According to Rolle (2005, p185), the definitions of three efficiencies are as follows:

- Technical efficiency: maximizing student learning and organizational policy outcomes while utilizing given sets of financial and human resource inputs.

- Allocative efficiency: maximizing student learning and organizational policy outcomes, given prices for inputs and the effectiveness of management strategies, while utilizing financial and human resources in optimal proportions.
- Total economic efficiency: the sum of technical and allocative efficiency, referring to maximizing student learning and organizational policy outcomes while pursuing allocative and technical efficiency simultaneously.

The technical efficiency shows the maximum output from a given sets of inputs. On the other hand, allocative efficiency refers to the maximum output and the input optimal proportions from a given sets of inputs, given input prices. In this context, different production technology is closely related to three types of efficiency. Generally, production, cost, revenue, and profit functions are utilized for various economic analyses. Technical efficiency and allocative efficiency measures are solved in the cost function simultaneously. However, the production function only gives a technical efficiency index, because the input price information is not given in the production function.

2.3.4 Stochastic Frontier Analysis

According to Kumbhakar & Lovell (2000), a production frontier can be expressed in the cross sectional data context as:

(2.2) $y_i = f(x_i; ß)\cdot TE_i$

in which TE_i is technical efficiency of *i* firm, y_i is the output of *i* firm, x_i is the inputs of *i* firm, and *ß* is a vector of parameters to be estimated.

In this production frontier, output-oriented technical efficiency is:

(2.3) $TE_i = [y_i / f(x_i; ß)]$

which signifies the ratio of observed output to maximum feasible output.

In considering the effect of producer-specific random shocks ($exp\{v_i\}$) on output, the production frontier will be rewritten as:

(2.4) $y_i = f(x_i; ß) \cdot exp\{v_i\} \cdot TE_i$

Also, technical efficiency will be expressed as:

(2.5) $TE_i = [y_i / f(x_i; ß) \cdot exp\{v_i\}]$

This shows the ratio of observed output to maximum feasible output under producer-specific random shocks.

2.3.4.1. Stochastic Production Frontier

Overview

Aigner, Lovell, & Schmidt (1977) and Meeusen & Van den Broeck (1977) proposed the new basic stochastic frontier model in cross sectional data which accounts for v_i.

(2.6) $ln(y_i) = (x_i' ß + v_i) - u_i$, in which, $\varepsilon_i = v_i - u_i$,

where v_i is the symmetric distribution term, *iid* $N [0, \sigma_v^2]$,

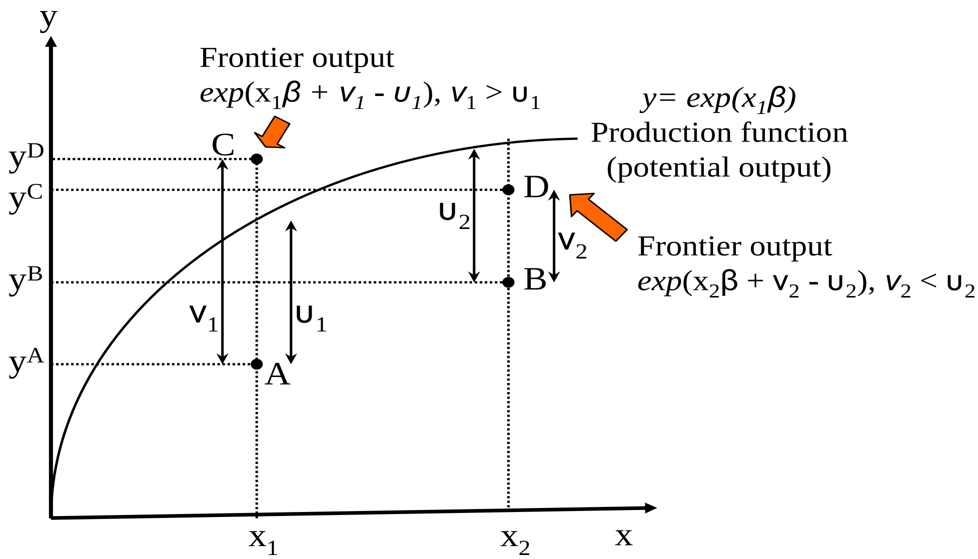
u_i is truncated above at 0, and distributed as *iid* $N^+ [0, \sigma_u^2]$,

and v_i's u_i's are independent of each other.

The output of this stochastic production function is bounded above by the stochastic frontier $exp(x_i ß + vi)$ rather than the deterministic frontier ($exp(x_i ß)$).

An Example of the Stochastic Frontier Approach

The stochastic production frontier can be explained by Figure 2.1 as is illustrated by Coelli et al. (2005, p244)'s and Rassouli-Currier (2002, p38)'s examples. This example is composed of one input (x), instructional expenditures per ADM and one output (y), reading proficiency rates for School Districts A and B. For a deterministic production function, $y_i = exp(x_i ß - u)$, the observed input-output values for school districts 1 and 2 are denoted by points A and B, respectively.



Source: Coelli et al. (2005) & Rassouli-Currier (2002)

Figure 2.1 Stochastic Production Frontier

If $v_i > u_i$, then, $y_i > exp(x_i\ ß)$. The value of stochastic frontier output for school district A is at C point. Also, If $v_i < u_i$, then, $y_i < exp(x_i\ ß)$. The value of stochastic frontier output is at D point. The observed outputs will be above the deterministic frontier if $v_i > u_i$ and below the deterministic frontier if $v_i < u_i$. The distance from the stochastic frontier to the observed value of reading proficiency rates of School District A and B is the efficiency measure of each school district. Contrary to economic efficiency, this index shows the technical efficiency. That is why economic efficiency requires input and output prices.

There are major two approaches to the efficiency measurement: input-oriented and output-oriented approaches. Traditionally, the educational school finances have focused more on the input-oriented perspective. How we can minimize the educational cost is the main topic of school finance. But, the NCLB act propels the school finance researchers to be interested in the output-oriented perspective. From the viewpoint of input-oriented approach, the efficiency measure will be calculated from the horizon of Figure 2.1.

However, the focus of this study is the proficiency rates of school districts under the influence of the NCLB Act. Therefore, the efficiency measure from output-oriented approach is the ratio of observed output to the corresponding stochastic frontier output:

(2.7) $TE_i = [exp(x_i'\beta + v_i - u_i)/exp(x_i'\beta + v_i)] = exp(-u_i)$.

Stochastic Production Frontier Model

Most importantly, v_i is the two-sided "noise" component and u_i is the nonnegative technical inefficiency component of the error term. Accordingly, the stochastic frontier model is referred to the "composed error" model, because of the error term $\varepsilon_i = v_i - u_i$.

Considering the normal – half normal model (Aigner, Lovell, & Schmidt, 1977), the critical parameter of this model, $\sigma = (\sigma_v^2 + \sigma_u^2)^{1/2}$, $\lambda = \sigma_u / \sigma_v$ is obtained by using the joint density function of u and v, and later the marginal density function of ε. The most critical λ parameter indicates the relative contributions of the inefficiency component. The larger λ is, the greater the inefficiency component is. In this context, we can estimate u_i using Jondrow et al.'s formula (1982) below:

(2.8) $E[u_i | \varepsilon_i] = \sigma\lambda\{\varphi(a_i) / [1 - \Phi(a_i)] - a_i\} / (1 + \lambda^2)$

where $\sigma = (\sigma_v^2 + \sigma_u^2)^{1/2}$ and $\varphi(z)$ and $\Phi(z)$ are the density and cumulative density function of the standard normal distribution.

However, replacing the half-normal distribution of u_i because of its narrow assumption, Stevenson (1980) suggested the truncated normal frontier model as $u_i \sim iid$ $N^+ [\mu, \sigma_u^2]$ and Greene (1990) proposed the gamma model as $u_i \sim iid\ G[\lambda, 0]$, that is to say, exponential with mean λ. However, these models pose problems in that the distribution of *ui* does not take into consideration the effects of individual school districts' heterogeneity on inefficiency (Greene, 2004).

Furthermore, the stochastic frontier models have been criticized, because choice of any distributional specification related to u_i*'s* is not justified *a priori*. In ranking individual firms according to predicted technical efficiency based on different assumptions, different assumptions have no significant impact on predicted technical efficiency (Coelli et al., 2005). In summary, other models to replace the half-normality assumption are as follows:

(2.9) $u_i \sim iid\ N^+ [\mu, \sigma_u^2]$ (truncated normal, Stevenson, 1980)

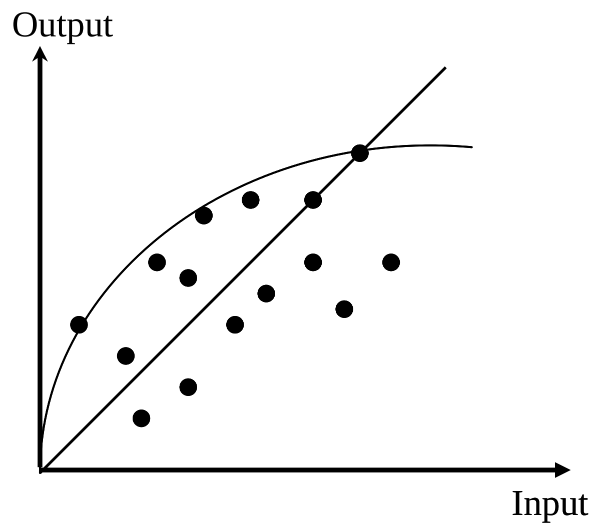
(2.10) $u_i \sim iid\ G [\lambda, 0]$ (exponential with mean λ, Greene, 1990) or

(2.11) $u_i \sim iid\ G [\lambda, m]$ (gamma with mean λ and degrees of freedom m, Greene, 1990).

In modeling stochastic production frontiers, ordinary least squares estimates are inefficient, because the distribution of the error term is asymmetric. Accordingly, the maximum likelihood estimation is preferred rather than the COLS estimator. In the maximum likelihood estimation, we have to use parameterization of lamda and sigma, because the first condition of loglikelihood function is nonlinear. In this context, the likelihood function will be maximized using an iterative optimization procedure. After that, we will select the starting values for the unknown parameters and systematically update them until the values that maximize the log-likelihood function.

Stochastic Frontier Analysis and Regression Line

Most importantly, the stochastic frontier analysis overcomes the regression analysis in obtaining the efficient frontier, as seen in Figure 2.2. If we use the regression framework for the efficiency measurement, the points above the regression line will be disregarded in the efficiency measurement. In other words, the frontier line will give the best function for the measurement of individual school district efficiency rather than the regression line. For this, the maximum likelihood estimation is more appropriate than the regression framework.



Source: Greene (2005b).

Figure 2.2 Comparison between Regression and Frontier Line.

Adequacy studies in school finance have followed four methods such as the professional judgment approach, successful school districts model, economic approach, and evidence-based approach (Odden & Picus, 2007). The econometric approach estimates cost functions related to district spending for student performance, input prices, and other district-specific characteristics (Odden & Picus, 2007). However, defining cost as the average spending among districts in this adequacy study shows the logically unexplainable result that about half the districts spend less than is required to achieve what they have achieved (Costrell et al., 2008). On the contrary, we get the best production frontier in this frontier analysis, rather than the average relationship.

Panel Data Models

Panel data analysis makes it possible to get more efficient estimators of the unknown parameters and more efficient predictors of technical efficiencies. Major advantages of panel data analysis suggested by Coelli et al. (2005) are as follows:

- Relaxing the strong distributional assumptions for separating inefficiency and noise effects.
- Getting consistent predictors of technical efficiencies.
- Exploring the change of technical efficiency and production technology.

According to the explanation of Coelli et al. (2005), generally, panel data analysis is divided into two types: time-invariant and time varying models. In the case of time-invariant inefficiency models, the inefficiency effects are expressed simply as:

(2.12) $u_{it} = u_i$ in which, $i = 1,\ldots,I$; $t = 1,\ldots,T$.

This model is also divided into the fixed effects model and random effects model according to the treatment of u_i. The fixed effects model considers u_i as a fixed parameter. On the other hand, u_i is thought of as a random variable in the random effects model.

According to Stefanou (2006), time-varying inefficiency models can be divided into three types. The main reason for this comes from the specification of time as a regressor. The first role of time is a proxy for technical change in the deterministic kernel of the stochastic production frontier. The second is that time is an indicator of technical efficiency change in the composite error term. As Kumbhakar & Lovell (2000) show, three time-varying models are as follows:

(2.13) First, $u_{it} = u_i \gamma(t)$, in which $\gamma(t)$ is a parametric function of time. In other words, this determines how technical inefficiency varies over time. And u_i is a nonnegative random variable (Kumbhakar, 1990; Battese & Coelli, 1992). The Battese & Coelli model is less flexible, because $\gamma(t) = \exp[\eta(t-T)]$.

(2.14) Second, $u_{it} = \Omega_{1i} + \Omega_{2i}t + \Omega_{3i}t^2$, in which, the Ω's are producer-specific parameters (Cornwell, Schmidt & Sickles, 1990). The rank ordering of firms changes over time.

(2.15) Third, $u_{it} = u_i \gamma_t$, in which, γ_t are the time effects represented by time dummies. The u_i term can be either fixed or random producer-specific effects (Lee & Schmidt, 1993).

Incorporating Exogenous Variables

Pitt & Lee (1981) proposed a two-stage model. Inefficiencies are predicted from an estimated stochastic production frontier at the first step. The predicted inefficiencies are regressed over firm-specific variables based on ordinary least squares at the second step. However, the two-stage approach has two major disadvantages (Kumbhakar & Lovell, 2000). The first is the possibility of the correlation of environmental variables and technical inefficiencies. The second is the assumption of the identical distribution of the inefficiencies at the first stage.

However, Kumbhakar, Gosh, & McGulkin (1991) and Reifschneider & Stevenson (1991) suggested other methods for dealing with this problem. These models simultaneously estimate the production frontier and efficiency term in one stage. Kumbhakar, Gosh, & McGulkin (1991) deal with this problem by including observable variables to have impact on the stochastic component of the production frontier as follows:

(2.16) $ln\,(y_i) = (x_i{'}\beta + v_i) - u_i$

and $u_i \sim N^+ [z_i{'}\gamma, \sigma_u^2]$

As a result, the inefficiency effects have variation with z_i and are not identically distributed. Battese & Coelli (1995) extended this model to panel data analysis.

On the other hand, Reifschneider & Stevenson (1991) suggested the following model:

(2.17) $ln\ (y_i) = (x_i'\beta + v_i) - u_i$

$u_i = g(z_i) + \varepsilon_i$

in which $g(\cdot)$ is a nonnegative function and $\varepsilon_i \sim N^+ [0, \sigma_\varepsilon^2]$.

However, this model has an identification disadvantage. That is to say, it is not certain whether the environmental variables have an impact on the inefficiency effects or the production technology.

2.4. Productivity Change

2.4.1 Overview

According to Fried et al. (2008), in general, efficiency and productivity are key concepts of the economic performance of producers in firms by most scholars. Therefore, school district performance could be analyzed on the productivity as well as efficiency. Which of school districts is more or less productive?

There could be different approaches to school district analysis in the arenas of productivity as well as efficiency. Therefore, productivity change is one of major themes in the panel data analysis. Simply, productivity is average product. According to Färe et al. (2007), productivity is thought as the ratio of output *y* (what we produce) over input *x* (the resources we use):

(2.18) Productivity = y/x.

As a result, productivity change is the percentage change in productivity over time:

(2.19) Productivity change = $[(y_1/x_1)/(y_o/x_o)]$.

There are two types of productivity measurement: partial and total factor productivity. Partial factor productivity deals with the impact of one important factor on output growth. Labor productivity and land productivity are examples of partial factor productivity. Therefore, the interesting factor productivity of this study could be performance per a financial variable. However, such measures ignore the potential for factors to serve as substitutes. This may be tolerable for a short run effect but not in the long run. As such, there are known as partial productivity measures.

For this reason, total factor productivity is a critical methodology for school district productivity than partial productivity measures. According to Coelli et al. (2005), there are four major approaches to productivity change: the Hicks-Moorsteen approach, the profitability approach, CCD (Caves, Christensen, & Diewart, 1982) approach, and component-based approach.

First of all, the Hicks-Moorsteen approach is to use a measure of output growth, net of growth in inputs. Second, the profitability approach is to measure productivity change using growth in profitability. Third, the CCD approach is to measure productivity by comparing the observed outputs in period *s* and *t* with the maximum level of outputs that can be produced using x_s and x_t operating under the reference technology.

For example, we can imagine one-input-one-output case of School District A example of Coelli et al. (2005). The school district produced 70 percent of the maximum feasible math proficiency rate for the given instructional expenditure per ADM in the 2001-02 school year. However, in the 2002-03 school year, it produced 30 percent above the maximum feasible math proficiency rate for the given instructional expenditure per ADM. As a result, productivity change of School District A from the 2001-2002 to the

2002-2003 school years is calculated as the ratio 1.30/0.70 = 1.857.

Last, in the case of the component approach, if various kinds of productivity change are recognized; technical efficiency change, technical change, change in the scale of operations and so on. Productivity change is the product of these measures.

2.4.2 Malmquist Total Factor Productivity

The productivity change is expressed as ratios of output distance functions under the constant return to scale (Färe et al., 2007). According to Färe et al. (2007)'s example, productivity change could be explained by distance functions.

According to Fried et al. (2008), using the period *t* benchmark technology, the period t output-oriented Malmquist productivity index is expressed:

(2.20) $M^t_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) = [D^t_{oc}(x^{t+1}, y^{t+1})/D^t_{oc}(x^t, y^t)]$

This index compares (x^{t+1}, y^{t+1}) to (x^t, y^t) by comparing their distances to the benchmark technology T^t_c. This comes from the forward-looking perspective of period t benchmark technology.

On the other hand, using period t+1 technology, the period t+1 output-oriented Malmquist productivity index is expressed:

(2.21) $M^{t+1}_{oc}(x^t, y^t, x^{t+1}, y^{t+1}) = [D^{t+1}_{oc}(x^{t+1}, y^{t+1})/D^{t+1}_{oc}(x^t, y^t)]$

This index compares (x^{t+1}, y^{t+1}) to (x^t, y^t) by comparing their distances to the benchmark technology T^{t+1}_c. This comes from the backward-looking perspective of period t+1 benchmark technology.

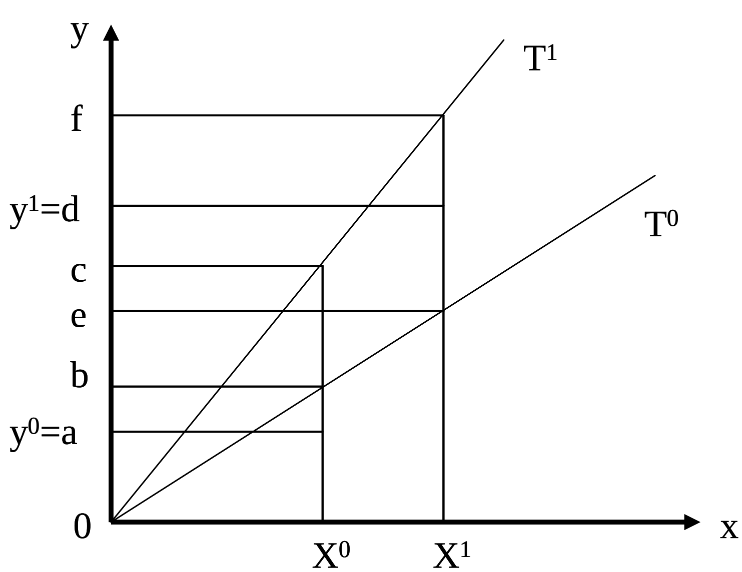
Because of the choice of benchmark technology, the Malmquist productivity index is defined as the geometric mean of the two.

The Malmquist index identifies the efficiency change and technical change under the framework of the distance function. According to Färe et al. (2008), the efficiency change (TEC) shows catching up the frontier. On the other hand, technical change (TC) expresses shifts in the frontier. As a result, the Malmquist index (M_o) is the multiplication of EC and TC. In this multiplication, EC can be expressed as:

(2.22) $[D^1_o(x^1,y^1)/D^0_o(x^0,y^0)]$.

On the other hand, technical change (TC) can be expressed as:

(2.23) $[\{D^0_o(x^1,y^1)D^0_o(x^0,y^0)\}/\{D^1_o(x^1,y^1)D^1_o(x^0,y^0)\}]$.



Source: Färe et al. (2008)

Figure 2.3 The Malmquist Productivity Index

As an example of Färe et al. (2008), the productivity change and its components, efficiency change and technical change, is explained as seen in Figure 2.3.

The move from (x^0,y^0) to (x^1,y^1) shows the productivity change as well as its components (efficiency change and technical change).

We starts at (x^0,y^0). We project the technology T^0 and move from *a* to *b*. In this case, considering a movement of technology T^0 and the increase in x^0 to x^1, we will get the movement of *b* to *e* on the *y*-axis. The consideration of technical change at x^1 gives the movement of *e* to *f*. However, considering technical inefficiency, we reach to *d* from *f* relative to T^1.

2.5. Application to Education

This part reviews the application of the stochastic frontier analysis to education. Generally, researchers have applied one method of these to education. The data envelopment analysis is preferred to the stochastic frontier analysis, but, some adopt two methods in order to get reliable analysis results. As a result, the first part explains simultaneous applications of two methods to education. The second part discusses from the viewpoint of institutional factors that are a focus of this study.

2.5.1. Two Methods Simultaneous Application

Some scholars (Chakraborty & Poggio, 2008; Rassouli-Currier, 2002; Chakraborty et al., 2001) applied both the data envelopment analysis and stochastic frontier analysis to education context to obtain reliable and robust results. Methodologically, there are common characteristics in the empirical estimation: DEA and SFA. On the one hand, two-stage data envelopment analysis was adopted in the empirical efficiency measurement. On the other hand, the stochastic frontier framework chose the Battese Coelli model extensively.

First, using Kansas school districts' panel data from the 2001 to 2005 school years, Chakraborty & Poggio (2008) estimated the education cost frontiers and inefficiencies. This study adopted the two-stage data envelopment analysis model and Battese & Coelli (1995) model. They identified that the results of two different approaches are about the same. Most importantly, this study indicated that there is no determinant evidence of lower efficiency. On the one hand, the inefficiency came from higher poverty for the Salina school district. On the other hand, the low efficiency of Dodge City resulted from a high population of minorities and poverty.

Second, adopting the data envelopment (second-stage Tobit approach) and the stochastic frontier analyses (Battese & Coelli model), Rassouli-Currier (2002) analyzed Oklahoma school districts from the 1996-97 to the 1998-99 school years. Most importantly, this study examined the existence of heteroscedasticity in the error term. She found that:

- Heteroscedastic stochastic frontier models are more reliable than the average response function, homoscedastic stochastic frontier, and DEA with second-stage homoscedastic Tobit regression.
- Environmental variables which are the percentage of minority students, percentage of students eligible for reduced or free lunch, and so on have explanatory power over the efficiency differences. However, the nontraditional inputs (teacher salary) do not explain efficiency differences except for the student/teacher ratio.
- Family background and students' characteristics rather than spending are primary factors for efficiency measures.

Third, Chakraborty et al. (2001) estimated the technical efficiencies of Utah school districts in the 1992-93 school year, using the stochastic and non-stochastic production functions. Non-stochastic estimation was based on two-stage data envelopment analysis.

Half-normal and exponential distributions was assumed in the stochastic approach. The two-stage model was utilized in order to get pure technical efficiency by excluding the effect of socioeconomic and environmental factors on efficiency measures. The education production of this study took the Cobb-Douglas functional form due to insufficient data. To summarize their findings, they discovered that:

- Efficiency measures are invariant in terms of the different assumptions of one-sided error term.
- Parental education is the most critical factor for student performance. And, socioeconomic and environmental variables have a strong impact on student success.
- Efficiency measures are not closely correlated with district size, geographic dispersion, or the local economic base.

2.5.2. Determinant Sources of Inefficiency

The analytical factors of the efficiency studies are the structural, institutional, and legislative impact on efficiency (Worthington, 2001). According to Worthington (2001) bank efficiency studies deal with more on competition and deregulation. On the other hand, ownership and control are the main themes of health services studies. How we can control out the socio-economic background effect on the education efficiency has been a critical task. Most scholars have used instrumental variables for socio-economic background:

- The percentage of students who are white.
- The percentage of students who are not in special education.
- The percentage of students who do not receive free or reduced lunch.

In general, for a long time, most scholars have explored the socio-economic background of students as a major reason for educational inefficiency. In this context, socio-economic factor is more critical factor than money for educational inefficiency. However, overcoming the deficit theory, some scholars related the institutional factors with educational inefficiency. From the theoretical and empirical background, the institutional factors could be policy tools for policy makers. The institutional factors could be one of policy mix from the viewpoint of policy making. How we can operationalize the competition and monitoring factors is the most important. This shows appropriate instrumental variables for this. However, this will have a possibility of weak relationship of institutional factors and educational inefficiency, because experimental design could be difficult for researchers.

In this context, recently, some researchers have connected institutional factors with inefficiency. First, reviewing the theoretical background of Leibenstein (X-inefficiency theory, 1978; 1966) and Niskanen (principal-agent model, 1971; 1975), Ruggiero, Duncombe, & Miner (1995) divided potential factors related to inefficiency into competition, government size, external factors, and internal characteristics.

In the first stage, using modified data envelopment analysis, they showed that 11 percent of school districts, 68 school districts of New York State, were inefficient in terms of the Farrell efficiency measure. However, contrary to inefficiency measures of all inputs, some inputs were inefficient at 14.9 percent. Considering discretionary inputs, teacher aides were most utilized inefficiently. In analyzing determinants of inefficiency empirically, they found that:

- Inefficiency was positively related to the number of private school students, and, on the other hand, negatively associated with school district size, wealth, poverty rate, and relative administrative expenditures. These were unexpected results of theoretical background.

- However, the percentage of minority students and tenured teachers, the capital intensity of production, the area of school districts, and city district status matched theoretical expectations.

Table 2.3 Causes of Technical Inefficiency by Ruggiero et al.' Study

Inefficiency Factors	Operationalization	Theoretical Background
Competition	• Private school students	• Hirschman (1970)
Government Size	• Enrollment • Squares miles • School size	• Niskanen (1975) • Chubb & Moe (1990) • Debate on consolidation
External Factors	• Wealth ratio • Children not in poverty	• Citizen-voters theory
Internal Characteristics	• Tenured teachers • Administrative expenditures • Capital intensity	• Labor Contract (Leibenstein) • Overuse of capital (DeAlessi, 1969) • Bureaucracy (Chubb & Moe, 1990)

Source: Ruggiero et al. (1995)

Second, Kang & Greene (2002) estimated the effects of monitoring and competition on outputs using the stochastic frontier analysis. This study differentiated environmental variables and institutional variables. Institutional variables were monitoring and competition factors. Monitoring factors were the percentage of housing owners in public school districts, the percentage of public school district revenues from nonresidential property sources and state revenue, and the percentage of households with school children. These factors were closely related to principal-agent theory.

The composition of competition was the percentage of private school enrollments in a county where the public school district is located and the Herfindahl index of school district concentration. The percentage of private school enrollments could be biased due to simultaneity and urbaneness. Accordingly, this study used instrumental variables like the population density of each county, the percentage of Catholics in the population, and a central school district dummy variable. The Herfindahl index of school district concentration was calculated by the size of the squares of school districts' enrollment shares in a county. As a result, they found that:

- A higher level of homeownership has negative effects on inefficiency for all outputs (Regent examinations, a Regent diploma, and dropout) except for 2-or 4-year college output.
- The percentage of district revenues from nonresidential property sources and state aid has a positive effect on inefficiency except for a Regent diploma.
- Most districts could reduce inefficiency if public school concentration (Herfindahl index) is lower.
- Higher parental choice among public school districts could improve efficiency. However, more competition from private schools would have a negative impact on efficiency.

Table 2.4 Causes of Technical Inefficiency by Kang & Greene's Study

Inefficiency Factors	Operationalization	Theoretical Background
Monitoring	• The percentage of housing owners in public school district • The percentage of households with school-aged children • The percentage of public school district revenues from nonresidential property sources and state aid	• Arrow theory (1995) • Consumer-voters theory • Flypaper effect
Competition	• The percentage of private school enrollments in a county where the public school districts is located (Herfindahl index)	• Parental choice • Private schools as alternatives

Source: Kang & Greene (2002)

Third, Grosskopf et al. (2001a) examined the determinants of school district efficiency from the viewpoint of competition and monitoring using the Shephard input distance function and regression estimations. The Shephard input distance function was utilized for modeling education production. This study showed that monitoring increases the technical and allocative efficiency of school districts. However, even though competition reduced allocative efficiency, there was no evidence that competition has a relationship with technical inefficiency. They found that:

- Technical efficiency is positively correlated with higher proportions of homeowners, highly educated individuals, and households with school age children. Also, allocative efficiency is positively related to higher tax rates.
- As market concentration grows, allocative inefficiency increases.
- Allocative inefficiency tends to have competition demands. However, technical inefficiency does not have these demands. That is why school district plays a role as a supplier of educational services as well as the employer of educational personnel.

As a result, they concluded that monitoring school districts have a tendency to increase technical and allocative efficiency, but, increased competition is not a panacea because of mixed results.

Table 2.5 Causes of Technical Inefficiency by Grosskopf et al.' Study

Inefficiency Factors	Operationalization	Theoretical Background
Monitoring	• Four-firm concentration ratios for each metropolitan statistical area • Herfindahl indices of student enrollment for each metropolitan statistical area	• Voter monitoring • Homeowners
Competition	• The school district's effective tax rate • The share of occupied housing that is owner-occupied • The shares of the population over 20 years old that attended at least some college • The shares of the population over 20 years old that completed high school but did not attend college • School district enrollment • The share of households in the school district that have school-age children	• Tibout competition

Source: Grosskopf et al. (2001)

CHAPTER 3. RESEARCH DESIGN & DATA COLLECTION

3.1. Overview

This study used *Ex Post Facto* design, because manipulating variables like experimental design was impossible (Krathwohl, 2004). Independent variables occurred naturally and were not under the researcher's control. Therefore, a causal relationship of this study was considered with caution. Specifically, according to Belfield & Levin (2002), there are many approaches to exploring the relationship between the competition factors of institutional factors and school district inefficiency measures: the lagged value of the percentage of private school enrollments, the percentage of private school enrollments, the lagged value of the percentage of the number of private schools, and the percentage of the number of private schools.

Table 3.1 School Districts Excluded from This Study

N	ID	School District	Reason
1	53	Bryn Athyn SD	Data unavailability of PSSA scores
2	189	Hempfield SD	Non-instructional service cost per ADM is zero.
3	251	Midland Borough SD	Data availability of PSSA scores
4	281	New Castle Area SD	Data availability of salary and benefits of total expenditures in the 2003-04 school year
5	320	Panther Valley SD	Data availability of salary and benefits of total expenditures in the 2003-04 school year
6	336	Philadelphia SD	Different governance system
7	341	Pittsburgh SD	Different governance system
8	370	Saint Clair Area SD	Data availability of PSSA scores
9	378	Scranton SD	Data availability of salary and benefits of total expenditures in the 2003-04 school year

The school district was the unit of analysis in this study. Accordingly, 492 school districts in Pennsylvania, with the exception of Philadelphia, Pittsburgh, and a few other school districts, from the 2001-02 to 2005-06 school years were analyzed due to different governance systems and data availability. As a result, school districts being excluded in his study are seen in Table 3.1. All observations of school districts on a 5-year period were 2460.

The main data source was the Pennsylvania Department of Education (http://www.pde.state.pa.us). The methods of collecting data included searching for school finance-related web sites, obtaining data published on the Pennsylvania Department of Education websites in *Finance (*http://www.pde.state.pa.us/k12_finances/site/default.asp*)* and *Academic Achievement Data* (http://www.paayp.com) areas, and obtaining data from *Standard & Poor's* School Evaluation Services (http://www.schoolmatters.com and http://www.schooldatadirect.org), United States Census 2000 (http://www.census.gov/main/www/cen2000.html), and *National Center for Education Statistics' Common Core of Data* (http://nces.ed.gov/ccd). Specifically, all data were collected from the Department of Education website. However, teacher-related variables of the 2004-05 school year were obtained from government officials of the Department of Education in Pennsylvania. That is why teachers' average salary and service years were omitted from Pennsylvania Department of Education website. Therefore, I contacted with the state officials and got them.

3.2. Variables of Interest

3.2.1 Input Variables

The input variables in the output-oriented approach for this study are instructional expenditure per ADM (INST) and support service cost per ADM (SUP). According to the definition of *Standard and Poor's* (2007), core spending is directly associated with teaching and learning. Overall, the three major cost measures in Pennsylvania are total expenditures, current expenditures, and actual instructional expenses. Furthermore, the expenditure data is divided into instructional costs, support service costs, and non-instructional service costs. Therefore, in this study, on the one hand, instructional expenditure per ADM under the function 1000 expenditure category was used as an INST variable. On the other hand, support service cost per ADM under the function 2000 category was used as a SUP variable.

3.2.2 Input Quality Differences & Quantity Adjustment Variables

ADM (student enrollment measured by average daily membership) and SIZE (population per square mile) were also included as quantity adjustment variables in this analysis. Input quality differences variables can influence the school district education production process. A school district cannot control input quality differences such as SERVICE (the average years of experience for teachers) and SALARY (average salary of teachers) variables fully.

Also, professional personnel are defined as the public school codes of 1949, section 1011 as professional employees, as well as other professional personnel (PDE, 2008). This includes administrative/supervisory, classroom teachers, and coordinate services personnel. In the 2005-06 school year, only classroom teachers were sorted for teachers' SERVICE and SALARY out of all professional employees.

3.2.3 Output Variables

The eleventh grade math and reading proficiency rates were used as the output variables for this study. Measuring output variables is the most important and difficult factor in the education production function. There are two major approaches to the efficiency measurement: the input-oriented and output-oriented approaches. This study was interested in the change of proficiency rates under the influence of the NCLB Act. Therefore, the math and reading proficiency rates of school district were chosen as output variables for this study.

Specifically, the Pennsylvania System of School Assessment (PSSA) measures how much students have achieved in reading and mathematics according to Pennsylvania's academic standards (Pennsylvania Department of Education, 2008). The federal No Child Left Behind Act requires that students achieve 100 percent proficiency in reading and math by 2014.

3.2.4 Exogenous Variables

3.2.4.1 Overview

According to Kumbhakar & Lovell (2000), the two critical components of an efficiency study are the estimation of the frontier (production, cost, profit, and revenue) and assessing the impact of exogenous forces on generating the frontier. This plays a key role on the basis of inefficient school districts' benchmarking for improving technical efficiency while reaching the frontiers. The exogenous factors are relevant to the extent that they have policy significance and that they may be impacted by past policy designs (Kumbhakar & Lovell, 2000). Important examples of exogenous variables are the degree of competitive pressure, input and output quality indicators, network characteristics, ownership form, and various managerial characteristics (Kumbhakar & Lovell, 2000). Therefore, incorporating exogenous variables is a critical force to the estimation of the stochastic and non-stochastic production frontier. Exogenous variables in this study were environmental, institutional, input-quality differences, and quantity adjustment variables.

Recognizing importance of the exogenous variables, this study divided the exogenous variables into four types: 1) environmental variables; 2) institutional variables; 3) input quality differences variables; and 4) quantity adjustment variables. As a consequence, the school district environmental variables of this study were the percentage of students who are not in IEP (individual education programs, NIEP) and the percentage of students who are not economically disadvantaged, determined through eligibility for free and reduced lunch (NECO).

3.2.4.2 Importance of Institutional Variables

This study explored the determinant sources of school district technical inefficiency from the viewpoint of school district institutional phenomena. The theoretical background of institutional factors comes from the review of the theoretical background of the "X-inefficiency" theory (Leibenstein, 1978; 1966), the "principal-agent" model (Niskanen, 1994; 1975; 1971), "vote with their feet" theory (Tibout, 1956), and "consumer-voters" theory (Downes, 1996). These institutional phenomena are closely associated with competitive pressure from public school districts and private schools as well as monitoring activities that might vary with consumer voters' incentives to monitor school district performance.

3.2.4.3 Consumer Voters' Theory & Others

Following Kang & Greene (2002)'s study, institutional variables were introduced in order to explore the effects of competition and monitoring on public education efficiency. These institutional factors come from the consumer-voters theory and others.

The public would choose the community which best satisfies their preference pattern for public goods (Tiebout, 1956). The inefficiency in public goods provision came from two missing factors: shopping and competition (Tiebout, 1956). Despite the problems of this Tiebout model, a major argument that individuals “vote with their feet” has still been a strong one because of resident similarity and capitalization (Gruber, 2007). This signifies inter-school district competition rather than intra-school district competition.

According to Kang & Greene (2002) and Downes (1996), public education inefficiency comes from two factors. The first is that the public is not uncertain about the education process as the black box transformation. The second is that the public as consumers of public goods, such as education, cannot observe school outputs fully. As a result, inefficient public education provisions could result from insufficient monitoring of the consumer-voters and inefficient educational bureaucracy (Kang & Greene, 2002). This theory can also be explained from the viewpoint of a principal-agent problem (Kang & Greene, 2002). This problem causes a moral hazard for school district administrators due to information asymmetry.

It is very difficult for policy makers and practitioners to control for environmental factors. As a consequence, managing institutional factors is a more natural method for policy makers to improve educational output, constrained to educational circumstances (Kang & Greene, 2002). Consequently, policy makers have to make a policy decision for increasing competition and monitoring activities of consumer-voters at the local level.

Unlike most studies that have connected uncontrollable student socio-economic background inputs with inefficiency, some efficiency analyses have tried to associate efficiency variation with institutional factors. According to Duncombe et al. (1997), factors reflecting monitoring costs and the ability and interest of citizens/voters put pressure on school boards to monitor school district (school) performance. At the same time, this will also affect school district efficiency. As a result, they argued that incentives for such involvement may be lower in the following cases:

- wealthier districts
- taxable property composition for school districts to permit greater tax exporting to other sources (which is why fewer financial constraints of school districts decreased political pressure for efficiency).

At the public goods' provision at the local level, there is a competition, because individuals can vote with their feet by moving to another town without much interruption (Tiebout, 1956). As a result, he argued that the exit threat can increase efficiency in local public goods production. The competition among public school districts and from private schools would be instrumental factors for the "vote with their feet" concept. As a result, one monitoring variable that comes from the consumer-voters theory was introduced as the market value/personal income aid ratio (MV/PI AR, WEAILTH).

On the other hand, in a review of the literature on the effects of competition between schools on educational outcomes, Belfield & Levin (2002) divided the measures of competition into the Herfindahl index, private school enrollment, and other measures. Accordingly, proxy variables for competition were two types: 1) the percentage of private school enrollments in a county where the public school districts are located (PRIVATE); and 2) the Herfindahl index of school district concentration (HERF). The Herfindahl index (Kang & Greene, 2002) was calculated from the size of the squares of school districts' enrollment shares in a county as:

(3.1) $$H = \sum P_i^2,\ P_i = E_i / \sum E_i$$

in which E_i is enrollment in the ith public school district in a county, n is the number of public school districts within the county, and P_i is the enrollment share of the *i*th district in the county.

However, the percentage of private school enrollments has a big problem related to instrumental variable for the competition from the private schools. Therefore, the causal relationship between competition from private schools and school district efficiency could be a weak one. As a result, this study overcame the causality problem, choosing the lagged value of private school enrollments rather than current value. That is why parents is dissatisfied with current public schools and would move their children to private schools next year as a form of a lagged adaptation.

Consequently, in summary, variables of interest and their definitions are illustrated in Table 3.2.

Table 3.2 Variable Definitions

Classification	Variables	Definition
1. Inputs		
1.1.	INST	Instructional expenditure per ADM
1.2.	SUP	Support services cost per ADM
2. Input Quality Differences		
2.1.	SERVICE	Average years of experience for teachers
2.2.	SALARY	Average teacher salary
3. Quantity Adjustment		
3.1.	ADM	Student enrollment measured by average daily membership
3.2.	SIZE	Population per square mile
4. Output Variables	PRO	The eleventh grade math and reading proficiency rates
5. Exogenous Variables		
5.1. Environmental		
5.1.1.	NIEP	The percentage of students who are not IEP
5.1.2.	NECO	The percentage of students who are not economically disadvantaged
5.2. Institutional		
5.2.1. Monitoring		
5.2.1.1.	WEALTH	Market value/personal income aid ratio (MV/PI AR)
5.2.2. Competition		
5.2.2.1.	LagPRIV	Lagged value of the percentage of private school enrollments in a county where the public school district is located
5.2.2.2.	HERF	The Herfindahl index of school district concentration

CHAPTER 4: RESEARCH METHODOLOGY

The *No Child Left Behind* (NCLB) Act has pushed the increase of student proficiency rates of school districts as a form of an accountability system. Accordingly, there has been an important expectation that school districts have to transform inputs into outputs efficiently.

As a result, this section presents the methodology to address the measurement of the efficient transformation of inputs into productive services. A methodological orientation of this study was a stochastic frontier approach to analyze the performance of school districts. One of the major objectives of this study was to estimate the frontier of educational services provided over the 2001-02 to 2005-06 school years, where this frontier is referred to as "the best attainable function" (Choi, 2002, p11). Accordingly, this frontier can provide the basis of evaluating school districts' efficiencies. Most importantly, this study utilized panel data estimation techniques to examine the technical efficiency and productivity change of each school district in Pennsylvania.

4.1. Conceptual Framework & Research Questions

This study investigated the efficiency and productivity of Pennsylvania school districts based on input-output-analysis framework (Hoy & Miskel, 2004) focusing mainly on how inputs are transformed into outputs. For this reason, production function studies have been supported by many scholars in the area of input-output-analysis framework. On the other hand, input-throughout-output framework could overcome this perspective, incorporating transformational processes such as classroom practices, school culture, organizational operations, and political relationships (Hoy & Miskel, 2004).

Many exogenous variables are involved in this transformation, as illustrated in Figure 4.1. School districts are to increase the student proficiency rate, controlling for the effects of these exogenous variables on student proficiency rate. Exogenous variables in this study were environmental, institutional, input-quality differences, and quantity adjustment variables. These variables of interest were explained in detail in Chapter 3. Educational stakeholders cannot control these exogenous variables fully. Currently, the NCLB Act has pushed to increase student proficiency rates of school districts, by requiring accountability, subject to the constraints related to exogenous variables.

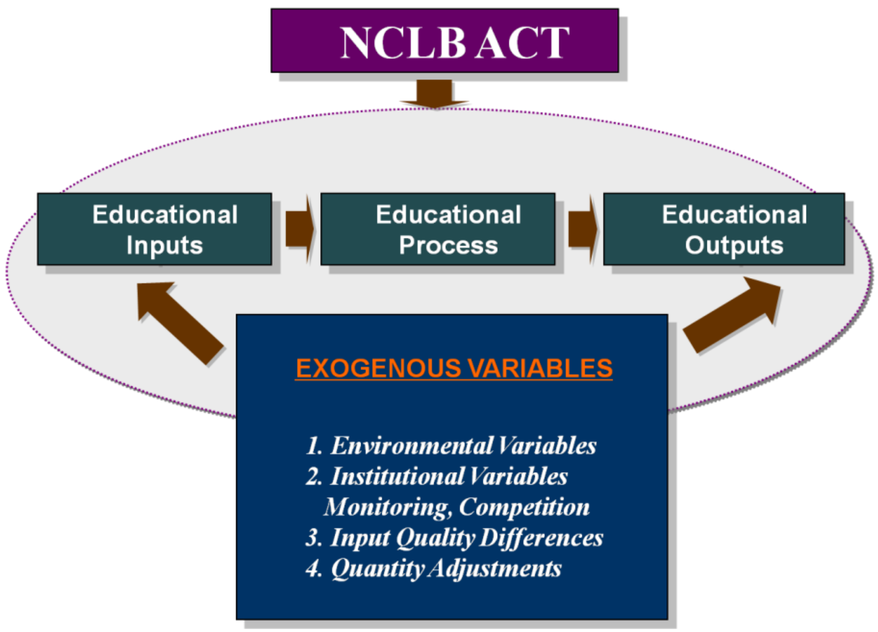


Figure 4.1 Conceptual Framework of This Study

Environmental variables can play a positive or negative role in transforming inputs into outputs. Most scholars including Hanusheck (1986) have argued that these non-discretionary socioeconomic factors are the most critical factors in this process since the Coleman report (1963). In analyzing pure efficiency or productivity measures of school districts and schools in education production function studies, environmental impacts have to be controlled. Moreover, the unobserved heterogeneity of school district-specific characteristics must be taken into consideration in the education production process.

From this input-output-analysis framework, the objectives of this study were to: 1) estimate school district efficiency, 2) identify the common characteristics of efficient school districts, 3) explore the critical determinants of school district inefficiency, and 4) assess the efficiency change and productivity change of school districts. As a result, the specific research questions addressed by this study were as follows:

RQ 1: What are the levels of efficiency measures in school districts?

RQ 2: How widely do efficiency measures vary across school districts?

RQ 3: What are the common factors presented by efficient school districts?

RQ 4: Has the efficiency of school districts improved since the 2001-02 school year? What explains the efficiency change of school districts?

RQ 5: Has the productivity of school districts improved since the 2001-02 school year?

Hanushek and following scholars concluded that "school inputs have little systematic impact on student outcomes, leading researchers to consider the possibility that schools are inefficient (Fukuyama & Weber, 2002, p994)." This conclusion suggests that the efficient translation of educational opportunities to actual student achievement is the most critical factor rather than inputs in the production function (Fukuyama & Weber, 2002). In this context, this study explored the efficiency for increasing the accountability of school districts in the turbulent times of the NCLB Act.

4.2. Procedures for Research Questions

Research procedures for this study are described in detail according to five research questions, as seen in Figure 4.2.

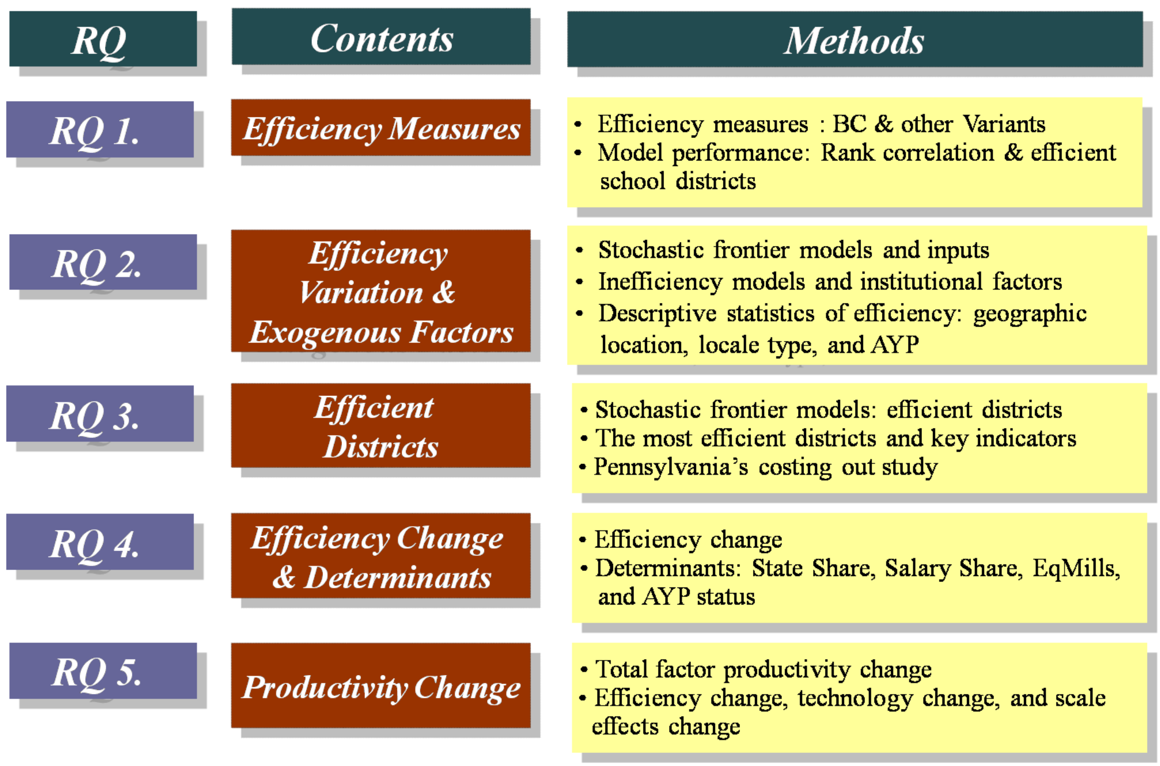


Figure 4.2 Research Procedures of This Study

In *RQ 1*, the efficiency measures of school districts were calculated from the Battese & Coelli model under the framework of the stochastic frontier model. However, efficiency measures of this basic model were compared with other panel data variants of stochastic frontier analysis in order to deal with the unobserved heterogeneity problem of school districts and so obtain reliable efficiency measures. Therefore, other panel data variants of efficiency measurement included the pooled data model, the time-invariant inefficiency random effects model (Pitt & Lee, 1981), and the true random effects model (Greene, 2005a) based on the model specification criteria: 1) time-varying or time-invariant of efficiency; 2) fixed or random effects of the inefficiency term; and 3) the incorporation of the unobserved school district heterogeneity. Most importantly, disregarding the unobserved heterogeneity of school districts leads to biased efficiency estimates in the human-related education context. Most importantly, rank correlation among these panel data estimators of the stochastic frontier models was explored for model performance in the education production frontier analysis. The reason for this is that the ranking of school district efficiency measures is of much more interest rather than their absolute values.

For *RQ 2*, most importantly, using the Battese & Coelli models and other panel data estimators of the stochastic frontier models, we explored the relationship between efficiency measures and monitoring and competition variables that are assumed to have a great positive or negative effect on them, from a theoretical background.

Furthermore, the stochastic frontier models represented the impact of educational inputs on the proficiency rates of school districts. As a result, the efficiency measures of 492 school districts were descriptively analyzed according to geographic location, locale type and related socio-demographic variables. The NCES (National Center Educational Statistics, 2006) divides local types into the urban-centric locale code system of 12 locale codes, as seen in Table 4.1.

Table 4.1 Urban-Centric Locale Codes

	Codes	Definition
City: Large	11	Territory inside an urbanized area and inside a principal city with population of 250,000 or more.
City: Midsize	12	Territory inside an urbanized area and inside a principal city with population less than 250,000 and greater than or equal to 100,000
City: Small	13	Territory inside an urbanized area and inside a principal city with population less than 100,000.
Suburb: Large	21	Territory outside a principal city and inside an urbanized area with population of 250,000 or more.
Suburb: Midsize	22	Territory outside a principal city and inside an urbanized area with population less than 250,000 and greater than or equal to 100,000.
Suburb: Small	23	Territory outside a principal city and inside an urbanized area with population less than 100,000.
Town: Fringe	31	Territory inside an urban cluster that is less than or equal to 10 miles from an urbanized area
Town: Distant	32	Territory inside an urban cluster that is more than 10 miles and less than or equal to 35 miles from an urbanized area
Town: Remote	33	Territory inside an urban cluster that is more than 35 miles of an urbanized area.
Rural: Fringe	41	Census-defined rural territory that is less than or equal to 5 miles from an urbanized area, as well as rural territory that is less than or equal to 2.5 miles from an urban cluster
Rural: Distant	42	Census-defined rural territory that is more than 5 miles but less than or equal to 25 miles from an urbanized area, as well as rural territory that is more than 2.5 miles but less than or equal to 10 miles from an urban cluster.
Rural: Remote:	43	Census-defined rural territory that is more than 25 miles from an urbanized area and is also more than 10 miles from an urban cluster

Source: NCES Common Core of Data (2006)

And, geographic location is divided in nine types: the Northwest region, North-central region, Southwest region, South Allegheny region, Central, South-central region, Southeast, Northeast region, and Northern Tier region, as seen in Table 4.4. There was a variation in instructional expenditures (INST) per ADM, support service costs (SUP) per ADM, and non-instructional services cost (NINST) per ADM.

Table 4.2 Geographic Regions and Expenditure Variation

	Region	INST Per ADM	SUP Per ADM	NINST Per ADM
1	Northwest	5438.62	2877.47	203.40
2	North-central	5775.92	3085.70	180.29
3	Southwest	5864.61	3089.70	218.51
4	South Allegheny	5450.69	2882.79	192.47
5	Central	5496.46	2752.33	149.37
6	South-central	5393.74	2717.22	141.65
7	Southeast	6506.74	3380.62	185.08
8	Northeast	5552.14	2794.37	174.28
9	Northern Tier	5773.60	3085.81	215.94

Table 4.3 Urban-Centric Locale Codes and Expenditure Variation

	Locale	Codes	INST Per ADM	SUP Per ADM	NINST Per ADM
1	City: Large	11	N	N	N
2	City: Midsize	12	5614.84	2604.15	117.96
3	City: Small	13	6122.02	2805.17	112.74
4	Suburb: Large	21	6255.11	3229.29	210.26
5	Suburb: Midsize	22	5410.46	2684.79	168.40
6	Suburb: Small	23	5351.62	2809.69	172.35
7	Town: Fringe	31	5546.74	2770.32	163.86
8	Town: Distant	32	5488.64	2708.84	175.39
9	Town: Remote	33	5597.22	3086.84	178.14
10	Rural: Fringe	41	5493.12	2885.88	183.76
11	Rural: Distant	42	5588.04	3040.01	183.50
12	Rural: Remote:	43	5817.94	3233.95	199.57

And, two natural dimensions of geographic area were used to group school districts (Kuang, 2003). Two is the geographic region and the locale type. For this reason, policy makers would choose a locale type and geographic location as one of policy tools for better Pennsylvania public education.

Table 4.4 Pennsylvania State Regions

Name	Counties
Northwest	Clarion, Crawford, Erie, Lawrence, Mercer, Venango, Warren
North-central	Cameron, Clearfield, Elk, Jefferson, McKean, Potter
Southwest	Allegheny, Armstrong, Beaver, Butler, Fayette, Greene, Indiana, Washington, Westmoreland
South Allegheny	Bedford, Blair, Cambria, Fulton, Huntington, Somerset
Central	Centre, Clinton, Columbia, Juniata, Lycoming, Mifflin, Montour, Northumberland, Snyder, Union
South-central	Adams, Cumberland, Dauphin, Franklin, Lebanon, Perry, York
Southeast	Berks, Bucks, Chester, Delaware, Lancaster, Montgomery, Philadelphia
Northeast	Carbon, Lackawanna, Lehigh, Luzerne, Monroe, Northampton, Pike, Schuylkill, Wayne
Northern Tier	Bradford, Sullivan, Susquehanna, Tioga, Wyoming

Source: Kuang (2003)

To answer *RQ 3*, this study searched for the similarities and differences of the most efficient school districts given the results of *RQ 1 and RQ 2*. The efficient school districts came from the highest group. The highest school districts were identified as five percent of all school districts of calculated from variants of the stochastic frontier models. However, efficient school districts once identified by panel data models were excluded in a pool of efficient school districts, because various panel data models have different assumptions about the stochastic frontier analysis. Furthermore, these efficient school districts were compared with the results of Pennsylvania's costing out and *Standard & Poor's*. According to student achievement fast facts (Pennsylvania Department of Education, 2008), struggling school districts in Pennsylvania have much in common:

- struggling districts educate at-risk students; in 39 percent of the schools that missed their AYP targets, at least three in ten students were classified as minorities or low-income

- they also share under-funded conditions. More than three quarters of school districts not making AYP have a shortfall of at least $2,000 per pupil from the viewpoint of adequacy
- their high schools exhibit low levels of achievement; more than half of Pennsylvania's high schools did not make AYP this year

Moreover, Pennsylvania's costing out study adopted two approaches to identify successful school districts: an absolute standard and a growth standard. As a result, this study identified 67 districts in Pennsylvania that met the absolute standard and 21 districts that met the growth standard. With only six school districts being members of both groups, the combined analysis yielded 82 total districts, which formed the core of this analysis.

According to *Standard & Poor's* (2005), 47 school districts outperformed demographically similar school districts in reading and math proficiency scores during the 2001-02 and 2005-06 school years. These "outperforming" school districts are diverse-serving student populations that range from 0.7 to 88.4 percent for the economically disadvantaged, while achieving average proficiency rates in reading and math that range from 11.7 to 87.9 percent.

In the case of *RQ 4*, average efficiency measures of each school district from the 2001-02 to 2005-06 school years were obtained in order to explore the efficiency change. Most importantly, the efficiency change of an individual school district calculated from *RQ 4* could be divided into various kinds of efficiency change categories such as the constant type, increasing type, decreasing type, and others. But, this efficiency change measures were regressed on the regressors such as the status of warning, improvement, and corrective action of school districts, the percentage of state aid, equalized mills, and the percentage of expenditures dedicated to salaries and benefits spending in order to get the critical determinants of the school district efficiency change, using the Tobit model. The equalized mills regressor signifies the school district's tax effort as a decision variable of the school district in order to influence the school district efficiency change. On the other hand, the percentage of state aid is decided by the state government as the state decision variable, showing the district's dependence on the state. Also, the percentage of expenditures dedicated to salaries and benefits refers to the fixed cost of the school district that has an impact on the school district efficiency change.

Under the Pennsylvania Accountability System and the No Child Left Behind law, districts that do not meet their AYP targets receive designations that follow the same pattern as individual schools as seen in Table 4.5, that is: first, a district that did not meet its performance targets the first year receives a warning designation. Second, a district that did not meet its performance targets for two or three consecutive years receives a district improvement designation. A district that did not meet its performance targets for four or more years receives a corrective action designation.

The AYP status of school districts was issued by the Pennsylvania Department of Education from 2002-03 school year. Therefore, we could not analyze the school district efficiency in the 2001-02 school year. As a result, the efficiency measures of school district in the 2001-02 school year were dropped from data set.

Table 4.5 AYP (Adequate Yearly Progress) and Definition

Codes	Designation	Definition
1	Met AYP	The school will receive rewards and/or recognition after two consecutive years of meeting its targets.
2	Making progress	
3	Warning	In the first year of not meeting AYP, a district is placed in "warning" status. Warning means that the school fell short of the AYP targets but has another year to achieve them.
4	School improvement I	If a school district does not meet its AYP for two years in a row, students will be eligible for school choice, school officials will develop an improvement plan to turn around the school, and the school will receive technical assistance to help it get back on the right track.
5	School improvement II	If a district does not meet its AYP for three years in a row, it must continue to offer public school choice and plan improvements. Additionally, the school district will need to offer supplemental education services such as tutoring. The district will be responsible for paying for these additional services
6	Correction I	A school district is categorized in Corrective Action I when it does not meet its AYP for four consecutive years. At this level, schools are eligible for various levels of technical assistance and are subject to escalating consequences (e.g., changes in curriculum, leadership, professional development).
7	Correction II	If a school district does not meet its AYP for five years in a row, it is subject to governance changes such as reconstitution, chartering, and privatization. In the meantime, improvement plans, school choice, and supplemental education services are still required.

Source: Pennsylvania Department of Education (2008)

Last, answering RQ 5, the total factor productivity change of Pennsylvania school districts was calculated using a translog stochastic production frontier. The total factor productivity change of school districts over a 5-year period was the product of efficiency change, technical change, and scale change.

4.3. Education Production Function & Functional Form

Under the input-output-analysis framework, this study utilized the output-oriented approach rather than the input-oriented approach. Generally, two major functions used in analyzing education are the cost function and production function approaches. Hanusheck (1986) admits that school administrators are assumed to act as output maximizers. The behavioral assumption of the cost function approach is that school districts utilize inputs to minimize costs subject to output constraints given input prices (teachers' salaries) (Schwartz et al., 2005). In this context, Rassouli-Currier (2002) chose the production function approach for the following reasons:

- school districts are assumed to maximize outputs; accordingly, their objective is to attempt to reach the production frontier
- input and output prices are not available for school districts; therefore, the cost function approach is not appropriate because of data availability

For this reason, this study utilized education production function rather than cost function in the stochastic frontier analysis. Before exploring model specifications, the production function approach demands specifying the functional form for the econometric estimation of the production function. The functional form examples are Cobb-Douglas, translog, quadratic and so on. This study utilized the translog functional form, because this is more accurate than the usual Cobb-Douglas in the panel data context. Also, a Cobb-Douglas function has restrictive assumptions about the elasticity of substitution and scale properties (Chakraborty et al., 2001).

4.4. Model Specification: Stochastic Frontier Model

The stochastic frontier analysis is a methodology to estimate the production frontier and individual school districts' efficiency measures that accounts for statistically variation in the data series and models deviations from the frontier as a one-sided random error. The stochastic analysis based on the production function chose the Battese & Coelli time decay model (1992) and heterogeneity model (1995) as basic models for analyzing school district inefficiency in the panel context. That is why most scholars (Chakraborty & Poggio, 2008; Melvin & Sharma, 2007; Rassouli-Currier, 2002; Chakraborty et al., 2001; Kang & Grenne, 2000; Adkins & Moonaw, 1997) applied the Battese & Coelli model to an educational context extensively. However, in this analysis, school district-specific effects may be considered as inefficiencies. Moreover, the school district-specific effects may be correlated with the explanatory variables. As a result, this study compared the Battese & Coelli model specification with other model specifications for a better model specification.

4.4.1. Importance of the Stochastic Frontier Approach

The "econometric" stochastic frontier analysis approach to the production frontier construction and the measurement of efficiency relative to the constructed frontiers differs from the data envelopment analysis approach based on the mathematical programming. These two approaches use different techniques to envelop data in different ways. According to Kang & Greene (2000) and Lovell (1993), the major two differences between the two methods are as follows:

First, the econometric approach is "stochastic," and so attempts to distinguish the effects of statistical noise from the effects of inefficiency. On the other hand, the linear programming approach is "nonstochastic," and so lumps statistical noise and inefficiency together. Accordingly, measurement errors may have a large impact on the shape and position of the estimated frontier.

Second, the econometric approach is "parametric" and so confounds the effects of misspecification of functional form with inefficiency. On the other hand, the linear programming approach is "non-parametric" and so, is less prone to this type of specification error.

In an educational context, most scholars have utilized the data envelopment analysis rather than the stochastic frontier analysis. However, this study adopted the stochastic frontier analysis. As Kang & Greene (2000) argued, the stochastic frontier analysis is more appropriate in education efficiency analysis than the data envelopment analysis due to:

- the education production function has large errors in the input and output variables
- measures of educational performance are unlikely to capture the full importance of quality differences and may distort how quality differs across school districts
- the input variables in the education production function are subject to a measurement error because instrumental variables for them do not represent exactly the quality difference across school districts

4.4.2. Battese & Coelli Model

4.4.2.1. Overview

In the panel data estimation, Greene (2005a: 2005b; 2004) maintained three important considerations when estimating the stochastic frontier function: 1) whether the one-sided error presents fixed or random effects, 2) whether the inefficiency is fixed over time or not, and 3) how we can deal with the unobserved heterogeneity in the model.

Regarding these considerations, the fixed effects model considers that the unobservable variables in the model are correlated with the included variables (Greene, 2008b). Accordingly, this approach gets a school district-specific constant. On the contrary, the random effects model assumes that the omitted effects are uncorrelated with the included variables (Greene, 2008b). Considering these three criteria, basically, this study built on the Battese & Coelli model in order to estimate the stochastic production frontier and efficiency of school districts. The reason for this is that most researchers used the Battese & Coelli model extensively. Consequently, this Battese & Coelli model served as the random effects and time varying model. However, the Battese & Coelli model posed a dilemma in that any time-invariant unobserved school district heterogeneity is pushed into the inefficiency component (Greene, 2008c).

Consequently, most importantly, this study compared the results of this model with ones of the pooled data model, Pitt & Lee's conventional random effects model, and Greene's true random effects model in order to obtain reliable efficiency measures. The stochastic frontier models were estimated using the Limdep 9.0 program (Greene, 2002).

4.4.2.2. Model Specification

Extending the two-equation stochastic production frontier, the Battese & Coelli (1995; 1992; 1988) models estimated the parameters of the stochastic frontier and the inefficiency model. One of two models was the time-decay model (1992) for efficiency measurement of this study. The other was the heterogeneity model (1995) for the phenomena of institutional factors of this study.

Accordingly, the Battese & Coelli model (1995) permits the estimation of both technical change in the stochastic frontier and time-varying technical inefficiencies, given the inefficiency effects are stochastic. They applied this model to ten years of data on paddy farmers from an Indian village.

They considered the stochastic frontier production function for panel data accordingly:

(4.1) $Y_{it} = exp\,(X_{it}\beta + v_{it} - u_{it})$

- X_{it}: inputs associated with the *i*-th firm at the *t*-th observation
- β: unknown parameters to be estimated
- $v_{it}s$: a random error with $N\,[0,\, \sigma_v^2]$
- $u_{it}s$: non-negative random variable, associated with technical inefficiency, such that u_{it} is obtained by truncation (at zero) of the normal distribution with mean $z_{it}\delta$ and variance σ^2
- z_{it}: explanatory variables with technical inefficiency over time
- δ: unknown coefficients

Consequently, the technical inefficiency effect, u_{it} , in the stochastic frontier is expressed as:

(4.2) $u_{it} = z_{it}\delta + w_{it}$, in which $z_{it}s$ are explanatory variables, which include any variable that shows the extent to which the production observations are below the stochastic frontier production. Moreover, w_{it} is a random variable distributed $N\,[0,\, \sigma^2]$ truncated at - $z_{it}\delta$.

Finally, the technical efficiency of production is expressed as:

(4.3) $TE_{it}=exp(-u_{it})=exp(-z_{it}\delta-w_{it})$.

In this model, the parameters are estimated by the maximum likelihood method rather than the regression. In the model specification, this study chose the heterogeneity model, because the school districts were heterogeneous with the explanatory variables such as the school district size, MV/PI Aid Ratio, Herfindahl index, and the percentage of private school enrollments. The time-decay model is expressed as:

(4.4) $g(z_{it}) = exp\,[-\eta(t\text{-}T)]$.

In here, T is the number of periods in the balanced model.

In summary, the general form of these models (Greene, 2008a) is expressed as:

(4.5) $u_{it} = g(z_{it})\,|\,U_i\,|$

in which, Z_{it} is a vector of school district-specific covariates, t is variation over time, and $g(\cdot)$ is a deterministic, positive function.

4.4.2.3. Empirical Model for Pennsylvania School Districts

Accordingly, first, the fundamental education production translog model for Pennsylvania school districts from the 2001-02 to 2005-06 school years is:

(4.6)

$$lnP_{it}=\beta_0+\beta_1 ln(\text{INST}_{it})+\beta_2 ln(\text{SUP}_{it})+0.5\beta_3[ln(\text{INST}_{it})]^2+0.5\beta_4[ln(\text{SUP}_{it})]^2+\beta_5 ln(\text{INST}_{it})ln(\text{SUP}_{it})+(V_{it}-U_{it})$$

Second, after that, incorporating environmental, input quality, and quantity adjustments variables, this model can be modified as:

(4.7) $$lnP_{it}=\beta_0+\beta_1(\text{NIEP}_{it})+\beta_2(\text{NECO}_{it})+\beta_3(\text{SALARY}_{it})+\beta_4(\text{SERVICE}_{it})+\beta_5(\text{ADM}_{it})+\beta_6 ln(\text{INST}_{it})+\beta_7 ln(\text{SUP}_{it})+0.5\beta_8[ln(\text{INST}_{it})]^2+0.5\beta_9[ln(\text{SUP}_{it})]^2+\beta_{10} ln(\text{INST}_{it})ln(\text{SUP}_{it})+(V_{it}-U_{it})$$

Last, incorporating differences in quantity adjustments and institutional variables, the inefficiency model can be described as:

(4.8) $$TE_{it}=\delta_0+\delta_1(\text{SIZE}_{it})+\delta_2(\text{WEALTH})_{it}+\delta_3(\text{PRIVATE})_{it}+\delta_4(\text{HERF})_{it}+(e_{it})$$

Also, square of $(\text{WEALTH})_{it}$ was added in this model specification in order to explore the rate of the impact of WAELTH on the inefficiency measures.

4.4.2.4. Maximum Likelihood Estimation

The regression framework cannot estimate the best attainable production frontier. This framework estimates the average input and output relationship and so disregards observed school districts above the average fitted input and output regression line. Therefore, in order to overcome the regression framework, the maximum likelihood estimation is needed from the viewpoint of the efficiency measurement framework.

The ordinary least squares (OLS) estimator of the intercept coefficients is biased downwards when using the OLS (Greene, 2008c). According to Coelli et al. (2005), a better solution of this problem is to make some distributional assumptions concerning the two error terms and estimate the model using the maximum likelihood method. That is why the maximum likelihood estimators have many desirable large sample properties. As a result, maximum likelihood estimators are preferred over other estimators.

In the stochastic frontier analysis of this study, the maximum likelihood estimation was used. Maximum likelihood estimation shows that a particular sample of observations is more likely to have been generated from some distributions than from others (Coelli et al., 2005). As a result, the maximum likelihood estimate of an unknown parameter is defined to be the value of the parameter that maximizes the probability (or likelihood) of randomly drawing a particular sample of observations.

Jondrow et al. (1982) proposed the stochastic frontier production function to measure technical inefficiency. This estimator of the Jondrow et al. estimator of $E[u_i \mid \varepsilon_i]$ is the standard estimator. This is the indirect estimator of u. That is why it is impossible to estimate u_i directly from any observed sample information.

A three-step procedure in estimating the maximum likelihood estimates of the parameters of a stochastic frontier production function (Coelli, 1996) is:

- the first: OLS estimates of the function are obtained; all β estimators with the exception of the intercept will be unbiased
- the second: a two-phase grid search of $\gamma = \sigma_u^2 (\sigma_v^2 + \sigma_u^2)^{-1}$ is conducted, with the β parameters (except β_0) set to the OLS values and the β_0 and $\sigma^2 = \sigma_v^2 + \sigma_u^2$ parameters adjusted according to the corrected OLS formula; Any other parameters are set to zero in this search
- the third: the values selected in the grid search are used as starting values in an iterative procedure (using the Davidon-Fletcher-Powell Quasi-Newton method) to obtain the final maximum likelihood estimates

4.4.3. Panel Data Models & School District Heterogeneity

4.4.3.1. Overview

Since there could be a possibility of strong unobserved heterogeneity among school districts that differ from one another in exogenous dimensions of school districts, inefficiency is allowed to change according to school district variations. School district education production would be decided by heterogeneous school district production conditions than other areas. The sensitivity of the estimated results based on various model specifications is dependent on the extent to which the school district-specific heterogeneity is correlated with the explanatory variables (Abdulai et al., 2007). If we cannot deal with the unobserved school district heterogeneity in the model specification, the unobserved heterogeneity will be pushed into the inefficiency component. As a result, estimation techniques that do not account for unobserved heterogeneity produced biased efficiency estimates (Abdulai et al., 2007).

Greene's true random effects model could be a solution for unbiased estimates and efficiency scores in the context of the unobserved heterogeneity problem (Abdulai et al., 2007). Therefore, following Abdulai et al. (2007) and Farsi et al. (2003)'s stochastic production and cost frontier studies, this study estimated conventional production frontier panel data models and Greene's true random effects for examining the unobserved heterogeneity problem and its impact on inefficiency estimates simultaneously. Therefore, this study included the pooled data model, the random-effects model, and the true random-effects model in addition to basic the Battese and Coelli (1995; 1992) model. To my knowledge, this study could be the first study to deal with the unobserved heterogeneity problem of school district in the education production frontier analysis.

4.4.3.2. Various Panel Data Models

Based on Greene's considerations, this study explored the unobserved school district heterogeneity as well as the performance of the Battese & Coelli (1995; 1992) model specification in the panel data analysis. As a result, we can draw the model specification matrix as seen in Table 4.6. The criteria of model specification assumption are: 1) whether the one-sided error term is fixed or random effects, 2) whether inefficiency is time-invariant or time varying, and 3) whether the model can deal with unobserved heterogeneity or not.

Table 4.6 Variants of the Efficiency Models in the Panel Data

Effects	Fixed effects models		Random effects models	
Heterogeneity		Unobserved heterogeneity		Unobserved heterogeneity
Time-invariant	Cornwell, Schmidt, & Sickles fixed effects model		Pitt & Lee random effects model	
Time-varying		True fixed effects model	Battese and Coelli model	True random effects model

Through various models, we could question the basic Battese and Coelli model's specification performance. That is to say, whether this model can explain the Pennsylvania efficiency analysis properly or not was obtained through the comparison with other variants of the efficiency model. In other words, which model could explain the Pennsylvania school district efficiency the best?

The first criterion was whether an inefficiency term is a fixed parameter or a random variable. The fixed effects model can be estimated from the familiar fixed effects regression (Cornwell, Schmidt, & Sickles, 1998). In the production frontier analysis, the inefficiency scores of the fixed effects model are estimated as the distance from the school district-specific intercept (α_i) to the maximum intercept (max(α_i)). On the other hand, the Pitt & Lee (1982) random effects model can be estimated from the maximum likelihood approach.

The second criterion was whether inefficiency is time-varying or time-invariant. The conventional fixed and random effects models assume time-invariant inefficiency. On the other hand, time-invariant models are the Battese & Coelli model, the true fixed effects model, and the true random effects model. Most importantly, the educational context has to consider the unobserved heterogeneity of school districts in the case of school district efficiency study. That is why education deals with human capital formation. Unlike other areas, we cannot specify the appropriate instrumental variables associated with production function model fully, compared with firm efficiency models. Education has a large possibility of omitted environmental and other school district-specific variables from stochastic frontier model specification due to the lack of information and human-related factors. Therefore, the neglected heterogeneous environmental production condition will lead to biased estimates of the parameters of the production frontier and overestimation of technical efficiency (Abdulai et al., 2007).

As a consequence, Greene (2005a) proposed two model specifications in order to incorporate the heterogeneity problem and time-variant efficiency in the efficiency analysis. In the case of the heterogeneity, there are observed heterogeneity and unobserved heterogeneity. In terms of observed heterogeneity, this heterogeneity can be dealt with in the model specification, because measured efficiency is conditional upon these factors (Abdulai et al, 2007).

However, the unobserved school district heterogeneity will have difficulties for efficiency analysis. To address this issue, Greene suggested the "true" fixed effects model and "true" random effects model. These models can distinguish unobserved heterogeneity from the inefficiency component. The true fixed effects model can distinguish school district-specific fixed effects measuring heterogeneity from time-varying inefficiency term. However, as Greene (2005a) argued, estimates of the individual effects may be inconsistent and can directly affect the inefficiency estimates in the case of a small analysis period. On the other hand, the true random effects model adds the time-invariant and school district-specific random term to the basic random effects model. This term will capture school district-specific heterogeneity. The true random effects model is a better solution to the unobserved school district heterogeneity than the true fixed effects model (Greene, 2005a). Therefore, this study estimated technical efficiency under the unobserved heterogeneity with the true random effects model.

4.4.4. Total Factor Productivity Change

The total factor productivity change of this study also considered the translog stochastic production frontier for calculating school district productivity change using the stochastic frontiers. There are two approaches to the productivity change: data envelopment analysis and stochastic frontier analysis.

Following Coelli et al. (2005) and Orea (2002), the total factor productivity index of this study was the product of a technical efficiency change, technical change, and scale change of school districts.

To begin with, the technical efficiency change of school districts was calculated as:

(4.9) Efficiency change = TE_{it}/TE_{is}.

That is to say, efficiency change was calculated between period *s* and *t* for the *i*-th school district efficiency measures.

Next, the technical change index between period *s* and *t* for the *i*-th school district can be calculated directly from the estimated parameters.

First, the partial derivatives of the production function with respect to time using the data for the *i*-th school district in periods *s* and *t* were obtained. Then, the technical change index between the adjacent periods *s* and *t* was calculated as the geometric mean of these two partial derivatives. In the case of a translog production function of this study, this was the exponential function of the mean of the log derivatives:

(4.10) Technical change = $exp\ \{1/2[(\partial lnP_{is}/\partial s)+(\partial lnP_{it}/\partial t)]\}$

A Malmquist total factor productivity index was obtained from the multiplication of the technical efficiency change and technical change index.

However, according to Coelli et al. (2005), scale economics of school districts was identified in the total factor productivity change index. Therefore, a solution was an approach suggested by Orea (2002). Orea’s suggestion was the inclusion of a scale change component to the total factor productivity measurement:

(4.11) Scale change = $exp\{1/2\Sigma[\varepsilon_{nis}SF_{is}+ \varepsilon_{nit}SF_{it}]ln(x_{nit}/x_{nis})\}$

in which, $SF_{is}=(\varepsilon_{is}-1)/\varepsilon_{is}$, $\varepsilon_{is}=\Sigma\varepsilon_{nis}$, and $\varepsilon_{nis}=(\partial lnP_{is}/\partial lnx_{nis})$

If the scale elasticity (ε_{is}) is one, the production technology is the constant return to scale and so the scale change is one. This study was based on this approach. However, this study further considered the elasticity of the technical efficiency. The elasticity of mean education production with respect to the input factors in the translog non-neutral stochastic frontier models was composed of two parts: 1) the elasticity of frontier output; 2) elasticity of the technical efficiency (Battese & Broca, 1997).

The elasticity of frontier output was calculated from the derivative of the stochastic frontier model with respect to the input variable using the maximum likelihood estimates for the parameters of the frontier. On the other hand, the second component was calculated from the derivative of the inefficiency model with the input variable. Following Huang & Liu (1994), interactions between input variables of the stochastic frontier model and school district-specific variables were identified in the second component calculation of this study.

CHAPTER 5: DATA ANALYSIS & RESULTS (I)

Inputs, input quality differences, quantity adjustments, and environmental and institutional data for efficiency and productivity measurement were investigated and analyzed under the framework of the stochastic frontier analysis in this chapter. The results were divided into and presented according to five research questions. First, the efficiency measures of school districts were calculated from the Battese & Coelli model. However, efficiency measures of this basic model were compared with other panel data variants in order to investigate their explanatory power. Second, the efficiency measures were descriptively presented according to geographic location, locale type, and AYP status of the NCLB Act. Furthermore, the relationship between the efficiency and institutional factors was presented. Third, the similarities of the most efficient school districts were presented. Fourth, the Tobit model was estimated to explore the relationship between the efficiency change of each school district and the determinants for the efficiency change. Last, the productivity change of each school district was presented in addition to the efficiency change.

Most interestingly, the Analysis section was divided into two parts: math proficiency rate and reading proficiency rate. The comparison of math proficiency rate to reading proficiency rate was discussed in Chapter 7. Therefore, this chapter discusses the stochastic frontier analysis results of math proficiency rate according to the research questions.

5.1 Descriptive Statistics

The math and reading proficiency rates of eleventh grade students' PSSA tests were used as output variables. The absolute scores of these eleventh grade students may also be possible as output variables. However, the proficiency rates were appropriate instruments under the No Child Left Behind (NCLB) accountability system, rather than the absolute scores, because the AYP component of the NCLB Act focuses on the proficiency rates. The mean reading proficiency rate was larger than the mean math proficiency rate. The NIEP and NECO variables were also obtained from the PSSA data as well as math and reading proficiency rates. The percentages of these variables were the percentages of students who had math and reading tests in eleventh grade.

Most interestingly, the mean of NECO variable was lower than the mean NIEP variable. Since Pennsylvania had many economically disadvantaged students among environmental factors, this could have the largest impact on the PSSA scores and proficiency rates.

The mean of the INST and SUP per ADM were $5,788.67 and $3,005.18. These traditional inputs were scaled by 1/1000 for the stochastic frontier analysis. The average of the instructional expenditures (INST) per ADM was about two times that of the support services costs (SUP) per ADM.

In this context, the average salary of classroom teachers (SALARY) was also scaled by 1/1000. The average salary of classroom teachers in Pennsylvania was $50,390.

For easy interpretation, ADM and SIZE variables were scaled by 1/ADM and 1/SIZE. For this reason, 1/ADM and 1/SIZE would have a positive impact on math and reading proficiency rates. As a result, we could explain these results more easily for analytic interpretation.

Institutional variables of this study were WEALTH, PRIVATE, and HERF. Market value/personal income aid ratio (MV/PI AR) was an instrumental variable for school district wealth. Lower values of MV/PI AR show higher wealth of school districts. The Herfindahl index represents the concentration of school districts. This index was calculated using the size of the squares of school districts' enrollment shares in a county. The focus of this calculation was on each school district's enrollment at the eleventh grade level. Most importantly, the sample school districts were heterogeneous with SIZE, MV/PI AR, HERF, and PRIVATE, ranging from 5.8 to 10640.9, from 0.1500 to 0.8526, from 0.0000 to 1.0000, and from 0.0000 to 0.2502, as seen in Table 5.1.

Table 5.1 Summary of Descriptive Statistics of All Variables in This Study

Variables	Mean	Std. Dev.	Minimum	Maximum
MathPRO	51.8879	13.8766	2.30000	89.8000
ReadingPRO	64.9122	12.4822	2.6000	96.5000
INST	5788.67	988.936	3710.62	10864.1
SUP	3005.18	641.269	1717.85	7045.07
SALARY	50390.7	6558.51	31030.0	81409.0
SERVICE	16.1579	3.6365	9.1000	156.000
MathNIEP	0.8900	0.460425E-01	0.5800	1.0000
ReadNIEP	0.8900	0.460194E-01	0.5800	1.0000
MathNECO	0.8276	0.1428	0.0000	1.0000
ReadNECO	0.8275	0.1428	0.0000	1.0000
ADM	3129.13	2601.51	233.249	20163.8
SIZE	938.029	1553.94	5.8000	10460.9
MV/PI AR	0.5492	0.1684	0.1500	0.8526
HERF	0.423286E-01	0.1400	0.0000	1.0000
PRIVATE	0.808246E-01	0.641122E-01	0.0000	0.2502
StateShare	0.4157	0.1690	0.834000E-01	0.7690
SalaryShare	0.6533	0.649125E-01	0.2298	0.8430
EqMills	21.2396	5.1249	8.3000	49.8000

However, private school enrollments could have a causality problem, because this study focused on using *Ex Post Facto* design, not an experimental design. For this reason, the lagged value of private school enrollments was used as a form of lagged adaptation for the competition effect from private schools rather than the current value.

Lastly, StateShare, SalaryShare, EqMills, and AYP factors were discussed in association with the efficiency change of each school district. Finally, the descriptive statistics for all variables in this study are summarized in Table 5.1.

5.2 Efficiency Measures

5.2.1 Overview

The average efficiency index of Pennsylvania school districts in math proficiency rate ranged from 77.5 to 83.0 percent, resulting from various panel data models in the stochastic frontier analysis, as seen in Table 5.2.

Table 5.2 Efficiency Measures of Various Panel Models in Math Proficiency Rate

	Mean	Std. Dev.	Minimum	Maximum
E_{BC}	0.775884	0.133745	0.109159	0.983361
E_{POOL}	0.790845	0.108913	0.542703	0.973232
E_{PLRE}	0.774816	0.134036	0.120676	0.982369
$E_{PLREHT1}$	0.794846	0.143622	0.117529	0.982204
E_{TRE}	0.829832	0.104381	0.518544	0.983713

Basically, the efficiency measure of the Battese & Coelli model (E_{BC}) was 77.6 percent in math proficiency. In other words, school districts had an average inefficiency of 22.4 percent in math proficiency. An examination of the true random effects model (E_{TRE}) indicates that Pennsylvania public school district efficiency generated by the stochastic frontier analysis had a 83.0 percent in math proficiency rate.

Table 5.3 Efficiency Levels and Key Indicators in Math Proficiency Rate

N	E_{BC}	E_{TRE}	Math PRO	INST	SUP	SA LARY	SER VICE	NIEP	NECO	ADM	SIZE	MV/PI AR	State Share	Salary Share	Eq Mills
2	0.1571	0.5872	7.85	7861.84	3636.44	54218.01	15.95	0.8494	0.4963	7915.22	4895.70	0.7829	0.5082	0.5270	33.97
1	0.2145	0.6535	11.56	8550.20	4023.24	46690.04	13.14	0.8274	0.1224	1824.30	8345.70	0.6466	0.3753	0.6079	46.42
4	0.3461	0.6708	18.86	6600.93	3202.28	48636.21	15.62	0.8408	0.5213	6082.27	5018.15	0.7524	0.5441	0.6340	33.92
11	0.4506	0.7124	23.87	6734.50	3177.77	49938.03	14.48	0.8213	0.6057	3543.50	3912.26	0.6687	0.4889	0.6310	26.74
27	0.5601	0.7715	33.86	6085.44	3060.05	49536.66	15.85	0.8819	0.7151	3135.36	1641.35	0.6362	0.4652	0.6543	23.75
69	0.6548	0.7965	41.96	5663.48	2913.87	49029.01	16.64	0.8942	0.8009	2888.24	729.00	0.6198	0.4688	0.6484	21.31
142	0.7506	0.8233	49.00	5739.64	2979.26	49848.54	16.57	0.8948	0.8211	2678.46	664.16	0.5895	0.4586	0.6498	20.67
153	0.8503	0.8534	57.87	5710.83	3020.67	50878.24	15.65	0.8910	0.8744	3278.11	834.86	0.4905	0.3635	0.6543	21.06
51	0.9236	0.8700	64.23	5745.15	3022.86	51972.14	16.08	0.8917	0.8730	3770.24	668.58	0.4654	0.3623	0.6731	19.29
32	0.9621	0.8846	70.82	5824.75	3013.34	51852.77	16.86	0.8929	0.8695	3139.16	922.10	0.4745	0.3578	0.6615	20.45

Also, in considering group of efficiency levels in math proficiency, most school districts fell into 75.1 percent and 85.0 percent according to the Battese & Coelli model and 82.3 percent and 85.3 percent according to the true random effects model, as seen in Table 5.3. Generally, as the efficiency measures increased, the math proficiency rate became better. However, other key indicators showed the diversity of education production factors and other indicators.

The values of this study were also compared with other results. The mean technical efficiency of Illinois over the period from 2002 to 2005 of Melvin & Sharma (2007) was 90 percent. Utah school districts' mean technical efficiency, as measured by Chakaborty et al. (2001), ranged from 86 percent to 90 percent. Therefore, this study shows that Pennsylvania school district efficiency measures were lower than other studies, even though these studies had different models for school district education production. However, the gap between efficient and inefficient school districts was larger than those of other studies, at 11 percent to 98 percent of the Battese and Coelli model. Melvin & Sharma's (2007) study showed ranges from 44 percent to 98 percent.

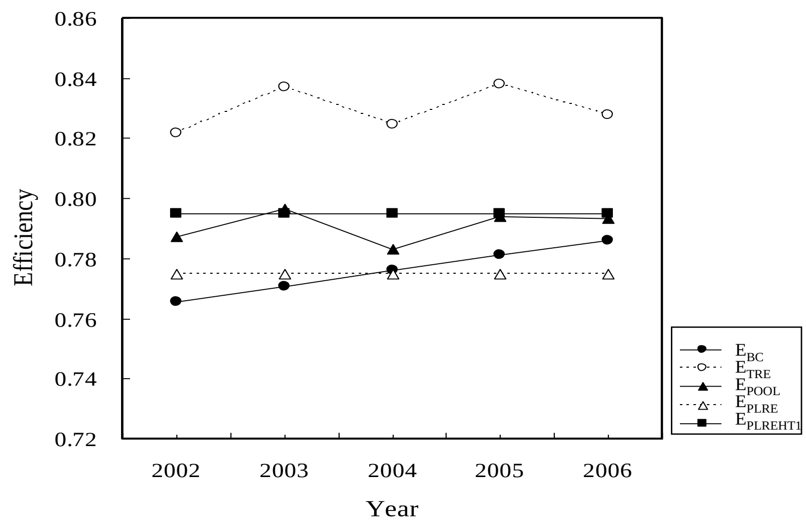


Figure 5.1 Efficiency Change of Various Panel Models in Math Proficiency Rate

As Figure 5.1 show, over a five-year period, efficiency measures of the Battese & Coelli model, true random effects model, and pooled data model improved.

5.2.2 Explanatory Power of Panel Data Models

The technical efficiency of school districts was estimated for individual models for the purpose of comparison. The aim was to examine the effects of different assumptions about the unobserved school district heterogeneity and school district efficiency. Table 5.2 provides a summary of the estimated efficiency measures of all school districts in Pennsylvania for various panel data models. Thus, the mean, the standard deviation, and the lowest and highest efficiencies for each model are presented in this table. Specifically, the computation of the random parameters models in the true random effects model was executed with 150 times the replications in terms of Halton sequences rather than pseudorandom numbers for the simulations according to Greene's suggestion (2008a) in Lemdep Version 9.

First, the mean efficiency measures of the Pitt & Lee conventional random effects models (E_{PLRE}, 77.48 percent) were lower than those of the Pitt & Lee heterogeneous models ($E_{PLREHT1}$, 79.48 percent). This shows that consideration of school district observed heterogeneity increased the efficiency measures. The differentiation between observed heterogeneity and efficiency measures resulted in efficiency measure improvement. In this case, school district observed heterogeneity was represented as the SIZE, WEALTH, PRIVATE, and HERF factors of school districts. This explains the importance of school district observed heterogeneity. That is to say, school district observed heterogeneity factors were school district size-related factor (school district size) and school district institutional factors (MV/PI AR, the Herfindahl index, and lagged private school enrollments).

Second, generally, efficiency measures of the conventional random effects model (E_{PLRE}, 77.48 percent) were lower than those of other panel data models. Basically, it is important to note that the random effects model (E_{PLRE}, 77.48 percent) assumes that efficiency is constant over time. On the other hand, the pooled model (E_{POOL}, 79.08 percent), the true random effects (E_{TRE}, 82.98 percent), and the Battese & Coelli model (E_{BC}, 77.59 percent) assume school district efficiency to be time-variant. Consequently, the results reveal that the efficiency estimates of the Battese & Coelli model and the true random effects model were larger than those of the models in which efficiency is time-invariant.

Third, the true random effects model (E_{TRE}) can separate time-invariant differences across school districts from inefficiency estimates. As a consequence, the efficiency measures (82.98 percent) were higher than those of other panel data models. Furthermore, we can differentiate the unobserved heterogeneity from the observed and unobserved heterogeneity problem in this study. This study also supports the overall heterogeneous problem of school districts. Greene (2005a) argued that the efficiency measures by the Battese & Coelli model and the Pitt & Lee random effects model misunderstand the heterogeneity problem for efficiency measures. As a result, the true random effects model can differentiate efficiency measures from the heterogeneity problem. Accordingly, efficiency measures of the true random effects models were much larger than those of the Battese & Coelli model and the Pitt & Lee traditional random effects model. The true random effects framework model assumes that the school district-specific heterogeneity is uncorrelated with the explanatory variables. Therefore, the extent of the correlation between the unobserved heterogeneity and the explanatory factors will decide the explanatory power of each variant of the panel data models. To summarize, in the true random effects model, time-invariant differences across school districts could be separated from inefficiency estimates, whereas the potential correlation between school district heterogeneity and explanatory variables takes place in this model. Consequently, the higher values for the true random effects model indicate that controlling for school district-specific heterogeneity reduced inefficiency.

For the explanatory power of various models, rank correlation was also calculated from the Spearman rank correlation coefficient for two sets of ranks, as seen in Table 5.4.

Table 5.4 Rank Correlation Among Various Models in Math Proficiency Rate

	E_{BC}	E_{POOL}	E_{TRE}	E_{PLRE}	$E_{PLREHT1}$
E_{BC}	1				
E_{POOL}	0.7280	1			
E_{TRE}	0.3055	0.7532	1		
E_{PLRE}	0.9977	0.7280	0.3047	1	
$E_{PLREHT1}$	0.9510	0.6833	0.3129	0.9533	1

This study focuses on the rank of school district efficiency rather than absolute value. The reason for rank correlation is that the rank of school district efficiency is more appealing to policy makers and practitioners (Abdulai et al., 2007). For this reason, the Analysis section of this study presents policy makers and practitioners with policy implications for meeting Pennsylvania's high standards under the NCLB accountability system. Also, rank correlation investigation results in the determination of which model is the best in order to explain accurately the situation of Pennsylvania school districts. For this reason, an issue that is potentially interesting for policy makers is the ranking of school districts by technical efficiency scores (Abdulai et al., 2007). The ordering of school districts according to technical efficiency scores can be useful for policy makers interested in information on the impact of the structural change on school district efficiency (Abdulai et al., 2007). However, if individual methods rank school districts completely differently, then policy conclusions may be fragile and, as such, depend on which frontier efficiency approach is employed (Abdulai et al., 2007).

Table 5.4 contains the Spearman rank correlation coefficients, computed at school district level for comparability, from the five different estimation techniques. These coefficients show how close the rankings of the school districts are among each other, using the full sample of school districts. For each model, the efficiency score was computed as the school district's average score over the same period. A high correlation between the efficiency estimates could indicate "mutual" consistency among the individual approaches (Abdulai et al, 2007; Bauer et al., 1998).

The strongest average correlations were between the Battese and Coelli model and the Pitt & Lee random effects model (0.9977) and between the random effects heterogeneous model and the random effects model (0.9533). A low correlation (0.3047) between the random effects and the true random effects model indicates that the production frontier coefficients and efficiency measures from both models were affected by heterogeneity bias and so did not exhibit mutual consistency with regard to efficiency estimation. The correlation was between the Battese & Coelli model and the true random effects model at 0.3055. As a consequence, the time-decay model was more appropriate than the other models. The true random effects model had a low relationship with the Battese & Coelli model and the random effects model, at 0.3047 and 0.3129 respectively. On the other hand, the Battese & Coelli model had a high correlation with the random effects model at 0.9977 and a low correlation with the true random effects model at 0.3055. That is to say, the Battese and Coelli model had common ground with the other models rather than the true random effects model, in terms of rank correlation. Therefore, the Battese & Coelli model served as the basic model for Pennsylvania school district analysis.

Table 5.5 is consistent with the fact that the Battese & Coelli model was basic for the stochastic frontier model of Pennsylvania school districts. The rank of 39, 158, 384, 261, 193, 492, and 381 school districts were above 400 in the Battese & Coelli model, random effects model, and heterogeneous random effects model. However, the rank of these school districts in the true random effects model was below 400.

Table 5.5 Efficient School Districts (E_{BC}) and Their Rank of Other Variant Models in Math Proficiency Rate

ID	E_{BC}	E_{TRE}	E_{POOL}	E_{PLRE}	$E_{PLREHT1}$	Rank E_{BC}	Rank E_{TRE}	Rank E_{POOL}	Rank E_{PLRE}	Rank $E_{PLREHT1}$
263	0.9824	0.9212	0.9542	0.9824	0.9822	492	492	491	492	492
39	0.9793	0.8181	0.9274	0.9786	0.9747	491	165	480	491	483
177	0.9780	0.9200	0.9599	0.9777	0.9779	490	491	492	490	487
419	0.9746	0.9170	0.9262	0.9747	0.9799	489	490	479	489	490
489	0.9737	0.9061	0.9406	0.9736	0.9752	488	481	490	488	484
158	0.9722	0.8570	0.9378	0.9720	0.9720	487	319	489	486	480
110	0.9718	0.8799	0.9074	0.9727	0.9781	486	425	456	487	488
455	0.9707	0.9091	0.9202	0.9708	0.9795	485	488	475	484	489
384	0.9702	0.8094	0.9036	0.9712	0.9690	484	142	446	485	476
10	0.9678	0.9068	0.9292	0.9680	0.9713	483	482	482	483	479
274	0.9670	0.8959	0.9143	0.9672	0.9769	482	471	467	482	485
261	0.9640	0.8574	0.9339	0.9624	0.9563	481	324	486	481	445
355	0.9635	0.8950	0.9337	0.9623	0.9806	480	468	485	480	491
193	0.9621	0.8637	0.9292	0.9613	0.9640	479	353	481	479	463
60	0.9598	0.9079	0.9103	0.9599	0.9676	478	486	460	478	473
492	0.9587	0.8573	0.9200	0.9588	0.9536	477	323	474	477	437
381	0.9583	0.7606	0.8616	0.9574	0.9545	476	51	382	476	441
347	0.9568	0.8820	0.9178	0.9566	0.9557	475	431	472	473	443
144	0.9565	0.9035	0.9212	0.9568	0.9645	474	478	476	474	465
454	0.9564	0.8770	0.9131	0.9570	0.9700	473	413	464	475	477
232	0.9563	0.8928	0.9160	0.9560	0.9641	472	465	471	472	464
235	0.9554	0.8876	0.9066	0.9559	0.9630	471	450	454	471	460
157	0.9550	0.9073	0.9110	0.9552	0.9661	470	485	461	469	468
197	0.9549	0.9041	0.9358	0.9543	0.9651	469	479	488	466	466
119	0.9549	0.8974	0.9126	0.9552	0.9713	468	472	463	468	478

5.3 Efficiency Variation & Exogenous Factors

5.3.1 Overview

The estimates of the six panel stochastic frontier models are presented in Table 5.9, with the t-values. The Limdep 9.0 program was used to estimate the six models. The random effects model and the Battese and Coelli model were also used for the heterogeneous models in order to explore the relationship between the efficiency measures and institutional and size factors. The heterogeneous factors were size-related factor (SIZE) and institutional factors (WEALTH, PRIVATE, and HERF) for the efficiency models.

5.3.2 Production Frontier and Estimation

This analysis was based on the translog education production frontier model, incorporating environmental and input quality differences factors. As a consequence, the INST, SUP, SALARY, SERVICE, NIEP, NECO, and 1/ADM variables could have a positive or negative impact on the math and reading proficiency rates of school districts. So, we can explore the impact of these factors on proficiency rates, estimating the education production frontier models of two proficiency rates: math and reading proficiency rates.

Table 5.6 Education Production Frontier and Estimation of Coefficients in Math Proficiency Rate

	POOL	t value	BC	t value	BC & Het.	t value	PLRE	t value	PLRE & Het.	t value	TRE	t value
Constant	0.2680	30.068*	0.2777	20.413*	0.2385	23.347*	0.2800	21.079*	0.2526	23.302*		
β 1 (INST)	-0.3946	-7.549*	-0.1994	-2.337*	-0.1397	-1.999*	-0.1940	-2.275*	-0.1330	-1.850	-0.3923	-13.514*
β 2 (SUP)	0.0788	5.130*	0.1606	2.501*	0.0298	0.552	0.1572	2.449*	0.0844	1.540	0.1576	8.325*
β 3 (SALARY)	0.4514	7.323*	0.3348	3.079*	0.2891	3.290*	0.3390	3.135*	0.2307	2.470*	0.3365	10.153*
β 4 (SERVICE)	-0.0394	-1.135	-0.1629	-2.708*	-0.1180	-2.627*	-0.1674	-2.769*	-0.1263	-2.595*	-0.1764	-9.456*
β 5 (NIEP)	0.6862	6.609*	0.8270	6.584*	0.8459	7.508*	0.8269	6.632*	0.8420	7.445*	0.9426	16.764*
β 6 (NECO)	0.7360	21.789*	0.4138	10.288*	0.3226	8.990*	0.4028	10.486*	0.3530	10.033*	0.4716	28.526*
β 7 (1/ADM)	0.0438	5.154*	0.0076	0.556	-0.0010	-0.092	0.0069	0.507	0.0224	1.840	0.0469	10.454*
β t (TIME)	0.0437	11.985*	0.0210	3.685*	0.0326	7.893*	0.0282	5.865*	0.0305	7.049*	0.0382	19.732*

(*): Statistical significance at the five percent level

In the case of math proficiency rate, the t-values show that the number of coefficients significant at the five percent level varied from 38 for the true random effects model (TRE), through 24 for the Pitt & Lee random effects model (PLRE), to 23 for the Battese & Coelli model (BC). Most importantly, the TIME coefficients appeared to be statistically significant in all model specifications, suggesting that the time-dependent variation over the period was not linear.

Table 5.7 Inputs and Predicted and Actual Sign in Math Proficiency Rate

	Predicted sign	POOL	BC	BC & Het.	PLRE	PLRE & Het.	TRE
Constant		(*)	(*)	(*)	(*)	(*)	
β 1 (INST)	+	- (*)	- (*)	- (*)	- (*)	-	- (*)
β 2 (SUP)	-	+ (*)	+(*)	+	+ (*)	+	+ (*)
β 3 (SALARY)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 4 (SERVICE)	+	-	- (*)	- (*)	- (*)	- (*)	- (*)
β 5 (NIEP)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 6 (NECO)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 7 (1/ADM)	+	+ (*)	+	-	+	+	+ (*)
β t (TIME)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)

(*): Statistical significance at the five percent level

To begin with, the INST and SUP inputs were traditional inputs of school district education production function. On the one hand, from a theoretical background, the INST factor had an expected positive impact on the math proficiency rate of school districts. But, the result was negative from all stochastic panel data models. On the other hand, the SUP variable was expected to have a negative impact on the school district proficiency rate. On the contrary, the result was positive from all stochastic panel data models.

Next, as expected, the NIEP and NECO factors had a positive impact on the education production frontier in the math proficiency rate. This fact is consistent with other studies that show the importance of students' socioeconomic variation on their performance, and therefore, increasing spending per student in school districts with a higher percentage students of these factors could result in school districts' poor performance. These results confirm Adkins and Moomaw's (1997) study and others.

Most interestingly, the environmental socio-economic backgrounds of students were statistically significant in terms of impact on the math proficiency rates of school districts. Moreover, the environmental factors of students had a larger impact on the school district education production than teacher-related factors, SALARY and SERVICE.

Third, teacher factors, SALARY and SERVICE, were expected to have a positive impact on the education production of school districts. However, this study shows a positive impact of SALARY and negative impact of SERVICE. The SALARY factor had a positive impact on the education production function statistically significant. This differs from other results which had a negative relationship with the education production (Rassauli-Currier, 2002). On the contrary, the SERVICE variable had a negative impact on the school district math proficiency rate. SERVICE represents average years of experience for classroom teachers. Therefore, the increase of classroom teacher experience was not automatically related to an increase in a school district's math proficiency rate. Consequently, this is consistent with the fact that the experiences of classroom teachers are not as important at the eleventh grade level, opposed to elementary school levels (Melvin & Sharma, 2007).

Last, 1/ADM factor had a positive impact on the education production except for the Battese & Coelli heterogeneous model (BC & Het.), which was expected to be positive based on theory. ADM represents student enrollment measured by average daily membership. This confirms the Pennsylvania education production regression model estimated by Kuang (2003).

5.3.3 Inefficiency and Institutional Factors

After the estimation of education production frontiers, next is the focus on the relationship between school district inefficiency measures and quantity adjustments and institutional variables. The SIZE, WEALTH, PRIVATE, and HERF factors were the examples under investigation. In other words, size-related factor and institutional factors were identified as the causes of school district inefficiency in this study. Recently, some researchers have connected institutional variables with educational inefficiency in addition to environmental variables. The estimation of the inefficiency equation model provides the monitoring effects of voters and citizens and the competition effects of private and public school settings on the school district inefficiency, using the Battese & Coelli (BC & Het.) and Pitt & Lee (PLRE & Het.) heterogeneous models.

Most importantly, school district size-related factor (SIZE) and institutional factors (AR, AR^2, HERF, and LagPRIV) were explained from the framework of the heterogeneous stochastic frontier models. The first heterogeneous model was the Battese & Coelli heterogeneous model. The heterogeneous model is expressed as: $g\ (z_{it}) = exp\ (\eta' z_{it})$. As a result, this model contained a school district-related size variable (SIZE), monitoring factor (WEALTH), and competition factors (LagPRI and HERF). In this model specification, the SIZE variable was scaled as 1/SIZE in order to express the input having a positive relationship with outputs. The second was the Pitt & Lee heterogeneous model.

Table 5.8 Inefficiency and Estimation of Coefficients in Math Proficiency Rate

	BC & Het.	t value	PLRE & Het.	t value	Predicted sign	Actual sign
Constant	-0.2161	0.000	-1.2191	0.000		
α1(1/SIZE)	-0.1572	-5.395(*)			+	-
α2 (AR)	1.7113	9.319 (*)	3.4495	10.847(*)	+	+
α3 (AR^2)	-0.4211	-0.960	0.8321	1.332	+	-/+
α4 (HERF)	-0.0170	-0.712	-0.1522	-3.095 (*)	+	-
α5 (LagPRIV)	0.0215	2.223 (*)	-0.0065	-0.095	-	+/-

(*): Statistical significance at the five percent level

First of all, the 1/SIZE factor had a negative association with the school district inefficiency with statistical significance at the five percent level in the Battese & Coelli heterogeneous model. SIZE inverse reduces the inefficiency of school districts. In other words, SIZE had a positive relationship with the school district inefficiency.

Next, in the case of a monitoring factor of voters and citizens, market value/personal income aid ratio (MV/PI AR) was an instrumental factor for school district wealth. In wealthier school districts, voters increase the pressure to monitor school district performance (Duncombe et al., 1997). For this reason, this shows a measure of the relative wealth of a school district using a real property and personal income per student, compared to all other districts (Pennsylvania School Boards Association, 2006). This result shows the WEALTH factor, MV/PI AR, increased school district inefficiency in math proficiency rate. Interestingly, as the school district became poorer, school district inefficiency increased. That is to say, the WEALTH factor had a positive impact on the school district inefficiency. As the school district MVPI AR increased, the school district efficiency decreased. This coefficient was statistically significant.

Squares of aid ratio could provide the interesting policy implications from the framework of education policy tools. The Battese & Coelli heterogeneous model represented that there was a U-shaped relationship between school district performance and school district wealth due to the negative squares of aid ratio. In other words, the negative sign provided the saturation of school district wealth in terms of efficiency. As a consequence, we can say that, following the Kuznets curves, the U-shaped symbol could be called the educational Kuznets curve under the correlation between wealth inequalities and efficiency in education. After the lowest point of school district efficiency, wealthier school districts could draw the energy to drive school district inefficiency into efficiency as illustrated in Figure 5.2. This is similar to the original Kuznets paradox theory (1995).

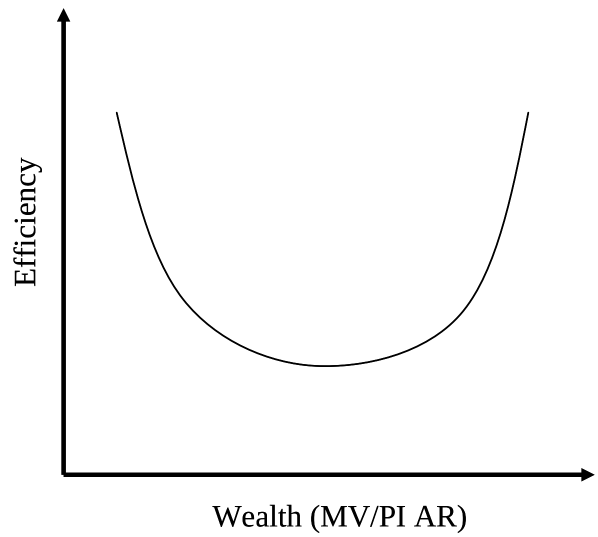


Figure 5.2 Efficiency and Aid Ratio in Math Proficiency Rate

Therefore, so-called educational Kuznets curve of this study could give the foundation for wealth redistribution among school districts and activation of grassroots movement in educational activities through the relationship between the efficiency and wealth of school districts. Following original Kuznets curve, there could be a possible explanation for this phenomenon. After reach at the basic standard of wealth, citizens and voters of school district want to participate in the monitoring activities of school district performance. In this process, the school district wealth is closely related to monitoring activities. This represents the recognition of social interest as a form of grassroots movement in the arena of education. However, minimum aid ratio, 2.03, was unrealistic.

Third, in terms of the competition from private schools, the lagged value of private school enrollments (LagPRIV) was used for private competition factors rather than the current value. As parents become dissatisfied with public school performance, they will move their children to private schools to obtain a better education. Therefore, the lagged value of private school, the PRIVATE factor, increases the school district efficiency. Also, the Herfindahl index (HERF) was chosen for public school district competition. That is to say, this is the public school concentration index in a county. Most districts could reduce inefficiency if public school concentration (the Herfindahl index) was lower. In other words, as the market concentration of school districts grows, technical inefficiency increases. As the public school district concentration increases, the school district has a total power on educational market and so tends to be inefficient.

Overall, competition variables had an opposite result, which was expected from a theoretical background, as seen in Table 5.8. From the framework of the Battese & Coelli heterogeneous model, the HERF factor had a negative relationship with the school district inefficiency. That is to say, the competition among public school districts increased the school district inefficiency, which was not expected from a theoretical background. As a school district dominates the county's education system, school district inefficiency will be reduced. The HERF represents the public school district concentration. This was statistically significant at the five percent level in the Pitt & Lee random effects model.

On the other hand, LagPRIV showed a mixed impact on school district inefficiency. This factor was statistically significant at the five percent level in the case of the Battese & Coelli heterogeneous model. Kang & Greene's work (2002) produced the same result that more competition from private schools would have a negative impact on efficiency.

As a result, monitoring school districts had a tendency to increase technical efficiency, but, increased competition was not a panacea (Grosskopf et al., 2001). This study shows a policy mix of policy tools was not appropriate for public school education,

Table 5.9 Estimated Parameters of the Stochastic Frontier Models and Inefficiency in Math Proficiency Rate

	POOL	t value	BC	t value	BC & HET.	t value	PLRE	t value	PLRE & HET.	t value	TRE	t value
Constant	0.2680	30.068*	0.2777	20.413*	0.2385	23.347*	0.2800	21.079*	0.2526	23.302*		
β 1 (INST)	-0.3946	-7.549*	-0.1994	-2.337*	-0.1397	-1.999*	-0.1940	-2.275*	-0.1330	-1.850	-0.3923	-13.514*
β 2 (SUP)	0.0788	5.130*	0.1606	2.501*	0.0298	0.552	0.1572	2.449*	0.0844	1.540	0.1576	8.325*
β 3 (SALARY)	0.4514	7.323*	0.3348	3.079*	0.2891	3.290*	0.3390	3.135*	0.2307	2.470*	0.3365	10.153*
β 4 (SERVICE)	-0.0394	-1.135	-0.1629	-2.708*	-0.1180	-2.627*	-0.1674	-2.769*	-0.1263	-2.595*	-0.1764	-9.456*
β 5 (NIEP)	0.6862	6.609*	0.8270	6.584*	0.8459	7.508*	0.8269	6.632*	0.8420	7.445*	0.9426	16.764*
β 6 (NECO)	0.7360	21.789*	0.4138	10.288*	0.3226	8.990*	0.4028	10.486*	0.3530	10.033*	0.4716	28.526*
β 7 (1/ADM)	0.0438	5.154*	0.0076	0.556	-0.0010	-0.092	0.0069	0.507	0.0224	1.840	0.0469	10.454*
β 12(X1X2)	1.3801	3.061*	0.0782	0.126	-0.0424	-0.083	0.0675	0.109	0.1602	0.310	0.5478	2.361*
β 13 (X1X3)	3.2061	4.670*	2.5375	2.562*	0.9400	1.000	2.6601	2.761*	1.3516	1.401	1.8329	5.488*
β 14 (X1X4)	-0.9390	-2.306*	-1.0733	-1.996*	-0.5676	-1.214	-1.0953	-2.035*	-0.6859	-1.421	-1.3487	-6.381*
β 15 (X1X5)	2.7777	2.638*	0.6448	0.648	-0.3794	-0.383	0.4129	0.412	-0.1338	-0.140	3.3329	6.395*
β 16 (X1X6)	-0.4236	-2.268*	-0.6234	-2.745*	-0.5273	-2.207*	-0.5749	-2.434*	-0.5423	-2.238*	-0.5141	-4.972*
β 17 (X1X7)	0.3075	3.247*	0.2845	2.315*	0.0846	0.725	0.2957	2.496*	0.2313	1.969*	0.4548	10.225*
β 23 (X2X3)	-1.9504	-4.493*	-1.7607	-2.486*	-1.5981	-2.864*	-1.7158	-2.443*	-1.9208	-3.280*	-0.6514	-3.005*
β 24 (X2X4)	0.9257	3.440*	0.4397	1.110	0.8141	2.558*	0.4540	1.184	0.7719	2.368*	0.5592	4.163*
β 25 (X2X5)	-2.0647	-2.912*	-1.2632	-1.828	-0.8215	-1.249	-1.1563	-1.691	-0.9759	-1.486	-1.3449	-4.087*
β 26 (X2X6)	0.8858	5.938*	0.6263	3.131*	0.6204	3.144*	0.6029	2.960*	0.6549	3.419*	0.7304	11.349*
β 27 (X2X7)	-0.3307	-5.096*	-0.1962	-1.857	-0.2150	-2.442*	-0.1835	-1.763	-0.2490	-2.916*	-0.1115	-3.315*
β 34 (X3X4)	-0.8813	-1.950	-0.2610	-0.397	-0.4096	-0.724	-0.2593	-0.394	-0.4638	-0.804	-0.5513	-2.425*
β 35 (X3X5)	-1.3609	-1.143	-2.2946	-1.806	-2.0675	-1.732	-2.1649	-1.702	-2.0358	-1.747	-4.0643	-6.812*
β 36 (X3X6)	3.5271	12.363*	3.0544	10.406*	3.0817	10.401*	3.0790	10.465*	3.1217	10.339*	3.0319	21.473*
β 37 (X3X7)	0.1578	1.489	-0.2162	-1.291	0.0654	0.502	-0.2473	-1.517	-0.1135	-0.870	-0.1846	-3.717*
β 45 (X4X5)	-0.0526	-0.076	1.6868	2.612*	1.6609	2.590*	1.6057	2.507*	1.5668	2.439*	1.8844	5.798*
β 46 (X4X6)	-0.9219	-5.952*	-0.8967	-5.384*	-0.6535	-3.923*	-0.9139	-5.700*	-0.7306	-4.411*	-0.9917	-13.906*
β 47 (X4X7)	-0.2166	-3.662*	-1.0060	-1.183	-0.1621	-2.402*	-0.1043	-1.225	-0.1802	-2.496*	0.0002	0.007
β 56 (X5X6)	1.3746	4.216*	0.7857	2.408*	0.7362	2.381*	0.8090	2.508*	0.7707	2.547*	1.5888	11.297*
β 57 (X5X7)	-0.1151	-0.673	0.0129	0.070	-0.0002	-0.001	0.0361	0.197	0.0786	0.438	-0.1526	-1.849
β 67 (X6X7)	-0.0641	-2.559*	0.1605	4.172*	0.2058	4.945*	0.0757	4.535*	0.1707	4.221*	0.0438	3.326*
β 11 ($X1^2$)	-3.9579	-4.954*	-0.5666	-0.532	0.1253	0.124	-0.6036	-0.564	-0.2279	-0.211	-2.1630	-5.462*
β 22 ($X2^2$)	-0.2973	-0.830	0.0695	0.121	0.2431	0.648	0.0644	0.115	0.3276	0.796	-0.2895	-1.518
β 33 ($X3^2$)	-3.5868	-3.666*	-3.0719	-1.986*	-2.1998	-1.761	-3.4144	-2.278*	-2.2093	-2.119*	-0.8185	-1.733
β 44 ($X4^2$)	0.0359	0.354	0.1450	0.585	0.1701	0.714	0.1620	0.630	0.1524	0.661	0.1569	2.074*
β 55 ($X5^2$)	-4.6453	-2.087*	-2.5697	-1.642	-1.9757	-1.286	-2.4248	-1.557	-2.0419	-1.349	-1.4532	-1.604
β 66 ($X6^2$)	0.1681	7.141*	0.0527	2.514*	-0.0144	0.686	0.0502	2.441*	0.0244	1.160	0.0805	8.125*
β 77 ($X7^2$)	0.0573	2.894*	0.0334	-1.011	0.0289	1.123	-0.0335	-1.027	0.0087	0.316	-0.0813	-7.922*
βt (TIME)	0.0437	11.985*	0.0210	3.685*	0.0326	7.893*	0.0282	5.865*	0.0305	7.049*	0.0382	19.732*
βtt ($TIME^2$)	-0.0157	-2.857*	-0.0097	-1.656	-0.0123	-2.242*	-0.0112	-2.041*	-0.0109	-2.010*	-0.0074	-2.256*
βt1 (TX^1)	0.1494	3.596*	0.0029	0.058	-0.0038	-0.090	0.139	0.288	0.0075	0.164	0.1038	4.626*
βt2 (TX2)	-0.0270	-1.009	0.0220	0.708	0.0228	0.866	0.0194	0.625	0.0147	0.554	-0.0171	-1.211
βt3 (TX3)	-0.0619	-1.346	0.0029	0.057	0.0739	1.662	-0.0040	-0.080	0.0693	1.550	-0.0834	-3.725*
βt4 (TX4)	0.0146	0.530	0.0436	1.299	-0.0114	-0.452	0.0412	1.233	0.0101	0.384	0.0546	3.758*
βt5 (TX5)	0.2197	2.869*	0.1771	2.681*	0.2114	3.358*	0.1820	2.790*	0.2038	3.212*	0.1375	3.690*
βt6 (TX6)	-0.1777	-10.004*	-0.1167	-7.698*	-0.1306	-8.553*	-0.1283	-8.616*	-0.1304	-8.831*	-0.1430	-15.835*
βt7 (TX7)	-0.0112	-1.800	-0.0001	-0.019	0.0068	1.224	-0.0007	-0.104	0.0033	0.565	-0.0171	-5.771*
Sigma (u)	0.3311		0.3337	221.817	0.3106	0.000	0.3551	31.490	0.4621	0.000	0.2672	
Sigma (v)	0.1091		0.1485		0.1503		0.1485	0.1491	0.1491		0.0331	
Lamda	3.0352	20.750	2.2476	153.258	2.0665	0.000	2.3916	17.391	3.0992	0.000	8.0766	11.473
Eta			0.0279	2.732								
Constant					-0.2161	0.000			-1.2191	0.000		
α1(1/SIZE)					-0.1572	-5.395*						
α2 (AR)					1.7113	9.319*			3.4495	10.847*		
α3 (AR^2)					-0.4211	-0.960			0.8321	1.332		
α4 (HERF)					-0.0170	-0.712			-0.1522	-3.095*		
α5 (LagPRIV)					0.0215	2.223*			-0.0065	-0.095		
Log Likelihood	267.827		652.69		746.6738		649.991		731.542		675.177	
	0		62				5		0		9	

because the manipulation of the number of private schools automatically does not result in a good-quality public school education.

In summary, Table 5.9 shows the estimated parameters of the stochastic frontier models and inefficiency in the case of math proficiency rate.

5.3.4. Efficiency and Socio-Economic Factors

The efficiency measures of 492 school districts were descriptively analyzed according to geographic locations (nine types), locale types (the urban-centric locale code system, 12 codes), and AYP (Adequate Yearly Progress) of school districts under the Pennsylvania accountability system. According to Kuang (2003), two dimensions of geographic area are used to divide and sort Pennsylvania school districts. The first is the geographical region in which school districts are located. The second is the locale type.

5.3.4.1. Location Type

There is a variation in instructional expenditures per ADM, support service costs per ADM, and non-instructional services cost per ADM among Pennsylvania's nine areas. For this reason, policy makers would choose a locale type as one of the policy tools for improved public education in Pennsylvania.

Table 5.10 Location Types and School District Efficiency Measures

MathPRO	E_{BC}	E_{POOL}	E_{PLRE}	E_{TRE}
Northwest region	0.769	0.790	0.768	0.843
North-central region	0.756	0.768	0.755	0.822
Southwest region	0.771	0.792	0.770	0.826
South Allegheny	0.818	0.821	0.817	0.840
Central region	0.795	0.806	0.794	0.806
South-central region	0.785	0.796	0.784	0.840
Southeast region	0.725	0.741	0.723	0.806
Northeast region	0.734	0.756	0.733	0.812
Northern Tier	0.822	0.830	0.821	0.847

The efficiency level of the Northern Tier in math proficiency rate was the highest among the nine areas of Pennsylvania in the case of all various panel stochastic frontier models. The Southeast area had the lowest efficiency scores among these areas in math proficiency. The Northern Tier area includes Bradford, Sullivan, Susquehanna, Tioga, and Wyoming counties. On the other hand, the Southeast region includes Berks, Bucks, Chester, Delaware, Lancaster, Montgomery, and Philadelphia counties. Interestingly, Montgomery SD was one of the efficient school districts. But, this was included in Montgomery County. In the case of math proficiency rate, the highest efficiency index was the Northern Tier of the true random effects model at 84.7 percent. The Southeast region was the lowest of the Pitt & Lee heterogeneous random effects model at 72.3 percent.

5.3.4.2. Locale Type

In the case of math proficiency rate, *remote town* had the highest efficiency values in the Battese & Coelli model (E_{BC}, 81.8), pooled data model (E_{POOL}, 81.1), Pitt & Lee random effects model (E_{PLRE}, 81.7), and Greene true random effects model (E_{TRE}, 84.7).

Table 5.11 Locale Types and School District Efficiency Measures

MathPRO	E_{BC}	E_{POOL}	E_{PLRE}	E_{TRE}
Midsize city	0.773	0.793	0.772	0.833
Small city	0.773	0.783	0.772	0.828
Large suburb	0.736	0.758	0.734	0.804
Midsize suburb	0.643	0.798	0.630	0.827
Small suburb	0.657	0.796	0.649	0.811
Fringe town	0.802	0.790	0.800	0.846
Distant town	0.762	0.776	0.761	0.811
Remote town	0.818	0.811	0.817	0.847
Fringe rural	0.797	0.804	0.796	0.835
Distant rural	0.800	0.808	0.799	0.847
Remote rural	0.801	0.795	0.800	0.835

Distant rural also had the highest efficiency in the Greene true random effects model. *Midsize suburb* and *large suburb* had the lowest efficiency values at 64.3, 63.0, 75.8, and 80.4, respectively.

5.3.4.3. AYP Status

As a result of PSSA and meeting AYP (Adequate Yearly Progress), the state government assigns each school district and school one of the following designations: *Met AYP*, *making progress*, *warning*, *school improvement I*, *school improvement II*, *correction I*, and *correction II*, under the spirit of the accountability system of the NCLB Act.

The AYP status of school districts was issued by the Pennsylvania Department of Education from the 2002-03 school year. Therefore, we could not analyze the 2001-02 school district efficiency. As a result, the efficiency measures of school districts in the 2001-02 school year were dropped from the data set.

Table 5.12 AYP Status and School District Efficiency Measures in Math Proficiency Rate

	E_{BC}	E_{POOL}	E_{PLRE}	E_{TRE}
Met AYP (001)	0.805	0.804	0.799	0.838
Making progress (002)	0.766	0.787	0.769	0.832
Warning (003)	0.735	0.752	0.733	0.802
School improvement I (004)	0.747	0.783	0.739	0.838
School improvement II (005)	0.604	0.755	0.590	0.825
Correction I (006)	0.602	0.697	0.584	0.729
Correction II (007)	0.239	0.627	0.241	0.620

Logically, the efficiency measures of school districts *Meet AYP* were the highest among the AYP status in math proficiency rate. Also, *Correction II* status was the lowest. However, this analysis captures the tough picture of the accountability system. For a detailed analysis, we have to see the correlation between the efficiency change of school districts and decision factors of school district efficiency change in Research Question #4.

5.4 Efficient School Districts

Detailed descriptions of efficient school districts provide the state government and school districts with a benchmarking tool for the school district education production frontier and inefficiency. An efficient school district framework drawn from these descriptions plays a major role in meeting the best frontier for inefficient school districts. In general, most school finance research was able to identify successful school districts, high-performing school districts in terms of academic performance and low spending school districts in the arena of fiscal expenditures. As a consequence, the efficiency measurement framework can carry out the task of this study, although most studies have different perspectives on the definition of school district success. This study defined school district success as having a high level of efficiency and productivity. Productivity change was discussed in the next chapter in Research Question #5.

5.4.1 Major Pennsylvania Study

Before recognizing the standard type of Pennsylvania efficient school districts, the first step focuses on the high performing school districts of major studies in Pennsylvania. To begin with, a costing out study (APA, 2007) identified successful school districts that not only outperform others in the state academically, but also those that do so without spending significantly higher resources than their other successful peers. As a result, this study identified high performing school districts of the costing study and compares these school districts with the most efficient school districts. Although the focus of the costing out study is on equitable and adequate funding for education, these successful school districts were simply recognized in both absolute and relative standards, as seen in Table 5.13.

Table 5.13 Successful School Districts in Pennsylvania Costing Out Study

Absolute Standard			
Abington Heights	Freeport Area	Moon Area	Shanksville-Stonycreek
Abington	Gamet Valley	Mt. Lebanon	Southern Area
Avonworth	Great Valley	New Hope-Solebury	South Fayette Twp
Beaver Area	Greensburg Salem	North Hills	Southern Lehigh
Bethel Park	Hatboro-Horsham	Norwin	State College Area
Camp Hills	Haverford Township	Palisades	Tredyffrin-Easttown
Central Bucks	Hempfield Area	Parkland	Upper Dublin
Colonial	Jenkintown	Penn-Trafford	Wallingford-Swarthmr
Council Rock	Kiski Area	Perkiomen Valley	West Chester Area
Cumberland Valley	Lampeter-Strasburg	Peters Township	West Jefferson
Dallas	Lower Merion	Pine-Richard	Willahickon
Derry Township	Lower Moreland Township	Quaker Valley	Wyoming Area
Downingtown Area	Manheim Township	Radnor Township	York Suburban
Fairview	Marple Newtown	Richland	
Fox Chapel Area	Methacton	Rose Tree Media	
Franklin Regional	Midland Borough	Sallisbury Township	
A Growth Standard			
Avon Grove	Homer-Center	Port Allegheny	Susquehanna Comm
Bellwood-Antis	Jeannette City	Scranton	Tri-Valley
Cornwall-Lebanon	Old Forge	South Williamsport A	Wayne Highlands
General McLane	Oswayo Valley	Southern Fulton	
	Both Standards		
	Greater Latrobe	North Allegeheny	
	Hampton Township	Unionville-Chadds Fd	
	Lewisburg Area	Upper Saint Clair	

Source: Augenblick, Palaich, and Associates, Inc. (2007) from Costing Out the Resources Needed to Meet Pennsylvania' Public Education Goals.

Adequate funding of school districts was identified through three major approaches of adequacy study; a successful school district, a professional judgment, and an evidence based approach. As a result, the needs of school districts were calculated as the weighted students over unweighted students in this study. According to the Pennsylvania Costing

Out Study of APA, Table 5.14 shows the needs of Pennsylvania school districts over a five-year period. This represents the needs of school districts. For this reason, this study compared the most efficient school districts with high needs school districts. That is why just allocating adequate money to school districts is not meaningful without efficiency analysis and the relationship between the needs and efficiency measures provides justification for adequate education budget. Accordingly, the relationship between school district needs and efficiency measure is the focal point of this analysis.

Table 5.14 Needs of School Districts and Efficiency Measures in Math

Number of districts	Needs	E_{BC}
2	1.192	0.859
33	1.183	0.785
75	1.175	0.780
98	1.164	0.759
107	1.154	0.784
120	1.145	0.778
47	1.136	0.787
3	1.126	0.887
5	1.111	0.657
2	1.090	0.513

Using the formula of weighted students over unweighted students, the mean of school districts needs was 1.157. Regarding the comparison with school district needs, the Battese and Coelli efficiency measures were used. There was no clear relationship between school district needs and efficiency measures. However, we can draw one critical implication in the classification of needs into 10 types. As the school district needs did grow, school district efficiency became better, generally.

Furthermore, the costing out study calculated the comparison of the adequacy level of school districts with the actual spending level. The discrepancy represents how much adequate funding school districts demand for meeting their high standards under the actual spending level per ADM. Comparison was the distance between adequacy per pupil level and actual spending per pupil level. In this context, the association between comparison and efficiency measures was also explained from the adequacy framework of school finance.

The Lower Merion school district was the highest in comparison and efficiency index. For this reason, we can justify that the state government has to allocate the adequate funding, $4,972, to the Lower Merion School District for better quality education. That is why this school district manages their education inputs for better proficiency rate under the influence of exogenous factors under the NCLB accountability system. This school district had the rationality for its adequate funding.

Table 5.15 Comparison of Adequacy and Actual Spending Per Pupil with Efficiency Measures in Math Proficiency Rate

N	School District	Comparison	Math	Rank
1	Lower Merion (233)	$4972	0.9199	432
2	Jenkintown (203)	$2792	0.8503	329
3	Bryn Athyn (N)	$2712		
4	Pittsburgh (N)	$2330		
5	Radner Twp (355)	$2048	0.9635	480
6	Upper Merion Area (452)	$1933	0.7301	156
7	New Hope-Solebury (282)	$1904	0.8474	324
8	Cheltenham Twp (81)	$1675	0.7231	147
9	Quaker Valley (353)	$1586	0.8962	404
10	Fox Chapel Area (155)	$1171	0.8891	391
11	Tredyffrin-Easttown (431)	$1082	0.9370	448
12	Neshaminy (278)	$1062	0.6083	53
13	Colonial (92)	$985	0.6603	85
14	Springfield Twp (417)	$979	0.8174	283
15	North Allegheny (286)	$773	0.9456	456
16	Phoenixville Area Twp (338)	$622	0.8223	285
17	Mt Lebanon (274)	$556	0.9670	482
18	Rose Tree Media (369)	$442	0.8027	263
19	Wissahickon (493)	$367	0.8526	334
20	Indiana Area (197)	$269	0.9549	469
21	Sullivan County (424)	$259	0.9133	425
22	Allegheny Valley (5)	$217	0.8721	369
23	State College Area (419)	$165	0.9746	489
24	Marple Newtown (240)	$131	0.7868	238
25	Saucon Valley (374)	$119	0.8033	265

* Comparison: Adequacy and actual spending per pupil

However, the Cheltenham Township School District could ask for $1,675 as adequate funding. Its efficiency index was 72.31 percent of the math proficiency rate. In this context, this efficiency study says that giving the adequate funding for Cheltenham Township was not meaningful and productive, because this school district tried to increase the efficiency measure at first. The marginal effect of adequate funding in this school district was minimal with the simultaneous analysis of the adequacy and efficiency study. What is worse, the Neshaminy School District and Colonial School District had backgrounds similar to Cheltenham Township School District.

As a consequence, it is reasonable that the state government require school districts to make a plan of action in order to obtain adequate funding for productive efficiency and adequacy. For this reason some researchers have argued that school funding has to be explained under three frameworks; equity, adequacy, and efficiency.

5.4.2. Efficient School Districts

For efficient school districts in Pennsylvania, we obtained the efficiency measures of 492 school districts from various models of the stochastic frontier such as the pooled model, the Battese & Coelli model, the Pitt & Lee random effects model, and the true random effects model. After ranking school district efficiency, each model gave the highest efficient school districts in terms of five percent of all school districts. Among these school districts, 32 school districts were chosen as efficient school districts for benchmarking because 14 school districts were efficient only in one model as seen in Table 5.16.

Table 5.16 Efficient School Districts and Various Models in Math Proficiency Rate

	E_{POOL}	E_{BC}	E_{PLRE}	$E_{PLREHT1}$	E_{TRE}
1	177 (GROVE CITY AREA SD)	263 (MONTGOMERY AREA SD)	263 (MONTGOMERY AREA SD)	263 (MONTGOMERY AREA SD)	263 (MONTGOMERY AREA SD)
2	263 (MONTGOMERY AREA SD)	39 (BLACKLICK VALLEY SD)	39 (BLACKLICK VALLEY SD)	355 (RADNOR TOWNSHIP SD)	177 (GROVE CITY AREA SD)
3	489 (WILMINGTON AREA SD)	177 (GROVE CITY AREA SD)	177 (GROVE CITY AREA SD)	419 (STATE COLLEGE AREA SD)	419 (STATE COLLEGE AREA SD)
4	158 (FRAZIER SD)	419 (STATE COLLEGE AREA SD)	419 (STATE COLLEGE AREA SD)	455 (UPPER SAINT CLAIR SD)	238 (MANHEIM TOWNSHIP SD)
5	197 (INDIANA AREA SD)	489 (WILMINGTON AREA SD)	489 (WILMINGTON AREA SD)	110 (CUMBERLAND VALLEY SD)	455 (UPPER SAINT CLAIR SD)
6	174 (GREENSBURG SALEM SD)	158 (FRAZIER SD)	110 (CUMBERLAND VALLEY SD)	177 (GROVE CITY AREA SD)	471 (WEST CHESTER AREA SD)
7	261 (MONESSEN CITY SD)	110 (CUMBERLAND VALLEY SD)	158 (FRAZIER SD)	431 (TREDYFFRIN-EASTTOWN SD)	60 (CAMP HILL SD)
8	355 (RADNOR TOWNSHIP SD)	455 (UPPER SAINT CLAIR SD)	384 (SHANKSVILLE-STONYCREEK)	274 (MT LEBANON SD)	157 (FRANKLIN REGIONAL SD)
9	366 (RIVERVIEW SD)	384 (SHANKSVILLE-STONYCREEK)	455 (UPPER SAINT CLAIR SD)	489 (WILMINGTON AREA SD)	286 (NORTH ALLEGHENY SD)
10	458 (WALLENPAUPACK AREA SD)	10 (ANNVILLE-CLEONA SD)	10 (ANNVILLE-CLEONA SD)	39 (BLACKLICK VALLEY SD)	180 (HAMPTON TOWNSHIP SD)
11	10 (ANNVILLE-CLEONA SD)	274 (MT LEBANON SD)	274 (MT LEBANON SD)	233 (LOWER MERION SD)	10 (ANNVILLE-CLEONA SD)
12	193 (HOLLIDAYSBURG AREA SD)	261 (MONESSEN CITY SD)	261 (MONESSEN CITY SD)	234 (LOWER MORELAND TOWNSHIP)	489 (WILMINGTON AREA SD)
13	39 (BLACKLICK VALLEY SD)	355 (RADNOR TOWNSHIP SD)	355 (RADNOR TOWNSHIP SD)	158 (FRAZIER SD)	233 (LOWER MERION SD)
14	419 (STATE COLLEGE AREA SD)	193 (HOLLIDAYSBURG AREA SD)	193 (HOLLIDAYSBURG AREA SD)	10 (ANNVILLE-CLEONA SD)	197 (INDIANA AREA SD)
15	171 (GREATER LATROBE SD)	60 (CAMP HILL SD)	60 (CAMP HILL SD)	119 (DERRY TOWNSHIP SD)	144 (FAIRVIEW SD)
16	483 (WILKES-BARRE AREA SD)	492 (WINDBER AREA SD)	492 (WINDBER AREA SD)	454 (UPPER PERKIOMEN SD)	335 (PETERS TOWNSHIP SD)
17	144 (FAIRVIEW SD)	381 (SHADE-CENTRAL CITY SD)	381 (SHADE-CENTRAL CITY SD)	384 (SHANKSVILLE-STONYCREEK)	431 (TREDYFFRIN-EASTTOWN SD)
18	455 (UPPER SAINT CLAIR SD)	347 (PORTAGE AREA SD)	454 (UPPER PERKIOMEN SD)	340 (PINE-RICHLAND SD)	122 (DOWNINGTOWN AREA SD)
19	492 (WINDBER AREA SD)	144 (FAIRVIEW SD)	144 (FAIRVIEW SD)	286 (NORTH ALLEGHENY SD)	70 (CENTRAL BUCKS SD)
20	164 (GENERAL MCLANE SD)	454 (UPPER PERKIOMEN SD)	347 (PORTAGE AREA SD)	60 (CAMP HILL SD)	174 (GREENSBURG SALEM SD)
21	347 (PORTAGE AREA SD)	232 (LOWER DAUPHIN SD)	232 (LOWER DAUPHIN SD)	238 (MANHEIM TOWNSHIP SD)	119 (DERRY TOWNSHIP SD)
22	232 (LOWER DAUPHIN SD)	235 (LOYALSOCK TOWNSHIP SD)	235 (LOYALSOCK TOWNSHIP SD)	446 (UNIONVILLE-CHADDS FORD)	274 (MT LEBANON SD)
23	40 (BLAIRSVILLE-SALTSBURG S)	157 (FRANKLIN REGIONAL SD)	180 (HAMPTON TOWNSHIP SD)	471 (WEST CHESTER AREA SD)	483 (WILKES-BARRE AREA SD)
24	115 (DANVILLE AREA SD)	197 (INDIANA AREA SD)	157 (FRANKLIN REGIONAL SD)	180 (HAMPTON TOWNSHIP SD)	33 (BETHEL PARK SD)
25	441 (TYRONE AREA SD)	119 (DERRY TOWNSHIP SD)	119 (DERRY TOWNSHIP SD)	157 (FRANKLIN REGIONAL SD)	355 (RADNOR TOWNSHIP SD)

As a consequence, the common characteristics of efficient school districts in math proficiency rate are summarized in Table 5.17.

The efficient school districts of this study presented more diversity in differences rather than evident similarities under the stochastic frontier analysis. This is similar to Standard & Poor's (2007) study of Kansas school districts using the data envelopment analysis. As a result, this result gives the foundation counter to the common perspective that efficient school districts have to spend less or perform better (or both) than other school districts (Standard & Poor's, 2007). Consequently, it is very difficult to find common ground among efficient school districts.

First of all, in terms of size-related factors, ranking of the efficient school districts ranged from 484 (12,136) to 6 (479) in ADM (student enrollment measured by average daily membership). Also, rank of SIZE (population per square mile) ranged from 33 (44.1) to 480 (5,457). Efficient school districts showed diversity of ADM and SIZE.

Second, the math proficiency rate of efficient school districts was above 60 percent. But, the lowest ranking of efficient school districts was 283 (53.4 percent). INST and SUP of efficient school districts had different expenditure levels. The highest INST ($9,200) of efficient school districts was about two times the lowest INST ($4,982) of efficient school districts. The ranking range of SUP in efficient school districts was lower than that of INST in efficient school districts.

Third, in the case of NIEP and NECO, the ranking of efficient school districts also showed their diversity. However, their ranking of NIEP and NECO was smaller than INST, SUP, and SALARY.

Table 5.17 Efficient School Districts and Ranking of Key Indicators in Math Proficiency Rate

	E_{BC}	E_{TRE}	Math PRO	INST	SUP	SALARY	NIEP	NECO	ADM	SIZE	MV/PI AR	STATE SHARE	SALARY SHARE	EQMILLS	LOCAT	LOCALE
10	483	482	447	83	103	141	113	402	159	251	151	223	196	110	6	41
39	491	165	326	405	350	145	4	38	18	186	463	492	261	106	4	31
60	478	486	467	328	352	296	236	477	73	454	29	32	463	309	6	21
110	486	425	473	68	202	191	269	458	466	300	47	94	164	94	6	41
119	468	472	484	245	386	264	465	461	349	352	32	16	74	220	6	21
144	474	478	468	131	378	341	420	351	149	272	48	125	350	237	1	41
157	470	485	478	103	157	384	427	463	368	328	83	117	280	283	3	21
174	465	473	441	122	102	339	450	165	350	316	219	207	53	210	3	21
177	490	491	445	379	123	243	51	210	248	199	248	249	355	44	1	32
180	466	483	448	313	201	448	479	475	318	385	105	91	344	423	3	21
193	479	353	387	261	179	153	101	180	367	214	153	246	349	69	4	23
197	469	479	437	448	317	433	419	231	323	281	150	165	474	359	3	32
232	472	465	432	255	168	228	216	396	381	221	168	184	190	306	6	21
233	432	480	485	492	492	490	50	445	449	437	12	2	472	23	7	21
235	471	450	469	254	357	403	430	328	123	315	91	90	232	298	5	23
238	462	489	470	115	288	321	276	424	427	394	41	36	385	239	7	21
261	481	324	400	240	294	44	233	21	71	441	426	361	116	393	3	23
263	492	492	474	287	282	213	11	215	52	113	367	399	445	194	5	31
274	482	471	490	365	419	436	281	467	430	480	52	35	450	418	3	21
286	456	484	487	427	406	478	480	480	468	379	37	47	478	396	3	21
347	475	431	376	241	235	166	184	51	58	242	465	478	158	159	4	31
355	480	468	489	490	490	483	28	465	334	427	11	5	451	85	7	21
381	476	51	283	211	369	257	178	23	12	76	455	409	24	198	4	42
384	484	142	381	168	265	14	43	415	6	33	145	189	52	70	4	42
419	489	490	479	384	416	329	244	365	462	318	30	42	470	151	5	13
431	448	476	491	465	479	462	243	487	437	395	5	8	340	29	7	21
454	473	413	486	390	232	481	485	348	341	279	170	188	318	312	7	21
455	485	488	492	412	423	464	356	488	390	421	45	29	377	431	3	21
471	437	487	461	442	437	456	235	446	484	392	6	31	159	50	7	21
483	464	470	426	396	261	428	223	235	458	322	221	192	440	428	8	13
489	488	481	451	87	86	96	133	262	153	139	290	303	58	66	8	31
492	477	323	424	177	19	297	373	97	132	179	447	490	192	4	4	23

Fourth, MV/PI AR, StateShare, SalaryShare, and EqMills of efficient school districts also had different sizes. Most interestingly, the state share of revenue in the school district ranged from the lowest level (2, 9.5 percent) to the highest level (492, 73.9 percent).

Last, efficient school districts came from various location areas. As seen in Table 5.18, the North-central region and Northern Tier had no efficient school districts. The Southwest area had eight efficient school districts. In terms of locale, *large suburban* had 15 efficient school districts. *Midsize city*, *midsize suburb*, *remote town*, and *remote rural* had no efficient school districts, as seen in Table 5.19.

Table 5.18 Location Types and Efficient School Districts

Type	Code	Number of efficient districts
Northwest region	1	2
North-central region	2	0
Southwest region	3	8
South Allegheny	4	6
Central region	5	3
South-central region	6	5
Southeast region	7	6
Northeast region	8	2
Northern Tier	9	0

Table 5.19 Locale Types and Efficient School Districts

Type	Code	Number of efficient districts
Large city	11	0
Midsize city	12	0
Small city	13	2
Large suburb	21	15
Midsize suburb	22	0
Small suburb	23	4
Fringe town	31	4
Distant town	32	2
Remote town	33	0
Fringe rural	41	3
Distant rural	42	2
Remote rural	43	0

This study did not draw the standard type of efficient school districts. As a consequence, according to Rolle (2005)'s recommendation in the stochastic frontier analysis, given the level of efficient school districts of educational outcomes in public school districts, the logical step is to examine the curricular and policy practices of the school district categories as relatively efficient and then compare them to the curricular and policy practices of the relatively inefficient school districts. At the same time that these educational policies and practices are being examined, state-level policies and policy goals need to be reviewed to determine if the mandated educational goals are being obtained by the high-performing school districts. If the current state goals are being met by these school districts, then a secondary analysis, which is a determination of the characteristics of the school district that can be altered to improve educational attainment versus those that cannot, needs to determine a series of best practices that would lead to the improvement of educational services offered by Pennsylvania school districts.

However, even if the methods do not always rank the school districts similarly, they may be useful for some policy purposes if they are consistent in identifying which are the most efficient and least efficient school districts (Abdulai et al., 2007). Table 5.20 shows the least efficient school districts of Pennsylvania in terms of math proficiency rates for various panel data models.

Table 5.20 School Districts Inefficient in Math Proficiency Rate

	E_{POOL}	E_{BC}	E_{PLRE}	$E_{PLREHT1}$	E_{TRE}
1	82 (CHESTER-UPLAND SD)	82 (CHESTER-UPLAND SD)	82 (CHESTER-UPLAND SD)	82 (CHESTER-UPLAND SD)	82 (CHESTER-UPLAND SD)
2	93 (COLUMBIA BOROUGH SD)	185 (HARRISBURG CITY SD)	185 (HARRISBURG CITY SD)	185 (HARRISBURG CITY SD)	406 (SOUTHEASTERN GREENE SD)
3	485 (WILLIAM PENN SD)	484 (WILKINSBURG BOROUGH SD)	484 (WILKINSBURG BOROUGH SD)	484 (WILKINSBURG BOROUGH SD)	485 (WILLIAM PENN SD)
4	346 (PORT ALLEGANY SD)	485 (WILLIAM PENN SD)	485 (WILLIAM PENN SD)	85 (CLAIRTON CITY SD)	93 (COLUMBIA BOROUGH SD)
5	272 (MOUNT UNION AREA SD)	406 (SOUTHEASTERN GREENE SD)	406 (SOUTHEASTERN GREENE SD)	356 (READING SD)	422 (STO-ROX SD)
6	421 (STEELTON-HIGHSPIRE SD)	85 (CLAIRTON CITY SD)	85 (CLAIRTON CITY SD)	485 (WILLIAM PENN SD)	484 (WILKINSBURG BOROUGH SD)
7	396 (SOUTH ALLEGHENY SD)	356 (READING SD)	356 (READING SD)	406 (SOUTHEASTERN GREENE SD)	185 (HARRISBURG CITY SD)
8	242 (MCGUFFEY SD)	421 (STEELTON-HIGHSPIRE SD)	421 (STEELTON-HIGHSPIRE SD)	421 (STEELTON-HIGHSPIRE SD)	421 (STEELTON-HIGHSPIRE SD)
9	406 (SOUTHEASTERN GREENE SD)	422 (STO-ROX SD)	422 (STO-ROX SD)	125 (DUQUESNE CITY SD)	387 (SHENANDOAH VALLEY SD)
10	367 (ROCHESTER AREA SD)	268 (MORRISVILLE BOROUGH SD)	268 (MORRISVILLE BOROUGH SD)	422 (STO-ROX SD)	181 (HANOVER AREA SD)

5.5. Efficiency Change & Determinants

5.5.1 Overview

Withstanding the importance of each school district efficiency level, the change of the efficiency during a 5-year period is more appealing to policy makers and practitioners. It is more reasonable that policy makers put pressure on increasing the efficiency change, considering the starting point of the school district efficiency. That is why school districts have different backgrounds in terms of students, their parents, and school district factors. For this reason, it is unfair to treat school districts as equal in terms of the starting line.

The yearly mean technical efficiency of all school districts for the time-variant and time-invariant models presented in Table 5.21 suggests that with the exception of the Battese & Coelli model efficiency measures (E_{BC}) of math proficiency rate, mean efficiency measures from the individual models varied very little over the years.

Table 5.21 Average Efficiency Measures Over Time in Math Proficiency Rate

	E_{BC}	E_{TRE}	E_{POOL}	E_{PLRE}	$E_{PLREHT1}$
2002	0.7655	0.8218	0.7874	0.7748	0.7949
2003	0.7708	0.8370	0.7965	0.7748	0.7949
2004	0.7760	0.8247	0.7830	0.7748	0.7949
2005	0.7811	0.8380	0.7941	0.7748	0.7949
2006	0.7861	0.8277	0.7932	0.7748	0.7949

5.5.2 Determinants

How we can change the efficiency for school district outputs is a question that must be solved for policy makers. This study identified four decisive factors: 1) state share of school district revenue; 2) salary share of school district expenditure; 3) equalized mills of school district; and 4) AYP status of the NCLB Act. Currently, AYP status under the influence of the NCLB accountability regime is a major concern for policy makers and practitioners.

State share represents the decisive factor of the state government. Through the manipulation of state share, the state government has to push school districts to change the efficiency positively for school district performance. On the other hand, the equalized mills variable shows the decision factor for school district efficiency change. Salary and benefits is a big burden for school districts. For this reason, this has been used as the fixed cost by the school district. Now, the relationship between AYP status and school district efficiency change could be a helpful evidence for the NCLB Act reauthorization.

Table 5.22 Relationship Between Efficiency Change and Determinants in Math Proficiency Rate

Math, Tobit Model	Coefficient (BC)	t-value	Coefficient (RE)	t-value
Constant	-0.1888	-1.437	-10.4920	-1.876
β_1 (State Share)	1.1645	17.104(*)	17.5896	6.119(*)
β_2 (Salary Share)	-1.1296	-6.657(*)	-3.9938	-0.553
β_3 (Equalized Mills)	0.0445	19.691(*)	0.2445	2.586(*)
β_4 (AYP Status)	0.1386	14.790(*)	-0.3276	-0.830

Table 5.22 explains the impact of these four factors on school district efficiency change for increasing the math proficiency rate of school district, using the Tobit model. StateShare had a positive impact on the efficiency change statistically significant at the five percent level. On the other hand, SalaryShare had a negative association with the efficiency change. The more school districts' salary share increases, the less they try to increase their efficiency for better school district performance.

Table 5.23 Predictive Sign and Actual Sign of Efficiency Change Determinants in Math Proficiency Rate

Math	Expected sign	Actual sign
Constant		
β_1 (State Share)	+	+
β_2 (Salary Share)	-	-
β_3 (Equalized Mills)	+	+
β_4 (AYP Status)	+	+

According to theoretical expectations, all decisive factors had an association with the school district efficiency change, as seen in Table 5.22 and Table 5.23 Most importantly, the coefficients were statistically significant, with the exception of the SalaryShare and AYP status coefficients in the heterogeneous random effects model (RE).

The equalized mills of school districts signify their tax effort. Consequently, their effort resulted in good quality school district output. This study confirms the rationality for the equalized mills.

As discussed in Chapter 2, the spirit of the NCLB Act expects the assignment of AYP status to combine resources in order to improve their programs for achieving high standards. A major component of NCLB Act has pushed the increase of student proficiency rates in school districts as a form of an accountability system. Accordingly, there has been an important expectation that school districts have to transform inputs into outputs efficiently. The positive relationship between AYP status and efficiency change provides evidence of the AYP status component. Contrary to the level of school district efficiency, the efficiency change is a representation for capturing the NCLB Act. That is why school districts have a variation of starting line in inputs, outputs, and exogenous factors. Therefore, this identified the growth model supported by educators and the federal government during the NCLB Act reauthorization.

5.6 Productivity Change

5.6.1. Overview

This section presents the summary of the indices for technical efficiency change (TEC), technical change (TC), and scale change (SC), and total factor productivity change (TFPC) of Pennsylvania school districts from the 2001-02 to 2005-06 school years. The total factor productivity change is decomposed into the efficiency change, technical change, and scale change under the framework of Orea (2002) and Coelli et al. (2005), as discussed in Chapter 4.

Most importantly, the elasticity of mean education production with respect to the input factors in the translog non-neutral stochastic frontier models was composed of two parts: 1) the elasticity of frontier output and 2) elasticity of the technical efficiency

(Battese & Broca, 1997). The elasticity of frontier output was calculated from the derivative of the stochastic frontier model with respect to the input variable using the maximum likelihood estimates for the parameters of the frontier. On the other hand, the second component was calculated from the derivative of the inefficiency model with the input variable. In this case, following Huang & Liu (1994), there were interactions between input variables of the stochastic frontier model and school district-specific variables.

5.6.2 Productivity Change and Elasticity

As a result, on average, the total factor productivity change of Pennsylvania school districts from the 2001-02 to 2005-06 school years was 14.24 percent, as seen in Table 5.24 and Figure 5.3. A value less than one implies deterioration or decrease of Pennsylvania school district productivity, and a value greater than one shows growth or improvement of Pennsylvania school district productivity.

The cause of increase in the total factor productivity (TFPC) was furthermore analyzed by classifying it into technical efficiency change (TEC), technical change (TC), and scale change (SC).

Table 5.24 Cumulative Percentage Change Measures of TEC, TC, SC, and TFPC in Math Proficiency Rate

E_{BC}	TEC	TC	SC	TFPC
2002	0.0000	0.0000	0.0000	0.0000
2003	0.7956	3.2910	-0.9669	3.1197
2004	1.5692	5.9284	1.9691	9.4667
2005	2.3215	7.6794	2.9179	12.9188
2006	3.0531	8.5558	2.6273	14.2362
Mean	0.7633	2.1389	0.6568	3.5591

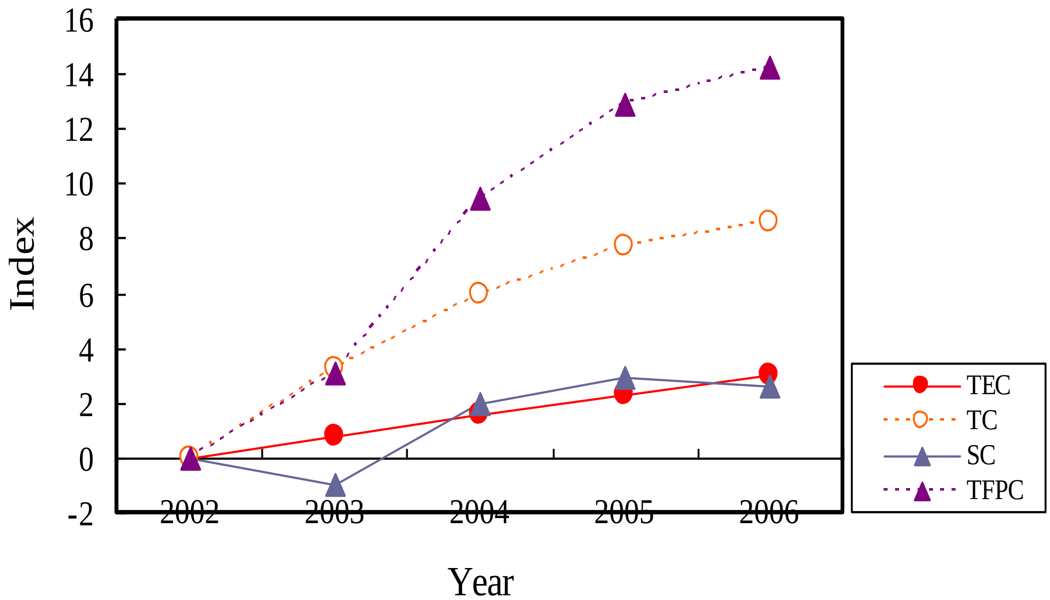


Figure 5.3 Cumulative Percentage Change Measures of TEC, TC, SC, and TFPC in Math Proficiency Rate

The increase of school district total factor productivity was the net effect of growth in technical efficiency change (3.05 percent), growth in technical change (8.56 percent), and growth in scale change (2.63 percent). A major component of school district total factor productivity change in Pennsylvania, on average, came from technical change. Positive technical change could occur due to the impact of skilled and trained personnel for the state government or school districts causing an outward shift of the school district educational production frontier initiated by the NCLB Act accountability system and its highly qualified teachers and professional development (Chakraborty, 2003). That is to say, this could be the capacity building and improvement of the state government and school districts in Pennsylvania. Another explanation for this could be the measurement error of input and output variables of this study with the presence of outliers in the data set (Chakraborty, 2003). The smaller size of scale effect was not more surprising than the other effects, because there were minimal changes in school district sizes over this period (Coelli et al., 2005). It is also clear that technical change occurred at an increasing rate, as seen in the signs of the estimated coefficients. In this calculation, annual percentage change measures of technical efficiency change (TEC), technical change (TC), scale change (SC), and total factor productivity change (TFPC) were calculated for each school district in each pair of adjacent years using the translog education production frontier model. These measures were averaged across school districts and then converted into cumulative percentage change measures, as seen in Table 5.24.

Table 5.25 Elasticity of Input Variables in Math Proficiency Rate

E_{BC}	Elasticity							Scale
	X1 (INST)	X2 (SUP)	X3 (SALARY)	X4 (SERVICE)	X5 (NIEP)	X6 (NECO)	X7 (1/ADM)	
02	-0.305	0.163	0.607	-0.198	0.698	0.474	-0.018	1.420
03	-0.231	0.131	0.389	-0.154	0.758	0.415	-0.028	1.280
04	-0.198	0.136	0.380	-0.164	0.865	0.350	-0.029	1.341
05	-0.158	0.126	0.330	-0.164	0.946	0.293	-0.025	1.348
06	-0.095	0.118	0.303	-0.142	1.002	0.251	-0.027	1.410
Mean	-0.197	0.135	0.402	-0.165	0.854	0.357	-0.025	1.360

During the five-year period, the sum of seven production elasticities was 1.382, being calculated from the BC model sum of (-0.1994+0.1606+0.3348-0.1629+0.8270+0.4138+0.0076), as seen in Table 5.9. This represents increasing returns to scale at the sample mean data point. This came from coefficients of maximum-likelihood estimates of the stochastic frontier model. However, considering the elasticity of the technical efficiency with respect to the input variable, the sum of seven production elasticities resulted in 1.360, as seen in Table 5.25.

As discussed in Chapter 4, the elasticity associated with the NIEP factor was the largest. The time coefficient was 0.021, which indicates a mean technical progress of 2.1 percent per year. The coefficient of time squared was negative and not significant at the five percent level. Therefore, the rate of technical change decreased at a decreasing rate through time.

From the perspective of the interaction of inputs and time, the coefficients of time interacting with the INST, SERVICE, and NIEP were positive, but, SUP, SALARY, NECO, and 1/ADM were negative. Therefore, school district technical change came from INST and SERVICE-saving and SUP and SALARY-using over the period.

5.6.3. Productivity Change and Socio-Economic Factors

The total factor productivity change was also discussed in terms of location types, locale types, and AYP status of Pennsylvania school districts. As a result, two geographic dimensions of Pennsylvania school districts were location type and locale type. The AYP status of school districts is the focal point of the NCLB accountability regime.

5.6.3.1 Location Type

As shown in Table 5.26, the Northwest region was the highest in the total factor productivity change at 5.235 percent. The major impact came from the scale change. That is to say, over the five-year period, the total factor productivity increased by 5.235 percent, due to an 0.821 increase in technical efficiency, a 0.679 percent upward shift in the technology, and a b3.736 percent increase in scale effects. On the other hand, the lowest was Southeast region at -1.743 percent. The decrease of the total factor productivity change in this area was from scale effects at -5.585 percent.

Table 5.26 Total Factor Productivity Change and Location Types in Math Proficiency Rate

	TEC	TC	SC	TFPC
Northwest region (1)	0.821	0.679	3.736	5.235
North-central region(2)	0.809	1.870	0.521	3.199
Southwest region (3)	0.795	2.978	0.659	4.432
South Allegheny (4)	0.578	2.588	0.985	4.151
Central region (5)	0.685	3.380	-3.258	0.807
South-central region(6)	0.746	0.904	0.992	2.642
Southeast region (7)	0.922	2.920	-5.585	-1.743
Northeast region (8)	0.887	3.694	0.505	5.087
Northern Tier (9)	0.564	2.199	-0.139	2.624

5.6.3.2 Locale Type

Midsize suburb had the highest total factor productivity change. More interestingly, *large suburb* decreased in the total factor productivity change during this period at -0.618. The technical change had a major role in the increase of the total factor productivity change in *midsize suburb*. However, scale effect had a negative impact on the total factor productivity change of *large suburb*.

Table 5.27 Locale Types and Total Factor Productivity Change in Math Proficiency Rate

MathPRO	TEC	TC	SC	TFPC
Midsize city (000)	0.806	1.829	2.275	4.910
Small city (001)	0.749	1.662	0.336	2.747
Large suburb (002)	0.901	3.288	-4.808	-0.618
Midsize suburb (003)	1.296	6.659	4.093	12.049
Small suburb (004)	1.438	5.894	3.587	10.919
Fringe town (005)	0.628	0.363	0.367	1.358
Distant town (006)	0.791	2.584	-0.720	2.655
Remote town (007)	0.585	1.894	-0.072	2.406
Fringe rural (008)	0.656	2.604	0.333	3.593
Distant rural (009)	0.656	2.570	-2.565	0.661
Remote rural (010)	0.634	2.839	5.519	8.993

Table 5.28 City, Suburb, Town, and Rural Types and Total Factor Productivity Change in Math Proficiency Rate

MathPRO	TEC	TC	SC	TFPC
City	0.7775	1.7455	1.3055	3.8285
Suburb	1.2117	5.2803	0.9573	7.4500
Town	0.7095	1.6137	-0.1417	2.1397
Rural	0.6487	2.6710	1.0957	4.4157

As seen in Table 5.28, the total factor productivity change of *suburb* was the highest. *Town* was the lowest among locale types. This fact concurs with the general conception of urban, suburban, and rural areas. *Suburban* area was the highest due to the highest values of technical efficiency change and technical change. On the other hand, *town* was the lowest because of the lowest values of technical change and scale effects change. As a result, technical change was a major component of the total factor productivity change for better education. Consequently, policy makers should pay attention to the improvement of technical change of school districts in terms of locale types.

5.6.3.3 AYP Status

As the NCLB Act becomes a critical concern for the state government and school districts in Pennsylvania education, policy makers and practitioners have become interested in the policy mix of educational policy tools. The total factor productivity change approach provides them with useful information from the viewpoint of technical efficiency change, technical change, scale effect change, and total factor productivity change. Table 5.29 presents the importance of scale effects in the improvement of the total factor productivity change of school districts. *Correction I* had negative total factor productivity change due to negative scale effects.

Table 5.29 AYP Status Types and Total Factor Productivity Change in Math Proficiency Rate

	TEC	TC	SC	TFPC
Met AYP (000)	0.643	1.572	0.367	2.582
Making Progress (001)	0.803	2.978	0.911	4.692
Warning (002)	0.947	2.662	3.366	6.975
School Improvement I (003)	0.891	1.823	-0.054	2.661
School Improvement II (004)	1.558	4.172	7.082	12.811
Correction I (005)	1.778	5.744	-43.008	-35.486
Correction II (006)	4.436	18.241	-9.491	13.186

5.6.3.4 Highest Total Factor Productivity Change

As a consequence, the highest school districts in the total factor productivity change in math proficiency rate are seen in Table 5.32. The highest productive school districts came mainly from *Southwest* and *Southeast* regions. However, *Central region* did not have the highest school districts, as seen in Table 5.30.

Table 5.30 Location Types and Productive School Districts

Type	Code	Number of productive school districts
Northwest region	1	2
North-central region	2	2
Southwest region	3	7
South Allegheny	4	1
Central region	5	0
South-central region	6	2
Southeast region	7	7
Northeast region	8	3
Northern Tier	9	1

Table 5.31 Locale Types and Productive School Districts

Type	Code	Number of productive districts
Large city	11	0
Midsize city	12	1
Small city	13	3
Large suburb	21	12
Midsize suburb	22	0
Small suburb	23	0
Fringe town	31	2
Distant town	32	1
Remote town	33	1
Fringe rural	41	1
Distant rural	42	1
Remote rural	43	2

As Table 5.31 shows, the highest productive school districts came mainly from *large suburb*. *Midsize suburb* and *small suburb* did not have the highest school districts.

The school districts with the highest total factor productivity change presented the diversity of factors. SIZE and StateShare of these school districts ranged from 11.0 to 8071.6 and 19.1 percent to 68.8 percent, respectively. In this context, SalaryShare and EqMills also showed various forms. Most importantly, the total productivity change of these school districts resulted from higher scale effect change than other districts.

Table 5.32 The Highest School Districts in Total Factor Productivity Change and Exogenous Factors in Reading Proficiency Rate

N	ID	TEC	TC	SC	TFPC	X1 (SIZE)	X2 (StateShare)	X3 (SalaryShare)	X4 (EqMills)	X6 (LOCAT)	X7 (LOCALE)
1	27	1.438	3.337	221.977	226.752	2787.9	0.2200	0.6899	23.68	7	21
2	356	2.803	10.056	83.917	96.774	8071.6	0.5815	0.7164	28.45	7	13
3	396	1.852	1.630	56.981	60.464	1369.8	0.5745	0.5913	29.53	3	21
4	361	0.436	4.105	54.987	59.529	42.7	0.5451	0.6838	22.13	2	33
5	405	2.366	2.466	46.630	51.463	6874.7	0.3497	0.6984	30.65	7	21
6	494	1.243	6.215	34.506	41.963	3922.5	0.2983	0.6402	31.05	3	21
7	49	2.247	2.478	33.022	37.746	3244.2	0.2909	0.6580	30.48	7	21
8	125	2.244	36.399	-5.644	33.000	3610.8	0.6720	0.5629	38.75	3	21
9	36	1.467	4.958	21.867	28.292	690.2	0.5604	0.6444	30.95	3	21
10	145	1.692	0.769	25.556	28.017	34.3	0.4743	0.6035	10.73	6	43
11	185	4.635	15.834	5.562	26.030	4292.0	0.4760	0.5774	34.93	6	13
12	14	1.425	1.613	19.867	22.905	80.1	0.5418	0.7013	23.93	9	31
13	150	0.418	4.999	17.055	22.472	11.0	0.3800	0.6247	16.88	1	43
14	222	1.998	4.213	16.068	22.279	5223.8	0.4133	0.6705	25.58	7	13
15	236	0.848	5.637	14.705	21.190	177.3	0.5115	0.4905	26.43	8	31
16	126	1.292	4.031	15.698	21.020	1708.7	0.3555	0.5608	33.58	3	21
17	285	1.480	2.737	16.407	20.624	3759.5	0.1909	0.7205	28.53	7	21
18	140	0.696	8.011	9.417	18.124	3705.8	0.4704	0.6899	24.28	1	12
19	48	0.759	6.123	10.241	17.123	5051.0	0.4491	0.7084	19.63	7	21
20	420	1.498	3.244	12.320	17.061	4430.0	0.4132	0.6979	25.05	3	21
21	269	1.733	4.902	9.418	16.053	92.1	0.6877	0.6356	19.03	2	41
22	147	0.949	5.525	8.867	15.341	952.3	0.6753	0.6109	23.30	4	23
23	305	1.000	4.391	9.686	15.077	76.2	0.5976	0.6554	18.93	8	42
24	102	1.660	5.184	6.273	13.117	1986.5	0.2628	0.6303	27.55	3	21
25	387	1.116	5.644	5.880	12.639	978.4	0.4799	0.5584	26.18	8	32

CHAPTER 6: DATA ANALYSIS & RESULTS (II)

This chapter discusses the results of the reading proficiency rate, by answering the research questions. The research questions consist of five parts: 1) efficiency measures, 2) efficiency variation and exogenous factors, 3) efficient school districts, 4) efficiency change and determinants, and 5) productivity change.

6.1 Efficiency Measures

6.1.1 Overview

As seen in Table 6.1, the efficiency measure of 492 Pennsylvania school districts in reading proficiency rate was 85.8 percent (E_{BC}) in the case of basic Battese & Coelli model. This presents that Pennsylvania school districts had an average technical inefficiency of 14.2 percent, on average. The average efficiency indices of districts in reading proficiency ranged from 85.1 percent (E_{POOL}) to 87.4 percent (E_{TRE}) in various models.

Table 6.1 Efficiency Measures and Various Models for Reading Proficiency Rate

	Mean	SD	Minimum	Maximum
E_{BC}	0.85763	0.939460E-01	0.236363	0.984995
E_{POOL}	0.85103	0.810409E-01	0.681267	0.985731
E_{PLRE}	0.85629	0.939072E-01	0.282454	0.982915
$E_{PLREHT1}$	0.87102	0.10233	0.246995	0.987209
E_{TRE}	0.87400	0.822366E-01	0.551913	0.989091

In considering efficiency levels, there was no clear relationship between efficiency levels and inputs and exogenous factors, as seen in Table 6.2. However, the reading proficiency rate increased as efficiency level became better. The ADM and MV/PI AR factors of the lowest efficiency level were two times those of the highest efficiency level.

Moreover, the SIZE factor of the lowest level was five times that of the highest level.

Table 6.2 Efficiency Levels and Key Indicators in Reading Proficiency Rate

N	E_{BC}	E_{TRE}	Read PRO	INST	SUP	SA LARY	SER VICE	NIEP	NECO	ADM	SIZE	MV/PI AR	STATE SHARE	SALARY SHARE	EQ MILLS
1	0.2896	0.5545	16.26	7530.91	3104.57	59087.44	17.34	0.8411	0.6537	7460.02	5499.40	0.8391	0.5437	0.4893	33.70
2	0.4298	0.7229	21.98	8371.48	4095.78	48019.31	13.85	0.8406	0.2300	5097.37	6318.85	0.6867	0.4240	0.5863	40.33
5	0.5412	0.7275	31.16	6745.60	3434.71	48466.32	13.79	0.8600	0.3980	5321.97	5454.56	0.7566	0.5249	0.6477	32.33
15	0.6517	0.8111	42.08	6461.84	2983.52	51022.61	15.02	0.8465	0.6882	3796.27	3472.25	0.6484	0.4553	0.6435	26.04
90	0.7630	0.8441	55.83	5911.41	3049.60	50549.43	16.50	0.8890	0.7964	3156.64	1052.19	0.5876	0.4406	0.6540	21.69
198	0.8551	0.8748	64.32	5638.97	2969.02	49369.53	16.23	0.8929	0.8325	2759.75	685.93	0.5706	0.4338	0.6478	21.13
111	0.9269	0.8951	71.36	5735.95	2965.93	51306.83	15.95	0.8919	0.8626	3130.46	709.67	0.5036	0.3863	0.6607	20.30
70	0.9636	0.9095	77.27	5826.57	3053.98	51567.71	16.32	0.8930	0.8780	3718.80	781.89	0.4673	0.3603	0.6630	19.91

6.1.2 Explanatory Power of Panel Data Models

Comparing the results of various frontier models, this study examined the impact of different assumptions about efficiency and the unobserved school district heterogeneity.

First, the true random effects model (E_{TRE}, 87.40) explains that 85.76 percent of the Battese & Coelli model (E_{BC}) included the unobserved school district heterogeneity differences. As a result, the school district efficiency measures of the true random effects model resulted in 87.4 percent.

Second, the impact of time-variant efficiency assumption was very small. The Pitt & Lee conventional random effects model assumes time-invariant efficiency. The efficiency of the Pitt & Lee random effects model (E_{PLRE}) was a little higher than that of the Battese & Coelli model (E_{BC}). Considering the time varying efficiency, the efficiency of the conventional random effects model resulted in 85.76 percent of the Battese & Coelli model.

Last, the school district observed heterogeneity had a positive impact on the efficiency measurement. SIZE, WEALTH, PRIVATE, and HERF were instrumental variables for the school district observed heterogeneity of this study. This heterogeneity was mixed with the pure school district efficiency. Therefore, eliminating the school district heterogeneity, we can get a higher efficiency measurement in the case of the Pitt & Lee heterogeneous random effects model ($E_{PLREHT1}$).

6.1.3 Rank Correlation

Table 6.3 shows the Spearman rank correlation coefficients of the five panel data models in reading proficiency rate. Policy makers are interested in the rank of efficiency measures rather than absolute values. That is why one model cannot explain school district education production fully. Most importantly, the rank correlation between the Battese & Coelli and the true random effects model was 0.3117, revealing different assumptions about unobserved heterogeneity of school districts.

Table 6.3 Rank Correlation Among Various Models in Reading Proficiency Rate

Reading	E_{BC}	E_{POOL}	E_{TRE}	E_{PLRE}	$E_{PLREHT1}$
E_{BC}	1				
E_{POOL}	0.7179	1			
E_{TRE}	0.3117	0.7938	1		
E_{PLRE}	0.9858	0.7152	0.3050	1	
$E_{PLREHT1}$	0.9481	0.6804	0.3020	0.9607	1

As a consequence, we delved deep into the efficiency measures and their rank of efficient school districts for Research Question #3. The Battese & Coelli model misunderstands school district unobserved heterogeneity for school district efficiency. Therefore, Greene (2004) suggested the true random effects model for dealing with the unobserved heterogeneity problem. This correlation confirms the average efficiency measures, as shown in Table 6.3.

The correlation between the Battese & Coelli model and the Pitt & Lee random effects model was high at 0.9858 and 0.9841. Therefore, the time-varying effect of efficiency was small. Consequently, there is a mutual consistency between these two models.

Table 6.4 Efficient School Districts (E_{BC}) and Their Rank of Other Variant Models in Reading Proficiency Rate

School district	E_{BC}	Rank E_{BC}	E_{TRE}	Rank E_{TRE}	E_{POOL}	Rank E_{POOL}	E_{PLRE}	Rank E_{PLRE}	$E_{PLREHT1}$	Rank $E_{PLREHT1}$
441	0.9825	492	0.9177	450	0.9721	492	0.9829	492	0.9872	492
177	0.9809	491	0.9195	452	0.9654	491	0.9802	491	0.9786	484
455	0.9787	490	0.9400	492	0.9550	489	0.9783	489	0.9845	491
60	0.9785	489	0.9197	453	0.9446	477	0.9788	490	0.9823	490
489	0.9757	488	0.9069	399	0.9484	483	0.9743	488	0.9787	485
115	0.9744	487	0.8926	313	0.9512	485	0.9739	486	0.9755	473
360	0.9742	486	0.9272	479	0.9504	484	0.9741	487	0.9778	479
78	0.9738	485	0.9323	487	0.9548	488	0.9727	481	0.9737	466
228	0.9738	484	0.9040	384	0.9400	465	0.9731	484	0.9782	482
144	0.9737	483	0.9274	480	0.9456	480	0.9731	485	0.9781	481
157	0.9733	482	0.9266	475	0.9478	481	0.9730	483	0.9792	486
158	0.9732	481	0.9163	445	0.9438	475	0.9717	478	0.9750	472
274	0.9731	480	0.9119	429	0.9435	474	0.9725	480	0.9800	488
180	0.9721	479	0.9356	490	0.9443	476	0.9723	479	0.9781	480
54	0.9715	478	0.9117	427	0.9483	482	0.9712	477	0.9724	462
355	0.9712	477	0.9208	455	0.9432	472	0.9692	474	0.9797	487
72	0.9705	476	0.9128	434	0.9446	478	0.9693	475	0.9737	465
110	0.9703	475	0.9272	478	0.9283	445	0.9729	482	0.9784	483
171	0.9698	474	0.9292	483	0.9538	486	0.9696	476	0.9728	463
431	0.9690	473	0.9328	488	0.9433	473	0.9671	469	0.9820	489
150	0.9688	472	0.8902	296	0.9379	462	0.9675	471	0.9777	478
39	0.9688	471	0.8533	114	0.9168	417	0.9684	473	0.9703	455
347	0.9685	470	0.9066	397	0.9395	464	0.9670	468	0.9719	459
276	0.9679	469	0.8841	263	0.9378	461	0.9684	472	0.9741	469
492	0.9676	468	0.9002	364	0.9408	467	0.9663	464	0.9639	432

Policy makers are interested in school district rank rather than absolute value of school district efficiency. Most importantly, the commonalities of efficient school districts are benchmarking tools for inefficient school districts. Recognizing efficient school districts is one of the critical policy implications. However, there is no perfect model for efficiency measurement. Therefore, this study had multiple approaches to efficient school districts. This is closely related to the explanatory power of each panel data model. For this reason, this study chose the basic model as the Battese & Coelli model. Other models were complimentary to this basic model. The reason for using this model is that efficient school districts of the Battese and Coelli model were similar to those of the pooled model, the random effects model, and the heterogeneous random effects model. As Table 6.4 shows it, Wilmington (489), Danville Area (115), Lewisburg Area (228), Forest Area (150), Blacklick Valley (39), Portage Area (347), Muncy (276), and Windber (492) school districts were some of the 25 efficient school districts in the Battese & Coelli model. However, the ranks of these school districts in the true random effects model were below 400, but they were above 400 in other models. As a result of this inconsistency, the Battese & Coelli model was chosen as a basic model. The highest of rank of school districts refers to the most efficient school districts.

6.2 Efficiency Variation & Exogenous Factors

6.2.1 Overview

The second research question dealt with the efficiency variation among school districts and the relationship between the efficiency measurement and exogenous factors in reading proficiency rate. In this context, we discussed the impact of the competition and monitoring factors on school district inefficiency

6.2.2 Education Production Frontier Estimation

The education production function of reading proficiency rate of this study was composed of seven inputs such as environmental and quality differences variables based on the translog model. The education stochastic frontier models explain the relationship between the stochastic frontier of the reading proficiency rate and seven variables. The seven variables are: INST, SUP, SALARY, SERVICE, NIEP, NECO, and 1/ADM.

The t-values of inputs, quality differences, and environmental factors in the reading proficiency rate captured the statistical significance of inputs and environmental factors at the five percent level, ranging from 21 for the Battese & Coelli (BC) model to 34 for the true random effects (TRE) model.

First, as Tables 6.5 and 6.6 show, INST had a negative impact on the education production, which was not expected from a theoretical perspective. Also, SUP was expected to be negative. However, the result of SUP was positive. SALARY of input quality differences was positively associated with the proficiency rate. Contrary to theoretical expectations, SERVICE had a negative association with the reading proficiency rate of school district education production, except for the pooled (POOL) model.

Table 6.5 Education Production Frontier and Estimation of Coefficients in Reading Proficiency Rate

ReadPRO	POOL	t value	BC	t value	BC & Het.	t value	PLRE	t value	PLRE & Het.	t value	TRE	t value
Constant	0.1769	30.599*	0.1687	15.482*	0.1609	17.311*	0.1737	16.358*	0.1541	17.047*		
β1 (INST)	-0.2286	-6.639*	-0.1824	-3.057*	-0.1180	-2.228*	-0.1746	-2.834*	-0.0656	-1.203	-0.2105	-9.414*
β2 (SUP)	0.1353	5.870*	0.1496	3.487*	0.0967	2.441*	0.1473	3.258*	0.0592	1.504	0.1248	8.450*
β 3 (SALARY)	0.2026	4.962*	0.1895	2.581*	0.1394	2.006*	0.1900	2.551*	0.1729	2.637*	0.1650	6.376*
β 4 (SERVICE)	0.0235	1.037	-0.0464	-1.097	-0.0302	-0.796	-0.0482	-1.156	-0.0480	-1.351	-0.0253	-1.730
β 5 (NIEP)	0.6521	9.626*	0.7810	9.149*	0.7776	9.657*	0.7666	8.861*	0.7648	9.444*	0.7078	16.333*
β 6 (NECO)	0.5074	22.543*	0.2878	9.322*	0.2353	7.677*	0.2708	8.508*	0.2105	7.224*	0.3603	26.254*
β 7 (1/ADM)	0.0358	6.287*	0.0057	0.510	0.0152	1.394	0.0043	0.384	-0.0036	-0.345	0.0355	9.865*
βt (T)	0.0505	20.614*	0.0359	8.180*	0.0473	14.302*	0.0472	13.290*	0.0451	14.056*	0.0469	28.274*

(*): Statistical significance at the five percent level

Second, the environmental factors, that is, NIEP and NECO, confirmed theoretical expectations. All coefficients were statistically significant in all stochastic panel models.

The 1/ADM factor as one of the quantity adjustments variables had a positive role in the education production, except for the Pitt & Lee heterogeneous random effects (PLRE & Het.) model.

Table 6.6 Inputs and Predicted and Actual Sign in Reading Proficiency Rate

ReadPRO	Predicted sign	POOL	BC	BC & Het.	PLRE	PLRE & Het.	TRE
Constant		(*)	(*)	(*)	(*)	(*)	
β 1 (INST)	+	- (*)	- (*)	- (*)	- (*)	-	- (*)
β 2 (SUP)	-	+ (*)	+(*)	+ (*)	+ (*)	+	+ (*)
β 3 (SALARY)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 4 (SERVICE)	+	+	-	-	-	-	-
β 5 (NIEP)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 6 (NECO)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 7 (1/ADM)	+	+ (*)	+	+	+	-	+ (*)
βt (TIME)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)

(*): Statistical significance at the five percent level

Most importantly, environmental factors had the greater impact on the proficiency rate among seven inputs, as seen in Table 6.5. Therefore, the socio-economic background of the students was more important than traditional inputs in Pennsylvania.

6.2.3 Inefficiency and Institutional Factors

Table 6.7 summarizes the effects of institutional and size factors on the inefficiency of school districts in reading proficiency rate.

As one of the school district size factors, 1/SIZE had a negative impact on the inefficiency like theoretical expectations. SIZE refers to population per square mile of county in which the school districts are located. AR signifies school district wealth, showing the MV/PI AR. This aid ratio is utilized in school funding by the state government. As expected theoretically, the aid ratio had a positive impact on the inefficiency of school districts. As the school district becomes poorer, the school district inefficiency increases. In this mechanism, school district wealth was closely related to the monitoring activities of voters and citizens involved in school district education production.

Table 6.7 Inefficiency and Estimation of Coefficients in Reading Proficiency Rate

	BC & Het.	t value	PLRE & Het.	t value	Predicted sign	Actual sign
Constant	-0.5387	0.000	-1.7358	0.000		
α1(1/SIZE)			-0.3972	-6.115 (*)	+	-
α2 (AR)	1.3634	10.182 (*)	3.0694	7.632 (*)	+	+
α3 (AR^2)	0.4031	1.865	0.9200	1.789	+	+
α4 (HERF)	-0.0546	-3.200 (*)	0.0398	0.696	+	-/+
α5 (LagPRIV)	0.0196	1.353	0.0180	0.202	-	+

(*): Statistical significance at the five percent level

HERF and LagPRIV were competition factors from public school districts and private schools for school district efficiency, respectively. As one of the competition factors, HERF had a positive impact on school district inefficiency in the Pitt & Lee conventional heterogeneous random effects model (PLRE & Het.), as expected theoretically. However, the Battese & Coelli heterogeneous model (BC & Het.) obtains the opposite result statistically significant at the five percent level. The lagged value of private school enrollments (LagPRIV) was positively associated with the inefficiency, which differs from the theoretical expectations.

In summary, Table 6.8 shows the estimation of the stochastic education production frontier and the inefficiency model under various stochastic panel data models in the case of reading proficiency rate.

Table 6.8 Estimated Parameters of the Stochastic Frontier Models and Inefficiency in Reading Proficiency Rate

	POOL	t value	BC	t value	BC & HET.	t value	PLRE	t value	PLRE & HET.	t value	TRE	t value
Constant	0.1769	30.599*	0.1687	15.482*	0.1609	17.311*	0.1737	16.358*	0.1541	17.047*		
β 1 (INST)	-0.2286	-6.639*	-0.1824	-3.057*	-0.1180	-2.228*	-0.1746	-2.834*	-0.0656	-1.203	-0.2105	-9.414*
β 2 (SUP)	0.1353	5.870*	0.1496	3.487*	0.0967	2.441*	0.1473	3.258*	0.0592	1.504	0.1248	8.450*
β 3 (SALARY)	0.2026	4.962*	0.1895	2.581*	0.1394	2.006*	0.1900	2.551*	0.1729	2.637*	0.1650	6.376*
β 4 (SERVICE)	0.0235	1.037	-0.0464	-1.097	-0.0302	-0.796	-0.0482	-1.156	-0.0480	-1.351	-0.0253	-1.730
β 5 (NIEP)	0.6521	9.626*	0.7810	9.149*	0.7776	9.657*	0.7666	8.861*	0.7648	9.444*	0.7078	16.333*
β 6 (NECO)	0.5074	22.543*	0.2878	9.322*	0.2353	7.677*	0.2708	8.508*	0.2105	7.224*	0.3603	26.254*
β 7 (1/ADM)	0.0358	6.287*	0.0057	0.510	0.0152	1.394	0.0043	0.384	-0.0036	-0.345	0.0355	9.865*
β 12(X1X2)	-0.1934	-0.648	-0.4146	-0.945	-0.2753	-0.747	-0.3496	-0.822	-0.5198	-1.346	0.7087	3.844*
β 13 (X1X3)	2.2942	5.220*	2.3056	3.110*	1.8150	2.523*	2.4020	3.197*	1.4670	1.963*	2.6679	10.343*
β 14 (X1X4)	-0.3896	-1.421	-0.4405	-1.049	-0.4717	-1.180	-0.5278	-1.235	-0.3941	-1.016	-0.0983	-0.548
β 15 (X1X5)	0.6642	0.959	1.2292	1.635	0.4793	0.670	0.8010	1.063	0.2927	0.396	1.9882	4.699*
β 16 (X1X6)	-0.0577	-0.509	-0.6717	-3.825*	-0.6320	-3.477*	-0.6442	-3.390*	-0.5950	-3.163*	-0.1930	-2.587*
β17 (X1X7)	0.2828	4.589*	0.3122	3.313*	0.2660	2.847*	0.3181	3.491*	0.1656	1.669	0.4208	12.026*
β 23 (X2X3)	-0.9635	-3.320*	-0.5601	-1.053	-0.8246	-1.723	-0.5352	-1.011	-0.7044	-1.545	-0.8240	-4.793*
β 24 (X2X4)	0.4709	2.593*	0.2649	0.866	0.5148	1.815	0.3001	0.966	0.5373	2.016*	0.0247	0.219
β 25 (X2X5)	-0.8535	-1.869	-1.3745	-2.528*	-1.1417	-2.251*	-1.2481	-2.285*	-0.8954	-1.761	-0.7966	-2.971*
β 26 (X2X6)	0.0980	1.985*	0.3711	2.386*	0.4040	2.304*	0.3624	2.105*	0.3843	2.269*	0.2196	3.062*
β 27 (X2X7)	-0.2662	-6.110*	-0.1762	-2.238*	-0.2008	-2.894*	-0.1634	-2.146*	-0.1761	-2.428*	-0.1688	-6.654*
β 34 (X3X4)	-0.7416	-2.500*	-0.5044	-1.025	-0.5547	-1.248	-0.5177	-1.057	-0.6440	-1.478	-0.7414	-4.011*
β 35 (X3X5)	0.4529	0.573	0.5286	0.592	0.7653	0.910	0.9415	1.075	0.7506	0.919	-1.2503	-2.689*
β 36 (X3X6)	2.0388	10.687*	1.7970	7.203*	1.9320	8.688*	1.8673	7.651*	1.8650	7.857*	1.7146	16.835*
β 37 (X3X7)	0.1457	2.085*	-0.1024	-0.819	-0.0832	-0.734	-0.1551	-1.255	0.0282	0.236	-0.0593	-1.442
β 45 (X4X5)	0.1929	0.423	0.8197	1.856	0.6043	1.358	0.6565	1.471	0.7924	1.750	1.2072	4.709*
β 46 (X4X6)	-0.7211	-7.121*	-0.8797	-5.964*	-0.7959	-5.893*	-0.9165	-6.324*	-0.6854	-4.713*	-0.8372	-15.236*
β 47 (X4X7)	-0.1356	-3.500*	-0.0900	-1.404	-0.1347	-2.461*	-0.1000	-1.604	-0.1147	-2.049*	-0.0061	-0.269
β 56 (X5X6)	0.1563	0.762	-0.5849	-1.856	-0.6065	-2.096*	-0.6109	-2.000*	-0.6425	-2.251*	0.4391	3.386*
β 57 (X5X7)	0.1373	1.217	0.2518	1.994*	0.3154	2.624*	0.3169	2.590*	0.3188	2.678*	-0.0235	-0.378
β 67 (X6X7)	-0.0498	-2.881*	0.0559	2.382*	0.0741	2.768*	0.0697	2.829*	0.0845	3.270*	0.0096	0.912
β 11 ($X1^2$)	-1.2206	-2.305*	-0.7606	-0.983	-0.4557	-0.624	-0.9123	-1.173	0.0992	0.129	-2.4811	-8.021*
β 22 ($X2^2$)	0.4665	1.958*	0.3114	0.793	0.3008	1.027	0.2536	0.684	0.4846	1.574	-0.3069	-2.017*
β 33 ($X3^2$)	-2.4099	-3.888*	-2.5095	-2.154*	-2.6456	-2.590*	-2.8570	-2.450*	-2.5067	-2.386*	-2.1525	-5.890*
β 44 ($X4^2$)	-0.0074	-0.110	0.0897	0.583	0.0841	0.549	0.1078	0.665	0.0838	0.567	0.1213	2.383*
β 55 ($X5^2$)	-1.5690	-1.112	1.0560	0.909	1.3977	1.209	1.0619	0.919	1.4796	1.316	-1.1544	-1.652
β 66 ($X6^2$)	0.1692	9.781*	0.0763	4.163*	0.0546	2.668*	0.0731	3.924*	0.0444	2.173*	0.1173	12.222*
β 77 ($X7^2$)	0.0566	4.342*	0.0090	0.364	0.0090	0.412	0.0175	-0.714	0.0216	0.978	-0.0109	-1.381
βt (TIME)	0.0505	20.614*	0.0359	8.180*	0.0473	14.302*	0.0472	13.290*	0.0451	14.056*	0.0469	28.274*
βtt ($TIME^2$)	-0.0145	-3.984*	-0.0117	-2.638*	-0.0139	-3.343*	-0.0143	-3.494*	-0.0130	-3.187*	-0.0106	-3.649*
βt1 (TX1)	0.0831	3.057*	0.0307	0.912	0.0149	0.462	0.0423	1.283	0.0043	0.137	0.0834	4.755*
βt2 (TX2)	-0.0137	-0.781	0.0109	0.503	0.0142	0.696	0.0082	0.391	0.0186	0.915	-0.0296	-2.527*
βt3 (TX3)	-0.0620	-2.044*	-0.0490	-1.304	0.0036	0.108	-0.0490	-1.369	0.0143	0.312	-0.0776	-4.126*
βt4 (TX4)	0.0136	0.762	0.0267	1.194	0.0091	0.454	0.0249	1.135	0.0140	0.713	0.0243	2.093*
βt5 (TX5)	0.0981	1.952	0.0913	1.836	0.1103	2.273*	0.0955	1.916	0.0183	2.196*	0.0575	1.868
βt6 (TX6)	-0.1112	-10.465*	-0.0803	-7.265*	-0.1016	-9.749*	-0.0997	-9.717*	-0.0984	-9.490*	-0.1027	-15.923*
βt7 (TX7)	0.0043	-1.027	-0.0010	-0.173	0.0013	0.279	-0.0016	-0.294	0.0055	1.164	-0.0096	-3.904*
Sigma (u)	0.2179		0.1781	429.628	0.2769	0.000	0.2107	23.840	0.3508	0.000	0.1906	
Sigma (v)	0.0679		0.1106		0.1150		0.1111		0.1111		0.0301	
Lamda	3.3574	19.423	1.6107	63.225	2.4829	0.000	1.8963	15.511	3.1569	0.000	6.3347	12.683
Eta			0.0752	4.513								
Constant					-0.5387	0.000			-1.7358	0.000		
α1(1/SIZE)									-0.3972	-6.115*		
α2 (AR)					1.3634	10.182*			3.0694	7.632*		
α3 (AR^2)					0.4031	1.865			0.9200	1.789		
α4 (HERF)					-0.0546	-3.200*			0.0398	0.696		
α5 (LagPRIV)					0.0196	1.353			0.0180	0.202		
Log Likelihood	1257.738		1465.510			1508.778	1453.113		1545.465		1568.971	

6.2.4 Efficiency and Socio-economic Factors

As with the math proficiency rate, the efficiency measures of 492 school districts in reading proficiency rate were descriptively analyzed according to geographic location (seven types), locale types (the urban-centric locale code system, 12 codes), and AYP (Adequate Yearly Progress) of school districts under the Pennsylvania accountability system. This analysis gives the foundation of capturing efficiency variation of school districts in reading proficiency rate.

6.2.4.1. Location Type

As illustrated in Table 6.9, the Northern Tier area had the highest efficiency value. The range of the highest efficiency measures in the Northern Tier region was from 88.2 percent of the pooled model (E_{POOL}) to 89.8 percent of the Battese & Coelli model (E_{BC}). The lowest area was the Northeast region, ranging 82.1 percent of the pooled model (E_{POOL}) to 85.7 percent of the true random effects model (E_{TRE}). As a consequence, we could say that the location type as one of the unobserved school district heterogeneity factors could have an impact on the efficiency measurement.

Table 6.9 Location Types and School District Efficiency Measures in Reading Proficiency Rate

	E_{BC}	E_{POOL}	E_{PLRE}	E_{TRE}
Northwest region	0.850	0.850	0.848	0.880
North-central region	0.852	0.840	0.852	0.874
Southwest region	0.853	0.855	0.852	0.873
South Allegheny	0.887	0.869	0.886	0.883
Central region	0.878	0.865	0.875	0.863
South-central region	0.846	0.839	0.844	0.871
Southeast region	0.834	0.825	0.833	0.866
Northeast region	0.834	0.821	0.831	0.857
Northern Tier	0.898	0.882	0.897	0.886

6.2.4.2 Locale Type

Fringe town (the Battese & Coelli and Pitt & Lee random effects models) and *distant rural* (the pooled and true random effects models) was the highest among urban-centric locale types. On the other hand, *small suburb* was the lowest, except for the pooled model. Locale type had a negative impact on the efficiency measurement of the Battese & Coelli model, in comparison with the true random effects model. That is to say, locale could be one of the unobserved heterogeneity factors in the stochastic frontier model and inefficiency model. In this context, school district heterogeneity was misunderstood for efficiency. As a consequence, the true random effects model could disentangle the unobserved heterogeneity from efficiency.

Table 6.10 Locale Types and School District Efficiency Measures in Reading Proficiency Rate

	E_{BC}	E_{POOL}	E_{PLRE}	E_{TRE}
Midsize city	0.846	0.849	0.846	0.876
Small city	0.864	0.850	0.862	0.878
Large suburb	0.834	0.823	0.832	0.850
Midsize suburb	0.806	0.871	0.801	0.875
Small suburb	0.752	0.835	0.741	0.839
Fringe town	0.894	0.868	0.893	0.886
Distant town	0.859	0.843	0.858	0.864
Remote town	0.886	0.867	0.885	0.882
Fringe rural	0.859	0.852	0.856	0.873
Distant rural	0.887	0.875	0.885	0.887
Remote rural	0.860	0.839	0.859	0.875

6.2.4.3. AYP Status

Under the accountability of the NCLB Act, school districts receive one of the following ranks: *Met AYP*, *Making progress*, *Warning*, *School improvement I*, *School improvement II*, *Correction I*, and *Correction II* based on meeting AYP (adequate yearly progress) by the state government.

Table 6.11 generally confirms the effect of AYP status on school district efficiency as a major component of the NCLB Act. Efficiency measures of *Met AYP* were the highest among the seven statuses, except for the true random effects model. The efficiency measures of school districts of *Met AYP* were the second highest in the true random effects model. The lowest efficiency measures were *correction II* phase among them. Therefore, the NCLB act has the rationality of the school district efficiency improvement assumption in reading proficiency rate. On the other hand, Research Question #4 explored the relationship between efficiency change and AYP status of the NCLB Act in terms of efficiency change rather than absolute value.

Table 6.11 AYP Status and School District Efficiency Measures in Reading Proficiency Rate

	E_{BC}	E_{POOL}	E_{PLRE}	E_{TRE}
Met AYP	0.885	0.864	0.876	0.884
Making progress	0.846	0.836	0.852	0.861
Warning	0.826	0.820	0.823	0.850
School improvement I	0.841	0.861	0.826	0.900
School improvement II	0.742	0.810	0.717	0.851
Correction I	0.719	0.758	0.686	0.766
Correction II	0.404	0.731	0.390	0.760

6.3 Efficient School Districts

6.3.1 Overview

Capturing commonalities of efficient school districts provide inefficient school districts with the chance to benchmark in the arena of reading proficiency rate. To begin with, the needs analysis of school districts in the case of reading proficiency rate explains whether adequate funding is closely related to their efficiency measures. The needs of school districts were calculated as the ratio of weighted students over unweighted students, as is similar to the math proficiency rate suggested by the costing out study.

Table 6.12 Needs of School Districts and Efficiency Measures in Reading Proficiency Rate

N	Needs	E_{BC}
2	1.090	0.603
5	1.111	0.769
3	1.126	0.943
47	1.136	0.855
120	1.145	0.858
107	1.154	0.866
98	1.164	0.848
75	1.175	0.866
33	1.183	0.861
2	1.192	0.911

As Table 6.12 shows, generally, we could say that as the needs of school districts increased, their efficiency became better. Therefore, adequate funding for higher needs had the rationality from the viewpoint of efficiency measurement.

From the policy perspective, adequate funding of the Upper Merion Area, Cheltenham Twp, Neshaminy, and Colonial school districts had a weak foundation for adequacy level and actual spending level, because their efficiency measures were below 80 percent. Therefore, the state government has to investigate these school districts under the framework of mixed methodology to obtain the rationality of their adequate funding. More importantly, it is reasonable that the state government require school districts to make a plan in order to obtain adequate funding for productive efficiency and adequacy.

Table 6.13 Comparison of Adequacy with Actual Spending and Efficiency in Reading Proficiency Rate

	School district	Comparison	Efficiency	Rank
1	Lower Merion (233)	$4972	0.9545	435
2	Jenkintown (203)	$2792	0.9266	361
3	Bryn Athyn (N)	$2712		
4	Pittsburgh (N)	$2330		
5	Radner Twp (355)	$2048	0.9712	477
6	Upper Merion Area (452)	$1933	0.7427	42
7	New Hope-Solebury (282)	$1904	0.8825	265
8	Cheltenham Twp (81)	$1675	0.7981	107
9	Quaker Valley (353)	$1586	0.8988	307
10	Fox Chapel Area (155)	$1171	0.9558	440
11	Tredyffrin-Easttown (431)	$1082	0.9690	473
12	Neshaminy (278)	$1062	0.7598	62
13	Colonial (92)	$985	0.7822	92
14	Springfield Twp (417)	$979	0.8844	271
15	North Allegheny (286)	$773	0.9584	445
16	Phoenixville Area Twp (338)	$622	0.9535	429
17	Mt Lebanon (274)	$556	0.9731	480
18	Rose Tree Media (369)	$442	0.9488	422
19	Wissahickon (493)	$367	0.9418	407
20	Indiana Area (197)	$269	0.9513	427
21	Sullivan County (424)	$259	0.9415	406
22	Allegheny Valley (5)	$217	0.8917	286
23	State College Area (419)	$165	0.9658	462
24	Marple Newtown (240)	$131	0.8979	304
25	Saucon Valley (374)	$119	0.8928	290

* Comparison: Adequacy and actual spending per pupil

6.3.2 Efficient School Districts

6.3.2.1 Background

This study also identified Pennsylvania school districts demonstrating efficiency in reading proficiency rates, as seen in Table 6.14 and Table 6.15. Table 6.14 shows the efficient school districts under various stochastic frontier models: the pooled (E_{POOL}), Battese & Coelli (E_{BC}), Pitt & Lee conventional random effects (E_{PLRE}), Pitt & Lee heterogeneous random effects ($E_{PLREHT1}$), and true random effects models (E_{TRE}).

Table 6.14 Efficient School Districts and Various Models in Reading Proficiency Rate

	E_{POOL}	E_{BC}	E_{PLRE}	$E_{PLREHT1}$	E_{TRE}
1	441 (TYRONE AREA SD)	441 (TYRONE AREA SD)	441 (TYRONE AREA SD)	441 (TYRONE AREA SD)	455 (WALLENPAUPACK AREA SD)
2	177 (GROVE CITY AREA SD)	177 (GROVE CITY AREA SD)	177 (GROVE CITY AREA SD)	455 (WALLENPAUPACK AREA SD)	233 (LOWER MERION SD)
3	458 (WALLENPAUPACK AREA SD)	455 (WALLENPAUPACK AREA SD)	60 (CAMP HILL SD)	60 (CAMP HILL SD)	180 (HAMPTON TOWNSHIP SD)
4	455 (WALLENPAUPACK AREA SD)	60 (CAMP HILL SD)	455 (WALLENPAUPACK AREA SD)	431 (TREDYFFRIN-EASTTOWN SD)	419 (STATE COLLEGE AREA SD)
5	78 (CHARLEROI SD)	489 (WILMINGTON AREA SD)	489 (WILMINGTON AREA SD)	274 (MT LEBANON SD)	431 (TREDYFFRIN-EASTTOWN SD)
6	8 (ALTOONA AREA SD)	115 (DANVILLE AREA SD)	360 (RICHLAND SD)	355 (RADNOR TOWNSHIP SD)	78 (CHARLEROI SD)
7	171 (GREATER LATROBE SD)	360 (RICHLAND SD)	115 (DANVILLE AREA SD)	157 (FRANKLIN REGIONAL SD)	290 (NORTH PENN SD)
8	115 (DANVILLE AREA SD)	78 (CHARLEROI SD)	144 (FAIRVIEW SD)	489 (WILMINGTON AREA SD)	321 (PARKLAND SD)
9	360 (RICHLAND SD)	228 (LEWISBURG AREA SD)	228 (LEWISBURG AREA SD)	177 (GROVE CITY AREA SD)	335 (PETERS TOWNSHIP SD)
10	489 (WILMINGTON AREA SD)	144 (FAIRVIEW SD)	157 (FRANKLIN REGIONAL SD)	110 (CUMBERLAND VALLEY SD)	171 (GREATER LATROBE SD)
11	54 (BURGETTSTOWN AREA SD)	157 (FRANKLIN REGIONAL SD)	110 (CUMBERLAND VALLEY SD)	228 (LEWISBURG AREA SD)	286 (NORTH ALLEGHENY SD)
12	157 (FRANKLIN REGIONAL SD)	158 (FRAZIER SD)	78 (CHARLEROI SD)	144 (FAIRVIEW SD)	197 (INDIANA AREA SD)
13	144 (FAIRVIEW SD)	274 (MT LEBANON SD)	274 (MT LEBANON SD)	180 (HAMPTON TOWNSHIP SD)	144 (FAIRVIEW SD)
14	162 (GARNET VALLEY SD)	180 (HAMPTON TOWNSHIP SD)	180 (HAMPTON TOWNSHIP SD)	360 (RICHLAND SD)	360 (RICHLAND SD)
15	72 (CENTRAL COLUMBIA SD)	54 (BURGETTSTOWN AREA SD)	158 (FRAZIER SD)	150 (FOREST AREA SD)	110 (CUMBERLAND VALLEY SD)
16	60 (CAMP HILL SD)	355 (RADNOR TOWNSHIP SD)	54 (BURGETTSTOWN AREA SD)	234 (LOWER MORELAND TOWNSHIP)	238 (MANHEIM TOWNSHIP SD)
17	180 (HAMPTON TOWNSHIP SD)	72 (CENTRAL COLUMBIA SD)	171 (GREATER LATROBE SD)	446 (UNIONVILLE-CHADDS FORD)	338 (PHOENIXVILLE AREA SD)
18	158 (FRAZIER SD)	110 (CUMBERLAND VALLEY SD)	72 (CENTRAL COLUMBIA SD)	384 (SHANKSVILLE-STONYCREEK SD)	157 (FRANKLIN REGIONAL SD)
19	274 (MT LEBANON SD)	171 (GREATER LATROBE SD)	355 (RADNOR TOWNSHIP SD)	119 (DERRY TOWNSHIP SD)	369 (ROSE TREE MEDIA SD)
20	431 (TREDYFFRIN-EASTTOWN SD)	431 (TREDYFFRIN-EASTTOWN SD)	39 (BLACKLICK VALLEY SD)	115 (DANVILLE AREA SD)	106 (COUNCIL ROCK SD)
21	355 (RADNOR TOWNSHIP SD)	150 (FOREST AREA SD)	276 (MUNCY SD)	158 (FRAZIER SD)	162 (GARNET VALLEY SD)
22	366 (RIVERVIEW SD)	39 (BLACKLICK VALLEY SD)	150 (FOREST AREA SD)	335 (PETERS TOWNSHIP SD)	70 (CENTRAL BUCKS SD)
23	193 (HOLLIDAYSBURG AREA SD)	347 (PORTAGE AREA SD)	335 (PETERS TOWNSHIP SD)	286 (NORTH ALLEGHENY SD)	446 (UNIONVILLE-CHADDS FORD)
24	335 (PETERS TOWNSHIP SD)	276 (MUNCY SD)	431 (TREDYFFRIN-EASTTOWN SD)	276 (MUNCY SD)	471 (WEST CHESTER AREA SD)
25	447 (UNITED SD)	492 (WINDBER AREA SD)	347 (PORTAGE AREA SD)	10 (ANNVILLE-CLEONA SD)	10 (ANNVILLE-CLEONA SD)

Each panel data model presented the 25 school districts demonstrating efficiency in reading proficiency rate.

Exploring the explanatory power of each model, efficient school districts of the Battese and Coelli model were rearranged in each model as a form of school district rank. The highest of ranking (for example, 492) shows the highest efficiency measure of the school district.

Each model suggested 25 efficient school districts. However, school districts which were once recognized in each model were excluded from the efficient school districts. As a result, we saw 30 school districts with efficiency in reading proficiency rates, as seen in Table 6.15. Table 6.15 represents the relationship between 30 efficient school districts and exogenous factors in order to obtain the common characteristics of efficient school districts.

6.3.2.2 Key Indicators

As a consequence, the common characteristics of school districts efficient in reading proficiency rate are summarized, as seen in Table 6.15. The efficient school districts of this study presented their diversity for differences rather than evident similarities under the stochastic frontier analysis, which is similar to the results of the math proficiency rate.

First, the rank of the efficient school districts in terms of size related factors ranged from 480 (5457) to 3 (11) in SIZE and from 468 (3928.68) to 17 (717.81) in ADM, respectively. Consequently, the efficient school districts represented the diversity of ADM and SIZE.

Second, the reading proficiency rate of efficient school districts was above 60 percent. But, the lowest ranking of efficient school districts was 283 (53.4). The INST and SUP of efficient school districts had different expenditure levels. The highest INST ($9,200) of efficient school districts was about two times the lowest ($4,982) of efficient school districts. The ranking range of SUP in efficient school districts was lower than that of INST in efficient school districts.

Third, in the case of NIEP and NECO, the ranking of efficient school districts also showed their diversity. However, their ranking of NIEP and NECO was smaller than the ranking of INST, SUP, and SALARY.

Fourth, the MV/PI AR, StateShare, SalaryShare, and EqMills of efficient school districts also had different sizes. Most interestingly, state share of revenue in school district ranged from the lowest level (2, 9.5 percent) to the highest level (492, 73.9 percent).

Last, efficient school districts came from various location areas. The North-central and Northern Tier had no efficient school districts. The Southwest area had eight efficient school districts. In terms of locale, *large suburban* had 15 efficient school districts. *Midsize city*, *midsize suburb*, *remote town*, and *remote rural* had no efficient school districts, as seen in Table 6.17.

Table 6.16 Location Types and Efficient School Districts in Reading Proficiency Rate

Type	Code	Number of efficient districts
Northwest region	1	3
North-central region	2	0
Southwest region	3	10
South Allegheny	4	4
Central region	5	4
South-central region	6	3
Southeast region	7	4
Northeast region	8	1
Northern Tier	9	0

Table 6.15 Efficient School Districts and Ranking of Key Indicators in Reading Proficiency Rate

	E_{BC}	E_{TRE}	ReadPRO	INST	SUP	SALARY	NIEP	NECO	ADM	SIZE	MV/PI AR	STATE SHARE	SALARY SHARE	EQMILLS	LOCAT	LOCALE
10	465	468	420	83	103	141	114	402	159	251	151	223	196	110	6	41
39	471	114	166	405	350	145	4	38	18	186	463	492	261	106	4	31
54	478	427	318	139	23	41	21	229	143	121	357	344	376	231	3	42
60	489	453	481	328	352	296	236	477	73	454	29	32	463	309	6	21
72	476	434	475	24	104	299	487	398	237	192	195	262	345	54	5	31
78	485	487	351	258	100	121	37	161	160	312	341	323	209	405	3	23
110	475	478	471	68	202	191	264	455	466	300	47	94	164	94	6	41
115	489	313	452	277	85	156	473	263	288	168	171	216	263	126	5	31
144	483	480	474	131	378	341	418	351	149	272	48	125	350	237	1	41
150	472	296	293	438	486	206	100	43	17	3	131	218	124	114	1	43
157	482	475	485	103	157	384	425	461	368	328	83	117	280	283	3	21
158	481	445	400	273	278	219	117	134	81	161	377	455	132	51	3	41
162	433	472	459	418	381	292	97	481	380	359	53	21	403	386	7	21
171	474	483	449	37	30	318	431	248	396	294	154	201	109	163	3	21
177	491	452	418	379	123	243	53	210	248	199	248	249	355	44	1	32
180	479	490	489	313	201	448	478	475	318	385	105	91	344	423	3	21
228	484	384	479	232	297	290	464	456	181	290	93	84	27	327	5	31
274	480	429	490	365	419	436	281	468	430	480	52	35	450	418	3	21
276	469	263	411	306	309	170	34	200	68	202	161	226	155	181	5	31
286	445	482	483	427	406	478	479	480	468	379	37	47	478	396	3	21
335	467	484	488	25	144	376	490	483	371	361	73	78	300	213	3	21
347	470	397	394	241	235	166	183	51	58	242	465	478	158	159	4	31
355	477	455	478	490	490	483	28	464	334	427	11	5	451	85	7	21
360	486	479	486	33	345	289	426	417	150	348	70	77	5	61	4	23
431	473	488	492	465	479	462	241	487	437	395	5	8	340	29	7	21
441	492	450	465	22	290	12	30	157	194	103	352	422	125	11	4	31
446	370	470	487	409	468	459	179	490	374	246	18	26	466	195	7	21
455	490	492	491	412	423	464	362	488	390	421	45	29	377	431	3	21
489	488	399	432	87	86	96	135	262	153	139	290	303	58	66	8	31

Table 6.17 Locale Types and Efficient School Districts in Reading Proficiency Rate

Type	Code	Number of efficient districts
Large city	11	0
Midsize city	12	0
Small city	13	0
Large suburb	21	12
Midsize suburb	22	0
Small suburb	23	2
Fringe town	31	8
Distant town	32	1
Remote town	33	0
Fringe rural	41	4
Distant rural	42	1
Remote rural	43	1

As a reference of efficient school districts in reading proficiency rate, ten inefficient school districts are summarized in Table 6.18.

Table 6.18 Ten School Districts Inefficient in Reading Proficiency Rate

	E_{POOL}	E_{BC}	E_{PLRE}	$E_{PLREHT1}$	E_{TRE}
1	485 (WILLIAM PENN SD)	82 (CHESTER-UPLAND SD)	82 (CHESTER-UPLAND SD)	82 (CHESTER-UPLAND SD)	82 (CHESTER-UPLAND SD)
2	82 (CHESTER-UPLAND SD)	185 (HARRISBURG CITY SD)	185 (HARRISBURG CITY SD)	185 (HARRISBURG CITY SD)	485 (WILLIAM PENN SD)
3	225 (LEBANON SD)	484 (WILKINSBURG BOROUGH SD)	484 (WILKINSBURG BOROUGH SD)	484 (WILKINSBURG BOROUGH SD)	268 (MORRISVILLE BOROUGH SD)
4	93 (COLUMBIA BOROUGH SD)	485 (WILLIAM PENN SD)	485 (WILLIAM PENN SD)	125 (DUQUESNE CITY SD)	499 (YORK CITY SD)
5	420 (STEEL VALLEY SD)	422 (STO-ROX SD)	422 (STO-ROX SD)	485 (WILLIAM PENN SD)	422 (STO-ROX SD)
6	27 (BENSALEM TOWNSHIP SD)	125 (DUQUESNE CITY SD)	125 (DUQUESNE CITY SD)	356 (READING SD)	484 (WILKINSBURG BOROUGH SD)
7	84 (CHICHESTER SD)	4 (ALIQUIPPA SD)	4 (ALIQUIPPA SD)	422 (STO-ROX SD)	185 (HARRISBURG CITY SD)
8	422 (STO-ROX SD)	356 (READING SD)	356 (READING SD)	499 (YORK CITY SD)	4 (ALIQUIPPA SD)
9	314 (OTTO-ELDRED SD)	225 (LEBANON SD)	225 (LEBANON SD)	4 (ALIQUIPPA SD)	125 (DUQUESNE CITY SD)
10	421 (STEELTON-HIGHSPIRE SD)	146 (FARRELL AREA SD)	499 (YORK CITY SD)	222 (LANCASTER SD)	15 (AUSTIN AREA SD)

6.4 Efficiency Change & Determinants

6.4.1 Overview

The efficiency change of reading proficiency rate provides policy makers with information about the NCLB Act's impact under the turbulent times of the accountability regime. Furthermore, this study had determinants such as the salary share, state share, and equalized mills as well as AYP status of the NCLB Act. AYP status was used as an instrumental variable for the NCLB Act.

The yearly mean technical efficiency change of all school districts for variants of stochastic frontier models in reading proficiency rate presented in Figure 6.1 suggests that mean efficiency measures from the individual models increased slightly over the years with the exception of the Battese & Coelli model.

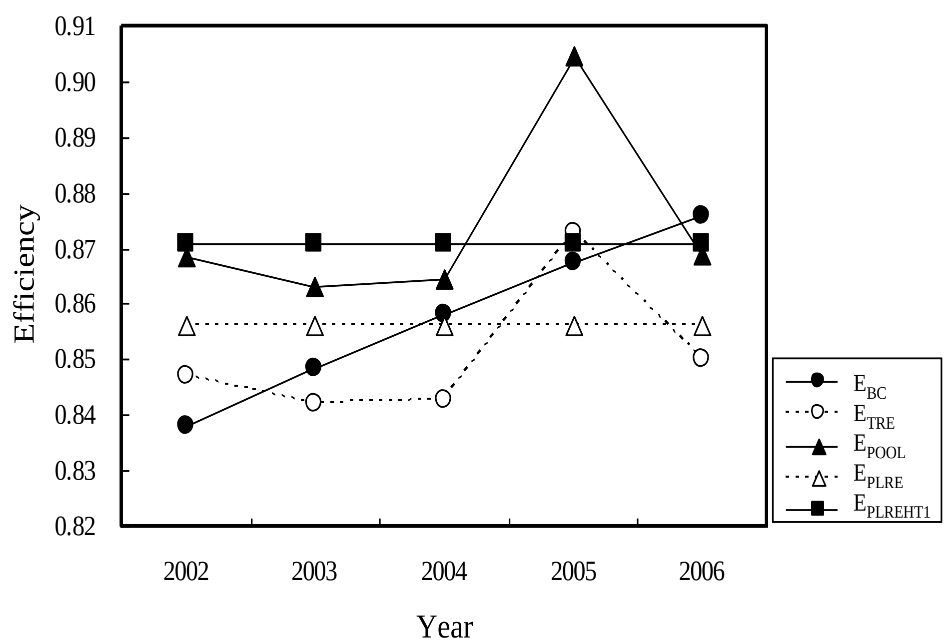


Figure 6.1 Average Efficiency Measures of Reading Proficiency Rate over Time

6.4.2 Determinants

As seen in Table 6.19, state share of school district revenue had a positive impact on efficiency change, as expected from a theoretical perspective. Also, the salary share of a school district was negatively associated with school district efficiency change. This is the same result as what could be theoretically expected. Equalized mills as the tax effort of school district had a positive impact on the efficiency change. This fact also confirms theoretical expectations.

Table 6.19 Relationship Between Efficiency Change and Determinants in Reading Proficiency Rate

Math, Tobit Model	Coefficient (BC)	t-value	Coefficient (RE)	t-value
Constant	-0.1606	-0.770	-5.8708	-1.387
β_1 (State Share)	1.4773	13.659(*)	9.7499	4.446(*)
β_2 (Salary Share)	-1.5888	-5.894(*)	-5.0590	-0.926
β_3 (Equalized Mills)	0.0604	16.836(*)	0.1560	2.170(*)
β_4 (AYP Status)	0.2692	18.088(*)	0.1828	0.608

(*): Statistical significance at the five percent level

Most importantly, the AYP status of the NCLB Act played a positive role in the efficiency change of school district. This supports AYP status, that is, the major component of the NCLB Act.

Table 6.20 Predictive Sign and Actual Sign of Efficiency Change Determinants in Reading Proficiency Rate

Math	Expected sign	Actual sign
Constant		
β *1* (State Share)	+	+
β 2 (Salary Share)	-	-
β 3 (Equalized Mills)	+	+
β *4* (AYP Status)	+	+

6.5. Productivity Change

6.5.1 Productivity change and Elasticity

During a five-year period, the productivity of Pennsylvania school districts related to reading proficiency rate increased by 4.2200, on average. In considering the cumulative percentage change, over a five-year period, the total factor productivity increased by 16.9 percent, due to the 8.6 percent upward shift in technology, the 4.8 percent increase in technical efficiency, and the 3.5 percent increase in productivity due to scale effects. According to Coelli et al. (2005), the annual percentage change measures of technical efficiency change, technical change, scale change, and total factor productivity change were calculated for each school district in each pair of adjacent years. These measures were averaged across school districts and then converted into cumulative percentage change measures, as seen in Table 6.21 and Figure 6.2.

Table 6.21 Cumulative Percentage Change of TEC, TC, SC, and TFPC in Reading Proficiency Rate

	Efficiency Change	Technical Change	Scale Change	Total Factor Productivity Change
2002	0.0000	0.0000	0.0000	0.0000
2003	1.3465	3.2866	-2.3072	2.3259
2004	2.5954	5.9218	-0.1326	8.3846
2005	3.7538	7.6724	1.2572	12.6834
2006	4.8282	8.5550	3.4968	16.8801
Mean	1.2071	2.1388	0.8742	4.2200

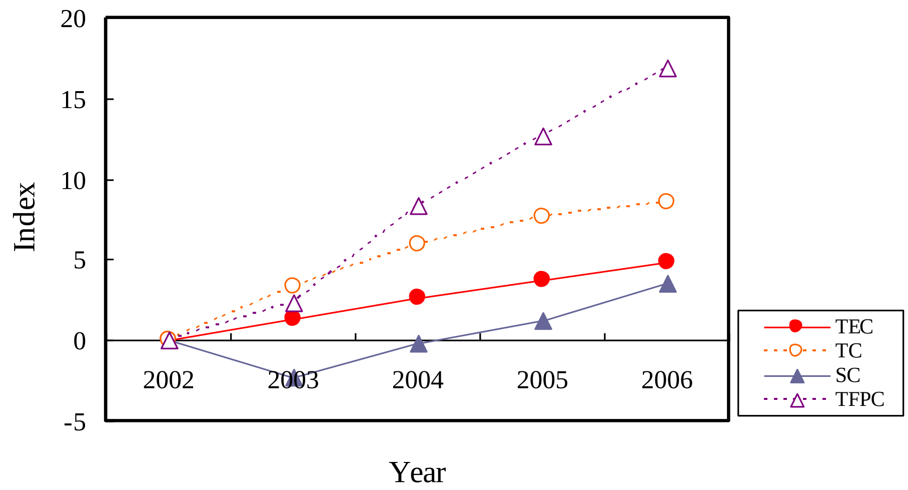


Figure 6.2 Cumulative Percentage Change of TEC, TC, SC, and TFPC in Reading Proficiency Rate

During a five-year period, the sum of seven production elasticities was 1.185, being calculated from the sum of (-0.1824+0.1496+0.1895-0.0464+0.7810+0.2878+0.0057), as seen in Table 6.8. This represents increasing returns to scale at the sample mean data point. This came from coefficients of maximum-likelihood estimates of the stochastic frontier model. However, considering the elasticity of the technical efficiency with respect to the input variable, the sum of seven production elasticities resulted in 1.371, as seen in Table 6.22.

Table 6.22 Elasticity of Input Variables in Reading Proficiency Rate

	Elasticity							Scale
	X1 (INST)	X2 (SUP)	X3 (SALARY)	X4 (SERVICE)	X5 (NIEP)	X6 (NECO)	X7 (1/ADM)	
2001	-0.305	0.174	0.564	-0.198	0.676	0.499	-0.005	1.406
2002	-0.232	0.144	0.358	-0.153	0.746	0.441	-0.014	1.289
2003	-0.199	0.148	0.337	-0.164	0.860	0.377	-0.014	1.346
2004	-0.159	0.141	0.306	-0.162	0.946	0.322	-0.010	1.384
2005	-0.097	0.131	0.259	-0.140	1.006	0.281	-0.011	1.429
Mean	-0.198	0.148	0.365	-0.163	0.847	0.384	-0.010	1.371

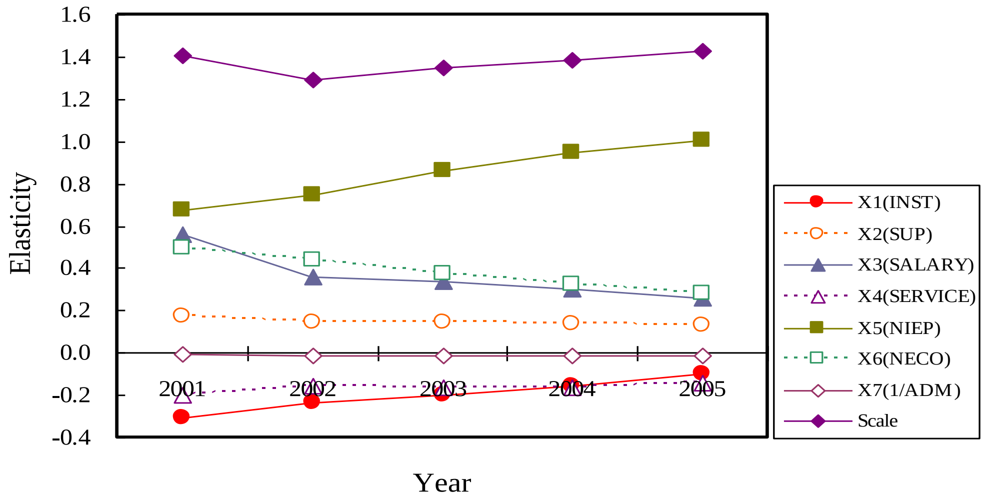


Figure 6.3 Elasticity of Input Variables in Reading Proficiency Rate

6.5.2 Productivity Change

6.5.2.1 Location Type

In the case of location type, the Northeast region had the highest total factor productivity change. This came from the improvement of scale effect change. The Southeast region had the lowest, because this region had the largest scale effect change at -11.53.

Table 6.23 Location Types and Total Factor Productivity Change in Reading Proficiency Rate

ReadPRO	TEC	TC	SC	TFPC
Northwest region (1)	1.309	0.675	0.970	2.954
North-central region (2)	1.235	1.869	0.286	3.389
Southwest region (3)	1.258	2.979	3.172	7.409
South Allegheny (4)	0.928	2.586	-0.202	3.312
Central region (5)	1.009	3.387	1.455	5.851
South-central region (6)	1.326	0.903	-0.023	2.206
Southeast region (7)	1.388	2.918	-11.528	-7.222
Northeast region (8)	1.385	3.694	5.118	10.197
Northern Tier (9)	0.831	2.201	-0.277	2.755

6.5.2.2 Locale Type

In considering locale type, the total factor productivity change of *remote rural* was the largest, resulting from the largest improvement of scale effect change. On the other hand, *small city* is the lowest.

Table 6.24 Locale Types and Total Factor Productivity Change in Reading Proficiency Rate

	TEC	TC	SC	TFPC
Midsize city (000)	1.340	1.827	1.607	4.775
Small city (001)	1.128	1.664	0.036	2.828
Large suburb (002)	1.406	3.288	-12.542	-7.848
Midsize suburb (003)	1.683	6.657	2.114	10.454
Small suburb (004)	2.384	5.887	0.186	8.458
Fringe town (005)	0.847	0.359	0.238	1.444
Distant town (006)	1.165	2.584	3.118	6.866
Remote town (007)	0.929	1.896	-0.098	2.726
Fringe rural (008)	1.162	2.614	0.286	4.061
Distant rural (009)	0.940	2.569	0.467	3.977
Remote rural (010)	1.148	2.831	9.201	13.180

6.5.2.3 AYP Status

The effect of AYP status on the total factor productivity change was positive except for the *correction I* phase. Most importantly, the *school improvement II* phase was the largest. On the contrary, the *correction I* phase had a negative impact on the productivity change. The reason for this is that the AYP status had a negative association with the scale effect of the *correction I* school districts.

Table 6.25 AYP Status and Total Factor Productivity Change in Reading Proficiency Rate

	TEC	TC	SC	TFPC
Met AYP (000)	0.973	1.574	0.028	2.575
Making Progress (001)	1.354	2.973	0.720	5.047
Warning (002)	1.561	2.660	2.790	7.011
School Improvement I (003)	1.411	1.829	2.072	5.312
School Improvement II (004)	2.435	4.162	27.438	34.035
Correction I (005)	2.797	5.740	-10.952	-2.415
Correction II (006)	7.283	18.213	-20.025	5.470

6.5.2.4 Highest Total Factor Productivity Change

As a result, the highest in the total factor productivity change in reading proficiency rate are seen in Table 6.28. The school districts highest in reading proficiency rate were the five percent of all school districts.

Based on the 25 highest total factor productivity change school districts, as seen in Table 6.28, we divided the highest productive school districts according to nine location types to obtain Table 6.26.

Table 6.26 Location Types and Productive School Districts

Type	Code	Number of productive school districts
Northwest region	1	1
North-central region	2	6
Southwest region	3	7
South Allegheny	4	4
Central region	5	0
South-central region	6	0
Southeast region	7	5
Northeast region	8	2
Northern Tier	9	0

As a result, the highest productive school districts came from the Southwest, North-Central, and Southeast regions. However, the Northern tier, South-central, and Central regions do not have the highest school districts.

Table 6.27 Locale Types and Productive School Districts

Type	Code	Number of productive districts
Large city	11	0
Midsize city	12	1
Small city	13	2
Large suburb	21	9
Midsize suburb	22	0
Small suburb	23	0
Fringe town	31	1
Distant town	32	0
Remote town	33	2
Fringe rural	41	8
Distant rural	42	0
Remote rural	43	1

Also, the 25 school districts were also divided into 12 locale types. As a result, the highest productive school districts came from *large suburb* and *fringe rural*. However, *Midsize suburb*, *small suburb*, and *distant rural* did not have the highest productive school districts in reading proficiency rate, as seen in Table 6.27.

Simultaneously, this study investigated the relationship between the highest total factor productivity change school districts and exogenous factors in order to find the commonalities of the highest total factor productivity change school districts for a benchmarking tool, as seen in Table 6.28.

Table 6.28 School Districts Highest in Total Factor Productivity Change and Exogenous Factors in Reading Proficiency Rate

N	ID	TEC	TC	SC	TFPC	X1 (SIZE)	X2 (StateShare)	X3 (SalaryShare)	X4 (EqMills)	X6 (LOCAT)	X7 (LOCALE)
1	494	1.916	6.228	311.673	319.816	3922.5	0.2983	0.6402	31.05	3	21
2	406	1.938	6.004	161.544	169.485	69.9	0.5924	0.5249	33.03	3	42
3	206	1.648	4.676	65.892	72.216	31.2	0.5762	0.5553	20.18	2	33
4	243	2.225	5.438	33.480	41.142	2485.1	0.5483	0.6890	29.45	3	21
5	381	0.774	7.032	25.569	33.375	61.2	0.5792	0.5335	19.20	4	42
6	125	4.921	36.403	-8.377	32.946	3610.8	0.6720	0.5629	38.75	3	21
7	361	0.837	4.120	26.189	31.146	42.7	0.5451	0.6838	22.13	2	33
8	268	2.287	3.344	22.990	28.621	5086.3	0.2632	0.6304	31.58	7	21
9	170	2.303	10.241	15.307	27.851	1080.8	0.5198	0.6151	24.00	4	13
10	36	1.987	4.979	19.834	26.800	690.2	0.5604	0.6444	30.95	3	21
11	167	1.231	5.555	18.590	25.376	56.6	0.6517	0.6378	23.58	2	42
12	437	1.951	0.192	21.256	23.398	29.1	0.6500	0.6247	10.48	4	42
13	356	3.960	9.991	8.379	22.329	8071.6	0.5815	0.7164	28.45	7	13
14	161	0.561	6.481	15.163	22.204	9.9	0.4569	0.7589	16.95	2	43
15	27	3.178	3.310	15.159	21.646	2787.9	0.2200	0.6899	23.68	7	21
16	480	1.933	4.739	13.522	20.195	91.2	0.3402	0.6334	16.98	8	42
17	102	2.248	5.184	11.199	18.632	1986.5	0.2628	0.6303	27.55	3	21
18	49	3.434	2.442	10.737	16.613	3244.2	0.2909	0.6580	30.48	7	21
19	35	0.671	3.986	9.541	14.198	168.8	0.6914	0.5831	20.58	3	42
20	439	1.551	5.625	6.638	13.814	44.4	0.6722	0.6977	14.88	4	42
21	405	3.577	2.531	7.676	13.784	6874.7	0.3497	0.6984	30.65	7	21
22	236	1.416	5.646	6.344	13.405	177.3	0.5115	0.4905	26.43	8	31
23	89	2.094	6.265	4.795	13.155	58.2	0.5385	0.6824	17.50	2	41
24	184	0.920	7.981	4.127	13.028	31	0.6638	0.6942	18.75	2	42
25	140	0.691	8.013	3.834	12.539	3705.8	0.4704	0.6899	24.28	1	12

The highest total factor productivity change school districts presented the diversity of factors that is similar to that of the efficiency study. The SIZE and StateShare of these school districts ranged from 69.9 to 8071.6 and 22 percent to 69 percent, respectively. In this context, SalaryShare and EqMills also showed various forms. Most importantly, these school districts resulted from higher scale effect change than other districts.

CHAPTER 7: COMPARISON, CONCLUSION, & POLICY IMPLICATIONS

This study investigated the efficiency of school districts as well as the productivity change over a five-year period. Chapter 5 and Chapter 6 discussed efficiency analyses in the math and reading proficiency rates as educational outputs of school districts, respectively. In this concluding chapter, to begin with, the efficiency and productivity of school districts are compared in both proficiency rates. Therefore, Section 7.1 also presents the conclusion of these analyses. The final section follows with the implications and limitations of this dissertation for policy makers and practitioners and then presents the suggestions for future study.

7.1. Comparison & Conclusion

The stochastic frontier analysis of math proficiency rate was compared with the reading proficiency rate according to these research areas: 1) efficiency measures; 2) efficiency variation and exogenous factors; 3) efficient school districts; 4) efficiency change and determinants; and 5) productivity change.

7.1.1. Efficiency Measures

Variants of the stochastic frontier models represents that the average efficiency of Pennsylvania school districts ranged from 77.48 percent (E_{PLRE}) to 82.98 percent (E_{TRE}) in math and 85.10 percent (E_{POOL}) to 87.40 percent (E_{TRE}) in reading, respectively, as seen in Table 7.1. That is to say, on average, this also shows that school districts in Pennsylvania had an average inefficiency of 22.52 percent to 17.02 percent in math and

14.90 percent to 12.60 percent in reading, respectively.

Table 7.1 Efficiency Measures of Various Panel Models in Math and Reading Proficiency Rate

	Math Proficiency Rate				Reading Proficiency Rate			
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
E_{BC}	0.7759	0.1337	0.1092	0.9834	0.8576	0.939460E-01	0.2364	0.9850
E_{POOL}	0.7908	0.1089	0.5427	0.9732	0.8510	0.810409E-01	0.6813	0.9857
E_{PLRE}	0.7748	0.1340	0.1207	0.9824	0.8563	0.939072E-01	0.2825	0.9829
$E_{PLREHT1}$	0.7948	0.1436	0.1175	0.9822	0.8710	0.1023	0.2470	0.9872
E_{TRE}	0.8298	0.1044	0.5185	0.9837	0.8740	0.822366E-01	0.5519	0.9891

Which of the five stochastic frontier models explains the efficiency of Pennsylvania best? The conclusion of this study was the Battese & Coelli model. In this study, the five stochastic frontier models were the Battese & Coelli model, pooled data model, conventional random effects model, heterogeneous random effects model, and true random effects model. The focus of the discussion was the school district rank of each model, because policy makers are interested in rank rather than absolute value. Even though the methods do not always rank the school districts similarly, they are useful for policy purposes if they are consistent in identifying which are the most efficient and least efficient school districts (Abdulai et al., 2007).

First, the rank of school districts in the Battese & Coelli model was closely related to that of other models rather than that of the true random effects model. Table 5.4 and Table 6.3 signify the Spearman rank correlation among variants of the stochastic frontier models in math and reading. The way to identify the best model is connected with the common ground of various panel data models. The efficiency measures of the true random effects model were larger than those of the other models. That is why the true random effects model could separate the unobserved school district heterogeneity from efficiency measures. However, a potential correlation between school district heterogeneity and explanatory variables in this model could be a reason for a rank problem.

Second, the rank of the efficient school districts in the Battese & Coelli model was consistent with that of other models rather than the true random effects model. All variants of the stochastic frontier models yielded school districts efficient in both math and reading proficiency at 0.05 percent of all 492 Pennsylvania school districts. Eliminating school districts chosen as one of the efficient districts by one model at one time, this study identified 32 and 29 efficient school districts in math and reading proficiency rates, respectively. These efficient school districts of the Battese & Coelli model had a mutual consistency with other models, rather than the true random effects model. These school districts are shown in Table 5.16 and 6.14, respectively.

7.1.2. Efficiency Variation and Exogenous Factors

7.1.2.1. Education Production Frontier Estimation

Inputs of the stochastic Pennsylvania school district frontier were INSTRUCT and SUPPORT of traditional inputs, SALARY and SERVICE of quality differences, NIEP and NECO of environmental variables, and 1/ADM of quantity adjustments. These could have a positive or negative impact on the education production of proficiency rates in math and reading. A maximum likelihood estimation of this study provided the actual sign of these variables, as seen in Table 7.2.

Table 7.2 Inputs and Predicted and Actual Sign in Math and Reading Proficiency Rate

	Expected Sign	Math Proficiency Rate						Reading Proficiency Rate					
		POOL	BC	BC & Het.	PLRE	PLRE & Het.	TRE	POOL	BC	BC & Het.	PLRE	PLRE & Het.	TRE
Constant		(*)	(*)	(*)	(*)	(*)		(*)	(*)	(*)	(*)	(*)	
β 1 (INST)	+	- (*)	- (*)	- (*)	- (*)	-	- (*)	- (*)	- (*)	- (*)	- (*)	-	- (*)
β 2 (SUP)	-	+ (*)	+(*)	+	+ (*)	+	+ (*)	+ (*)	+(*)	+ (*)	+ (*)	+	+ (*)
β 3 (SALARY)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 4 (SERVICE)	+	-	- (*)	- (*)	- (*)	- (*)	- (*)	+	-	-	-	-	-
β 5 (NIEP)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 6 (NECO)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)
β 7 (1/ADM)	+	+ (*)	+	-	+	+	+ (*)	+ (*)	+	+	+	-	+ (*)
βt (TIME)	+	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)	+ (*)	+(*)	+ (*)	+ (*)	+ (*)	+ (*)

(*): Statistical significance at the five percent level

First, INST of the traditional inputs had a negative impact on the education production, which was not expected according to a theoretical background. Also, SUP of the traditional inputs was expected to be negative. But, the actual sign of SUP was positive. SALARY of input quality differences was positively associated with both proficiency rates. Contrary to theoretical expectations, SERVICE had a negative association with the stochastic frontier of school district education production, except for the pooled model in reading proficiency. That is to say, longer experience of classroom teachers could prevent school district from increasing proficiency rates of school districts.

Second, the NIEP and NECO factors were consistent with theoretical background. All coefficients were statistically significant in all stochastic panel models. Their coefficients were the largest among inputs. This was consistent with other studies that show the importance of students' socioeconomic variation on their performance, and therefore, increasing spending per student in school districts with a higher percentage students of these factors could result in poor performance of school districts. Environmental variables had an explanatory power over educational outputs. That is, socio-economic factors had the strongest impact on student success.

Third, the 1/ADM factor as one of the quantity adjustments variables had a positive role in education production, except for the Battese & Coelli heterogeneous model (BC & Het.) in math and the Pitt & Lee heterogeneous random effects model (PLRE & Het.) in reading.

7.1.2.2 Inefficiency Model and Institutional Factors

Table 7.3 shows the relationship between school district inefficiency and size and institutional factors of school districts. These included 1/SIZE, AR, HERF, LagPRIV. As a size factor, SIZE was population per square mile in a county. As a monitoring factor, AR was the market value over personal income aid ratio (MV/PI AR) of school districts, representing school district wealth.

HERF was the Herfindahl index of school districts, meaning the school district concentration and representing public competition. Most districts could reduce inefficiency if public school concentration (Herfindahl index) is lower. Private school enrollments were represented as the lagged value rather than the current value in the form of LagPRIV. As parents are dissatisfied with public school performance, they will move their children to private schools for better education next year.

Table 7.3 Inefficiency Model and Estimation of Coefficients in Math and Reading Proficiency Rate

	Math Proficiency Rate				Reading Proficiency Rate				Predicted sign	Actual sign
	BC & Het.	t value	PLRE & Het.	t value	BC & Het.	t value	PLRE & Het.	t value		
Constant	-0.2161	0.000	-1.2191	0.000	-0.5387	0.000	-1.7358	0.000		
α1(1/SIZE)	-0.1572	-5.395(*)					-0.3972	-6.115 (*)	+	-/-
α2 (AR)	1.7113	9.319 (*)	3.4495	10.847(*)	1.3634	10.182 (*)	3.0694	7.632 (*)	+	+/+
α3 (AR^2)	-0.4211	-0.960	0.8321	1.332	0.4031	1.865	0.9200	1.789	+	-/+
α4 (HERF)	-0.0170	-0.712	-0.1522	-3.095 (*)	-0.0546	-3.200 (*)	0.0398	0.696	+	-/+
α5 (LagPRIV)	0.0215	2.223 (*)	-0.0065	-0.095	0.0196	1.353	0.0180	0.202	-	+/-

(*): Statistical significance at the five percent level

First, the 1/SIZE factor had a negative association with the school district inefficiency with statistical significance at the five percent level in the Battese & Coelli and Pitt & Lee heterogeneous models. In other words, SIZE had a positive relationship with school district inefficiency. Consequently, in this sense, as school districts become more densely-populated, they will be inefficient.

Next, representing monitoring effects of voters and citizens, MV/PI AR (Market value/personal income aid ratio) was an instrument variable for school district wealth. The wealthier school districts are, the more voters increase the pressure to monitor school district performance (Duncombe et al., 1997). The aid ratio factor had a positive impact on school district inefficiency statistically significant at the five percent level. As the MVPI aid ratio of school districts increases, the school district efficiency decreases.

Third, overall, there was no clear relationship between competition factors and inefficiency, as seen in Table 7.3. On the one hand, the HERF factor had a negative association with school district inefficiency, except for Pitt & Lee heterogeneous model in reading. As a school district dominates the county education system, school district inefficiency will be reduced. On the other hand, LagPRIV played a positive impact on school district inefficiency. However, there was a negative relationship between LagPRIV and inefficiency in the Pitt & Lee heterogeneous model in math.

To summarize, monitoring school districts had a tendency to increase technical efficiency, but, increased competition was not a panacea (Grosskopf et al., 2001). This study shows that a mix of policy tools is not appropriate for public education, because the manipulation of the number of private schools does not result in good-quality public education automatically.

7.1.3. Efficient School Districts

7.1.3.1 Needs Analysis

Table 7.4 compares efficiency measures of the Battese & Coelli model (E_{BC}) with needs of school districts (Needs) in terms of math and reading. Just allocating the adequate funding to school districts is meaningless without efficiency analysis. Accordingly, the relationship between school district needs and efficiency measure is the focus of this analysis

.

Table 7.4 Needs of School Districts and Efficiency Measures of Math and Reading Proficiency Rates

Math Proficiency Rate			Reading Proficiency Rate		
N	Needs	E_{BC}	N	Needs	E_{BC}
2	1.192	0.859	2	1.192	0.911
33	1.183	0.785	5	1.183	0.861
75	1.175	0.780	3	1.175	0.866
98	1.164	0.759	47	1.164	0.848
107	1.154	0.784	120	1.154	0.866
120	1.145	0.778	107	1.145	0.858
47	1.136	0.787	98	1.136	0.855
3	1.126	0.887	75	1.126	0.943
5	1.111	0.657	33	1.111	0.769
2	1.090	0.513	2	1.090	0.603

There was no evident relationship between school district needs and efficiency measures. However, overall, school districts of higher needs had better efficiency measures. Therefore, adequate funding for higher needs school districts had rationality from the viewpoint of efficiency measurement.

Table 7.5 also represents that 25 school districts were 0.05 percent highest adequate funding school districts among all school districts suggested by the costing out study.

The efficiency measures of the Upper Merion Area, Cheltenham Twp, Neshaminy, and

Colonial school districts in both proficiency rates were below 80 percent. However, their adequate funding was the highest among school districts.

Table 7.5 Comparison of Adequacy and Actual Spending Per Pupil with Efficiency Measures in Math and Reading Proficiency Rates

N	School District	Comparison	Math		Reading	
			E_{BC}	Rank	E_{BC}	Rank
1	Lower Merion (233)	$4972	0.9199	432	0.9545	435
2	Jenkintown (203)	$2792	0.8503	329	0.9266	361
3	Bryn Athyn (N)	$2712				
4	Pittsburgh (N)	$2330				
5	Radner Twp (355)	$2048	0.9635	480	0.9712	477
6	Upper Merion Area (452)	$1933	0.7301	156	0.7427	42
7	New Hope-Solebury (282)	$1904	0.8474	324	0.8825	265
8	Cheltenham Twp (81)	$1675	0.7231	147	0.7981	107
9	Quaker Valley (353)	$1586	0.8962	404	0.8988	307
10	Fox Chapel Area (155)	$1171	0.8891	391	0.9558	440
11	Tredyffrin-Easttown (431)	$1082	0.9370	448	0.9690	473
12	Neshaminy (278)	$1062	0.6083	53	0.7598	62
13	Colonial (92)	$985	0.6603	85	0.7822	92
14	Springfield Twp (417)	$979	0.8174	283	0.8844	271
15	North Allegheny (286)	$773	0.9456	456	0.9584	445
16	Phoenixville Area Twp (338)	$622	0.8223	285	0.9535	429
17	Mt Lebanon (274)	$556	0.9670	482	0.9731	480
18	Rose Tree Media (369)	$442	0.8027	263	0.9488	422
19	Wissahickon (493)	$367	0.8526	334	0.9418	407
20	Indiana Area (197)	$269	0.9549	469	0.9513	427
21	Sullivan County (424)	$259	0.9133	425	0.9415	406
22	Allegheny Valley (5)	$217	0.8721	369	0.8917	286
23	State College Area (419)	$165	0.9746	489	0.9658	462
24	Marple Newtown (240)	$131	0.7868	238	0.8979	304
25	Saucon Valley (374)	$119	0.8033	265	0.8928	290

* Comparison: adequacy and actual spending per pupi

Most interestingly, the Marple Newtown School District provided one of the important policy implications as to whether adequate funding could be utilized for attain a high math or reading proficiency rate. As a consequence, it is reasonable that the state government require school districts to make a plan of action in order to obtain adequate funding for productive efficiency and adequacy. For this reason, school funding has to be explained under three frameworks: equity, adequacy, and efficiency simultaneously (Ruggiero et al., 2002; Reschovsky & Imazeki, 2001).

7.1.3.2. Efficient School Districts

Identifying a standard type of efficient school districts is a critical task for researchers. That is why efficient school districts are a benchmarking tool for inefficient school districts. However, this study did not solidify key indicators of efficient school districts. Table 5.17 of Chapter 5 and Table 6.15 of Chapter 6 identified efficient school districts and rank key indicators in both math and reading proficiency rates. The efficient school districts of this study presented diversity in differences rather than evident similarities under the stochastic frontier analysis. This is similar to the result of the Kansas School District efficiency study by Standard & Poor's, using the data envelopment analysis. However, eight of the school districts efficient in math and ten of the school districts in reading were located in the Southwest region. Also, 15 and 12 of the school districts efficient in both proficiency rates were located in large suburbs. More interestingly, 19 efficient school districts in math and 14 efficient school districts in reading were located in the suburb area, as seen in Table 7.6.

Table 7.6 City, Suburb, Town, and Rural Types and Efficient School Districts in Math and Reading Proficiency Rates

	Math proficiency rate	Reading proficiency rate
City	2	0
Suburb	19	14
Town	6	9
Rural	5	6

7.1.4. Efficiency Change and Determinants

Table 7.7 represents the relationship between school district efficiency change and its determinants in both math and reading proficiency rates. The determinants of school district efficiency change were state share of school district revenue (StateShare), salary share of school district expenditure (SalaryShare), equalized mills (EqMills), and AYP status of school districts (AYP).

Table 7.7 Relationship between Efficiency Change and Determinants in Math and Reading Proficiency Rate

	Math Proficiency Rate				Reading Proficiency Rate			
	BC	t-value	RE	t value	BC	t-value	RE	t value
Constant	-0.1888	-1.437	-10.4920	-1.876	-0.1606	-0.770	-5.8708	-1.387
β_1 (State Share)	1.1645	17.104(*)	17.5896	6.119(*)	1.4773	13.659(*)	9.7499	4.446(*)
β_2 (Salary Share)	-1.1296	-6.657(*)	-3.9938	-0.553	-1.5888	-5.894(*)	-5.0590	-0.926
β_3 (Equalized Mills)	0.0445	19.691(*)	0.2445	2.586(*)	0.0604	16.836(*)	0.1560	2.170(*)
β_4 (AYP Status)	0.1386	14.790(*)	-0.3276	-0.830	0.2692	18.088(*)	0.1828	0.608

(*): Statistical significance at the five percent level

On the one hand, StateShare had a positive impact on the efficiency change statistically significant at the five percent level. On the other hand, SalaryShare was negatively associated with the efficiency change. The larger school districts' burden of salary share is, the less they try to increase their efficiency for better school district performance. School district tax effort, that is, equalized mills, was positively related to the efficiency change.

As discussed in Chapter 2, there has been a critical expectation that school districts have to transform inputs into outputs efficiently under the NCLB accountability regime. The relationship between the AYP status component and efficiency change convinces positive evidence of the AYP status component of the NCLB Act with the exception of the random effects model in math.

7.1.5. Productivity Change

In considering the cumulative percentage change over a five-year period, the total factor productivity increased by 14.2 percent and 16.9 percent, due to the 8.6 percent and

8.6 percent upward shift in educational technology, the 3.1 percent and 4.8 percent increase in technical efficiency, and the 2.6 percent and 3.5 percent increase in productivity due to scale effects in math and reading proficiency rates, respectively. In both proficiency rates, technical change improvement over a five-year period made a major contribution to the total factor productivity change of Pennsylvania school districts.

Table 7.8 Cumulative Percentage Change Measures of TEC, TC, SC, and TFPC in Math and Reading Proficiency Rate

	Math Proficiency Rate				Reading Proficiency Rate			
	TEC	TC	SC	TFPC	TEC	TC	SC	TFPC
2002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2003	0.7956	3.2910	-0.9669	3.1197	1.3465	3.2866	-2.3072	2.3259
2004	1.5692	5.9284	1.9691	9.4667	2.5954	5.9218	-0.1326	8.3846
2005	2.3215	7.6794	2.9179	12.9188	3.7538	7.6724	1.2572	12.6834
2006	3.0531	8.5558	2.6273	14.2362	4.8282	8.5550	3.4968	16.8801

The AYP status, as a major component of the NCLB Act, was a critical concern for the state government and school districts in Pennsylvania. In terms of AYP status component, *school improvement II* phase had the largest total factor productivity change in both proficiency rates. Therefore, *school improvement II* phase was effective for Pennsylvania productivity change for math and reading. However, *correction I* phase was not effective for productivity change in either math or reading. The reason for this resulted from scale change.

In summary, the effect of AYP status on total factor productivity change was positive except for the *correction I* phase. Most importantly, *school improvement II* phase had the largest effect on the productivity change of school districts.

Table 7.9 AYP Status Types and Total Factor Productivity Change in Math and Reading Proficiency Rate

	Math Proficiency Rate				Reading Proficiency Rate			
	TEC	TC	SC	TFPC	TEC	TC	SEC	TFPC
Met AYP (000)	0.643	1.572	0.367	2.582	0.973	1.574	0.028	2.575
Making Progress (001)	0.803	2.978	0.911	4.692	1.354	2.973	0.720	5.047
Warning (002)	0.947	2.662	3.366	6.975	1.561	2.660	2.790	7.011
School Improvement I (003)	0.891	1.823	-0.054	2.661	1.411	1.829	2.072	5.312
School Improvement II (004)	1.558	4.172	7.082	12.811	2.435	4.162	27.438	34.035
Correction I (005)	1.778	5.744	-43.008	-35.486	2.797	5.740	-10.952	-2.415
Correction II (006)	4.436	18.241	-9.491	13.186	7.283	18.213	-20.025	5.470

Among cities, suburbs, towns, and rural areas, *suburb* had the highest total factor productivity change in math and *rural* had the highest in reading, as seen in Table 7.10. *Suburb* came from the contribution of technical change. The lowest area was *town* in math and reading. Most importantly, the highest school districts of the total factor productivity change presented diversity in key indicators in both math and reading proficiency rates.

Table 7.10 City, Suburb, Town, and Rural Types and Total Factor Productivity Change in Math and Reading Proficiency Rates

	Math proficiency rate				Reading proficiency rate			
	TEC	TC	SC	TFPC	TEC	TC	SC	TFPC
City	0.778	1.746	1.306	3.829	1.234	1.746	0.822	3.802
Suburb	1.212	5.280	0.957	7.450	1.824	5.277	-3.414	3.688
Town	0.710	1.614	-0.142	2.140	0.980	1.613	1.086	3.679
Rural	0.649	2.671	1.096	4.416	1.083	2.671	3.318	7.073

7.2 Policy Implications

The findings and conclusions of this study provide several recommendations for policy makers and practitioners from policy and practice perspectives. Generally, the education community of school finance focuses on equity and adequacy rather than efficiency. Some of the education community tends to feel that the findings of this study could provide evidence of budget cuts and the performance-based merit pay system. However, appropriate equity and adequacy analysis is impossible without assessing the efficiency and productivity principle. The ultimate objective of this study is to recommend that policy makers include the efficiency index in state government funding. The policy implications of this study are: 1) the effect of the Adequate Yearly Progress (AYP) status component of the *No Child Left Behind* Act; 2) the identification of policy tools in school district efficiency change; 3) school district consolidation; 4) the foundation for school districts' operation plan; and 5) a benchmarking tool for school district efficiency and productivity improvement.

First, Pennsylvania school district efficiency change was closely related to the AYP status component of the NCLB Act. Furthermore, it is possible that technical change improvement of the total factor productivity change could result from the capacity building and improvement of the NCLB Act.

The impact of the NCLB Act has been under question among educational stakeholders. Therefore, the reauthorization of this law has been a difficult task for the federal government, the state government, school districts, and other stakeholders. The perspective of the ministry, that is, the top-down approach of education policy, supports the spirit of the NCLB Act from the viewpoint of efficiency. In this context, the results of this study are consistent with the fact that there is a positive correlation between efficiency change of the accountability regime and student achievement of the NCLB Act.

A major contribution of school district total factor productivity change in Pennsylvania, on average, came from the technical change. According to Chakraborty (2003), positive technical change could result from the impact of skilled and trained professionals for the state government or school districts causing an outward shift of the school district educational production frontier initiated by the NCLB Act accountability system, highly qualified teachers, and professional development. That is to say, this would be capacity building and improvement of the state government and school districts in Pennsylvania. Capacity building could be effective in terms of the efficiency change as one of the policy instruments of the NCLB Act. The capacity building of this act focuses on the enhancement of skill and competence of professionals (McDonell & Elmore, 1987).

Conclusively, the technical change of Pennsylvania school districts could come from three sources: professional development, curriculum improvements, and other improvements not specified. Further studies need to analyze the effects of the three factors on productivity change separately.

Next, this study further identified the determinants of the efficiency change as tools of school district efficiency change: 1) state share of school district revenue; 2) the salary and benefits share of school district expenditure; 3) equalized mills of school districts; and 4) AYP status of school districts.

Educators tend to have a deficit think theory (Rodriguez, 2004) associated with socio-economic backgrounds of students. That is, they cannot control these factors fully in an educational context. Therefore, some scholars have connected institutional factors with the efficiency. However, this study shows there was no consistent relationship between competition factors and the efficiency change of school districts. As a consequence, from a policy viewpoint, these determinants are effective policy tools of the state government and school districts of Pennsylvania for the improvement of school district efficiency. Most importantly, a massive stimulus plan for education has been underway in the United States. This plan is not meaningful without the efficiency and productivity framework. That is to say, these four policy tools have critical implications for policy makers and practitioners in times of financial crisis.

Third, this study supports school district consolidation in Pennsylvania in terms of enrollment. Currently, Governor Rendell in Pennsylvania proposed a commission to study how to right-size Pennsylvania's local school districts best (Office of the Governor, 2009). His full-scale school consolidation proposes to relieve the local property tax burden. The Herfindahl factor of this study had a negative association with school district inefficiency. As a school district dominates the county education system, school district inefficiency will be reduced.

There is a conventional perspective that consolidation of small districts based on enrollment can result in cost savings, particularly in rural areas (Duncombe & Yinger, 2001). However, Duncombe & Yinger (2001) divided the costs of consolidation into five sources: 1) lower parental involvement, 2) lower student motivation and effort, 3) lower staff motivation and effort, 4) labor relations effects, and 5) higher transportation costs. Accordingly, further studies need to incorporate the instrumental variables of five sources in addition to enrollment.

Fourth, the operation plan for efficiency improvement would be used as a pre-phase step for the inclusion of the efficiency index in educational funding by the state government. This is because the adequate funding of the costing out study is not meaningful without efficiency analysis. The most critical criterion is how policy makers can apply the efficiency index into the stream of equitable and adequate funding for the realization of equitable, adequate, and efficient school finance. Unfortunately, the education community tends to hesitate to include the efficiency index in education funding. In general, the efficiency measure calculated from the stochastic frontier analysis is a difficult concept for the education community. As a result, the operation plan will be used as a pre-phase step for the inclusion of the efficiency index in education funding by the state government. However, the preliminary warning is that we have to recognize that schools and school districts have different philosophies (objectives) about how to achieve student success.

The state government will require school districts to submit the operation plan of each school district for systemic education reforms for productivity and efficiency. The operation plan suggested by Bessent et al. (1982) includes the school district's (schools') goals, activities, resources for goals and activities, and socio-economic backgrounds. Most importantly, it also includes the technical efficiency measures, target values, and so on. According to Bessent et al. (1982), this plan will be composed of four critical components:

- School district information to be utilized in the proposed plan.
- Management audit information for reviewing these plans before approval.
- System scanning information to balance scarce resources among schools.

- Annual review and accomplishment evaluation of the previous year's plan.

Last, practically, this study provides school districts with a benchmarking tool for school district efficiency improvement. The department of education and school district can work together to write district efficiency profiles, as suggested by *Standard and Poor's* (2007). District efficiency profiles will play a role in assessing and reviewing the efficiency of each school district. This profile will be composed of five parts:

- The first: the school district's efficiency index, its definition, and its role.
- The second: improvement of its efficiency score, output actual value, and target value.
- The third: inputs, outputs, and constraints of school districts.
- The fourth: the most efficient school districts identified as the efficient frontier.
- The fifth: the comparison of this school district with the most efficient school districts in terms of two standards: most similar frontier district and best-performing district.

7.3 Limitations

The primary purpose of this study was to investigate efficiency and its determinants of Pennsylvania school districts. However, this study has three major limitations: 1) the linkage of the AYP status of the *No Child Left Behind* Act with the efficiency change; 2) an indicator of student performance; and 3) an efficiency concept as an education goal. Therefore, prior to interpreting and applying any possible policy implications of this study, it is important and prudent for educational stakeholders to note the weaknesses of this study.

First of all, the effect of the AYP status of the NCLB Act on the efficiency change could be an associated relationship rather than a causal relationship. This study analyzed the AYP status impact of the NCLB Act on the efficiency change from the 2001-02 to 2005-06 school years.

AYP status is one of the NCLB Act components, which include the following: school choice programs, rewards and punishments, schools needing improvement, funding and flexibility, supplemental educational services, and graduation rates. This study focused on the relationship between the AYP status component and the efficiency change. The state government did not issue the AYP status of Pennsylvania school districts in the 2001-02 school year. It is very difficult to generalize the results of the study across all components of the NCLB Act.

In this context, this study cannot rule out the possibility of the effect of other factors on the efficiency change, because a transformation process of education production function is based on an open-systems perspective related to a human enterprise of education. That is to say, confounding factors could have a positive or negative impact on the education production function of this study. Furthermore, this study focused only on one state, Pennsylvania.

Accordingly, most importantly, using comparative analysis across the United States of America, we can compare the intensity effect of AYP and other factors on the efficiency change. Also, we can explore other components of the NCLB Act. Consequently, this will increase the external validity for generalization.

Next, some could question whether math and reading proficiency rates of the 11th grade are adequate or not for educational performance. This question is closely related to the adequacy of student performance. The success of the accountability system depends on the quality of the performance measures (Kane & Staiger, 2002). This study chose math and reading proficiency rates of the 11^{th} grade, because the 11^{th} grade could be a cumulative indicator of student performance from the viewpoint of development stages of students. Accordingly, the 11^{th} grade is more appropriate than other grades.

However, the distance function approach can provide us with estimation and analysis of multiple output production frontiers (subject and grade levels). That is to say, the production function approach has a major disadvantage related to multiple outputs (reading and math scores, dropout rates, and graduation rates).

Last, the efficiency concept is not necessarily a primal goal for education. Public education has multiple and diverse purposes (King-Rice, 2004; Alexander; 2004; Rodriguez; 2004). According to Boyd (1997), there has been a struggle among the contradictive objectives from different values: democratic and economic values. On the one hand, education is leveling the playing field of cultural and racial difference problems for social justice. One the other hand, education is a major investment to economic development.

Accordingly, some outputs may be preferred to others due to policy limitations or cultural/social values. Specifically, each school and school district has a different philosophy about educational outcomes. Some focus more on increasing students' test scores for their academic achievement. Others pay more attention to decreasing students' drop out rates for their social wellbeing.

In this context, we can apply the directional distance function to education in terms of the directional input and output distance functions. In other words, education has multiple objectives from the viewpoint of the distance function approach. Student achievement could have a trade-off relationship with other objectives. As a consequence, broader efficiency could be investigated in terms of multiple input and output frameworks, even though it is difficult to find instrumental variables for multiple outputs. Consequently, this approach could be a holistic approach to the efficiency measurement of multiple educational objectives.

7.4 Future Study

Future studies can be designed to include qualitative study as a form of mixed methodology. That is why this quantitative study cannot fully describe how the inside of schools changes in terms of efficiency related to student performance (Lee, 2004).

That is to say, this is a process problem of the educational production function associated with student performance. Accordingly, qualitative methodology will be needed to capture instructional best practices as a form of mixed methods.

Therefore, through the qualitative study, the next step is to investigate the curricular and policy practices of the school districts categories as relatively efficient and compare them to the curricular and policy practices of the relatively inefficient school districts. This could lead to the improvement of educational services offered by Pennsylvania school districts.

Education has multiple objectives from the viewpoint of the distance function approach posed by the limitation of this study. In this context, we can apply the directional distance function to the education in terms of the directional input and output distance functions. Future studies will deal with the efficiency and productivity analysis under the directional distance function.

Recent developments in educational research have focused on the schools, school classrooms, and educational programs. Consequently, the efficiency and productivity study could be more effective in classrooms and schools than in school districts. In this context, the critical task is on how researchers can define the inputs and outputs of education production or cost function. A different definition of educational inputs and outputs would result in different results of efficiency and productivity.

More interestingly, the private management of public schools could have an impact on educational efficiency and productivity. Through the stochastic frontier analysis, future studies could investigate diverse educational models in terms of efficiency and productivity frameworks. This may be closely related to the effectiveness of private management in education.

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