The Technical Efficiency of Small-Size Public Schools Using Micro-Survey Data: A DEA and Bayesian Approach

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Abstract

This paper examines technical efficiency among small-size schools in two provinces of Thailand by employing Data Envelopment Analysis. The survey techniques, Public Expenditure Tracing Survey and Quantitative Service Delivery Survey, are used as research instruments. The average efficiencies in constant returns to scale production technology are 83.4% and the variable returns to scale are 93.6%, respectively. Subsequently, we examine a factor that affects the degree of efficiency using the heteroscedastic Gibbs sampling Tobit model, where the data are censored between 0% and 100%. The results suggest that the schools in each province exhibit significant differences in efficiency. The teacher absence rate and vacancy rate are negatively correlated with school efficiency scores. However, parent education, school size, ratio of female to male students, and parent participation are significantly in explaining school efficiency. The school-based management framework, which is an accountability relationship among policymakers, service providers, and clients, is introduced to explain school performance.

Keywords: *Technical Efficiency*; *Educational output*; *Accountability Relationship*

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การวิเคราะห์ข้อมูลจุลภาคเพื่อทำนายประสิทธิภาพทางเทคนิคของโรงเรียนรัฐขนาดเล็ก โดยวิธี DEA และ Bayesian

จิระเดช ทัศยาพันธุ์*

บทคัดย่อ

บทความนี้วัตถุประสงค์เพื่อทำนายประสิทธิภาพทางเทคนิคของโรงเรียนของรัฐขนาดเล็กใน 2 จังหวัดทางภาคตะวันออกเฉียงเหนือโดยใช้เทคนิค Data Envelopment Analysis การสำรวจกลุ่มตัวอย่างใช้เครื่องมือวิจัยที่เรียกว่า Public Expenditure Tracking Surveys และ Quantitative Service Delivery Surveys ซึ่งผลการทำนายประสิทธิภาพโดยใช้สมมุติฐาน constant returns to scale มีค่าเท่ากับ 83.4% และสำหรับสมมุติฐาน variable returns to scale มีค่าเท่ากับ 93.6% การทดสอบในขั้นที่สองใช้ตัวแบบ heteroscedastic Gibbs sampling Tobit ซึ่งคะแนนประสิทธิภาพมีค่าระหว่าง 0% ถึง 100% ในการวิเคราะห์แสดงให้เห็นว่า โรงเรียนจากทั้ง 2 จังหวัดมีคะแนนประสิทธิภาพแตกต่างกันอย่างมีนัยสำคัญ อัตราการขาดงานและอัตราการว่างงานทำให้ประสิทธิภาพโรงเรียนลดลง อย่างไรก็ตาม ระดับการศึกษาของผู้ปกครอง ขนาดของโรงเรียน อัตราส่วนนักเรียนหญิง และการมีส่วนร่วมของผู้ปกครองทำให้ประสิทธิภาพของโรงเรียนสูงขึ้นอย่างมีนัยสำคัญ การอธิบายประสิทธิภาพของโรงเรียนใช้กรอบความคิดการจัดการโดยโรงเรียน ซึ่งเป็นความสัมพันธ์ของความรับผิดชอบระหว่าง ผู้กำหนดนโยบาย ผู้ให้บริการ และผู้รับบริการ

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Introduction

Technical efficiency refers to the use of productive resources to produce goods and services in the most technologically efficient manner. In education, technical efficiency may then refer to the physical relationship between the inputs (e.g. capitation grants, teachers, facilities) and outputs, or educational outcomes. These outcomes may either be defined in terms of immediate outputs, such as standard test scores, or a final educational outcome such as graduates' employment rates, starting salaries, or acceptance rates into higher education (Worthington, 2001: 247). It follows that a strong assumption held in this type of analysis is that technical relationships are of central importance in the educational process. If such relationships exist and can be quantified, policy can be constructed so as to maximize conceptual outcome. Much of the empirical research in this area is focused on identifying these technical relationships. The economic theory of production function says that given the amount of inputs, the production function defining the Pareto efficient given set of outputs is that if it is not possible to increase the quantity of any outputs without decreasing the quantity of any other outputs; in other words, for given the outputs, it is not possible to decrease the quantity of any inputs without increasing the quality of any other inputs. Efficient firms will produce goods and services at the frontier of production technology, since the deviation from the frontier means inefficiency. Following this logic, the empirical study of efficiency difference involves determining the production function and measuring the distance to the frontier of these individual observations.

Data envelopment analysis (DEA) is used to predict the efficiency of production function, which can incorporate multiple outputs in the model. DEA essentially calculates the efficiency of a given educational institution relative to the performance of other institutions. Thus, the production process of education consists of school and non-school inputs to produce multiple outputs (test scores). The Coleman report (Coleman et al., 1966: 21) suggests an input-output relationship between administrative resources allocation and students' achievement. Hanushek (1986: 1148-1155) surveyed 147 studies and suggested that expenditure per pupil, student/teacher ratio, teachers' education and teachers' experience, and family characteristics are the primary determinants of students' achievement. The conclusion of this survey seems giving the consistent with other papers. Expenditure per pupil and students' performance is not systemically related; however, family characteristics have an effect on students' performance.

Charnes et al. (1981: 668-697) may be one of the first studies that used DEA to predict school efficiency. Later, Bessent et al. (1984: 1-8), Smith and Mayston (1987: 181-189), Ludwin and Guthrie (1989:362-372), Fare et al. (1989: 469-428), and BonesrØnning and RattsØ (1994: 289-304) employed DEA to detect differences in technical efficiency among schools. Other studies that compared efficiency scores obtained by DEA among schools and computed the residuals of conventional regression analysis, such as Mayston and Jesson (1988: 321-339) and Sengupta and Sfeir (1988: 297-307), also concluded that the choice of method of analysis affects the school's ranking. Ray (1991: 1620-1628), McCarty and Yaisawarng (1993: quoted in Fried, Lovell and Schmidts, eds., 2008: 271-287), and Kirjavainen and Loikkanen (1998: 377-393) have applied a two-stage procedure by first using variables that are controlled by schools. Thereafter these efficiency differences are explained by

uncontrollable factors using the Tobit regression analysis. Mayston (2003: 679-690) pointed out that DEA can be used to assist in the process of making all groups within the educational system better off. He did this by identifying the scope of the Pareto improvements; that is, the feasible movement of educational outcomes closer to the production possibility frontier for each relevant pupil group. Rassouli-Currier (2007: 53) employed the stochastic frontier regression (SFR) in estimating inefficiency effects simultaneously with the production function. In this study, the empirical results of the SFR and DEA technique of the majority of Oklahoma school districts are not identical, suggesting that the method of estimation affects the efficiency scores. In general, the SFR generated a more favourable score than that of the DEA. However, both methods suggest that the most important determinants of inefficiency are the socioeconomic factors associated with each district.

North (1990: 3) states that "institutions are the rules of the game in a society, or more formally, the humanly devised constraints that shapes human interaction." In an abstract sense, there is a great deal of agreement on this statement. A perusal of recent literature suggests, however, that there is much less agreement on how to measure institutions empirically. Does the difference in institutional quality affect explain differences in economic outcomes? This study will incorporate the institutional factors into the model, and discuss whether these factors have an impact on students' achievement. The efficiency of public education is of concern in Thailand, despite the fact that capitation grants for pre-primary to upper-secondary education between 2005 and 2008 increased more than 14.3% annually. However, standard test scores such as national tests have not increased. For example, the average test score was 37.3% in academic year 2006 and about 37.7% in 2007. A hypothetical explanation of such failures is that educational resources may not be reaching the schools, as shown in

official records, which is a utilization problem. This paper attempts to predict the efficiency by employing multiple input and output technology and by analyzing the connection of the exogenous factors to the efficiency scores. Primary data from surveys of small-size public school in two provinces of northeastern Thailand were used in the study. The school-based management framework, which is the accountability relationship among policymakers, service providers, and clients, was introduced to explain school performance.

The paper is organized as follows. Section 2 presents the school-based management framework. Section 3 presents the methods of analysis, and section 4 explains the data and variables. Section 5 presents the results and section 6 presents the conclusion and policy implications.

School-based management framework

The public sector has taken on the responsibility of delivery of services to citizens. The center of the analysis is accountability relationships, which are a set of relationships among the actors which have five features (World Bank, 2003: 47):

Delegating: explicit or implicit understanding that a service (or goods embodying the service) will be supplied

Financing: providing the resources to enable the service to be provided or paying for it

Performing: supplying the actual service

Having information about the performance: obtaining relevant information and evaluating performance against expectations

Enforcing: being able to impose sanctions for inappropriate performance or providing rewards where performance is appropriate.

We can explain typical employment, forming an accountability relationship, as follows: a person is given a set of tasks (*delegation*) and is paid a salary (*finance)* from the employers. The employee executes (*performance*) the given tasks. The contribution of the employee is assessed (*information*) by the employers, and the employer acts to reinforce good performance, or discourages bad performance (*enforceability*). Financing is the first step in creating an accountability relationship; consequently, in order to be a "stakeholder," we need to put up a "stake" (Figure 1).

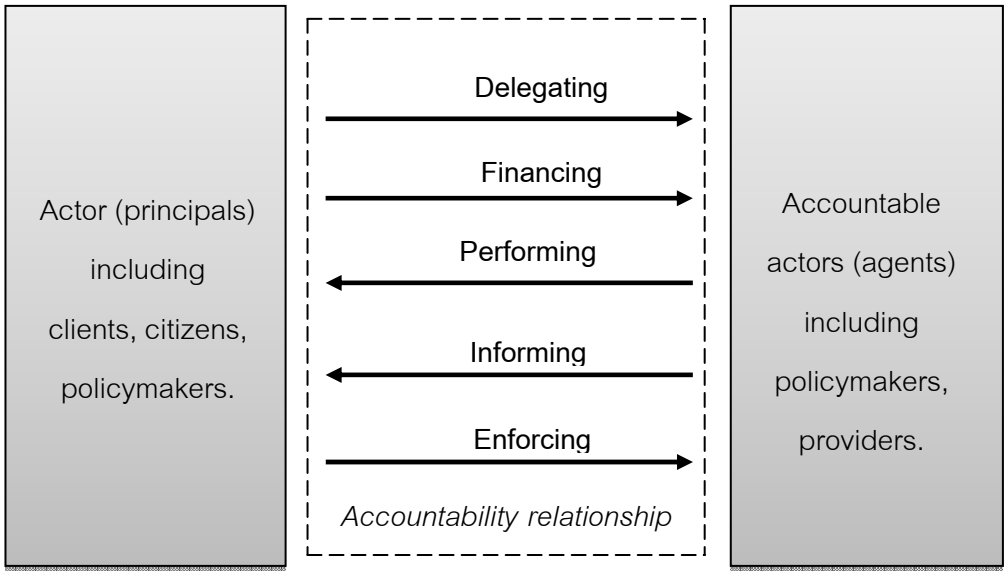

Figure 1: Five features of the accountability relationships

The four actors, which have five features in the chain of service delivery, can be defined as follows:

(*i*) *Citizens and clients*: they participate both as individuals and through coalitions in the political process; they also strive to control and direct public action in accomplishing objectives

(*ii*) *Politicians and policymakers*: politicians derive and control state power and discharge fundamental responsibilities. The actors that exercise the state power are policymakers. Politicians institute policy guidelines, and policymakers institute action plans for service providers to execute

(*iii*) *Organizational providers*: a provider organization can be an organization including a ministry, department, or agency. It can be large (educational ministries with tens of thousands of teachers and educational personnel) or small (a single community-run primary school). The policymakers make “internal policies” specific to the organization and enforce the action of frontline professionals to achieve the plan

(*iv*) *Frontline professionals*: all services require a provider that contacts clients; frontline professionals include teachers, doctors, nurses, and so on.

There are three accountability relationships among politicians/ policymakers, citizens/clients, and service providers. We explain each pair of the relationships as follows:

1) *Voice* use to express the complex relationships between politicians/ policymakers and citizens/clients. *Voice* is about politics, and covers formal and

informal relationships. *Delegation* and *financing* are about citizens/clients setting objectives, and politicians/policymakers allocate sufficient resources for service providers to deliver goods and services according to those objectives. Citizens/clients need *information* about the actions of service providers, and feed this performance information back to the politicians/policymakers. However, if politicians/policymakers neglect the needs of citizens/clients, they might have taken measures to make politicians/policymakers accountable to them.

2) *A compact* can be expressed as the relationship between politicians/ policymakers and service providers. *A compact* is not legally enforceable as a contract; it is a broad agreement and a long-term relationship between politicians/ policymakers. Politicians/policymakers allocate resources and delegate authority to the service providers.

3) *Management* is an administrative tool of providers to deliver efficient services in public organizations, and this tool seems to be inefficient compared to management in the business sector. Since frontline professionals (public officers) are the employees of the state. Citizens/clients do not directly *finance* the frontline professionals; as a result, it is difficult to strengthen accountability relationships.

4) *Client power* is a form of demand for services that citizens/clients reveal to service providers. Service providers respond to these demands of citizens/clients in exchange for their compensation. The “market link” is the “power of the purse” of the client, and which they pay in exchange for goods and services in the private sector. The market link is an idealized set of accountability relationships that relies on citizens/clients “choice,” backed by purchasing power. *The customer* “power of the purse” is the main creator of accountability relationships. The market link has

strengths and weakness in the service delivery process. One strength is that customers will buy goods and services with which they are satisfied; another strength is that the firm can manage its goods and services to meet the needs of customers. The weakness is that it responds exclusively to customer power, so there are no pressures for equity in the allocation of services and the collective objectives of citizens/clients in general will not be satisfied. The market link can be effective in providing customer power discipline providers only when the customer has the relevant information about the provider's performance. However, even if the customer has adequate information, if there is no "loyalty," it will be difficult to create accountability relationships.

A competitive market automatically creates accountability of sellers to buyers. The key information is customer satisfaction, and the key element of *enforceability* is the customer's choice of supplier. "Competitive markets have proved a remarkably robust institutional arrangement for meeting individual interests (World Bank, 2003)," but they are not enough for public services for three reasons:

- The market responds only to those with purchasing power, and does nothing to ensure universal access or equitable distribution, which societies often have as collective objectives.

- The sum of individual interests may not produce the best outcomes because markets may have failures of various kinds.

- Other collective objectives may require public action. For instance, the state and society have a strong concern about the role of schooling in the socialization of youth and may not want parents to choose for themselves.

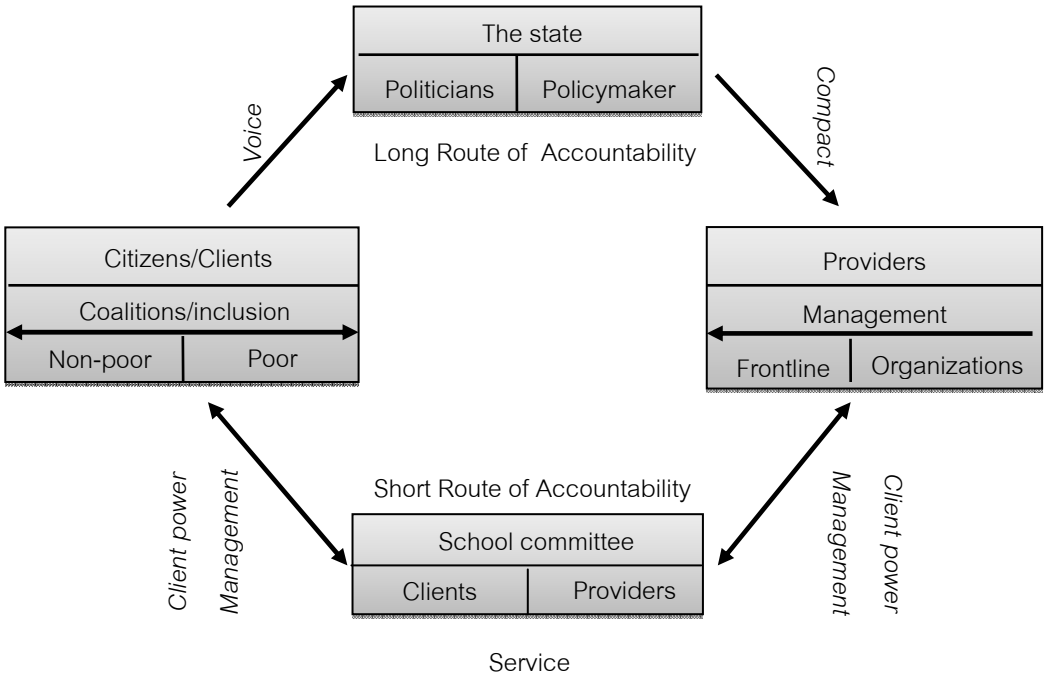

Figure 2: School-based management and accountability relationships

In a certain SBM framework, the accountability of school principals (service providers) is upward to the ministry (politicians/policymakers) that holds them responsible for providing services to the clients (parents/students) who, in turn, have put the politicians/policymakers in power and thus have the *voice* to hold them accountable for their performance. In most cases of SBM, the *management mechanism* change under reforms process. The clients themselves become part of the *management*; as a result, the short route of accountability becomes even shorter, as the representative of the clients (either parents or community members) gets the authority to make certain decisions and has a *voice* in decisions that directly affect the students attending the school. The SBM framework is introduced whereby the school administrator, whether the head teacher alone or a committee of parents and teachers,

acts as the accountable entity (Figure 2). This *client's power* and *management* institute the "non-market direct link."

The quality of public service is difficult to monitor; this is called a "monitoring problem" since locally-produced services such as basic education have some characteristics that make it particularly difficult to structure the relationship of accountability. In education, service is *transaction-intensive*, and this transaction requires discretionary judgments in the services delivery, present challenges for any relationship of accountability because it is difficult to know whether the provider has performed well. Additionally, it is difficult to monitor the millions of daily interactions of teachers with students. As a result, rigid, script rules would not provide enough latitude in the case of multi-principals and multi-tasks, where public servants "serve many masters."

Methods: DEA and Bayesian econometrics

The first stage of the analysis employed the DEA model using quantitative data, and the results of the analysis are represented by the technical efficiency scores. Subsequently, the second stage employed Bayesian econometrics, the Gibbs sampling Tobit model, connecting the exogenous variables to explain school efficiency.

Data envelopment analysis

The basis for the frontier analysis is provided by Koopmans (1951 quoted in Fried, Lovell and Schmidt: 2008: 20), which provided a formal definition of technical efficiency: "a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one input, and if a

reduction in any input requires an increase in at least one other input or a reduction in at least one output". Thus, a technically inefficient producer could produce the same outputs with less of at least one input or could use the same inputs to produce more of at least one output. Debreu (1951: 275-291) and Farrell (1957: 254-260) introduced a measure of technical efficiency. With an input-conserving orientation, their measure is defined as one minus the maximum equiproportionate (i.e., radial) reduction in all inputs that is feasible with given technology and outputs. With an output-augmenting orientation, their measure is defined as the maximum radial expansion in all outputs that is feasible with given technology and inputs. In both orientations, a value of unity indicates technical efficiency because no radial adjustment is feasible, and a value different from unity indicates the severity of technical inefficiency.

Farrell's (1957: 254-260) argument is contained in Figure 3, where two inputs, x_1 and x_2 , are utilized to produce a single output, y, so that the production frontier is $y = f(x_1 , x_2)$. If we assume constant returns to scale, then $1 = f(x_1/y, x_2/y)$. The isoquant of the fully-efficient firm SS' permits the measurement of technical efficiency. Now, for a given organization using quantities of inputs (x_1^*, x_2^*) defined by point P $(x_1^*/y, x_2^*/y)$ to produce a unit of output y^*, the level of technical efficiency may be defined as the ratio OQ/OP. This ratio measures the proportion of (x_1^*, x_2^*) actually necessary to produce y^*.

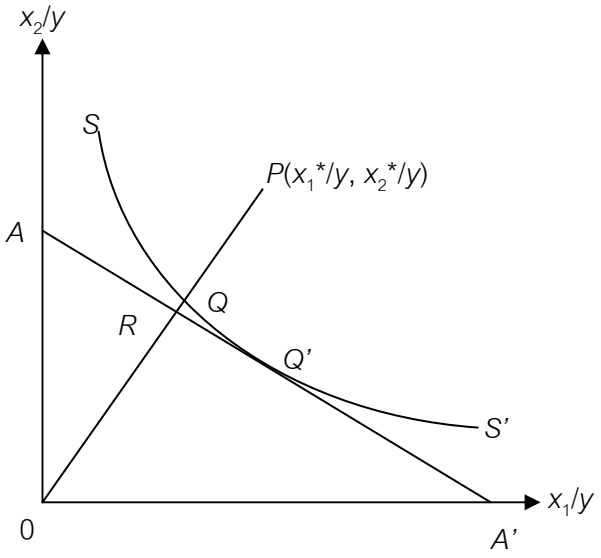

Figure 3: Farrell's technical and allocative efficiency

Thus, 1 – *OQ*/*OP*, the technical inefficiency of the organization, measures the proportion by which (x_1^*, x_2^*) could be reduced (holding the input ratio x_1/x_2 constant) without reducing output. It accordingly measures the possible reduction in the cost of producing y*. Furthermore, given constant returns to scale, it also roughly estimates the proportion by which output could be increased, holding (x_1^*, x_2^*) constant. Point *Q*, on the other hand, is technically efficient since it already lies on the efficient isoquant.

Let producers use inputs $x = (x_1, \ldots, x_N) \in R_N^+$ to produce output, $y = (y_1, \ldots, y_M) \in R_M^+$. Production technology can be represented by the production set

$$T = \{(y, x): x \text{ can produce } y\}. \quad (1)$$

Koopmans's definition of technical efficiency can now be stated formally as $(y, x) \in T$ is technically efficient if, and only if, $(y', x') \notin T$ for $(y' - x') \geq (y - x)$.

The orientated output augmentation production technology can be represented by output sets (Shephard, 1953 quoted in Fried, Lovell and Schmidt, eds., 2008: 21)

$$P(x)=\{y:(x,y)\in T\}, \quad (2)$$

which for every $x\in R_{+}^{N}$ has output isoquants

$$I(x)=\{y:y\in P(x),\lambda y\notin P(x),\lambda>1\} \quad (3)$$

and output efficient subsets

$$E(x)=\{y:y\in P(x),y'\notin P(x),y'\geq y\}, \quad (4)$$

and the three sets satisfy $E(x)\subseteq I(x)\subseteq P(x)$.

Shephard's (1970 quoted in Fried, Lovell and Schmidt, 2008: 22) output distance function provides another functional representation of production technology. The output distance function is

$$D_{o}(x,y)=min\{\lambda:(y/\lambda)\in P(x)\}.. \quad (5)$$

For $y\in P(x), D_{o}(x,y)\leq 1,$ and for $y\in I(x), D_{o}(x,y)=1,$ given a standard assumption of *T*, the output distance function $D_{o}(x,y)$ is non-increasing in *x* and is non-decreasing, homogeneous of degree +1, and convex in *y*.

The Debreu-Farrell output-orientated measure of technical efficiency TE_{0} can now be given a somewhat more formal interpretation as the value of the function

$$TE_{o}(x,y)=max\{\phi:\phi y\in P(x)\}. \quad (6)$$

and it follows from (5) that

$$TE_O(x,y) = \left[D_O(x,y)\right]^{-1} \tag{7}$$

For $y \in P(x)$, $TE_O(x,y) \leq 1$, and for $y \in I(x)$, $TE_O(x,y) = 1$. The output-orientated technical efficiency measures are illustrated in Figure 4.

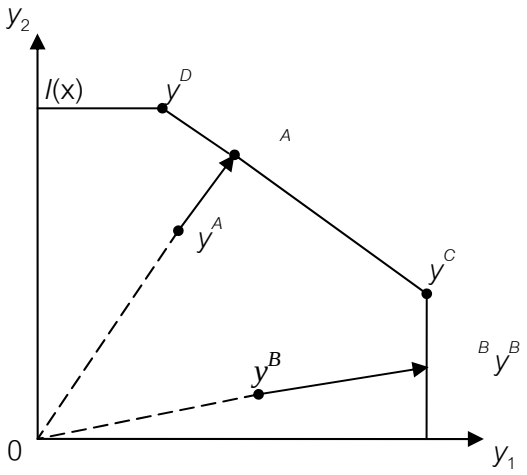

Figure 4: Output orientated technical efficiency

Output vectors y^C and y^D are technically efficient given input usage x, and output vectors y^A and y^B are not. Radially scaled output vector $^A y^A$ and $^B y^B$ are technically efficient, even though slack in output y_2 remains at $^B y^B$. Thus, $TE_O(x, \phi^A y^A) = TE_O(x, \phi^B y^B) = 1$ even though $\phi^A y^A \in E(x)$ but $\phi^B y^B \in E(x)$.

Following Coelli et al. (2005: 180), the output-orientated measure of technical efficiency is the solution to the constant returns to scale (CRS) DEA linear programming problem, which can be expressed as:

$$\max_{\phi,\lambda} \phi, \tag{8}$$

$$\text{st} \quad -\phi y_i + Y\lambda \geq 0,$$

$$x_i - X\lambda \geq 0,$$

$$\lambda \geq 0,$$

where ϕ is a scalar, y_i and x_i are the column vector of outputs and column vector of the inputs for the *i*-th school, respectively. λ is an $N \times 1$ vector of constants. The variable *Y* is an $M \times N$ output matrix, while *X* is a $K \times N$ matrix in which $1 \leq \phi < \infty$, and $\phi - 1$ is the proportional increase in outputs that could be achieved by the *i*-th firm, with input quantities held constant. For the variable returns to scale (VRS), the DEA linear programming problem can be expressed as:

$$\begin{aligned} &max_{\phi,\lambda}\phi, \qquad (9)\\ &\text{st} \quad -\phi y_i + Y\lambda \geq 0,\\ &\qquad x_i - X\lambda \geq 0,\\ &\qquad I1'\lambda = 1\\ &\qquad \lambda \geq 0, \end{aligned}$$

where $1 \leq \phi < \infty$, and $\phi - 1$ is the proportional increase in outputs that could be achieved by the *i*-th firm, with input quantities held constant. Note that $1/\phi$ defines a *TE* score (between 0 and 100%), and that this is the output-orientated *TE* score reported by DEAP 2.1 (Coelli, 1996: 31-33).

Bayesian method

Following Koop (2003: 212), the Tobit model gives the relationship between *y* and *y**, taking the form

$$\begin{aligned} y_i &= y_i^* \quad \text{if } y_i^* > 0 \qquad (10)\\ y_i &= 0 \quad \text{if } y_i^* \leq 0. \end{aligned}$$

If *y** are known, then *y* would also be known. Hence, $p(\beta, h|y^*) = p(\beta, h|y \times y^*)$ and can be derived as $p(y^*|y, \beta, h)$. Assume the

errors to be independent of one another. The posterior for the latent data (z), conditional on the parameter of the model, will exhibit as follows:

$$p(y^* \mid y, \beta, h) = \prod_{i=1}^{N} p\left(y_i^* \mid y_i, \beta, h\right) \qquad (11)$$

and focus on $p\left(y_i^* \mid y_i, \beta, h\right)$. If $y_i > 0$, having $y_i = y_i^*$,then the conditional posterior for y_i^* is a degenerate density with all probability located at the point $y_i = y_i^*$. For $y_i = 0$, combining (10) (i.e. that, unconditionally, y_i^* is normal distribution) with (11) implies $y_i^* \le 0$. That is, y_i^* has a truncated normal distribution if $y_i = 0$. We can write $p(y_i^* \mid y_i, \beta, h)$ as

$$\begin{aligned} y_i^* &= y_i && \text{if } y_i^* > 0 \\ y_i^* \mid y_i, \beta, h &\sim N\left(x'\beta, h^{-1}\right) 1\left(y_i^* < 0\right) && \text{if } y_i = 0 \end{aligned} \qquad (12)$$

where $1\left(y_i^* < 0\right)$ is the indicator function which is equal to one if $y_i^* < 0$, and equals zero otherwise.

The rule of probability (Koop, 2003: 159) implies that

$$p(\theta^* \mid y) = \int p(\theta^* \mid y, z)\, p(z \mid y)\, dz \qquad (13)$$

which can be evaluated using the Gibbs sampler, calculating $p(\theta^* \mid y, z^{(s)})$ for each draw (i.e. for s = 1, . . . , S) and averaging the result. Implying that if $z^{(s)}$ for s = 1, . . . , S are draws from the Gibbs sampler, then

$$\widehat{p(\theta^* \mid y)} = \frac{1}{S} \sum_{s}^{S} p(\theta^* \mid y, z^{(s)}) \qquad (14)$$

converge to $p(\theta^* \mid y)$ as S goes to infinity. Calculate $p(y \mid \theta^*)$, $p(\theta^*)$ and; $p(\theta^* \mid y, z)$, then the output from the Gibbs sampler with data augmentation using (14) obtaining the marginal likelihood.

Data and Variables

Resources are allocated for a particular purpose within legally-defined institutional arrangements, often passing through a few layers of government bureaucratic structure down to service facilities, which are charged with the accountability of exercising spending. Information on actual public spending, however, at the frontline service provider is seldom available, especially in developing countries. Public service provision could be affected by institutional inefficiencies such as leakage of public resources, weak institutional capacity, and inadequate incentives. Indeed, even if spending is officially allocated to services that target the poor, funds may not necessarily reach frontline service providers, and effectiveness of services may consequently be affected by such institutional inefficiencies (Ablo and Reinikka, 1998). There are two types of services provider surveys which complement each other, the Public Expenditure Tracking Survey (PETS) and the Quantitative Service Delivery Survey (QSDS), which have been developed to address questions of the efficiency and equity of public expenditure and service delivery.

A PETS tracks the flow of resources through these strata to determine how much of the originally-allocated resources reach each administrative level. It is therefore useful as a device for locating and quantifying political and bureaucratic capture, leakage of funds, and problems in the deployment of human and in-kind resources, such as staff and textbooks. It can also be used to evaluate impediments to the reverse *flow of information* to account for actual expenditures. Consequently, PETS could be used as diagnostic tool, an analytic tool, and as a tool for policy effectiveness evaluation (Reinikka and Smith, 2004);

(1) PETS as a diagnostic tool: a diagnostic survey seeks to ascertain concrete facts and identify basic problems without necessarily exploring why the problems are occurring and or the solution. Two common problems that PETS studies have diagnosed are leakage of funds, usually non-wage subsidies, and provider absenteeism. Studying each problem involves the collection of a sufficient amount of data within a well-designed sample. In general, non-wage subsidies are more prone to leakage than wage subsidies, as teachers know their salary and have an incentive to make sure that they receive it. A simple calculation of expenditure leakage (mismatch of expenditures data, that is collected at the frontline service providers and central administration) can be expressed as follows:

$$\text{Leakage of funds (mismatch)} = 1 \frac{\text{resources received by facility}}{\text{resources intend for the facility}} \quad (15)$$

(2) *PETS as an analytical tool*: it is important to understand the causes of the problems. A starting place for analysis may be the observation that the capture of funds varies across schools and perhaps across districts and regions; or it may be the widely different attendance behavior among teachers. The task that falls to analysis is to determine the factors that are correlated with the variable of interest, and to formulate and test the hypothesis discerning the causal relationships. If the causes are discovered, the appropriate policy intervention is often implied.

(3) *PETS as an impact evaluation tool*: following the previous purpose, a third reason to conduct a PETS is to examine the impact of a policy intervention that has already taken place. The likely occasion to use a PETS for impact evaluation is after an earlier PETS, so that the results of subsequent the PETS can be compared.

A QSDS has the primary aim of examining the *efficiency of public spending*, dissipation of resources, and incentives and various dimensions of service

delivery in provider organizations, especially at the frontline. It collects data on inputs, outputs, quality, pricing, oversight, and so forth. The facility or frontline service provider is typically the main unit of observation.

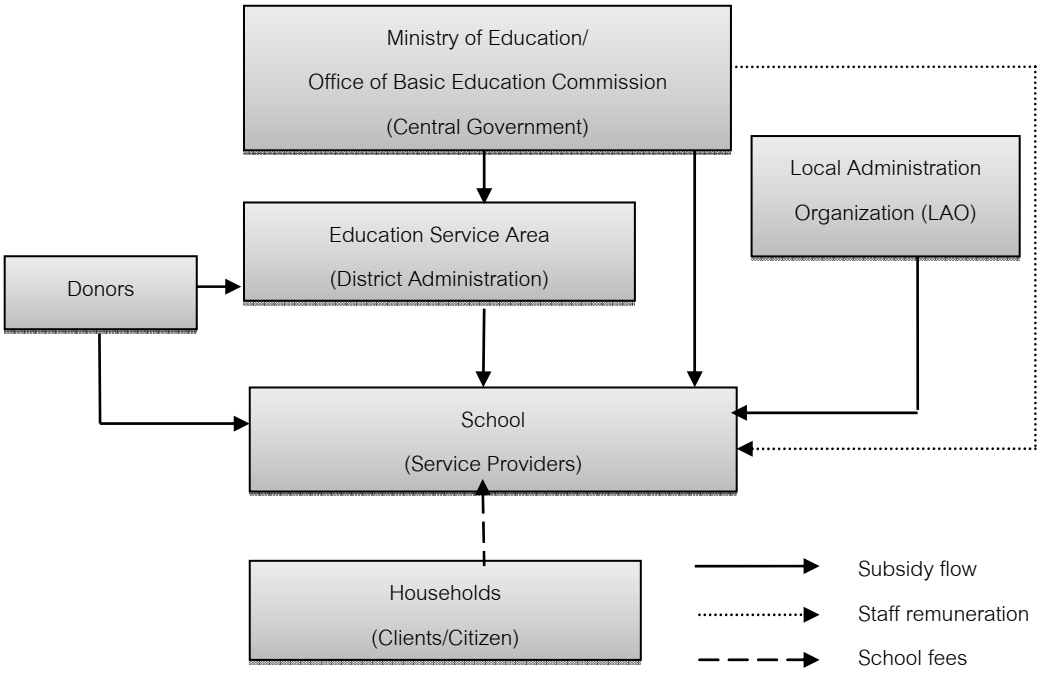

Figure 5: Flow of school subsidy

Resource flows in social sectors are complex. The various resources required for service delivery (financial resources, human resources, and in-kind transfers) originate from several sources (central government, ministries, decentralized administrative authority, bilateral and multilateral donors) and take various routes in the organizational system. In addition, these flows are generally governed by different allocation rules, administrative processes, and recording and accounting procedures. An essential initial stage in any tracking survey is thus to identify and analyze the

nature and characteristics of these various administrative structures and flows in order to grasp their role and responsibility in using the resources.

According to the PETS-QDSD survey, resources flow through two administrative levels. The administrative structure is the Office of Basic Education Commission (OBEC), and Education Service Area (ESA). Resource flows in the administrative system do not follow a simple top-down approach. At each level of the hierarchy, funds may be received directly from the central government or donors. The Local Administration Organization (LAO) could also support the approved school project. The ESA allocates public expenditure under the Government Financial Management Information System (GFMIS); for example, when schools purchase materials from merchandisers, they will send the evidence to the ESA and the electronic settlement process of this billing is carried out and money is paid directly to merchandisers by the ESA (Figure 5). There are two types of public expenditure from the OBEC included in this study: rule-based expenditure (capitation grants) and discretionary fund (fundamental-need funding). In the case of rule-based expenditure, all funds are allocated directly to schools, discretionary funds, and are allocated from the OBEC to ESA, which then allocated to the schools upon committee approval. In addition, some of incurred fees are paid by households that finance the school for a particular project.

The subsidy is carried out twice a year on a semester basis, fiscal year 2006 covering semester 2/2005 and 1/2006, and fiscal year 2007 covering semester 2/2006 and 1/2007. Hence, one can calculate a mismatch of capitation on an academic year basis, where academic year 2006 covers semester 1/2006 and 2/2006. Typically, public expenditures reach the school at about 80% (front-load allocation)

before the semester begins. There are claims that the “free education” policy had been resurrected; however, there has been tremendous confusion over whether parents are required to pay any fees at all. There is evidence, however, that a significant proportion of schools have not tried to raise resources from parents. The PETS-QSDS survey reveals a mismatch in the financial data available at schools. This is not for lack of effort on the part of the PETS-QSDS survey but primarily reflects the record keeping at the school level. For a large number of schools, the available financial information is incomplete. In summary, the mismatch of capitation grants per academic year of schools in Amnatcharoen and Nakhonratchasema is just under 4%, and the mismatch of fundamental-needed funds of schools in Amnatcharoen is 11.38% compared to 3.8% of schools in Nakhonratchasema (Table 1).

Table 1: Mismatch in school level financial information, academic year 2006

	All (n=70)	Nakhonratchasema (n=35)	Amnatcharoen (n=35)
Academic Year (AY) 2006			
Mismatch of capitation grants			
…semester1/2006	1.29	3.81	3.19
…semester2/2006	3.88	4.04	3.73
Average	2.59	3.93	3.46
Mismatch of fundamentally-needed funds			
…semester1/2006	8.56	5.58	11.04
…semester2/2006	7.35	2.06	11.72
Average	7.96	3.82	11.38
Average academic year 2006	**5.27**	**3.87**	**7.42**

The sampling design is generally referred to as a two-stage stratified cluster sampling. The sampling units at each stage are defined as follows. The first stage sampling units consist of individual, small-size schools that have average numbers of students, ranging from 200 to 300 students, in Amnatcharoen and Nakhonratchasema. These school are so-called “expand-opportunity schools,” and provide a compulsory education where students will leave the school after they finish their lower secondary education. The second stage includes a visitation to the sample school, and careful interviewing techniques and data quality determine the success of the study. The author began to collect data in November 2008 for Amnatcharoen followed by Nakhonratchasema province, and finished the survey at the end of March, 2009.

During the survey period, there were several intermittent breaks because of school closure. The package of questionnaires was sent to the sample school before the visitation. Many of the schools in the original sample could not be covered for a variety of reasons. In these cases, replacement schools (randomly selected from the same district) were used as substitution schools. A special effort was made to ensure coverage of remote schools. In particular, some schools were visited several times due to logistical difficulties. The total sample schools of both provinces in the analysis are equal to 70.

Table 2: Descriptive statistics of variables in the model

Abbreviation	Variables (at school level)	Mean	SD	Min	Max	Unit
	Inputs (*X*)					
PG	Avg. capitation grants received	472,982.00	242,694.97	165,060.00	1,650,400.00	baht
FF	Avg. fundamentally-needed received	139,518.21	91,641.48	26,954.00	324,670.00	baht
SA	Student attendance rate	90.41	16.59	32.40	100.00	percent
EXP	Teacher year of services	19.13	4.99	5.00	25.50	no. of year
CS	Student/teacher ratio	16.86	4.67	5.88	28.00	no. of student/class
	Outputs (Y)					
THAI	Avg. Thai languages test scores	41.66	4.40	32.78	50.00	percent
MATH	Avg. Mathematics test scores	28.49	4.49	22.22	40.00	percent
SCIENCE	Avg. Science test scores	37.34	6.83	24.46	51.00	percent
ENGLISH	Avg. English Languages test scores	28.81	5.22	21.25	47.33	percent
SOCIAL	Avg. Social studies test scores	39.07	5.37	28.12	48.00	percent
	Socioeconomic/Institutional (Z)					
PROVINCE	Province dummy (0/1)	0.50	0.00	0.00	1.00	1=Nakhonratchasema
POLITICIAN	Politicians' involvement (0/1)	0.34	0.49	0.00	1.00	1=involve
VACANT	Teacher vacancy rate	6.30	8.02	1.00	17.39	percent
ABSENT	Teacher absent	6.68	3.52	0.00	12.00	percent
SCHOOLSIZE	School size	6.49	5.08	2.53	11.00	classroom/100 student
MISPERCAP	Mismatch capitation grants	32,874.74	69,733.08	113.00	240,400.00	Baht
MISFUNDNEED	Mismatch fundamentally-needed funds	10,638.50	28,025.85	196.00	64,450.00	Baht
FEMALE	Share of female students	47.11	3.13	35.64	51.72	percent
HETERO	Heterogeneity	3.47	0.45	2.35	4.43	standard deviation
BITUMEN	Nearest bitumen road	1.85	3.93	0.50	20.00	kilometer
PARTICIPATION	Parent meeting with school	0.62	0.20	0.05	0.88	proportion (0 to 1)
INCOME	Household average income	4,637.14	1,527.10	1,000.00	7,500.00	baht/month
PARENTS	Living with parent (0/1)	0.50	0.51	0.00	1.00	1= live
PARENTEDU	Parent's education	9.43	2.76	6.00	12.00	year of schooling
INSPECTION	Number of Inspections	7.20	5.15	2.00	25.00	times

The data included in this study are the proxy of outputs; that is, the test scores (mathematics, science, Thai language, social studies, and foreign language (English)). The inputs included the data that could be controlled by the school

administrator, which were: capitation grants (rule-based expenditure), which represented the main resources of the school, and fundamentally-needed funds (discretionary funding), which target poor students. The other input variables were: student attendance rate, teacher experience, and student-teacher ratio. The explanatory variables outside the power of the school administrator were; mismatch of capitation grants and mismatch of fundamentally-needed funds, school size, distance of nearest bitumen road, delay of expenditure disbursement (number of process days since the schools received approval), and the teacher absent rate (teachers on the roster but absent on the day of the survey). All of these variables were considered as institutional arrangements.

The non-school inputs were the socioeconomic status of students, including average household income, living with parents (dummy), and parental education (number of school years). In addition, capturing the influence of peers on learning achievement, which were: proportion of female students and heterogeneity of students (standard deviation to the mean of the test scores). The other variable was politician's involvement, to reflect the *voice* of citizens/clients and to distinguish the provincial effect the dummy for the province was then included in the model. The descriptive statistics for all of the variables are reported in Table 2.

Results

Regarding the results of school technical efficiency where only the quantitative data of the inputs and outputs were included, the share of efficient schools was 37.1% when CRS was assumed and 48.5% when variable returns to scale (VRS) was assumed. The average efficiency of the school was 87.4%, assuming CRS technology, indicating an average saving potential of 12.6% (=100-87.4) in the use of

resources. The average efficiency of the school was 93.6%, assuming VRS technology, and a potential savings of 6.4 percent in the use of resources. This can be compared by depicting the efficiency distributions, as shown in Table 3.

The non-parametric approach is sensible to outliers data and tends to be affected the efficiency scores. This section tests the robustness of the efficiency score results in regards to outlier schools, which focus on efficiency units that construct production frontier (Kirjavainen and Loikkanen, 1998: 393).

Table 3: Technical efficiency scores distribution

School no.	*TE* (CRS)	*TE* (VRS)
Mean	87.4	93.6
Median	91.1	99.6
Standard deviation	13.1	8.3
Minimum	62.2	69.7
Maximum	100	100
% of efficient school	37.1	48.5

The author ran 26 additional DEA analyses for the CRS assumption technology by dropping out the schools that has fully efficient score, and 34 additional DEA analyses for the VRS assumption technology. Then the similarity of efficiency ranking between each iteration was tested. Kendall's Tau correlation coefficient was used to diagnose the similarity (Table 4).

The high ranking correlation coefficient shows that the rankings were relatively stable in regard to outlier schools when determining the efficiency frontier.

In the case of assuming CRS and VRS technology, the variation of rank correlation coefficient ranged from 0.99 to 1.00.

Table 4: The Stability of DEA results

	Number of efficient schools	The range of Kendall correlation coefficient		Mean efficiency	Iterated mean efficiency	Standard deviation of means
		Minimum	Maximum			
CRS	26	0.99	1.00	87.4	84.6	0.3
VRS	34	0.99	1.00	93.6	93.3	1.5

The VRS technology had more variation in mean; thus, relative to CRS technology, the VRS technology and efficiency scores were somewhat more sensitive to outliers. However, the author tested the stability of the outliers by comparing the means of the original DEA with the iterated DEA analysis. The *F*-test at a 5% significance level showed that the null hypothesis of the mean efficiency could not be rejected. Hence, all schools were included in the analysis.

Consider how efficiency is connected to variables of interest. The Tobit model in which efficiency differences can be explained by variables not included in the first stage DEA analysis. The factors that could more easily be influenced by the schools were included in the original DEA models and those outside the decision-making power of school administrator (McCarty and Yaisawarng, 1993: 271-287). Inefficiency may also be caused by a suboptimal scale of operation. Since VRS technology can bias efficiency scores upward (Coelli et al. l998 quote in Rassouli-Currier 2007: 64), the CRS technology efficiency scores were more appropriate as the independent variables in the second stage Tobit model. This can be taken into

account either by considering the efficiency differences obtained under assuming CRS technology. The efficiency equation estimated during the second stage was specified in (16). The efficiency scores, which were the dependent variables in the subsequent Tobit models, were based on the results of the sample schools. The variables passed the test of multicolinearity, and the regression was carried out using a MATLAB 7.10 program employing the Gibbs sampling Tobit model.

$$TE_i = \beta_0 + \beta_1 PROVINCE + \beta_2 POLITICIAN + \beta_3 ABSENT + \beta_4 MISPERCAP + \beta_5 MISFUNDNEED + \beta_6 HETERO + \beta_7 INCOME + \beta_8 PARENTS + \beta_9 PARENTEDU + \delta_{10} INSPECTION + \beta_{11} VACANT + \beta_{12} SCHOOLSIZE + \beta_{13} FEMALE + \beta_{14} BITUMEN + \beta_{15} PARTICIPATION + \varepsilon_i \quad (16)$$

Based on the analysis, the coefficient of the province dummy was negative and significant, which implies that there is a significant difference in school performance between the provinces. The higher teacher absence rate (*management*) negative and significant demote school efficiency, This implies that the teachers on the roster do not attend their regular class, while the teacher vacancy rate (*compact*), is the school that lacked teaching staff . Intuitively, students that live with parents that have a higher education should have more opportunity to receive educational guidelines. The analysis shows that parental education (*socioeconomics*) is significant in explaining school efficiency.

From the results, schools seem to inefficient. The unit measurement is classroom/100 students (*institutional arrangements*) because classrooms with more students significantly promote efficiency. The ratio of female students significantly increases school efficiency. The schools that are administered under a school-based management framework have the high level of parental participation (*client power*) and

are significantly increase school efficiency. Intuitively, the mismatches of any funds that the school uses for operation, consequently, decrease the bulk of the subsidy that should reach the school. However, in our model, the mismatch of capitation grants and the mismatch of fundamentally-needed funds are not significant in explaining school efficiency.

Table 5: Parameter estimates explaining efficiency (CRS assumption)

	Tobit		Bayesian Tobit	
	Coefficient	*t*-statistic	Coefficient	Std.dev.
Province (dummy)	-9.19***	2.96	-17.58***	6.18
Politician involvement	-2.23	0.69	-3.02	6.33
Teacher absence rate	-0.87**	2.10	-1.01*	0.82
Mismatch capitation	-0.000006	0.00	-0.00004	0.00005
Mismatch fundamentally-needed	-0.00002	0.31	-0.00003	0.0002
Heterogeneity	2.96	1.04	1.89	6.76
Avg. household income	0.001	1.06	0.003	0.003
Living with parents	1.30	0.44	3.19	6.05
Parents' education	0.96*	1.87	1.54*	1.01
Inspection	-0.04	0.11	0.08	0.67
Teacher vacancy rate	-0.42**	2.18	-0.77**	0.36
School size	0.39*	1.97	0.58*	0.42*
Share of female students	1.01***	3.74	0.86*	0.57*
Nearest bitumen road	0.75*	1.71	1.00	0.84
Parental participation	15.90**	2.30	25.88**	13.95
N	70		70	
R-squared	0.98		0.97	
Log-Likelihood	-270.87		-	

Note: ***significant at 1 percent, **significant at 5 percent, *significant at 10 percent

Overall, the model seems suitable for analyzing the connection of factors regarding school efficiency, which are: school inputs, the socioeconomic status of citizens/clients, and community involvement. Compared to the conventional Tobit regression, the equation almost yields the same conclusion; however, schools that are located nearer a bitumen road significantly explain school efficiency at a 10% significance level. This coefficient, nevertheless, explains school efficiency at a 15% significance level in the Bayesian Tobit model.

Conclusion and Policy Implications

This paper attempts to explain the success of service delivery be rendered comprehensive apply to SBM framework. The accountability relationship in the specific context of compulsory education services, as sketched in Figure 2, is used to interpret the results. According to this framework, the direct "market link" of accountability of schools (*service providers*) for parents/students (*client*) is not strong? because the system heavily subsidized for basic education. However, there is also a role for more "non-market" direct links between clients and providers through the institution of the parents' participation. From this perspective, this is a way to strengthen accountability relationships by connecting the *client power* in the school. The derived model is evidence that, parental participation significantly promotes efficiency. It can be concluded that in order to achieve efficiency, a school committee needs to be active, and that parents should regularly participate in school administrative affairs.

The absence rate is too high and can be associated to the school efficiency. Teacher absence rate can be controlled by the school administrator and the SBM framework encourages school autonomy, however, rigorous disciplinary action should be put in place, since inspection from higher authority is statistically

insignificant. The teacher vacancy rate is the *compact*, and this means that the OBEC may have to retain teachers in the system, for example, by extending the years of service before entering an early retirement program, or regular retirement at the age of 60.

Normally, the OBEC allocates generous education subsidies every year; however, there are other factors that influence school efficiency. The socioeconomic factors such as; parent education was promote the school efficiency. This implies that government subsidies alone are not sufficient for enhancing school efficiency. Despite the fact that the school has nothing to do with parental education, economists, as social planners, can suggesting the policy guidelines, in particular, addressing the issue of “educational equity”.

Schools seem to have optimum scale production, since school size significantly explains efficiency (about 6 classrooms per 100 students). The efficiency scores from the DEA model confirm that the average efficiency of a school is 87.4%, assuming CRS technology, indicating an average savings potential of 12.6% in the use of resources. About 37% of sampled school are operated at the frontier, and demonstrate relatively best practice schools. The ratio of female students to male students also significant explains school efficiency, and this information may help educational planners characterize efficient school from others. For the conventional Tobit model, it is suggest that the nearer the school is located to a bitumen road, the higher the school efficiency. This evidence suggests that governments should build a network of bitumen roads in the entire village.

The PETS and QSDS are useful research instruments which can capture the relevant factors in the analytical framework. These include: *voice*, *compact*, *client power,* and *management*. The research stems from two important research questions. First, a weakness in the accountability relationship can cause failure of service delivery; and the effectiveness of the SBM framework may collapse. Two features of accountability relationship which are; *informing* and *enforcing* are the feature that absence or weakness. Hence, lacking of *informing*, cause asymmetric information between the actors. At the same time, unreliable information may lead to the wrong recipe for addressing the issues; in the worst cases, the principals are reluctant to *enforce* agents or to take disciplinary action. *Financing* is the first step in creating accountability relationships; however, service providers in the public sector cannot easily create these relationships. *Voice* (or politicians' involvement) seems to be not strong enough in the SBM framework, and there is no statistical significance in the equation. However, the teacher absence rate is negative and significant in explaining school efficiency, implying that *management* is the most important accountability relationship in the SBM framework. There is evidence that there are weaknesses in the accountability relationships in the SBM framework since there exist mismatches of capitation grants and fundamentally-needed fund. The cause of the leakage may stem from asymmetric information and lack of enforceability (on-time disbursement). The Bayesian Tobit model shows that the leakages of subsidies are not associated with school efficiency.

From the point of view of the SBM framework, the combination of *voice* and *compact* instituted the long route accountability; however, *voice* is not controlled by the ESA; on the other hand, *compact* is controlled by the ESA. The analysis revealed that the relationships may not strong, since only the teacher vacancy rate (*compact*)

significantly promotes efficiency of service delivery (test scores). The strengthening of short route accountability may have to substitute for long route accountability in this case, an increasing of the parent participation rate, increase the school efficiency. Although schools have a high degree of autonomy under the SBM, they have to operate within the guidelines of the ESA. Nevertheless, the ESA alone is not the only influencer, since educational production is composed of tripartite institutions: the schools themselves, family background, and community.

In summary, in order to achieve successful service delivery in the public sector undertaking the SBM framework, accountability relationships need to be strengthened. The substitute of short route accountability needs to be instituted for long route accountability. Moreover, the institutional arrangements (individual school inputs, the influence of the family's socioeconomic status, and community characteristics) are the co-producers of educational production. Based on this analysis, it is obvious that all of the factors need to mix optimally.

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