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School-based Management Framework and Education Efficiency*

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This paper applies an aspect of school-based management, which describes the actors that shape and promote school management, their interests, and the network that links them. Four categories of actors are identified: policymakers, school committee, providers, and clients. The public expenditure tracking survey and the quantitative service delivery survey were the instruments used to collect the data. The stochastic frontier analysis was employed for estimating education efficiency. The variables, which determine education efficiency, are specified according to the school-based management framework. The results show that, on average, the school-based management was suitable for explaining student achievement in the sample schools. It suggests that both socio-economic and institutional factors drawn from the school-based management framework, in addition to higher budget allocation, are required to improve efficiency in providing education.

Keywords: school-based management, public expenditure, efficiency

JEL Classification: H52, I21, I28

Introduction

The failure of the functions of educational production to identify the relationship between key policy variables (such as resource spending) and educational achievement has been the subject of much inquiry. Four key reasons have been advanced. The first questions the validity of the educational production function framework itself (Worthington, 2001). The second centers on the possibility that public policy does not have any measurable impact on educational outcomes. This line of reasoning suggests that innate ability, combined with the influence of socio-economic background, may dominate the educational production process (Deller and Rudnicki, 1993). The third reason follows

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the argument that the lack of a positive relationship between educational outcome and educational expenditure is the result of schools balancing off demand-side considerations of “willingness to pay” for additional educational attainment against supply-side factors related to the genuine underlying production function (Mayston, 1996). Finally, it has been proposed that the educational production function approach relies on an assumption of efficiency.

This study is motivated by the observation that despite a substantial investment in public spending on education, official reports have shown no increase in Ordinary National Education Test (O-NET) scores. The hypothesis is that the efficiency of service delivery is worse than budgetary allocations, implying that public funds were subject to capture and did not reach the intended facilities, i.e. schools. Although a portion of the resources reaches the school, its weak institutional capacity may constrain the school from utilizing them efficiently. To test this hypothesis, two measures were carried out: 1) a Public Expenditure Tracking Survey (PETS) to collect data on budget allocations in comparison with those actually received at the frontline service providers through a layer of bureaucratic structure, and 2) a Quantitative Service Delivery Survey (QSDS) to collect various data at the frontline service providers within the service delivery framework (World Bank, 2003). The next section discusses the school-based management conceptual framework, followed by methods and data, the model, results, and policy recommendations.

School-based Management Framework

Institutions are “the rules of the game in a society or, more formally, the humanly devised constraints that shape human interaction” (North, 1990). The four broad roles of the actors in the chain of service delivery are as follows. First, *citizens and clients:* as citizens they participate both as individuals and through coalitions in the political process that define collective objectives; they also strive to control and direct public action in accomplishing those objectives. Second, *politicians and policymakers:* politicians derive and control state power and discharge fundamental responsibilities. The other actors that exercise the power of the state are policymakers. Politicians set general directions, but policymakers set the fundamental rules of the game under which service providers operate. Third, *organizational providers:* a provider organization can be a public line organization such as ministry, department, or agency. It can be large (public sector ministries with tens of thousands of teachers) or small (a single community-run primary school). The policymaker sets and enforces the rules of the games of organization providers and the head of the provider makes internal “policies” specific to the organization. Lastly, *frontline* professionals: all services require a provider who comes into direct contact with clients, including teachers, doctors, nurses, and so on. There are power relations among the state, citizens/clients and providers. Each pair of relationships has a complex accountability relationship between them. These relationships are explained as follows:

1) *Voice* used to express the complex relationships of accountability between citizens and politicians. Voice is about politics, but it covers the relationship of formal and informal political mechanisms.

2) *Compact* can express as the relationships between policymakers and service providers. Unlike a contract, it is not legally enforceable. It is a broad agreement on a long-term relationship.

3) *Management* is a tool in every organization that provides frontline workers with assignments and delineated areas of responsibility. In public agencies this management function may not be as clear as in the private sector, because providers are employees of the government.

4) *Client power* is a form of demand for services that citizen reveal to providers and a mean to monitor the provision of services. Clients and organizational providers interact through the individuals that provide services, such as frontline professionals and workers.

Weakness in any pair of relationships or in the capacity of actors can result in service failure. The school-based management framework has the potential to hold school-level decision makers accountable for their actions, but it would still be necessary to build the capacity of community members, teachers, and principals in order to create a culture of accountability.

From the school-based management framework, the accountability of school principals is upward to the ministry that holds them responsible for providing services to the clients who had have put the policymakers in power and thus have the voice to hold the policymakers and politicians accountable for their performance. In most cases, the *management mechanism* changes under a reform process. The clients themselves become part of the management, along with the frontline providers. As a result, the short route of accountability becomes even shorter as representatives of the clients, either parents or community members, have the authority to make certain decisions and have a voice in decisions that directly affect the students attending the school. The framework is presented in Figure 1, where the school manager, whether the head teacher alone or a committee of parents and teachers, acts as the accountable entity.

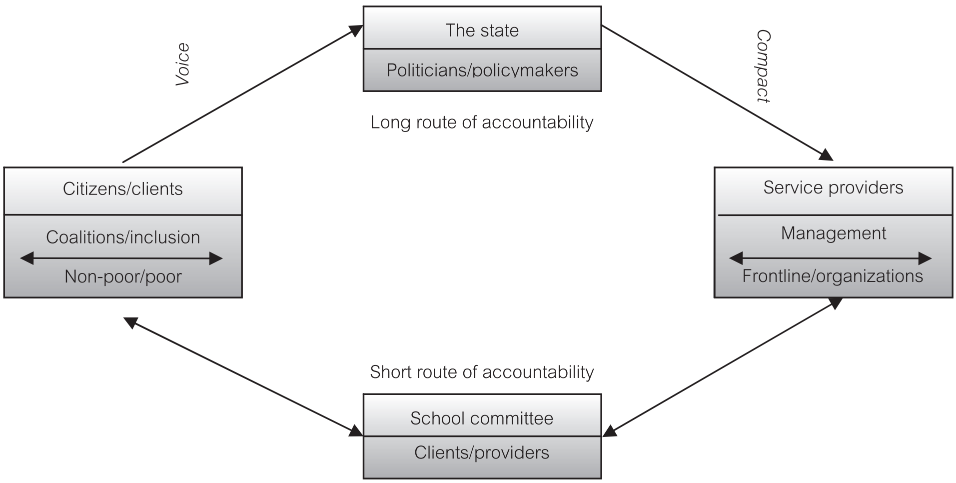

Figure 1 School-based management framework

Source: Barrera-Osorio *et al.* (2009)

Methods and Data

Data were collected through two types of services provider surveys, PETS and QSDS. They complement each other and have been developed to address questions of leakage, efficiency and equity of public expenditures, and service delivery. PETS tracks the flow of resources through the administration strata to determine how much of the originally-allocated resources reaches each level. It is therefore a useful 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. In general, non-wage funds appear more prone to leak than salary funds, as teachers know what their salary is and have an incentive to make sure that they receive it. A simple calculation of expenditures leakage can be expressed as:

$$\text{Leakage of funds (mismatch)} = 1 - \frac{\text{resources recieved by school}}{\text{resources intends for school}} \quad (1)$$

QSDS has the primary aim to examine the efficiency of public spending, dissipation of resources, incentives, and various dimensions of service delivery in provider organizations, especially on the frontline. It collects data on inputs, outputs, quality, pricing, oversight, and so forth.

In the education sector, public resources flow through two administrative levels before reaching the school (Figure 2). The administrative structure comprises the Ministry of Education (MOE), the Office of Basic Education Commission (OBEC), and the Education Service Area (ESA). Resources flowing 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 administration or donors. The Local Administration Organization (LAO) could also support the school if the school project is accepted, and the school could receive the same support from donors. There are two major types of public funds from the OBEC included in this study: rule-based expenditures (capitation) and discretionary funds (fundamentally-needed funds). In the case of rule-based expenditure, all funds are allocated directly to schools, but a portion of the discretionary funds are allocated from the OBEC to the ESA, which then redistributes the funds to schools upon approval of a ESA's committee. In addition, some of the incurred fees are paid by households to finance particular activities or projects of the school.

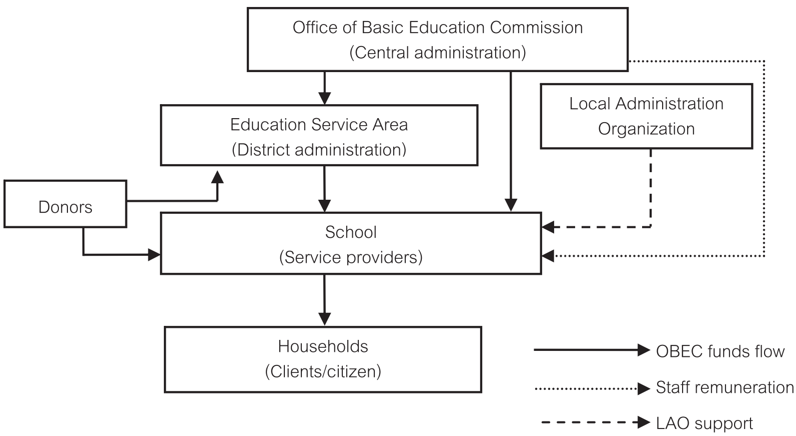

Figure 2 Flow of funding in the education sector

The primary data used in this study come from cross-sectional surveys that cover school, household, and student aspects of grade 9 in the northeast region of Thailand, in Nakhonratchasima and Amnatcharoen. By area, Nakhonratchasima is the largest province in the northeast; as an administrative center, it is the main transportation, industrial, and economic hub of the region. In 2006, the gross provincial product (GPP) was 134,007 million baht (NESDB, 2009). Amnatcharoen is located about 568 kms from Bangkok. Its GPP in 1988 price was 12,490 million baht and GPP per capita was 29,474 baht, ranking number 75 in the country and number 18 in the northeast region (NESDB, 2009).

The schools are called "expand-opportunity schools" that provide a compulsory education, whereby students can only leave the school after they finish their lower secondary education. They are usually located in small villages in rural areas. The sampling design is a two-stage stratified cluster sampling. In the first stage, schools in each district were randomly selected, while in the second stage, interview locations were randomly selected within each district. The data were collected during November 2008 - March 2009. A total of 70 schools are included in the analysis. The survey data include the variables of the accountability institution within the school-based management framework described as follows.

The proxy of inputs *(X)* includes the following variables that could be controlled by the school administrator. First, the capitation *(PG)* is the main financial resources of the school. Second, the fundamentally-needed fund *(FF)* is intended for poor students whose family earns an income under 40,000 baht per year. These students are eligible for this aid upon committee approval. The third input variables were the student attendance rate *(SA)*, where the number of students present in class was compared with the classroom roster. Fourth, the teacher's experience *(EXP)* is the key input that could lead to student achievement. Lastly, the student-teacher ratio was used as a proxy for class size *(CS)*; the variable was defined as number of students per classroom.

The proxy of outputs *(Y)* was composed of the average school test scores of the following subjects: mathematics *(MATH)*, science *(SCIENCE),* Thai language *(THAI),* social studies *(SOCIAL)*, and English language *(ENGLISH)*. Several other variables, socio-economic or institutional factors *(Z)*, were needed to estimate the production function (Table 1). It is often believed that females have more innate reading ability, while males are more skillful in mathematics. Age may be an indicator of ability; older children have more time to develop their innate skill. First-born children are also believed to have higher innate ability, at least partly due to lower maternal nutrient depletion (King, 2003). Also, parental education is used as an indicator of a child's ability; innate parental ability affects the parents' own level of education and is inherited by the child. Moreover, there is evidence that the mother's age when the child is born has a biological effect on the child's innate ability. Specifically, early childbearing has a negative biological impact on children's innate ability, although social factors also play a role (Pevalin, 2003). Hence, in order to capture the impact of children's innate ability, proportion of female student in the school *(FEMALE)*, and parental education *(PARENTEDU)*, were included in the analysis. In addition, capturing the influence of peers on learning achievement, the heterogeneity of students defined as the standard deviation of the test scores *(HETERO)* was included in the equation.

Table 1 Descriptive statistics of variables in the model

Abbreviation	Variables	Mean	Min	Max	Unit
	Inputs (*X*)				
PG	Capitation received	472,982	165,060	1,650,400	baht
FF	Fundamentally-needed received	139,518	26,954	324,670	baht
SA	Student attendance rate	90.41	32.40	100.00	percent
EXP	Teachers' experience	19.13	5.00	25.50	no. of year
CS	Student/teacher ratio	16.86	5.88	28.00	student/classroom
	Outputs (Y)				
THAI	Thai language	41.66	32.78	50.00	percent
MATH	Mathematics	28.49	22.22	40.00	percent
SCIENCE	Science	37.34	24.46	51.00	percent
ENGLISH	English language	28.81	21.25	47.33	percent
SOCIAL	Social studies	39.07	28.12	48.00	percent
	Socio-economic/Institutional (Z)				
PROVINCE	Province dummy (0/1)	0.50	0.00	1.00	1=Nakhonratchasima
POLITICIAN	Politicians' involvement (0/1)	0.34	0.00	1.00	1=involve
VACANT	Teacher vacancy rate	6.30	1.00	17.39	percent
ABSENT	Teachers that were absent	6.68	0.00	12.00	percent
SCHOOLSIZE	School size	6.49	2.53	11.00	classroom/ 100 students
LKPERCAP	Leakage of capitation grants	32,874	113	240,400	baht
LKFUNDNEED	Leakage of fundamentally-needed funds	10,638	196	64,450	baht
FEMALE	Share of female students	47.11	35.64	51.72	percent
HETERO	Heterogeneity	3.47	2.35	4.43	standard deviation
BITUMEN	Nearest bitumen road	1.85	0.50	20.00	kilometer
PARTICIPATION	Parent meetings with school	0.62	0.05	0.88	proportion (0 to 1)
INCOME	Household average income	4,637	1,000	7,500	baht/month
PARENTS	Living with parents (0/1)	0.50	0.00	1.00	1= live
PARENTEDU	Parent education	9.43	6.00	12.00	year of schooling
INSPECTION	Number of inspections	7.20	2.00	25.00	times

The explanatory variables outside the power of the school manager in this study are: leakage of capitation *(LKPERCAP)* and leakage of fundamentally-needed funds *(LKFUNDNEED),* see equation (1). The school size *(SCHOOLSIZE)* variable was constructed by dividing total students by total actual teachers in the school. In order to capture the effect of school location on educational outcomes, the distance of the nearest bitumen road *(BITUMEN)* is included. The proxy of variables representing weak institutional capacity in the organizations; for example, the teacher absent rate *(ABSENT)* is also included in the study. It was calculated based on teachers on the roster but were absent during the day of the survey. In addition, the teacher vacancy rate *(VACANT)* could have not been caused by weak institutional efficiencies; however, it is believed that this factor affects learning achievement of students, and consequently, sometimes the teachers practice the multi-grade teaching method.

There are also variables of interest that are associated with educational outcomes, i.e. household income *(INCOME)* as a proxy for student's socio-economic status, and a dummy variable *(PARENTS)* as a proxy for the family environment. It also includes the involvement of the members of parliament as proxy variable of politician's involvement *(POLITICIAN)*, reflecting the voice of citizens/clients. If the involvement helps improve the schooling system, the dummy variable is set to 1, and 0 if otherwise. In order to distinguish the provincial effect *(PROVINCE)*, the Nakhonratchasima dummy variable is set to 1, and Amnatcharoen is set to 0. In the SBM framework, parental participation *(PARTICIPATION)* could shorten long-route accountability; hence, the equation includes the number of parent meetings with the school. Finally, the proxy for the compact variable is the number of school inspections *(INSPECTION)* from higher authority. According to accountability institution framework, proxy for voice is politician involvement, proxy for compact is inspection, proxies for management are vacancy rate and school size, and proxy for clients power is parent participation.

Stochastic Frontier Analysis

The idea behind stochastic frontier analysis (SFA), introduced by Aigner, Lovell, and Schmidt (1977) and Meeusen and van der Broeck (1977), is to add to the production frontier an error term with two components; one allows for random error and another allows for technical inefficiency. The stochastic frontier model for cross-sectional data is as follows.

$$y_i = f\left(x_i;\beta\right)\cdot \exp\left(\nu_i\right)\cdot TE_i \qquad (2)$$

where y_i is the output of producer i, $i = 1,...,I$, x_i is the vector of K inputs used by producer i, β is a vector of $K+1$ technology parameters to be estimated. $y_i = f\left(x_i;\beta\right)$ is the deterministic production frontier, $\exp\left(\nu_i\right)\cdot TE_i$ embodies the random shocks on each producer. This becomes $f\left(x_i;\beta\right)\cdot \exp\left(\nu_i\right)$ which represents the stochastic production frontier. Finally, TE_i is the output-oriented technical efficiency of producer i, defined as

$$TE_i = \frac{y_i}{f(x_i;\beta)\cdot \exp(v_i)} \qquad (3)$$

That is the ratio of observed output to the maximum feasible output conditional on $\exp\left(\nu_i\right)$. Producer i attains the maximum feasible output if, and only if, TE_i=1; otherwise $0 < TE_i < 1$ provides a measure of the shortfall of observed output from the maximum feasible in an environment characterized by $\left(\nu_i\right)$.

In order to estimate the stochastic production frontier model in equation (2), $f(\cdot)$ is assumed to take a translog form because of its flexibility. Prior maximum likelihood estimation (MLE), a re-parameterization of the type $\sigma^2 = \sigma_u^2 + \sigma_v^2$ and $\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$ is typically introduced. The parameter γ measures the relative importance of σ_u^2. If $\gamma \rightarrow 0$ either $\sigma_v^2 \rightarrow +\infty$ or $\sigma_u^2 \rightarrow 0$: the two-side error component would dominate and the production frontier could be estimated by OLS. If $\gamma \rightarrow 1$ either $\sigma_u^2 \rightarrow +\infty$ or $\sigma_v^2 \rightarrow 0$: the technical inefficiency component would dominate and one would have a deterministic production frontier without noise. The parameters (σ^2, γ) are estimated together with the technology parameter in β , and the maximum likelihood estimators are consistent with I (number of producers). In the context of SFA: testing the significance of γ assumes particular importance, since if the null hypothesis $\gamma = 0$ were accepted, stochastic frontier methodology would not be necessary and all technology parameters could be consistently estimated by the OLS method.

The SFA makes it possible to estimate the efficiency of input utilization by producers. In order to gain further insight, producer performance is related with "exogenous" variables, which are not the discretion of the producer but nevertheless influence the outcome of the production process (referred to as producer heterogeneity). Such variables could, for instance, characterize the environment where productions take place. They are not supposed to influence the shape and/or location of the production frontier, but determine how far away the producer is from it. Several approaches have been suggested in the literature to incorporate appropriately inefficiency effects into the SFA. According to Battese and Coelli (1992), it is assumed that is a truncation below zero of a normal distribution with mean $\mu_{it} = \delta_0 + \sum_m \delta_m z_{m,it}$ and variance σ_u^2, where z_m is producer and time-specific variables that determine inefficiency is. If δ_m 's are equal to zero, with $\mu = \delta_0$, and can likewise be estimated by the maximum likelihood approach. Battese and Coelli (1995) considered a generalize frontier production function for education as:

$$y_{it} = \exp(x_{it}\beta + v_{it} - u_{it}) \tag{4}$$

where y_{it} denotes the output of the i-th school in the t-th time period (t=1 for cross-section data), x_{it} represents a $(1 \times k)$ vector of inputs and other explanatory variables for the i-th school in the t-th time, β is a $(k \times 1)$ vector of unknown parameters to be estimated, v_{it} 's are assumed to be $iid \sim N(0, \sigma^2)$ random variables associated with the technical efficiency of production, where technical inefficacy u_{it} in equation (4) is further defined as:

$$u_{it} = z_{it}\delta + c_{it} \tag{5}$$

where z_{it} is a $(1 \times M)$ vector of explanatory variables associated with technical inefficiency effects, δ is an $(M \times 1)$ vector of unknown parameters, and c_{it} is a non-negative observed random variable obtained by truncation of the $c_{it} \sim N^+(0, \sigma_c^2)$ such that $c_{it} \geq -z_{it}\delta.$ This is an alternative specification of u_{it} being a non-negative truncation of $N(z_{it}\delta, \sigma^2)$.

The production function can be estimated by the maximum-likelihood approach, upon making an assumption about the distributions of u_{it} and v_{it}. The log-likelihood function to be maximized is based on the density function $f(\varepsilon_i)$ for a sample of I producers; their respective density functions (Battese and Coelli, 1992) are:

$$g(u) = \frac{1}{\sigma\nu\sqrt{2\pi}\phi\left(\frac{\delta z}{\sigma_u}\right)} \exp\left(-\frac{(u-\delta z)^2}{2\sigma_v^2}\right), u \geq 0 \qquad (6)$$

$$g(v) = \frac{1}{\sigma\nu\sqrt{2\pi}} \exp\left(-\frac{\nu^2}{4\sigma_v^2}\right), -\infty < \nu < \infty \qquad (7)$$

where $\Phi(\cdot)$ denotes the distribution function for the standard normal random variable and by omitted subscribed i and t, the joint density function of and $\varepsilon = \nu - u$ is:

$$h(\varepsilon, u) = \frac{\exp\left\{-\frac{1}{2}\left[\frac{(u+\tilde{\mu})^2}{\tilde{\sigma}_v^2} + \frac{(\varepsilon-\delta z)^2}{\sigma_u^2+\sigma_v^2}\right]\right\}}{2\pi\sigma_u\sigma_v\Phi\left(\frac{\delta z}{\sigma_u}\right)} \qquad (8)$$

where

$$\tilde{\mu} = \frac{-\sigma_u^2\varepsilon + \delta z \sigma_v^2}{\sigma_u^2+\sigma_v^2} \text{ and } \tilde{\sigma}^2 = \frac{\sigma_u^2\sigma_v^2}{\sigma_u^2+\sigma_v^2} \qquad (9)$$

Integrating the joint density function $h(u,\varepsilon)$ over u yields the marginal density function of ε:

$$f(\varepsilon) = \int_0^\infty h(u,\varepsilon)du = \frac{\exp\left\{-\frac{1}{2}\left[\frac{\varepsilon^2}{\sigma_v^2} + \left(\frac{\sigma z}{\sigma_u}\right)^2 - \left(\frac{\tilde{\mu}}{\tilde{\sigma}}\right)^2\right]\right\}}{\sqrt{2\pi}\sigma_u\sigma_v\Phi\left(\frac{\delta z}{\sigma_u}\right)} \frac{\int_0^\infty \exp\left\{-\frac{1}{2}\frac{(u-\tilde{\mu})^2}{\tilde{\sigma}^2}\right\}du}{\sqrt{2\pi}} \qquad (10)$$

Simplification of equation (10) yields:

$$h(\varepsilon) = \frac{\exp\left\{-\frac{1}{2}\frac{(\varepsilon+\delta z)^2}{(\sigma_v^2+\sigma_u^2)}\right\}}{\sqrt{2\pi}(\sigma_v^2+\sigma_u^2)^{\frac{1}{2}}\left\{\frac{\Phi\left(\frac{\delta z}{\sigma_u}\right)}{\Phi\left(\frac{\hat{\mu}}{\tilde{\sigma}}\right)}\right\}} \qquad (11)$$

Using equations (8) and (11), the following condition density function of u given ε can be obtained:

$$f(u|\varepsilon) = \frac{\exp\left\{-\frac{1}{2}\frac{(u-\tilde{\mu})^2}{\tilde{\sigma}^2}\right\}}{\sqrt{2\pi}\tilde{\sigma}\Phi\left(\frac{\tilde{\mu}}{\tilde{\sigma}}\right)} \tag{12}$$

The conditional expectation of $\exp(-u_{it})$ given ε_{it} is obtained from equation (12):

$$TE_{it} = E\left(e^{-u_{it}} | \varepsilon_{it}\right) = \frac{\Phi\left[\left(\frac{\tilde{\mu}_{it}}{\hat{\sigma}}\right) - \tilde{\sigma}\right]}{\Phi\left(\frac{\tilde{\mu}_{it}}{\tilde{\sigma}}\right)} \exp\left(-\tilde{\mu}_{it} + \frac{1}{2}\tilde{\sigma}\right). \tag{13}$$

Frontier version 4.1, which can be downloaded from the Center for Efficiency and Productivity Analysis of The University of Queensland, Australia, is employed to estimate technical inefficiency in the utilization of inputs by producers (Coelli, 1996).

The production function is said to exhibit constant returns to scale (CRS), if a proportionate increase in inputs results in the same proportionate increase in output. In practice, a widely-used measure of returns to scale is the elasticity of scale (or total elasticity of production). The production function exhibits locally CRS as the elasticity of scale equal to 1. The stochastic production function of schools for academic year 2006 is modeled with a translog production function:

$$\begin{aligned} \ln TS_i = {} & \beta_0 + \beta_1 \ln PG_i + \beta_2 \ln FF_i + \beta_3 \ln SA_i + \beta_4 \ln EXP_i + \beta_5 \ln CS_i \\ & + 0.5\beta_6 (\ln PG)_i^2 + 0.5\beta_7 (\ln FF)_i^2 + 0.5\beta_8 (\ln SA)_i^2 + 0.5\beta_9 (\ln EXP)_i^2 + 0.5\beta_{10} (\ln CS)_i^2 \\ & + \beta_{11} \ln PG_i \ln FF_i + \beta_{12} \ln PG_i \ln SA_i + \beta_{13} \ln PG_i \ln EXP_i + \beta_{14} \ln PG_i \ln CS_i \\ & + \beta_{15} \ln FF_i \ln SA_i + \beta_{16} \ln FF_i \ln EXP_i + \beta_{17} \ln FF_i \ln CS_i + \beta_{18} \ln SA_i \ln EXP_i \\ & + \beta_{19} \ln SA_i \ln CS_i + \beta_{20} \ln EXP_i \ln CS_i \end{aligned} \tag{14}$$

where β_0 is the intercept, and β_1 through β_{20} are parameters to be estimated. The socio-economic variables and institutional arrangements (Z_i) are modeled as a function of several variables:

$$\begin{aligned} u_i = {} & \delta_0 + \delta_1 PROVINCE + \delta_2 POLITICIAN + \delta_3 ABSENT + \delta_4 MISPERCAP + \delta_5 MISFUNDNEED \\ & + \delta_6 HETERO + \delta_7 INCOME + \delta_8 PARENTS + \delta_9 PARENTEDU + \delta_{10} INSPECTION + \delta_{11} VACANT \\ & + \delta_{12} SCHOOLSIZE + \delta_{13} FEMALE + \delta_{14} BITUMEN + \delta_{15} PARTICIPATION + \varepsilon_i \end{aligned} \tag{15}$$

To check the production behavior of equation (14), the partial differentiation with respect to each input was computed. For each input x_i (i=1,2,3,4,5), there is a corresponding output elasticity which is defined as the percentage variation of the i-th school's output value for a 1% change in the i-th input factors. Outputs elasticity is given by:

$$e_{PG} = \frac{\partial \ln TS_i}{\partial \ln PG_i} = \beta_1 + \beta_6 \ln PG_i + \beta_{11} \ln FF_i + \beta_{12} \ln SA_i + \beta_{13} \ln EXP_i + \beta_{14} \ln CS_i \tag{16}$$

$$e_{FF} = \frac{\partial \ln TS_i}{\partial \ln FF_i} = \beta_2 + \beta_7 \ln FF_i + \beta_{11} \ln PG_i + \beta_{15} \ln SA_i + \beta_{16} \ln EXP_i + \beta_{17} \ln CS_i \tag{17}$$

$$e_{SA} = \frac{\partial \ln TS_i}{\partial \ln SA_i} = \beta_3 + \beta_8 \ln SA_i + \beta_{12} \ln PG_i + \beta_{15} \ln FF_i + \beta_{18} \ln EXP_i + \beta_{19} \ln CS_i \quad (18)$$

$$e_{EXP} = \frac{\partial \ln TS_i}{\partial \ln EXP_i} = \beta_4 + \beta_9 \ln EXP_i + \beta_{13} \ln PG_i + \beta_{16} \ln FF_i + \beta_{18} \ln SA_i + \beta_{20} \ln CS_i \quad (19)$$

$$e_{CS} = \frac{\partial \ln TS_i}{\partial \ln CS_i} = \beta_5 + \beta_{10} \ln CS_i + \beta_{14} \ln PG_i + \beta_{17} \ln FF_i + \beta_{19} \ln SA_i + \beta_{20} \ln EXP_i \quad (20)$$

The cross elasticity of substitution for input factor i and j can be defined as follows (Ferguson: 1969):

$$e_{ij} = \left[\frac{\beta_{ij}}{e_i e_j} \right] + 1 \quad (21)$$

A positive substitution elasticity value implies that the input factors i and j were jointly complementary. In addition, a negative value of cross substitution elasticity value indicates substitutability between the two inputs. Table 2 shows the output elasticity of the translog production function (16) - (20) and cross elasticity of substitution (21). Based on the estimated parameters in Table 2, note that all of the mean values of estimated output elasticities were positive, except for *EXP,* indicating a positive relationship between the output value and input factors. For example, the mean output elasticities of *PG* was 4.81, indicating that, while holding other input factors constant, a 1% increase in *PG* induces a 4.81% increase in output value. Interestingly, a 1% increase in *EXP* reduces the output 0.32%. The cross elasticities of substitution had an average positive substitution elasticity, indicating a complementary relationships between the pairs of inputs. These pairs of inputs needed to increase together to raise output.

Table 2 The output elasticity of translog production functions and cross elasticity of substitution

Input	Mean	Std. dev.	Min	Max	Cross elasticity [e_{ij}]	Mean	Min	Max
PG	4.81	0.13	4.52	5.26	e_{11}	1.11	0.88	2.77
FF	0.39	0.19	-0.19	0.82	e_{12}	1.14	-22.50	49.28
SA	0.04	0.18	-0.35	0.59	e_{13}	1.15	1.05	2.02
EXP	-0.32	0.15	-0.69	-0.03	e_{14}	1.08	1.05	1.15
CS	0.43	0.07	0.24	0.64	e_{15}	2.73	-469.57	250.43
					e_{16}	1.38	0.73	4.21
					e_{17}	0.72	-3.29	1.54
					e_{18}	1.36	-350.93	896.96
					e_{19}	2.39	-171.89	410.42
					e_{20}	1.93	1.21	11.00

Results

The γ parameter is equal to 0.21 and significant at 5% level, suggesting that the SFA is preferred to ordinary least square regression, and the variables in the inefficiency function could be used to explain a substantial part of the unconditional variance of the one-sided error term (Table 3).

Table 3 Parameter estimate of the SFA, inefficiency function of model, and technical efficiency

	Parameter	Coefficient	t-ratio		Parameter	Coefficient	t-ratio
Intercept	β_0	4.80	1.65*	Intercept	δ_0	0.50	1.89**
ln*PG*	β_1	0.02	0.25	Province (Dummy)	δ_1	-0.04	1.31
ln*FF*	β_2	0.01	0.21	Politician involvement	δ_2	-0.05	1.68**
ln*SA*	β_3	0.13	1.91**	Teacher absence rate	δ_3	-0.003	0.93
ln*EXP*	β_4	0.17	3.60	Leakage capitation	δ_4	0.000003	1.41*
ln*CS*	β_5	-0.99	0.47	Leakage funds-needed	δ_5	0.00001	1.20
$0.5\,(\ln PG)^2$	β_6	-0.02	0.14	Heterogeneity	δ_6	-0.02	0.58
$0.5\,(\ln FF)^2$	β_7	-0.22	2.89***	Avg. household income	δ_7	-0.004	1.64**
$0.5\,(\ln SA)^2$	β_8	0.02	0.06	Living with parents	δ_8	0.004	0.17
$0.5\,(\ln EXP)^2$	β_9	0.29	1.63**	Parents' education	δ_9	0.002	0.54
$0.5\,(\ln CS)^2$	β_{10}	-0.07	0.26	Inspection	δ_{10}	-0.006	2.11**
ln*PG*ln*FF*	β_{11}	0.12	1.32	Teacher vacancy rate	δ_{11}	0.005	2.89***
ln*PG*ln*SA*	β_{12}	-0.25	1.41*	School size	δ_{12}	-0.003	1.73*
ln*PG*ln*EXP*	β_{13}	-0.16	0.76	Share of female students	δ_{13}	-0.001	0.46
ln*PG*ln*CS*	β_{14}	0.17	0.90	Nearest Bitumen road	δ_{14}	-0.02	5.03***
ln*FF*ln*SA*	β_{15}	0.24	1.49*	Parents' participation	δ_{15}	0.14	2.27**
ln*FF*ln*EXP*	β_{16}	-0.03	0.18	Sigma-squared	$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.005	5.46***
ln*FF*ln*CS*	β_{17}	-0.03	0.32	Gamma	$\gamma = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$	0.21	1.50*
ln*SA*ln*EXP*	β_{18}	0.29	1.49*	Mean technical efficiency			89.3%
ln*SA*ln*CS*	β_{19}	-0.20	0.63	Min technical efficiency			84.6%
ln*EXP*ln*CS*	β_{20}	-0.08	0.49	Max technical efficiency			98.8%

Note: *** ** * significant at the levels of 1%, 5% and 10%, respectively

The estimated technical efficiencies of school production were impressively high. The values were ranged from 84.6 to 98.8%, with a mean of 89.3%. The high technical efficiency scores indicate that only little output was sacrificed to inefficiency. Based on the analysis, there were only 2 schools that had scores between 95.0% and 100%, while 66 schools had scores between 85.0% and 94.9%. In other words, there was a great potential for increasing education production through improvements in technical efficiency.

The exogenous factors that promote efficiency were also analyzed since investment in resource allocation without concerning other factors might not meet the objectives of the service provider. The coefficient of the politicians' involvement variable in the stochastic part was negative and significant, implying that the level of school efficiency would increase when there is a politicians' involvement. The socio-economic variable coefficients, such as average household income, would increase efficiency; however, the coefficient of institution-related variables, including leakage of capitation grants and teacher vacancy rate increase inefficiency. It should be noted that students from rich families, other things equal, would increase output. The variables of inspection received, bigger school size, and nearest bitumen road would increase efficiency. Poor management such as teacher vacancy rate increases inefficiency. Surprisingly, the coefficient of parent participation was positive and significant in reducing efficiency. Lastly, the coefficient of dummy variable representing school location was not statistically significant, implying the average inefficiency (the intercept term) of schools in both provinces are the same.

Conclusions and Recommendation

Based on the analysis, in order to enhance the schools' efficiency, schools need to prevent the leakage of capitation grants. The role of the government in promptly filling up the teacher's vacancy would help improve the efficiency. The nearest bitumen road was an important factor to enhance school efficiency. Surprisingly, parental participation was positive and significant in reducing efficiency; this suggests that the school committee should facilitate the parents' participation particularly concerns on student achievement issue and not just have regular meetings. Inspection is a factor that the government could easily deal with in practice; it is recommended that the respective authorities should frequently and officially visit the school. Regarding the socio-economic factor, household income would promote efficiency. Leakage of capitation was also significantly associated with school efficiency; the higher the leakage, the higher the inefficiency and it is recommended that the government lessen the leakage. In addition, the average inefficiencies of schools in both provinces were not statistically different.

The results show that, on average, the SBM framework is suitable for explaining the learning achievement of students in the sample schools; however, it suggests that improvements in educational outputs requires more than higher budget allocations since some socio-economic and institutional factors drawn from the framework significantly explain school efficiency. It can be concluded that not only schools itself but also family background and communities play important roles in the education production.

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