Technical Efficiency in Ghanaian Secondary Education[1]

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Abstract

This paper uses district-level panel data and a stochastic frontier production function to investigate the existence of, and the correlates of inefficiency in the production of secondary education in Ghana. Using the proportion of students passing the West African Eaxmination Council's Certificate examination, we find relatively large indices of technical inefficiency in the production of education in Ghana. These technical inefficiencies vary by subject matter and are higher at the Junior Secondary School level than at the Secondary School level. Furthermore, we find large regional differences in technical inefficiencies we estimate in this paper. Technical inefficiency, we find, also varies by subject; there tends to be large inefficiencies in the scienes and mathematics than in English. We find that average per student household expenditure on education, parent's education, and the number of siblings are highly correlated with technical ineficiencies in the production of secondary education in Ghana. The correlation between these family inputs and technical inefficiency is much stronger at the Senior Secondary School level than at the Junior Secondary School level. We also find that the education production function is neither of the Cobb-Douglas functional form nor constant returns to scale technology. Our results point to the importance of both school and family inputs in the production of cognitive abilities in Ghanaian secondary schools.

KEY WORDS: EFFICIENCY, EDUCATION, PRIMARY, SECONDARY, STOCHASTIC FRONTIER PRODUCTION FUNCTION, SCHOOL DISTRICT, TRANSLOG PRODUCTION FUNCTION, GHANA

J.E.L. CLASSIFICATION: O1, O4, O55, J2

Objectives

- Investigate Existence of Inefficiency
- What are the correlates of Inefficiency?
- Do family inputs matter in Education Production?

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Approach

- **Stochastic Frontier to Estimate Inefficiency**
- **Regress inefficiency on Family inputs**
- **Panel Data Methodology**
- **Limited to Public Schools**
- **3 outputs for JSS & SSS**

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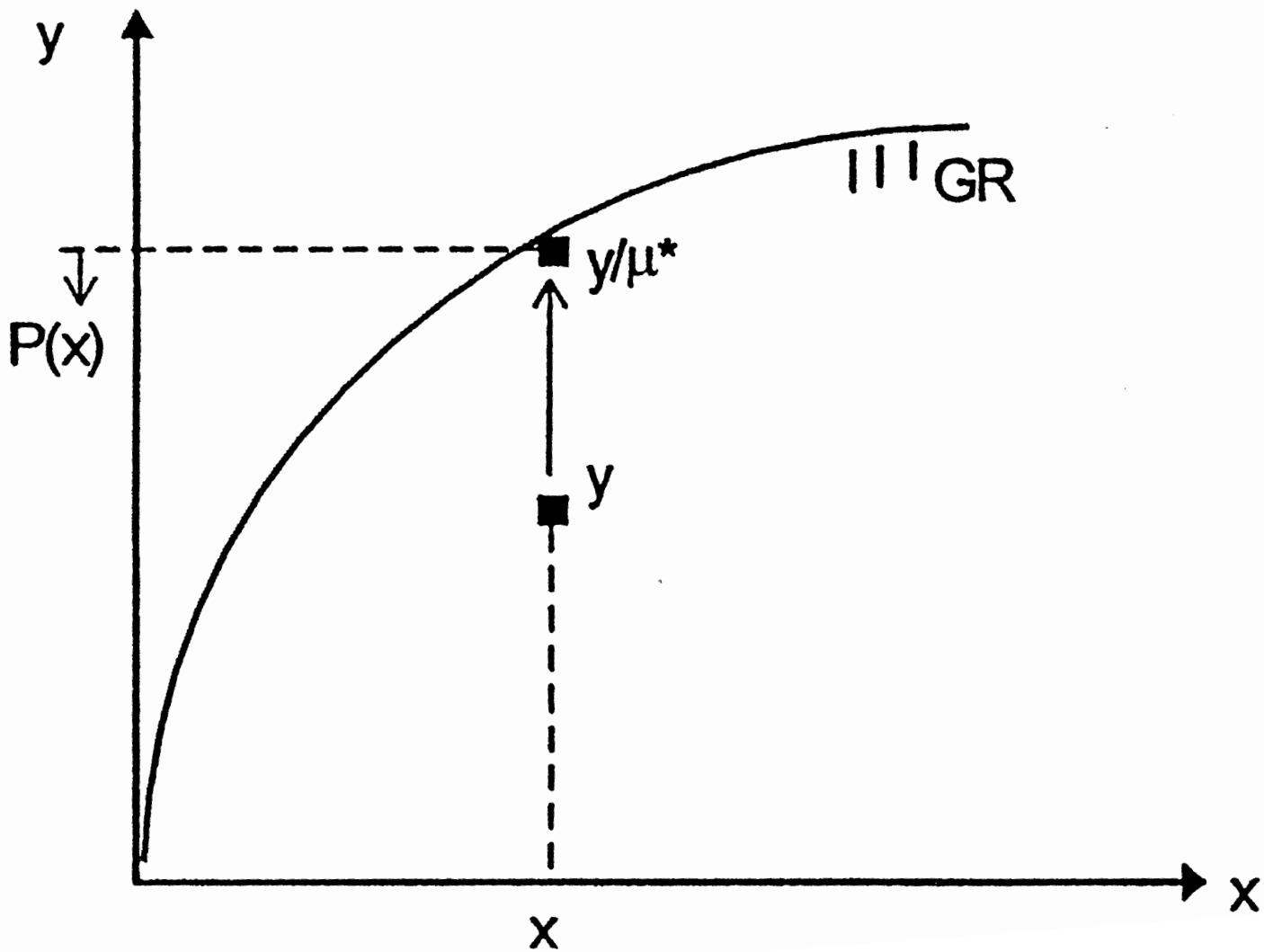
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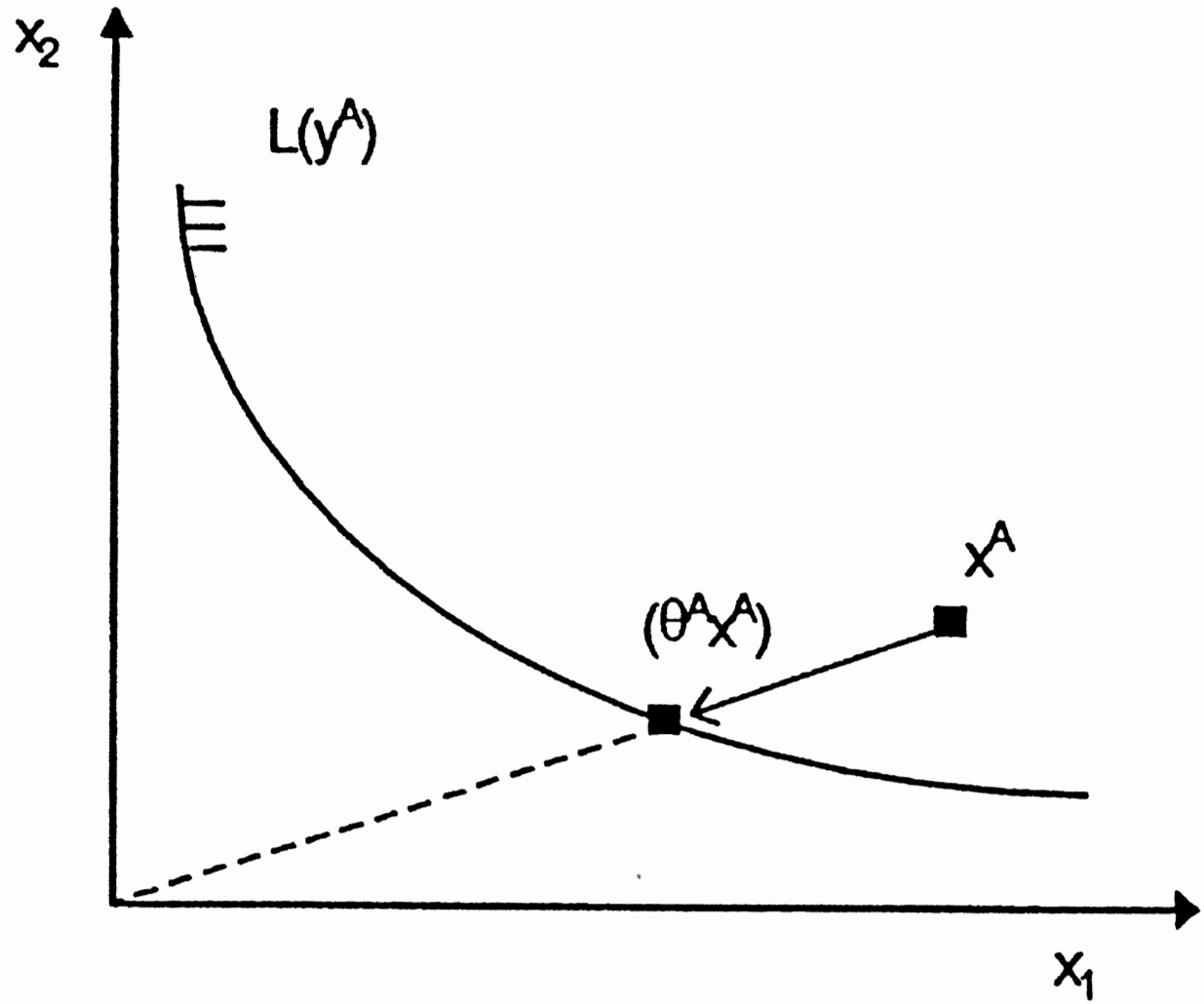


Figure 2.16 An Input-Oriented Measure of Technical Effi
($N = 2$)

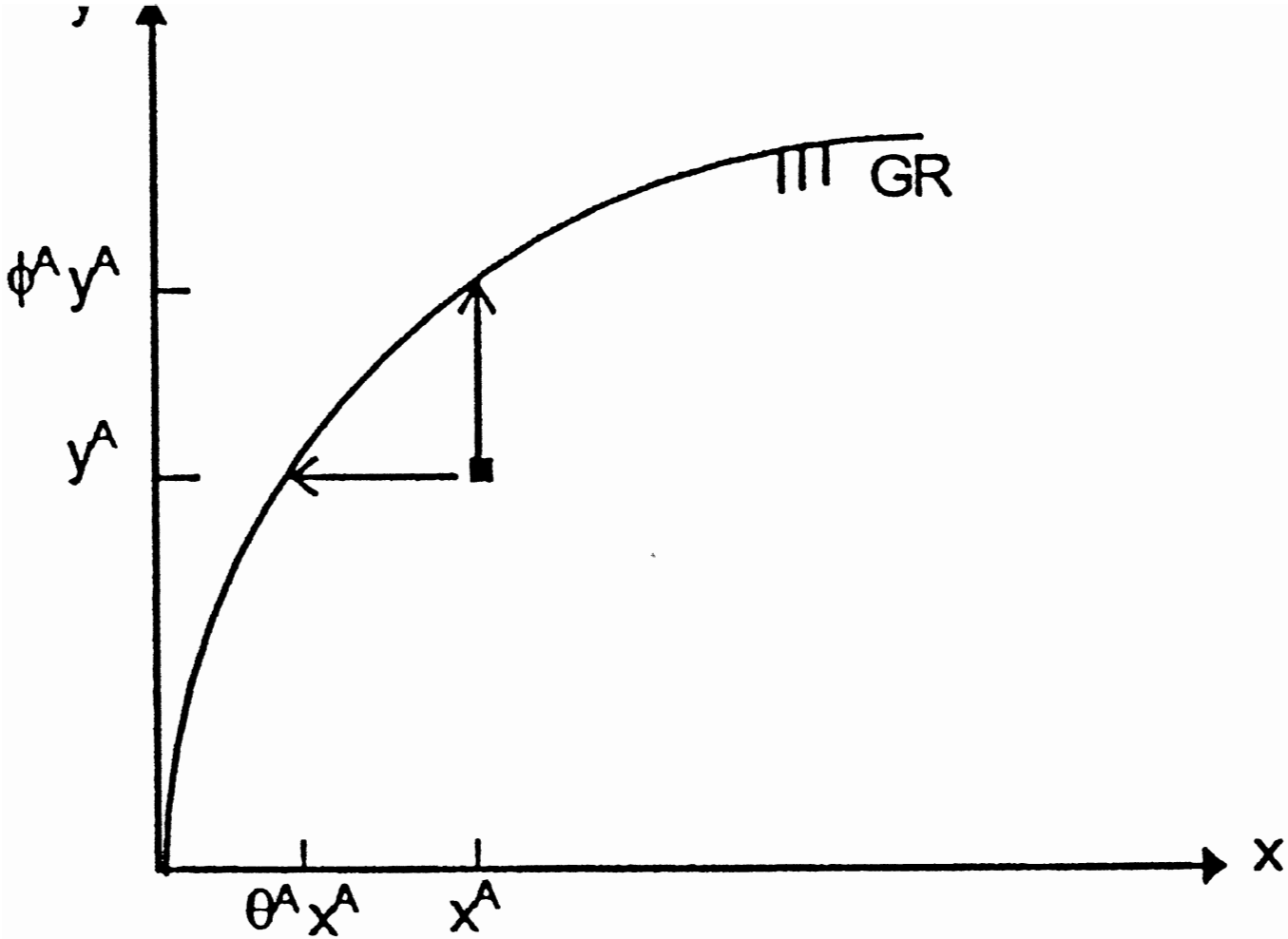
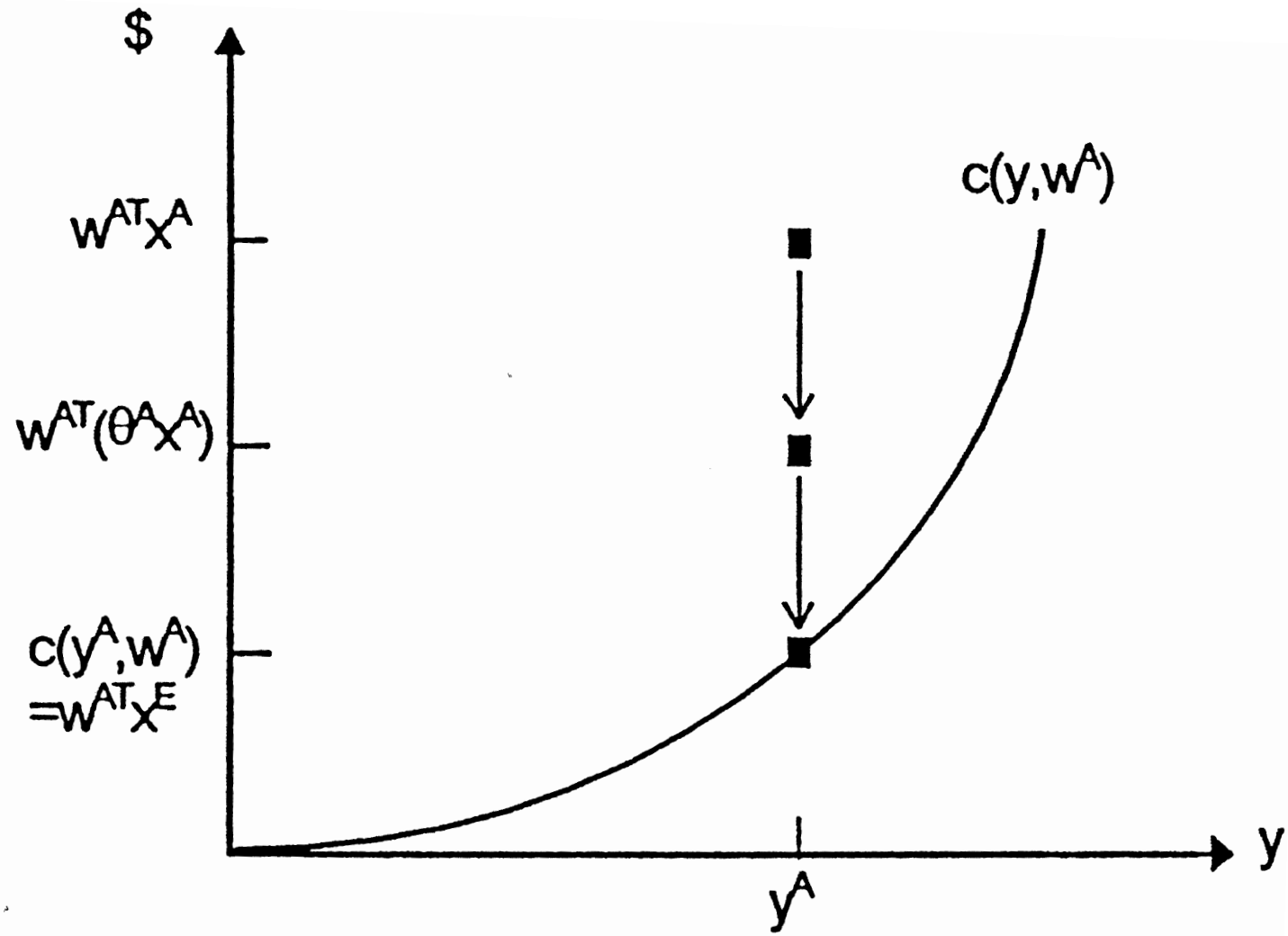


Figure 2.15 Input-Oriented and Output-Oriented Measures of Technical Efficiency ($M = 1, N = 1$)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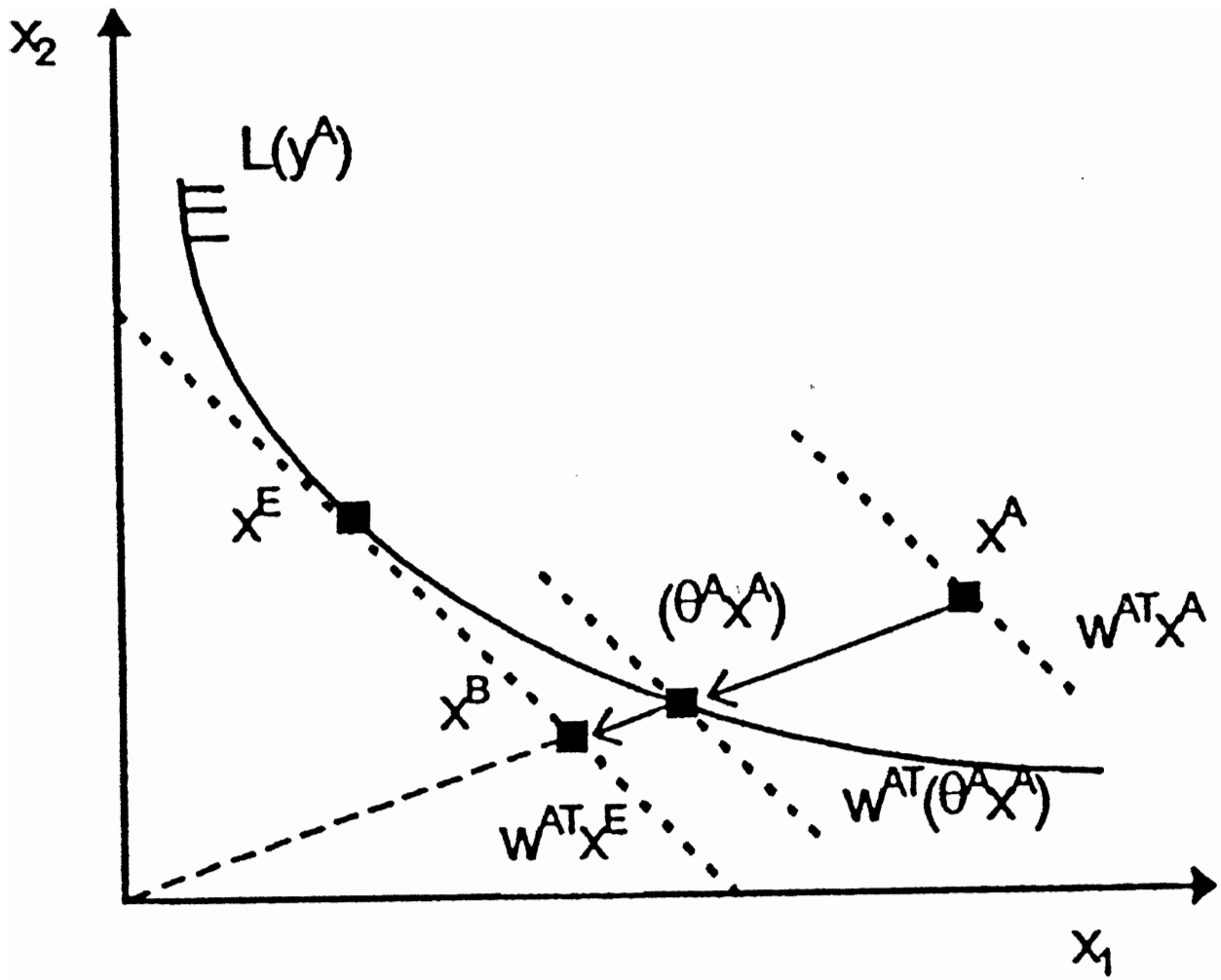
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$(\theta^A x^A)$
$w^{AT}x^A$
x^B
$w^{AT}(\theta^A x^A)$
$w^{AT}x^E$
x_1

Why Technical Efficiency?

Importance of Education in:

- Government budgeting
- Development Process
- As a way of Life
- Severe Resource Constraints
- The Need for Efficiency
- Necessary for Economic Efficiency

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Results

- Can be represented by translog function
- Substantial Inefficiency in all subjects and Levels
- Substantial Variation by District & Subject
- Increases with Cycle
- Inefficiency correlated with family inputs
- Parental education more important than exp.
- Correlation stronger for SSS

Organization

- Approaches to Economics Of Education
- Model
- Data & Estimation Method
- Results
- Conclusion

Approaches to Economics of Education

- Early Childhood Development
- Production Function
- Educational Institutions Approach
- All 3 affect Cognitive Performance
- Concentrate on first 2

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Model

- **Translog function Stochastic Frontier function**
- **Estimate with a new panel GMM approach (Chen & Wang)**
- **Obtain inefficiency (U)**
- **Regress U on family inputs (W)**
- **A check on whether family inputs matter.**

1 Model

$$\mathbf{Q}^* = \mathbf{f}(\mathbf{X}, \mathbf{v}) \tag{1}$$

where $\mathbf{v}$ is the usual stochastic error term assumed to be i.i.d. normally distributed with zero mean and a constant variance (σ_v^2).

$$\mathbf{Q_i} = \mathbf{f}(\mathbf{X}, \mathbf{v})\mathbf{e}^{-\mathbf{u_i}} \qquad u_i \geq 0 \tag{2}$$

$$\mathbf{Q} = \mathbf{e}^{\mathbf{X}'\beta + (\mathbf{V_i} - \mathbf{U_i})} \tag{3}$$

The translog production function we estimate in this paper is given as:

$$\begin{aligned} lnQ_{ijt} &= \alpha_0 + \alpha_1 STRATIO_{ijt} + \alpha_2 FEMALE_{ijt} + \alpha_3 TRAINED_{ijt} + \alpha_4 FREPAIR_{ijt} \\ &+ \frac{1}{2}[\alpha_{11} lnFEMALE * lnFEMALE + \alpha_{12} lnFEMALE * lnTRAINED \\ &+ \alpha_{13} lnFEMALE * lnSTRATO + \alpha_{14} lnFEMALE * lnFREPAIR \\ &+ \alpha_{22} lnTRAINED * lnTRAINED + \alpha_{23} lnTRAINED * lnSTRATIO \\ &+ \alpha_{24} lnTRAINED * lnFREPAIR + \alpha_{33} lnSTRATIO * lnSTRATIO \\ &+ \alpha_{34} lnSTRATIO * lnFREPAIR + \alpha_{44} lnFREPAIR * lnFREPAIR] \\ &+ \gamma REGION + \epsilon \end{aligned}$$

where We impose symmetry restrictions (i.e. $\alpha_{ij} = \alpha_{ji}$).

Output elasticity is: $\partial lnQ/\partial x_i = \alpha_i + \sum_j \alpha_{ij} X_j$

$$u_i = (q^* - q_i)/q^* \quad \text{or} \quad 1 - \mathrm{q_i}/\mathrm{q}^* \tag{4}$$

$$u_i = \beta_0 + \beta_1 EDUEXP + \beta_2 PARENTED + \beta_3 SIBLING + \varepsilon_i \tag{5}$$

Data

Dependent Variable:

- **Proportion Passing WAEC Exams**
- **BECEE, BECES, BECEM**
- **SSCEE, SSCES, SSCEM**

Regressors

School Inputs:

- **STRATIO**
- **FEMALE**
- **TRAINED**
- **FREPAIR**
- **BECE**

Family Inputs:

- EDUEXP
- DADEDUC (MOMEDUC)
- SIBLING

Table 1

Summary Statistics for Ghana Education Production Data

Variable	Mean*	Standard Error	Minimum	Maximum
JSS enrolment	6560.988	7160.018	923	67840
SSS enrolment	1669.253	2618.777	0.0	18892
JSS Female Teacher (%)	18.6518	11.826	0.2	56.8
SSS Female Teacher (%)	12.371	8.4117	0.0	37.8
JSS Trained Teacher (%)	62.8912	40.9555	5.0624	92.8913
SSS Trained Teacher (%)	42.9952	28.7550	0.0	100.0
JSS Student/Teacher ratio	19.1333	3.7349	9.00	35.5
SSS Student/Teacher ratio	17.0936	8.7411	0.0	92.6
JSS Fac. Repair (%)	37.3482	11.9433	4.50	76.90
BECEE	49.2272	14.6422	17.9	89.6
BECES	52.4654	13.8956	21.3	93.5
BECEM	52.0897	13.9255	24.2	100.00
SSSCEE	41.9694	20.5220	1.51	92.6
SSSCES	35.1151	17.3857	0.51	85.1
SSSCEM	39.6473	17.3544	0.00	89.6
DADEDU1215	2.0532	0.9547	1.0	5
MOMEDU1215	1.655	0.5218	1.0	3.11
DADEDU1620	2.5299	1.0899	1.0	5.2858
MOMEDU1620	1.5727	0.6039	1.0	3.75
EDUEXP1215 (Cedis)	92,353.47	65,063.36	11,533.33	373,731.60
EDUEXP1620 (Cedis)	230,695.00	287,410.60	24,750.00	2,166,750.00
SIBLIN1215	2.1	1.582	1.0	5.0
SIBLIN1620	1.432	1.30	1.0	4.0
N	330	330	330	330

These are unweighted means.

Table 2

Estimates of Translog Stochastic Frontier Production Function: JSS

Variable	coeff.	BECEE	BECES	BECEM
constant	α_0	1.3484	5.5022	6.4313
		$(0.71)^+$	(2.65)	(2.93)
female	α_1	0.2158	-0.0884	-0.1573
		(2.43)	(0.84)	(1.330
trained	α_2	0.8957	0.9728	0.0872
		(1.97)	(2.21)	(1.88)
stratio	α_3	0.2158	-1.4344	-1.4329
		(2.43)	(1.81)	(1.86)
sfrep	α_4	-0.4583	-0.5574	0.2435
		(1.84)	(1.97)	(0.88)
$(\text{female})^2$	α_{11}	0.0095	-0.0018	0.0018
		(1.67)	(0.09)	(1.84)
$(\text{trained})^2$	α_{22}	0.1289	0.0133	0.0081
		(1.91)	(1.71)	(0.10)
$(\text{stratio})^2$	α_{33}	0.1945	0.5507	-0.5333
		(0.57)	(1.37)	(1.85)
$(\text{sfrep})^2$	α_{44}	-0.2025	-0.2413	-0.1449
		(2.47)	(2.58)	(1.68)
female*trained	α_{12}	0.1389	0.1256	0.0387
		(2.19)	(1.89)	(1.72)
female*stratio	α_{13}	-0.0189	0.0017	0.1282
		(1.91)	(1.08)	(1.29)
female*sfrep	α_{14}	0.1506	0.1066	0.1319
		(2.68)	(1.64)	(1.86)
trained*stratio	α_{23}	0.1128	-0.0026	0.0481
		(1.923)	(1.21)	(1.89)
trained*sfrep	α_{24}	-0.0121	-0.0011	-0.1261
		(1.08)	(0.98)	(0.91)
stratio*sfrep	α_{34}	-0.1189	-0.1071	-0.0151
		(2.29)	(2.72)	(1.70)
region	γ	4.8701	0.0122	0.0051
		(5.65)	(1.95)	(0.91)
Log Likelihood		97.0679	87.9026	88.57
Wald χ^2		60.05	87.86	52.05
σ^2		0.0710	0.1565	0.623
σ_v^2		0.0179	0.0243	0.0116
σ_u^2		0.0530	0.1322	0.0507
λ		2.9461	5.4403	4.3707

+ absolute value of z score in parentheses.

Table 3

Estimates of Translog Stochastic Frontier Production Function: SSS

Variable	coeff.	SSCEE	SSCES	SSCEM
constant	α_0	1.5025	3.431	2.1996
		$(1.01)^+$	(2.2165)	(2.56)
female	α_1	0.2382	0.0412	0.4375
		(2.76)	(2.61)	(2.00)
trained	α_2	0.2339	0.0641	0.2822
		(1.78)	(2.21)	(2.47)
stratio	α_3	0.2546	-0.2159	-0.4186
		(0.27)	(1.92)	(2.56)
bece	α_4	0.1098	0.0827	0.7851
		(1.72)	(2.54)	1.77
$(\text{female})^2$	α_{11}	0.0945	0.0126	-0.0147
		(2.24)	(1.62)	(0.41)
$(\text{trained})^2$	α_{22}	-0.0564	0.0082	-0.0625
		(1.56)	(1.71)	(1.58)
$(\text{stratio})^2$	α_{33}	-0.1465	-0.0812	0.1908
		(1.66)	(1.68)	(0.64)
$(\text{bece})^2$	α_{44}	0.0072	0.0827	0.1851
		(1.62)	(2.54)	(1.77)
female*trained	α_{12}	0.0196	0.0110	0.1182
		(1.98)	(1.81)	(1.98)
female*stratio	α_{13}	0.0745	-0.1197	-0.2003
		(1.46)	(1.67)	(1.79)
trained*stratio	α_{23}	0.0086	-0.0386	0.0219
		(1.82)	(1.63)	(1.32)
trained*bece	α_{24}	0.0056	0.0582	0.0093
		(1.08)	(1.76)	(1.98)
region	γ	-0.0026	0.0214	-0.0068
		(2.22)	(1.76)	(1.56)
Log Likelihood		202.5618	176.2181	157.9870
Wald χ^2		88.56	93.2761	95.54
σ^2		1.0481	0.6513	0.5436
σ_v^2		0.1256	0.1287	0.1266
σ_u^2		0.9225	0.5225	0.4169
λ		7.3447	4.0614	3.2931

+ absolute value of z score in parentheses.

Table 4

Average Indices of Technical Inefficiency by Region

Region	BECEE	BECES	BECEM	SSCEE	SSCES	SSCEM
Ashanti	0.1094	0.1543	0.0918	0.0963	0.1035	0.0663
	(0.0620)$^{+}$	(0.0637)	(0.0521)	(0.0621)	(0.1295)	(0.0933)
Brong Ahafo	0.0827	0.1377	0.0990	0.0892	0.0752	0.0939
	(0.0526)	(0.0545)	(0.0476)	(0.0549)	(0.1297)	(0.0983)
Central	0.0937	0.1381	0.1110	0.0321	0.0502	0.0335
	(0.0646)	(0.0671)	(0.0623)	(0.0438)	(0.0997)	(0.0851)
Eastern	0.0609	0.1040	0.0828	0.0362	0.0237	0.0364
	(0.0607)	(0.0628)	(0.0556)	(0.0945)	(0922)	(0.0908)
Greater Accra	0.0112	0.0379	0.0295	0.0261	0.0518	0.0407
	(0.0376)	(0.0427)	(0.0333)	(0.0873)	(0.0796)	(0.0581)
Northern	0.0836	0.1345	0.0746	0.2903	0.3034	0.2128
	(0.0626)	(0.0587)	(0.0605)	(0.1773)	(0.2422)	(0.2646)
Upper East	0.0554	0.0965	0.0404	0.2023	0.1788	0.1236
	(0.0389)	(0.0356)	(0.0396)	(0.1233)	(0.1799)	(0.0976)
Upper West	0.0661	0.1040	0.0571	0.0841	0.0679	0.0.0636
	(0.0262)	(0.0231)	(0.0228)	(0.1033)	(0.0907)	(0.1051)
Volta	0.0782	0.1185	0.0835	0.0701	0.0427	0.0511
	(0.0301)	(0.0312)	(0.0253)	(0.0651)	(0.0543)	(0.0714)
Western	0.0824	0.1221	0.0737	0.0537	0.0827	0.0455
	(0.0701)	(0.0713)	(0.0704)	(0.0728)	(0.1359)	(0.0988)
Overall Average	0.102	0.127	0.091	0.108	0.119	0.089
Maximum	0.382	0.489	0.412	0.316	0.389	0.297
Minimum	0.00	0.00	0.00	0.00	0.00	0.00

+ standard errors in parentheses.

Table 5

Correlates of Technical Inefficiency

Region	**BECEE**	**BECES**	**BECEM**	**SSCEE**	**SSCES**	**SSCEM**
Constant	0.1368 (2.085)$^{+}$	0.0302 (1.03)	0.1569 (5.31)	0.5761 (4.63)	0.6798 (5.79)	0.4017 (4.13)
EDUCEXP	-0.0070 (0.84)	0.0010 (1.30)	-0.0078 (1.88)	-0.0386 (3.58)	-0.451 (4.35)	-0.0221 (2.58)
MOMEDU	—	-0.0609 (1.93)	-0.0267 (1.85)	-0.0734 (2.18)	—	—
DADEDU	-0.0346 (1.67)	—	—	—	-0.0331 (2.45)	-0.0593 (3.06)
SIBLING	0.0241 (1.98)	0.0221 (1.72)	0.0141 (1.78)	0.0026 (1.98)	0.0214 (2.16)	0.0093 (2.34)
N	102	101	101	96	96	96
Log Likelihood	103.849	104.126	157.873	52.247	67.923	96.143
PseudoR^2	0.155	0.245	0.187	0.2732	0.2377	0.0592
χ^2 [3]	8.36	9.98	8.26	22.42	26.09	22.07
sigma^2	0.0847	0.0863	0.0499	0.1054	0.0998	0.0851

+ absolute value of "t" statistics in parentheses.