International Journal of Science Academic Research
Vol. 02, Issue 02, pp.1006-1010, February, 2021
Available online at http://www.scienceijsar.com

ISSN: 2582-6425

Research Article

CONSTRUCTION OF EDUCATION DEVELOPMENT INDEX (EDI) FOR NORTH WESTERN ZONE IN NIGERIA

[1,*]Salawu, I. Saheed, [2]Muhammad Shamsudeen Sambo and [3]Zakariyau Abdulqadir Aliyu

[1]Department of Statistics, Air Force Institute of Technology, Kaduna Zaria
[2]Department of PRS, Ministry of Basic & Secondary Education, Sokoto, Nigeria
[3]Department of PRS, Kwara State Ministry of Education, Ilorin, Nigeria

Received 24th December 2020; **Accepted** 18th January 2021; **Published online** 15th February 2021

Abstract

The use of multiple indicators of heterogeneous nature to assess the overall development of education is a complex task and its misinformed policymakers and education managers. The need for an Education Development index (EDI) that sum all indices for policymakers and education managers to make decisions in identifying areas lagging in comparison to the national average. This paper proposed the construction of EDI for the North-Western Zones of Nigeria using the Principal Component and Average methods to compare the relationship of the access, participation, teacher, and equity index. A multiple regression model is developed, and the coefficient of determination for the models is 75 percent and 78 percent for the models. The results showed that access and equity in basic education are important in explaining the ex-pected outcomes in education delivery. A significant relationship interplays between the pair of access, equity, and infra-structure in explaining expected outcome in basic education. All test of significance was at 5 percent level.

Keywords: Principal Component Analysis, Average, Regression, Correlation, Indicators, and EDI.

INTRODUCTION

The Education Development Index is the initial step at developing the comprehensive and composite index of educational performance in Nigeria. The product is to facilitate better decision making in resource allocation for the education sector. Education performance indices support improvements in the design and implementation of educational policies. Education indices informed about prevailing problems and hint at some of the causes. As also emphasized in a recent World Bank study (Carvalho and White, 1994), indicators are precisely what the word says - "indicative" - and cannot be a substitute for in-depth analysis and evaluative work (Rob Vos, 1996). The annual update of the EDI helps monitor progress in the education sector and compare achievements across national and international. Numerous strategies are employed by policymakers and managers for improving the quality of education in the basic education sub-sectors with strong support from multilateral agencies, including the World Bank, USAID, DFID, and the IDB. These strategies include strengthening the proxies of access, quality, infrastructural facilities, equity, and improves reading outcomes. The stakeholders engaged in the provision of teaching and learning teaching materials, preservice and in-service training of teachers, expand the community of practices, supplies of inputs to schools, and engagement at the high – level policy ranking cadres. However, the design, monitoring, and evaluation of the cost-effectiveness of these programs and the educational sector, in general, is hampered by persistent deficiencies in the quality and timely availability of educational statistics. The federal, state, local government, and development partners have invested human, materials, and financial resources in the Basic Education sub-sectors towards the achievement of universal and quality basic education for all, improvement in the transitional rate, reduction in gender gaps, and sustaining efficient educational system.

Corresponding Author:** ***Salawu, I. Saheed
Department of Statistics, Air Force Institute of Technology, Kaduna Zaria.

However, no development index to measure the progress and achievement in the sectors. This made a comparison of performance in the education sectors to be a mirage. This paper discusses the operation of educational indicators, despite different heterogeneity structure that distinguishes between input, access, output, and outcome indicators, to generate development index. The EDI will be a base for comparing educational performances and investment across national and international borders. The Principal Component Analysis (PCA) and the Average approach used to build the EDI, and the model compared. The regression model is fit to explain the variation in the outcome index.

Sources of Data

The Annual School Census (ASC) data is collected from the Education Management Information System (EMIS) unit of the state Ministry of Basic and Secondary Education (MBSE) in Sokoto state was used for modeling the Education Development Index (EDI). The data is for the 2,050 public primary schools in the 23 local government areas across Sokoto state, North-West Geographical zone of Nigeria. Thus, the EDI constructed for this analysis is a summation of four major indices**.** These are: (i) input index, (ii) equity index, (iii) teacher index, and (iv) outcome index. A brief description of the indices is given in the table below.

METHODOLOGY

In reference to the EDI measure in Bangladesh (EDI, 2006), the methodology used to construct EDI in the UNESCO (2006) study was rather crude. Similar weights were assigned to all the parameters, which fails to consider the fact that different parameters might have different importance in the constructed aggregate EDI. Therefore, the Indian Planning Commission Study (1999) was very much subjective. No justification has been provided with respect to how those subjective weights were derived.

Table 1. Summary of the Steps of Constructing an Education Development Index (EDI)

Theme	Task	Remarks
Identifying Dimensions and Indicators	Literature Review and Stakeholder's workshop – list of possible indicators Identification of indicator's direction	Identify the dimensions and indicators under each dimension
Normalization	Normalization of data and grouping of indicators	Values can only be between 0 and 1
Principal Component Analysis	PCA – Factor Extraction for each dimension separately – Factor loadings calculation – Eigen Value Calculation – Weighting	PCs (factors) selected using Kaiser's criteria Weight for each variable is calculated from the product of factor loadings of the principal components with their corresponding Eigen values.
	Constructing Dimension Index Constructing overall index	Dimension Factors received weights according to their internal variation

Table 2. Structural Representation of the Education Development Index (EDI)

Dimension	Indicator	Dimension Indices	Sub-EDI Indicators
	Gross Intake Rate (+) Net Intake Rate (+)	Access Index	
	Pupil Classroom Ratio (Average Student Classroom Ratio) (-) Percentage of Schools with drinking water facility (+)		
Infrastructure	Percentage of Schools with Toilet (+) Percentage of Schools with Girl's Toilet (+) Percentage of Useable classroom (+)	Infrastructure Index	Input
	PTR		
Teacher	Percentage of Teachers with Professional Qualifications (+) Average Pupil-Teacher Ratio (-)	Teacher's index	
	Gross Enrolment Ratio (+)		
Output	Net Enrolment Ratio (+) Gender Parity Index in Enrolment (+)	Output Index	Output/Outcome Index
Equity	Girls' enrolment Percentage of Female Teachers (+)	Equity Index	Equity Index

Jingran and Sankar (2006) and Jadhav and Srivastava (2005) used a better and more scientific approach, the Principal Component Analysis (PCA) to construct an overall EDI for India. UNESCO used four parameters, such as universal primary education, adult literacy, quality education, and gender, to construct EDI for 121 countries (UNESCO 2006). India has had various efforts to construct Education Development Indices (EDIs) in recent years. The Ministry of Human Resource Development (MHRD) supported a study in 1998-99. One noteworthy recent one is the study conducted by the Institute of Applied Manpower Research (IAMR) sponsored by the Planning Commission (Yadav and Srivastava, 2005). The most important and complete one is the study done by Dhir Jingran and Deepa Sankar in 2005/6. They developed district-level educational development indices taking into account education development-related indicators related to dimensions such as inputs and equity for the year 2003-04 (Jhingran and Sankar 2006). The EDI constructed by Jingran and Sankar (2006) is a summation of the following indices input index, equity index, and outcome index.

Indicators

Input indicators measure the resources employed to facilitate the satisfaction of needs and, hence, reaching development objectives. Examples in education would include the number of teachers, school buildings, teaching materials supplies, and the cost and level of expenditures (public and private) on education. Since absolute numbers may not be very indicative of policy decisions, input indicators are often specified, smart, measurable, and realistic, such as the pupil/teacher ratios, PCR, and the average cost per pupil. Access indicators identify demand factors of potential users and would comprise variables that determine the use and accessibility of the supplied services. Examples of this type of indicator in education are the geographical distance to school facilities, family and cultural background of students, foregone earnings of individuals and households, and direct private costs of education (fees, utensils, uniforms, etc.), Gross Intake Rate (GIR), and Net Intake Rate (NIR). *Output and outcome* indicators measure the impact of a set of policies or a project on the living standards of the population. Improvement in these types of indicators should determine the success of policies and projects as they try to measure the development impact. The *immediate* objective of education policy may be to raise coverage of the educational system, GER, improve its internal efficiency, Promotional or retention rates, or raise the skills and knowledge of graduates, achievement tests. *Output indicators* measure to what extent immediate objectives are achieved. Better education may serve broader development goals, such as higher labor productivity, better health, and enhanced capabilities of individuals to participate in modern society. The bigger goals are the *outcomes* beyond the immediate influence of educational policies and programs. Below, we turn to this concept in greater detail.

PRINCIPAL COMPONENT ANALYSIS (PCA)

The PCA reduces the dimensionality (number of indicators) of the data set but retains most of the original variability in the data. It involves a mathematical procedure that transforms several possibly correlated variables into a smaller number of uncorrelated variables called principal components. Thus, PCA reduces the whole set of indicators into few *factors* (underlying dimensions) and construct *dimension* index using factor-loading values as the weight of the particular variable. The results of a PCA usually discussed in terms of component scores and loadings (Shaw, 2003). The PCA method enables us to derive the weight for each variable associated with each principal component and its associated variance explained. In the context of constructing a composite index where it is necessary to assign a weight to each indicator, PCA can be

used in weighing each indicator according to their statistical significance (Filmer and Pritchett, 1998, cited in Jhingran and Sankar, 2008). Principal components depend solely on the covariance matrix ∑ (or the correlation matrix ρ) of X1, X2, . . . , Xp.

Normalization

$$NV_{ij} = 1 - \left[\frac{\{Best\ X_i\ -\ Observed\ X_{ij}.\}}{\{Best\ X_i\ -\ Worst\ X_i\}}\right]$$

Normalized Values always lies between 0 and 1.

The BEST and the WORST values will depend upon the nature of an indicator.

In case of a positive indicator, the highest value will be treated as the best value and the lowest, will be considered as the worst value. Similarly, if the indicator is negative in nature, then the lowest value will be considered as the best value and the highest, the WORST value.

Standardization of the original data:

$$X_{ij} = \frac{X_{ij} - \mu_i}{\sqrt{\sigma_j}}, \quad i = 1, 2, \ldots, p.$$

$$\mu_j = \frac{1}{n}\sum_{i=1}^{n} X_{ij}$$

$$\sigma_j = \frac{1}{n-1}(x_{ij} - \mu_i)^2$$

The correlation coefficient matrix of the standardized data

$$R = \begin{bmatrix} r_{11} & \cdots & r_{1p} \\ \vdots & \ddots & \vdots \\ r_{p1} & \cdots & r_{pp} \end{bmatrix}$$

$$r_{ij} = \frac{1}{n-1}\sum_{i=1}^{n} x_{ij} * x_{ik}$$

$$r_{jj} = 1, and\ r_{ik} = r_{ki}$$

That is, R is a symmetrical matrix, the diagonal elements are 1 Calculate the characteristic value of related coefficient and the eigenvalue of the corresponding feature vector, and the contribution of variance

$$Q^1QR = \lambda_i \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$$

The $\lambda_1, \lambda_2, \ldots \lambda_p$ is the p eigenvalues of R. The contribution of each component of the variance $V_k = \frac{\lambda_k}{\sum_{j=1}^{p}\lambda_j}$. The biggest contribution is the first principal components, the main component, second for the second principal components, till the last component.

Determine the number of main components

According to the principle of more than 85% of the total variance contribution rate to determine the number of main components, the calculation formula of accumulative total variance contribution is

$$CV_k = \sum_{i=1}^{k} V_i = \frac{\sum_{i=1}^{k}\lambda_i}{\sum_{j=1}^{p}\lambda_j}$$

The cumulative variance contribution rate of the current m principal components is over 85 percent above, determine m, namely the number of the principal components is m.

RESULTS

In the correlation matrix average method, the coefficient of the individual indices has shown a significant relationship between outcome index and equity index, between outcome index and access index, and between teacher index and equity index. It showed that access and equity-related intervention by the stakeholders have a role to play in the expected outcome of an education system. A significant investment in teacher-related proxies will bridge the gap of equity in the school system. It is in line with the call of (UNESCO 2006) that investment and availability of teachers in the schools will boost girls' enrolment and bridge the gender gap. Recommendations for greater efforts to improve the schooling of females has been derived from various studies showing particularly strong correlations between the educational level of mothers and the nutritional status of children, infant mortality, and fertility (Cochrane 1979, Psacharopoulos and Woodhall 1985, Behrman 1993). The assessment of the impact of these externalities would require the use of the appropriate output indicators in health and nutrition. The correlation matrix of the PCA method, showed the same trend as the average method, with the addition of a positive relationship between the teacher index and the infrastructure index.

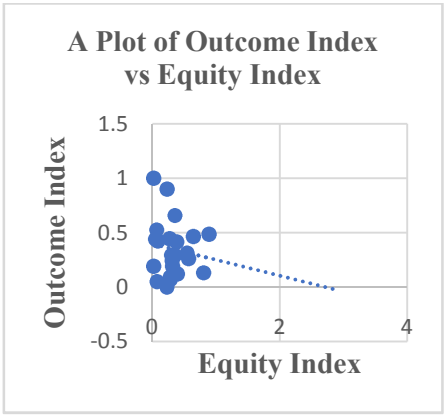

Fig. 1. As equity widens, the expected education outcome index is low, as more interventions are done to shorten the equity gaps, the expected outcomes in internal efficiency of school systems is at high

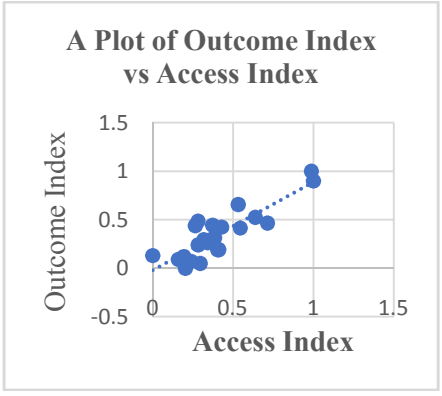

Fig. 2. The relationship between the expected outcome index and the access index is positive. The more access related activities conducted, relatively, the higher the education outcome index

Table 3. Correlation matrix of access, teachers, infrastructure, equity, and outcome indices using Average Method

	Access	Teacher	Infra	Equity	Outcomes
Access	1	-0.385^{NS}	-0.357^{NS}	-0.207^{NS}	0.431*
Teacher		1	0.286^{NS}	0.549**	0.013^{NS}
Infra			1	0.280^{NS}	-0.031^{NS}
Equity				1	0.587**
Outcomes					1

*Significant at 5%; **Significant at 1%; NS- Not Significant. *Source: Author's Calculation*

Table 4. Correlation matrix of access, teachers, infrastructure, equity, and outcome indices using Principal Component Analysis

	Access	Teacher	Infras	Equity	Outcomes
Access	1	-0.361^{NS}	-0.385^{NS}	-0.300^{NS}	0.860**
Teacher		1	0.465*	0.602**	-0.184^{NS}
Infras			1	0.268	-0.235^{NS}
Equity				1	-0.137^{NS}
Outcomes					1

*Significant at 5%; **Significant at 1%; NS- Not Significant. *Source: Author's Calculation*

Table 5. Regression Model of Outcome variable on Access, Teacher, Infrastructure, and Equity using Average and Principal Component Analysis (PCA) Method – EDI

	Average Method			Principal Component Analysis		
Model	**Coefficient**	**T**	**Sig.**	**Coefficient**	**T**	**Sig.**
Constant	0.133	1.321	0.203	-0.171	-1.304	0.209
Access	0.392**	4.429	0.000	0.989**	7.340	0.000
Teacher	-0.176	-1.721	0.102	0.072	0.463	0.649
Infrastructure	-0.002	-0.012	0.990	0.093	0.522	0.608
Equity	0.613**	6.315	0.000	0.087	0.564	0.580
R-Square	0.762			0.766		
Adj R-Square	0.709			0.713		

*Significant at 5%; **Significant at 1%; NS- Not Significant. *Source: Author's Calculation*

Table 6. Education Development Index (EDI) using the PCA and Average Method

	Principal Component Analysis (PCA) Method					Average Method				
Weight	**0.8936**	**3.9777**	**2.3777**	**0.0734**	**0.0042**					
	Access	**Teacher**	**Infrastructure**	**Equity**	**Outcome**	**Access**	**Teacher**	**Infrastructure**	**Equity**	**Outcome**
LG 1	0.342	0.206	0.677	0.570	0.263	0.352	0.153	0.748	0.631	0.631
LG 2	0.373	0.731	0.618	0.272	0.444	0.379	0.705	0.650	0.292	0.461
LG 3	0.240	0.778	0.511	0.281	0.071	0.246	0.713	0.537	0.259	0.180
LG 4	0.296	0.291	0.170	0.073	0.051	0.297	0.365	0.276	0.072	0.119
LG 5	0.363	0.500	0.406	0.352	0.293	0.361	0.504	0.443	0.388	0.422
LG 6	0.318	0.184	0.541	0.299	0.293	0.336	0.157	0.604	0.357	0.473
LG 7	0.204	0.345	0.505	0.230	0	0.209	0.378	0.513	0.261	0.232
LG 8	0.639	0.189	0.412	0.067	0.525	0.654	0.263	0.412	0.058	0.263
LG 9	0.533	0.711	0.745	0.356	0.657	0.539	0.566	0.750	0.385	0.553
LG 10	0.159	0.576	0.769	0.280	0.091	0.163	0.563	0.808	0.311	0.321
LG 11	0.283	0.652	0.812	0.310	0.242	0.287	0.593	0.829	0.304	0.223
LG 12	0.265	0.458	0.457	0.048	0.44	0.269	0.477	0.511	0.041	0.324
LG 13	0.988	0.460	0.394	0.019	1	0.986	0.406	0.340	0.017	0.551
LG 14	0.405	0.739	0.505	0.317	0.192	0.405	0.684	0.570	0.307	0.277
LG 15	0.412	0.379	0.729	0.021	0.192	0.420	0.305	0.741	0.034	0.248
LG 16	0	0.876	0.374	0.806	0.131	0	0.860	0.403	0.812	0.537
LG 17	0.282	0.998	0.799	0.893	0.485	0.288	0.998	0.814	0.872	0.634
LG 18	0.193	0.872	0.720	0.393	0.121	0.205	0.774	0.707	0.389	0.271
LG 19	1.001	0.090	0.124	0.231	0.899	1.008	0.137	0.366	0.288	0.681
LG 20	0.429	0.463	0.471	0.085	0.424	0.449	0.367	0.513	0.124	0.422
LG 21	0.715	0.860	0.576	0.645	0.465	0.751	0.787	0.595	0.640	0.544
LG 22	0.545	0.426	0.261	0.384	0.414	0.553	0.440	0.337	0.449	0.591
LG 23	0.385	0.725	0.454	0.546	0.313	0.391	0.671	0.494	0.581	0.555

Source: Author's Calculation

This result supports the argument that the supply of schools alone cannot ensure the expected outcome. The expected outcome is a function of teacher input and infrastructure. This assertion is in congruence with the findings of Dhir and Deepa (2009). The regression model for the average model indicated that access and equity index are significant in the expected outcomes of an education system concerning the data point. The government at every structure needed to invest in access related intervention with gender sensitivity. The investment in access yields expected results but, school attendance and completion remain a challenge for millions of children and youth, and its strongly influenced by such socioeconomic factors as age, sex, race, ethnicity, disability, language, poverty and location. At least 67 million primary school-age children remain out of school (UNESCO 2010), 53 percent of whom are girls. Over 45 percent of all out-of-school children live in sub-Saharan Africa (UNICEF, Thematic Report 2001).

$$Outcomes = 0.133 + 0.392Access - 0.176Teacher - 0.002Infra + 0.613Equity; \quad R^2 = 76.2\%$$

The PCA model indicated the same trend as the average method model, but with a significance in the access parameter. The campaign by stakeholders in ensuring learners are in schools and are accessible in the urban/rural settlement, reduction in the distance walk to schools by the learners, and schools built with all forms of sensitivity (age, sex, race, ethnicity, disability, language, poverty and location) strengthen.

$$Outcomes = -0.171 + 0.989Access + 0.072Teacher + 0.093Infra + 0.087Equity; \quad R^2 = 76.6\%$$

REFERENCES

Behrman, Jere, 1993. `Investing in Human Resources', in: Inter-American Development Bank, *Economic and Social Progress in Latin America. 1993 Report*, Washington D.C.: IDB.

Carvalho, Sonyia and Howard White, 1994. *Indicators for Monitoring Poverty Reduction*, World Bank Discussion Papers No. 254, Washington D.C.: The World Bank.

Cochrane, Susan, 1979. *Fertility and Education: What do we Really Know?*, Baltimore: Johns Hopkins University Press.

Dhir Jhingran and Deepa Sankar, 2006. *Orienting Outlays towards Needs: An evidence based, equity-focused approach for Shava Shiksha Abhiyan*

Dhir Jhingran and Deepa Sankar, 2009. Addressing Educational Disparity: Using District level Education Development Indices (EDI) for equitable resource allocations in India.

Education Development Index for Bangladesh, May 2009, Human Development Unit, South Asia Region, The World Bank

Filmer and Pritchett, 1998: Estimating Wealth Effects without Expenditure Data -- or Tears: An Application to Educational Enrollments in States of India, https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.5502&rep=rep1&type=pdf

Government of India, 2006. Education Development Index, Education Division, Planning Commission, Govt. of India

Jadhav and Srivastava, 2005. Institute of Applied Manpower Research (2005), Educational Development Index in India: An inter-state Perspective, Delhi.

Psacharopoulos, George and Maureen Woodhall, 1985. *Education for Development. An Analysis of Investment Choices*, New York, Oxford: Oxford University Press.

Shaw PJA (2003), Multivariate statistics for the Environmental Sciences, Hodder-Arnold.

UNESCO, 2006. EFA Global Monitoring Report, http://www.unesco.org/education/GMR2006/full

UNESCO, 2010: EFA Global Monitoring Report 2010: Reaching the Marginalized. UNESCO, Paris, 2010

UNICEF 2001, Thematic Report BASIC EDUCATION AND GENDER EQUALITY

Vos, Rob, 1996. Educational Indicators: What's To Be Measured? Working Paper Series, I-1, Washington D.C.

****