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Research Article

Efficiency of Public Educational Expenditures in Nigerian Manufacturing Sector: A Data Envelopment Analysis

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Abstract

Efficient resource allocation plays an essential role in manufacturing productivity, with a need to assess expenditure efficiency before addressing the impact of education. Amidst global growth in education budgets, financial strain requires improved allocation with a focus on efficiency to mitigate deficits. The manufacturing sector in Nigeria has experienced a consistent decline in productivity and prolonged stagnation over the years, as well as a decrease in capacity utilization. Based on this premise, this study aims to examine the effect of public educational expenditure on the efficiency of resources used in the Nigerian manufacturing sector over the period 1981-2019. The Data Envelopment Analysis is used to estimate the efficiency scores for the years under examination. The results show that, within the DEA estimation of efficiency, public educational capital expenditure does not result in the efficient use of resources for the majority of years under investigation except for the year 2019; only 16 years on public educational recurrence expenditure showed constant returns, and no years showed a decreasing return to scale, compared to the year 1982. The inefficiencies in utilising resources are linked to scale inefficiencies, and the government should target public spending policy to increase the size of capital projects in the education sector.

Keywords

Data Envelopment Analysis, Efficiency, Government Expenditure, Manufacturing Sector, Nigeria

1. Introduction

Enhancing productivity growth in the manufacturing sector relies upon the efficient use of allocated resources [1]. Prior to digging into public education expenditure and productivity, it is critical to assess the efficiency of government expenditure. Despite a surge in global public education expenditure, governments face a financial burden, necessitating a more efficient utilization of resources [2-4]. Improved spending efficiency is viewed as a means to alleviate budgetary constraints [5, 6]. Studies underscore the importance of exercising prudence in augmenting expenditure continually, advocating for a focus on efficiency instead [3, 7]. Nigeria has had low public education spending, falling short of UNESCO recommendations [8].

The manufacturing sector in Nigeria has experienced a continual decline in productivity, registering a 40.24% decrease from 1983 to 2019. Concurrently, the average manufacturing capacity utilization has dwindled from 73.3% in 1981 to 55% in 2019 [9]. World Bank surveys conducted in 2007 and 2014 revealed a noteworthy annual productivity contraction of -9.9% and -13.7%, signaling a significant de-

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cline [10]. Despite policy initiatives, the manufacturing sector grapples with a protracted deceleration, necessitating the imperative for a deeper understanding of productivity determinants [11, 12].

Empirical studies are required to address these challenges, with existing research linking manufacturing productivity to various factors [13-16]. However, the role of public expenditure in the manufacturing sector, especially in education, is underexplored in Nigeria. This study aims to fill this gap, presenting evidence-based research on how public educational expenditure affects manufacturing productivity.

The paper concludes with a structured outline, including theoretical and empirical literature review, methodology, model specification, results analysis, and economic policy implications.

2. Literature Review

Economics offers a variety of theories and models relating education to productivity [17]. Education increases an individual's earning potential, but also produces a "ripple effect" throughout the economy by way of series of positive externalities [18, 19]. Both the theory of human capital and endogenous growth theory emphasize the significant economic impacts of educational activities at both micro and macro levels [20]. The exploration of economic returns to education since the 1960s has been crucial in fostering economic development, particularly in developed countries. During the same period, the demand for trained workers has influenced private returns to education [21].

Limited research exists on the impact of public education expenditure on disaggregated economic productivity, especially in the manufacturing sector. Nevertheless, this paper conducts a review of empirical literature, examining the influence of public educational expenditure on productivity within the manufacturing sector and related studies on this theme.

The researchers [22] investigated the impact of education on labour productivity in China using panel data from 1998 to 2000 using Applied Fixed Effects estimation and found a positive relationship between mean years of schooling and labour productivity, especially for highly educated workers suggesting that education is a key driver of economic output, particularly for highly educated workers. Similarly, [23] explored the effect of government educational expenditure on labour productivity in the Turkish manufacturing sector. The study utilized a linear and non-linear ARDL and discovered that a positive change in educational expenditure has a negative effect on labour productivity.

Edmund, L. K. et al. [24] analyzed the impact of government expenditure and efficiency on economic growth in Sub Saharan African low-income countries. The study employed GMM on panel data and found that government expenditure accelerates economic growth, while government efficiency does not enhance the impact of government expenditure supporting efficient resource allocation and increased government expenditure is keys for economic growth in these countries, irrespective of government efficiency. According to the findings of [23], government educational expenditure has positive influence on labour productivity in a nonlinear manner.

Simon-Oke, O. [25] found a positive long-run relationship between government expenditure on education and industrial production indicating that prioritizing education spending in Nigeria contributes to sustained industrial growth and the role of human capital in industrial productivity, [26] sought to estimate the long-run and short-term dynamics between government expenditure and industrial development in Nigeria from 1981 to 2016. According to their findings, they confirmed that government expenditure did not positively impact industrial development in both the long and short run.

In a summary, while the literature on public educational expenditure is extensive in the Nigerian research arena, understanding of the efficiency effect of these expenditures in Nigeria, to the best of this study's review, is lacking. This study bridges the gap by estimating a data envelopment analysis (DEA) to determine how public educational capital and recurrent expenditures have affected the efficiency of resources used in the Nigerian educational sector. The development of a DEA methodology also creates a methodological gap.

3. Materials and Methods

The basic Data Envelopment Analysis (DEA) model developed by [27] is based on the assumption of a constant return to scale (CRS). This basic model has been modified by [28] in line with a variable return to scale (VRS), as production units usually do not operate at their optimal size. Both these DEA models have been created in both forms of input and output-oriented. In this study, government expenditure is considered as a Decision-Making Unit (DMU) or as producer using a given level of input(s) to produce a given amount of output(s) (goods and services). The DEA is conducted as a method to calculate efficiency use of resources in this study using a CRS model as specified in the equations.

(1) to (4). To ascertain the level of efficiency in educational sector, the following equations were estimated:

$$\max\ e_0 = \mu_1 + \mu_2 EI \tag{1}$$

Subject

$$v_1 CGEX\ (RGEX) = 1 \tag{2}$$

$$\mu_1 EI_i - V_1 PP \leq 0 \tag{3}$$

$$\mu_1, v_1 \geq 0 \tag{4}$$

The model of variable return to scale (VRS) in accordance

with the similarities to equations (5) to (8) are as follows:

$$\max e_o = \mu_1 + \mu_2 EI + \mu_o \quad (5)$$

Subject

$$v_1 CGEX\ (RGEX) = 1 \quad (6)$$

$$\mu_1 EI_i - V_1 PP \leq 0 \quad (7)$$

$$\mu_1,\ v_1 \geq 0 \quad (8)$$

Where
EI = Education index

CGEX = government educational capitals spending as a percentage of GDP

RGEX= government educational recurrent spending as a percentage of GDP

v_1 = the weight of input $CGEX$ $(RGEX)$ μ_1= the weight for the output EI Definition and Measurement of Variables

The time series data meant to proxy these variables are annual figures ranging from the period 1981 to 2019. The data period chosen was due to data availability and it was when output and productivity growth has increased. Data were sourced mainly from the Central Bank of Nigeria (CBN) Statistical Bulletin (various editions).

Table 1. *Definition of Variables, Measurement and Sources of Data.*

Variable	Description	Measurement	Sources of Data
RGEX	Government recurrent expenditure on education	Government expenditure on education, recurrent (N billion)	(Central Bank of Nigeria, 2021)
CGEX	Government capital expenditure on education	Government expenditure on education, capital (N billion)	(Central Bank of Nigeria, 2021)

Source: Authors (2024)

4. Result and Discussion

Table 2. *Descriptive Statistics.*

Variables	***CGEX***	***RGEX***
Mean	24.200	123.000
Median	12.200	43.600
Maximum	87.900	593.000
Minimum	8.500	0.162
Std. Dev.	18.100	163.000
Skewness	1.383	1.253
Kurtosis	4.840	3.398
Jarque-Bera	1.690	3.985
Probability	0.430	0.136
Sum	944.000	4810.000
Observations	39	39

Source: Authors (2024)

Table 3. *Data envelopment analysis result of the empirical investigation of the effect of public educational capital expenditure on efficient use of resources in Nigeria.*

DMU No.	DMU	CCR/CRS (Overall) Technical efficiency	BCC/VRS (pure) Technical efficiency	Scale efficiency	Return to scale
1	1981	0.875	0.987	0.887	1 (IRS)
2	1982	0.875	0.987	0.887	1 (IRS)
3	1983	0.875	0.987	0.887	1 (IRS)
4	1984	0.875	0.987	0.887	1 (IRS)
5	1985	0.875	0.987	0.887	1 (IRS)
6	1986	0.875	0.987	0.887	1 (IRS)
7	1987	0.875	0.987	0.887	1 (IRS)
8	1988	0.875	0.987	0.887	1 (IRS)
9	1989	0.875	0.987	0.887	1 (IRS)
10	1990	0.875	0.987	0.887	1 (IRS)
11	1991	0.875	0.986	0.887	1 (IRS)
12	1992	0.874	0.986	0.887	1 (IRS)
13	1993	0.875	0.987	0.887	1 (IRS)
14	1994	0.877	0.989	0.887	1 (IRS)
15	1995	0.876	0.988	0.887	1 (IRS)
16	1996	0.871	0.983	0.887	1 (IRS)
17	1997	0.871	0.983	0.887	1 (IRS)
18	1998	0.880	0.993	0.887	1 (IRS)
19	1999	0.887	1.000	0.887	1 (IRS)
20	2000	0.873	0.984	0.887	1 (IRS)
21	2001	0.855	0.964	0.887	1 (IRS)
22	2002	0.880	0.992	0.887	1 (IRS)
23	2003	0.865	0.976	0.887	1 (IRS)
24	2004	0.912	1.000	0.912	1 (IRS)
25	2005	0.869	0.950	0.914	1 (IRS)
26	2006	0.872	0.951	0.917	1 (IRS)
27	2007	0.865	0.940	0.921	1 (IRS)
28	2008	0.872	0.942	0.926	1 (IRS)
29	2009	0.882	0.949	0.929	1 (IRS)
30	2010	0.797	0.907	0.878	1 (IRS)
31	2011	0.861	0.944	0.912	1 (IRS)
32	2012	0.877	0.945	0.928	1 (IRS)
33	2013	0.964	0.991	0.973	1 (IRS)
34	2014	0.959	0.985	0.973	1 (IRS)
35	2015	0.969	0.996	0.972	1 (IRS)
36	2016	0.964	0.992	0.972	1 (IRS)

DMU No.	DMU	CCR/CRS (Overall) Technical efficiency	BCC/VRS (pure) Technical efficiency	Scale efficiency	Return to scale
37	2017	0.970	0.986	0.983	1 (IRS)
38	2018	0.978	0.990	0.988	1 (IRS)
39	2019	1.000	1.000	1.000	0 (CRS)
Mean	1981-2019	0.890	0.978	0.910	-
Median	1981-2019	0.875	0.987	0.887	-
Max.	1981-2019	1.000	1.000	1.000	-
Min.	1981-2019	0.797	0.907	0.878	-

Note: DMU is the decision-making unit; CRS represents constant return to scale; VRS is the variable return to scale; Max: maximum; Min: minimum; SD: standard deviation.
Source: Authors (2024)

Table 4. *Data envelopment analysis result of the empirical investigation of the effect of public educational recurrent expenditure on efficient use of resources in Nigeria.*

DMU No.	DMU	CCR/CRS (Overall) Technical efficiency	BCC/VRS (pure) Technical efficiency	Scale efficiency	Return to scale
1	1981	0.999	0.999	1.000	0 (CRS)
2	1982	0.992	0.992	1.000	0 (CRS)
3	1983	1.000	1.000	1.000	0 (CRS)
4	1984	0.989	0.989	1.000	0 (CRS)
5	1985	0.976	0.976	1.000	0 (CRS)
6	1986	0.975	0.975	1.000	0 (CRS)
7	1987	0.983	0.983	1.000	0 (CRS)
8	1988	0.896	0.896	1.000	0 (CRS)
9	1989	0.866	0.866	1.000	0 (CRS)
10	1990	0.875	0.875	1.000	0 (CRS)
11	1991	0.902	0.902	1.000	0 (CRS)
12	1992	0.970	0.970	1.000	0 (CRS)
13	1993	0.825	0.825	1.000	0 (CRS)
14	1994	0.832	0.832	1.000	0 (CRS)
15	1995	0.822	0.822	1.000	0 (CRS)
16	1996	0.816	0.816	1.000	0 (CRS)
17	1997	0.807	0.807	1.000	0 (CRS)
18	1998	0.810	0.810	1.000	0 (CRS)
19	1999	0.772	0.772	1.000	0 (CRS)
20	2000	0.763	0.763	1.000	0 (CRS)
21	2001	0.774	0.774	1.000	0 (CRS)
22	2002	0.753	0.753	1.000	0 (CRS)
23	2003	0.759	0.759	1.000	0 (CRS)

DMU No.	DMU	CCR/CRS (Overall) Technical efficiency	BCC/VRS (pure) Technical efficiency	Scale efficiency	Return to scale
24	2004	0.778	0.803	0.969	1 (IRS)
25	2005	0.779	0.808	0.965	1 (IRS)
26	2006	0.772	0.803	0.961	1 (IRS)
27	2007	0.770	0.807	0.955	1 (IRS)
28	2008	0.775	0.819	0.946	1 (IRS)
29	2009	0.786	0.835	0.940	1 (IRS)
30	2010	0.724	0.731	0.990	1 (IRS)
31	2011	0.735	0.758	0.969	1 (IRS)
32	2012	0.756	0.803	0.942	1 (IRS)
33	2013	0.819	0.932	0.878	1 (IRS)
34	2014	0.822	0.936	0.878	1 (IRS)
35	2015	0.822	0.935	0.880	1 (IRS)
36	2016	0.821	0.933	0.880	1 (IRS)
37	2017	0.833	0.962	0.866	1 (IRS)
38	2018	0.835	0.971	0.861	1 (IRS)
39	2019	0.847	1.000	0.847	1 (IRS)
Mean	1981-2019	0.842	0.872	0.967	-
Median	1981-2019	0.822	0.835	1.000	-
Max.	1981-2019	1.000	1.000	1.000	-
Min	1981-2019	0.724	0.731	0.847	-

Note: DMU is decision-making unit; CRS represents constant return to scale; VRS is the variable return to scale; Max: maximum; Min: minimum; SD: standard deviation
Source: Authors (2024)

The relatively higher mean compared to the median in Table 2 suggests that certain periods experienced significantly higher government recurrent expenditure on education while the standard deviation indicates a considerable degree of variability in recurrent expenditure on education suggesting fluctuations in budget allocations, making it challenging to predict and plan for consistent educational spending. For government capital expenditure on education, the maximum value suggests periods of substantial capital investment in educational infrastructure. This could lead to the development of modern educational facilities, classrooms and laboratories which signifies a commitment to investing in human capital development. This investment is crucial for the long-term economic growth and development of Nigeria as it contributes to a skilled and educated workforce.

Data Envelopment Analysis Result of the effect of Public Educational Capital Expenditure on Efficient Use of Resources in Nigeria.

DEA allows multiple inputs–outputs to be considered simultaneously without any assumption on data distribution. In each case, efficiency is measured in terms of a proportional change in inputs or outputs. Data envelopment analysis technique has been applied to measure efficiency in various areas of research, including total factor productivity [29], energy consumption [30], and efficiency of resource utilization [31].

In order to estimate the efficiency scores of resources used in the educational sector, this study adopts the two types of DEA models. First, the [27] model assume that production has constant returns to scale (CRS). It implies that any change in the input will result in a proportionate change in the output. The second model that this study estimate is the [28] model, which assumes that production has variable returns to scale (VRS), implying that an increase in the input will result in either an increase or a decrease in the output. We also measured the scale efficiency to see whether the educational system in Nigeria from 1981 - 2019 are operating at their optimal sizes or not. Scale efficiency scores provide information on the optimality of a DMU size; in this case, the use of resources

in Nigeria in a particular year.

Table 3 presents the efficiency scores of resource utilisation for all the years (1981-2019) considered in this study. The estimation follows the input-oriented assumption, and the models reported are the DEA-CCR, DEA-BCC and scale efficiencies. In the DEA models, overall technical efficiency (CCR, mean = 0.890) can be decomposed into pure technical efficiency (BCC, mean = 0.978) and scale efficiency (Scale, mean = 0.910). A potential strength of the DEA is that it provides clues on how inefficient utilisation of resources can be improved. Accordingly, the average BCC or VRS efficiency of 97.8% and CCR or CRS efficiency of 89.0% implies that if resources utilisation were to be technically efficient and for the educational sector to operate at the efficient level of resource utilisation, on average, the inefficiencies hindering the efficient use of resources could be reduced by 2.2% - 11%.

Since the mean of the scale efficiency is lesser than the mean of the pure technical efficiency, this result also predicts that the overall inefficiencies in the efficient resource utilisation in the educational sector are due to scale inefficiencies rather than pure technical inefficiencies (managerial inefficiencies). Hence, resource usage has room for improvements if the scale efficiencies are raised and the educational sector operates at their optimal sizes. Positive increasing returns to scale were reported from 1981 to 2018 against a constant return to scale reported in 2019. It implies that while a change in inputs brought about a proportionate change in output for the year 2019, the period 1981 to 2018 are periods where the output (efficient utilisation of resources measured by educational index) increases by a more significant proportion than the increase in inputs (public educational capital expenditure).

Hence, capital inputs in the educational sector are efficiently utilised. This result further reinforces that the inefficiencies experienced in the utilisation of resources in the Nigerian educational sector are not managerial (pure technical) inefficiency driven but scale inefficiency driven. Therefore, to efficiently utilise resources, capital expenditure needs to be raised by about 2.2% to 11% to ameliorate the inefficiencies that arise from scale inefficiencies.

Also discernible from Table 3 is that the resource utilisation and capital spending on education in Nigeria have been characterised with asymmetry in the spending years regarding their overall technical efficiency (in percentage terms) that ranges between 79.7% per cent and 100 per cent. Also, of all the 39 decision-making units, only the year 2019 (2.56 % of the total years) of public educational capital spending showed the maximum level of efficiency (efficiency score 1.0) in the CRS and VRS technical efficiency scale. The year also showed a scale efficiency of 1.0, implying that 2019 created the best practice frontier based on the input (public educational capital expenditure) and output (education index) combinations. About 97.4% (38 years) of the studied years on capital expenditure showed increasing returns to scale. Only one year of public educational capital expenditure (2.56%) showed constant returns to scale, and no years showed a decreasing return to scale. Further, only eight years of the public educational capital expenditure years (2004, 2013 to 2019) has CRS efficiency, and all the years (1981 and 2019) has VRS efficiency greater than 90%.

Table 4 presents the data envelopment analysis result of the empirical investigation of the effect of public educational recurrent expenditure on efficient use of resources in Nigeria. It presents the input-output model estimation of the efficiency scores for the years under examination (1981-2019). The DEA-CCR, DEA-BCC and scale efficiencies models are reported. The overall technical efficiency (CCR) has a mean value of 0.842, while the pure technical efficiency (VRS) and scale efficiency are associated with a mean value of 0.872 and 0.967, respectively. From these averages, a lower mean value of BCC to the mean value of scale efficiency suggests that when public educational recurrent expenditure is the primary input, the inefficiencies that occur in the output (efficient utilisation of resources) is driven by the pure technical inefficiencies (managerial inefficiencies) rather than the scale inefficiencies. Therefore, efficiency in resource utilisation can be improved if the pure technical efficiencies are raised and technical (managers) focus first on removing the pure technical inefficiency. The result further indicates that if efficient resource utilisation of resources is to be achieved when public educational recurrent expenditure serves as the primary input, the inefficiencies deterring the efficient use of resources should be reduced by 12.8% – 15.8%.

Also important in this result is that of all the 39 decision-making units, only the year 1983 (2.56 % of the total years) of public educational recurrent expenditure showed the maximum level of efficiency (efficiency score 1.0) in CRS, VRS technical efficiency, and the scale efficiency. Thus, implying that the year 1983 created the best practice frontier based on the input (public educational recurrent expenditure) and output (education index) combinations. About 58.97 (23 years) of the studied years on recurrent expenditure shows constant returns to scale. In contrast, only 16 years of public educational recurrent expenditure (41.02%) showed constant returns to scale, and no years showed a decreasing return to scale. Further, only nine years of the public educational recurrent spending years (1981 – 1987 and 1991 – 1992) has CRS efficiency, and 16 years (1981 – 1987; 1991 – 1992; and 2013 – 2019) has VRS efficiency greater than 90%. 90%.

5. Conclusion

The aim of this paper was to examine the effect of public educational expenditure on Nigeria's efficient use of resources over the period 1981 to 2019. The study measures the efficiency of resources used with the educational index. The results of our estimations show that first, within the DEA estimation of efficiency, public educational capital expenditure does not result in the efficient use of resources for the majority of years under investigation except for the year 2019. The result further shows that on average public educational

recurrent expenditure does not translate to efficient use of resources. Since the study found evidence that the inefficiencies in utilising resources are linked to scale inefficiencies, the government should target public spending policy to increase the size of capital projects in the education sector.

Abbreviations

DEA	Data Envelopment Analysis
DMU	Decision Making Unit

Conflicts of Interest

The authors declare no conflicts of interest.

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