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Assessment of the Disparities in the Applications to Higher Education in Nigeria: A Coefficient of Variation Approach

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Authors' contributions

This work was carried out in collaboration among all authors. Author CPO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors DCB and GUU managed the analyses of the study. Authors NPO and DCB managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

In this paper, we used the univariate coefficient of variation to estimate the disparities in the Joint Admissions and Matriculation Board (JAMB) applicants in all the States for both male and female from 2010 to 2018 and the multivariate coefficient of variation to estimate the disparities in the JAMB applicants for the different geopolitical zones for both male and female from 2010 to 2018. For the States, Zamfara State recorded the highest variation for both male and female while Adamawa and Osun States recorded the least variation for male and Edo State, the least for female. For the geopolitical zones, South West had the least variation for male and South-South, the least for the female while the North East had the highest variation for both male and female. The study shows that the Northern States and Zones had a high disparity rate in the study period.

Keywords: Coefficient of variation; disparity; Joint Admissions and Matriculation Board; states; geopolitical zones.

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1. INTRODUCTION

The population of each State in Nigeria has been on the increase with a minimum yearly growth rate of about 2.7% in Edo State and a maximum yearly growth rate of about 9.3% in Abuja [1]. More public and private tertiary institutions have been built since 2010, and there has been more awareness of the importance of being a graduate and having more educated people in the country in the last decade. These factors, among others, have resulted in an increase in the number of applicants in the Joint Admissions and Matriculation Board (JAMB) in different states and geopolitical zones. Data provided by JAMB showed that the Northern Zones have experienced more rate of change in the number of applicants than the Southern Zones. Yobe had the highest percentage increase of 323% from 2010 to 2018, followed by Borno with an increase of 286%. Not much has been said about the disparity rate of the JAMB applicants in each States and geopolitical zones in Nigeria. Measures of dispersion, a statistical technique, can be used to measure the disparity in the applicants of JAMB in each States and geopolitical zones in Nigeria. Measures of dispersion measures the extent a distribution are stretched [2]. We have different measures of dispersion used in measuring the variation in a data set. Standard deviation is one of the most used measures of dispersion but it fails to take cognizance of the differences in means of the different variables. This has made researchers prefer using the coefficient of variation to measure the variation between different variables. The standard deviation of a data must always be understood in the context of the mean of the data while the coefficient of variation is independent of the unit in which the measurement was taken, it is a dimensionless number. It is advisable to use the coefficient of variation over standard deviation for comparison between data sets with different units or widely different means.

Given a p-dimensional random vector $X^T = (X_1, X_2, ..., X_p)$ with mean $\mu \neq 0$ and variance-covariance matrix Σ. Reyment [3], the first to extend the univariate coefficient of variation to the multivariate case, defined the multivariate coefficient of variation (MCV) as

$$MCV = \sqrt{\frac{|\Sigma|^{\frac{1}{p}}}{\mu^T \mu}}.$$

His method is based on the generalized variance (determinant of the variance-covariance matrix). Albert and Zhang [4] modified Reyment's multivariate coefficient of variation by introducing a scaling factor $\sqrt{p}$. They said Reyment's MCV yields values that are too low compared to the methods which were introduced later on by other researchers. They estimated modified Reyment's MCV $MCV^* = \sqrt{\frac{p*|\Sigma|^{\frac{1}{p}}}{\mu^T \mu}}$. They also proposed another formula that can be used to calculate the MCV, $MCV = \sqrt{\frac{\mu^T \Sigma \mu}{(\mu^T \mu)^2}}$ which is derived based on a matrix generalizing the square of the CV. Van Valen [5] proposed another formula that can be used to calculate the MCV, he used the total variance (trace of the variance-covariance matrix) in place of the generalized variance proposed by Reyment [3].

$$MCV = \sqrt{\frac{tr(\Sigma)}{\mu^T \mu}}$$

Voinov and Nikulin [6] also worked on extending the coefficient of variance to the multivariate case. They believe the Mahalanobis distance $\mu^T \Sigma^{-1} \mu$ is a natural extension of the MCV

$$MCV = \sqrt{\frac{1}{\mu^T \Sigma^{-1} \mu}}$$

Zhang et al. [7] used MCV for comparing the performance of electrophoretic techniques in External Quality Assessment (EQA) using datasets from the French and Belgian national EQA programmes. Miroslaw and Lukasz [8] used the MCV to measure the variability in functional data. The coefficient of variation has also been used in comparing the reproducibility of assay techniques or equipment in laboratory medicine, Rodbard [9]; measuring economic inequality, Champernowne et al. [10]; measuring risk sensitivity for risky choices by humans and animals, Weber et al. (2004); measuring executive turnover among firms, Wagner et al. [11]; measuring heterogeneity in tenure distribution, Pelled et al. [12]; examining how age diversity affects conflict, Knight et al. [13]; investigating how the variation in age, tenure and education affect strategic consensus in top management teams, Carroll et al. [14].

This research is a descriptive study that seeks to know the disparity in the number of applicants in JAMB from 2010-2018 in all the states and geopolitical zones for both male and female in Nigeria using the univariate and multivariate coefficient of variation. This study identified the states and geopolitical zones that have the lowest and highest disparities in the number of JAMB applications in the period under study. The disparity rate was used as a measure of the change in the willingness of students to attain higher education in the different states and geopolitical zones.

2. METHODOLOGY

The univariate coefficient of variation, CV = $\frac{\sigma}{\mu}$ will be used to estimate the disparity in all the States for both male and female. For the different geopolitical zones, the multivariate coefficient of variation proposed by Albert and Zhang [4] will be used to estimate the disparity in the geopolitical zones. Albert and Zhang [4] formula $\left(MCV = \sqrt{\frac{\mu^T \Sigma \mu}{(\mu^T \mu)^2}} \right)$ was chosen because it is derived based on a matrix generalizing the square of the coefficient of variance.

Coefficient of Variation for the Univariate Case: Given the data set $x_1, x_2, ..., x_N$ of a particular variable, the univariate CV is the ratio of the standard deviation (σ) to the mean (μ) given by

$$\text{CV} = \frac{\sigma}{\mu}; \qquad \%\ \text{CV} = \frac{\sigma}{\mu} \times 100 \qquad (1)$$

Coefficient of Variation for the Multivariate Case: Given a p-dimensional random vector $X^T = (X_1, X_2, ..., X_p)$ with the mean $\mu \neq 0$ and variance-covariance matrix Σ. The multivariate coefficient of variation was computed using the formula proposed by Albert and Zhang [4].

$$MCV = \sqrt{\frac{\mu^T \Sigma \mu}{(\mu^T \mu)^2}}$$

$$\%\, MCV = \sqrt{\frac{\mu^T \Sigma \mu}{(\mu^T \mu)^2}} * 100.$$

$$X = \begin{pmatrix} X_{11} & X_{12} & . & . & . & X_{1N} \\ X_{21} & X_{22} & . & . & . & X_{2N} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ X_{p1} & X_{p2} & . & . & . & X_{pN} \end{pmatrix}$$ with mean vector μ and variance-covariance matrix Σ

$$\mu = \begin{pmatrix} \mu_1 \\ \mu_2 \\ . \\ . \\ . \\ \mu_p \end{pmatrix}; \text{ and } \quad \Sigma = \begin{pmatrix} \sigma_{11} & \sigma_{12} & . & . & . & \sigma_{1p} \\ \sigma_{21} & \sigma_{22} & . & . & . & \sigma_{2p} \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ \sigma_{p1} & \sigma_{p2} & . & . & . & \sigma_{pp} \end{pmatrix};$$

where

$$\sigma_{ij} = Cov(X_i, X_j) = \frac{\sum_{k=1}^{N} \sum_{l=1}^{N} (x_{ik} - \mu_i)(x_{jl} - \mu_j)^2}{N}$$

$$for\ i = j, Cov(X_i, X_i) = Var(X_i) = \sigma_{ii} = \sigma_i^2$$

Strength of the Variation: A proposed rule of thumb could be used to classify the variations within each state and geopolitical zones as low or high. The CV less than or equal to 20% were classified as low while the CV more than 20% were classified as high.

A state or geopolitical zone whose CV is classified as low indicates that almost the same number of applications were received each year from the state or geopolitical zone during the period under study while a state or geopolitical zone whose CV is classified as high indicates large differences in the number of applications received from the state or geopolitical zone during the period under study.

3. RESULTS

The data used is secondary data gotten from JAMB on application statistics by gender and states from 2010-2018. The univariate CV was estimated for all the States for both male and female to know the disparity of JAMB applicants within each States and the multivariate CV was

estimated for all the geopolitical zones for both male and female to know the disparity of JAMB applicants within each geopolitical zones.

3.1 Disparity in Male

The univariate CV was used to calculate the disparity of male JAMB applicant from 2010-2018 by dividing the standard deviation by the mean for each State, i.e. % CV = $\frac{\sigma}{\mu}\times 100$. Table 1 below gives the CV for each States.

Zamfara State recorded the highest variation with %CV of 43.30% from 2010 to 2018 in the number of JAMB applicants while Adamawa and Osun States recorded the least variation with %CV of 7.15%.

Table 1. Male coefficient of variation of all the States

State	CV	Strength	State	CV	Strength
Abia	11.16	Low	Kano	34.09	High
Adamawa	7.15	Low	Katsina	20.78	High
Akwa-Ibom	8.86	Low	Kebbi	31.50	High
Anambra	26.61	High	Kogi	10.54	Low
Bauchi	35.67	High	Kwara	11.47	Low
Bayelsa	12.39	Low	Lagos	12.98	Low
Benue	10.26	Low	Nassarawa	16.07	Low
Borno	38.95	High	Niger	21.87	High
Cross-River	12.05	Low	Ogun	9.07	Low
Delta	11.56	Low	Ondo	7.93	Low
Ebonyi	10.69	Low	Osun	7.15	Low
Edo	10.01	Low	Oyo	8.19	Low
Ekiti	8.27	Low	Plateau	26.37	High
Enugu	9.99	Low	Rivers	9.88	Low
FCT	31.82	High	Sokoto	40.38	High
Gombe	25.84	High	Taraba	27.67	High
Imo	11.97	Low	Yobe	41.14	High
Jigawa	24.70	High	Zamfara	43.30	High
Kaduna	22.06	High			

The MCV was used to calculate the variation in the geopolitical zones.

For North Central, the variance-covariance matrix is

$$\Sigma = \begin{bmatrix} 15699781 & 14237256.7 & 11544480.5 & 11256490 & 7404869.5 & 12257450.9 & 1830904.01 \\ 14237256.7 & 14544463.4 & 9250449.06 & 8759110.17 & 5865173.29 & 8306747.04 & 1453318.06 \\ 1154480.5 & 9250449.06 & 12730861.2 & 11250097.8 & 9334680.71 & 16648527.1 & 2480951.69 \\ 11256490 & 8759110.17 & 11250097.8 & 10699988 & 8263396.6 & 14523424.8 & 2185596.3 \\ 7404869.5 & 5865173.29 & 9334680.71 & 8263396.6 & 8571953 & 14090381 & 2475910 \\ 12257450.9 & 8306747.04 & 16648527.1 & 14523424.8 & 14090381 & 25786616.3 & 4038691.08 \\ 1830904.01 & 1453318.06 & 2480951.69 & 2185596.3 & 2475910 & 4038691.08 & 751528.194 \end{bmatrix}$$

and the mean matrix is

$$\mu = \begin{bmatrix} 38600.6 \\ 36193.2 \\ 31120.8 \\ 20352.3 \\ 13388.3 \\ 19256.3 \\ 2724.78 \end{bmatrix}$$

$$\mu^T \Sigma \mu = 299472140681272000$$

$$\mu^T \mu = \begin{bmatrix} 38600.6 & 36193.2 & 31120.8 & 20352.3 & 13388.3 & 19256.3 & 2724.78 \end{bmatrix} * \begin{bmatrix} 38600.6 \\ 36193.2 \\ 31120.8 \\ 20352.3 \\ 13388.3 \\ 19256.3 \\ 2724.78 \end{bmatrix}$$

$$\mu^T \mu = 224690292508197000 00$$

$$\frac{\mu^T \Sigma \mu}{\mu^T \mu} = 0.013328219$$

$$MCV = \sqrt{\frac{\mu^T \Sigma \mu}{\mu^T \mu}} = \sqrt{0.013328219}$$

$$MCV = 0.115447906$$

$$\%\text{MCV} \approx 11.54\%$$

The methods used here were applied to calculate for the %MCV for the other geopolitical zones. Table 2 gives us the summary %MCV of all the different geopolitical zones.

Table 2. The multivariate coefficient of variation of male JAMB applicant for all the geopolitical zones

Zone	North Central	North East	North West	South East	South-South	South West
%MCV	11.54	27.97	26.49	9.96	10.10	7.13
Strength	Low	High	High	Low	Low	Low

South West has the least variation with %MCV of 7.13% from 2010 to 2018 in the number of male JAMB applicants while North East has the highest variation with %MCV of 27.97%.

3.2 Disparity in Female

Table 3 gives the CV for each States.

Zamfara State recorded the highest variation with %CV of 48.23% from 2010 to 2018 in the number of female JAMB applicants while the Edo States recorded the least variation with %CV of 5.95%.

Table 4 gives us the %MCV of the different geopolitical zones.

South has the least variation with %MCV of 6.56% from 2010 to 2018 in the number of JAMB applicants while North East has the highest variation with %MCV of 30.71%.

Table 3. Female coefficient of variation of all the States

State	CV	Strength	State	CV	Strength
Abia	9.59	Low	Kano	44.03	High
Adamawa	25.07	High	Katsina	23.39	High
Akwa-Ibom	7.29	Low	Kebbi	41.84	High
Anambra	6.99	Low	Kogi	12.45	Low
Bauchi	36.28	High	Kwara	16.38	Low
Bayelsa	7.11	Low	Lagos	14.18	Low
Benue	12.10	Low	Nassarawa	23.67	High
Borno	40.38	High	Niger	25.45	High
Cross-River	8.86	Low	Ogun	12.13	Low
Delta	7.19	Low	Ondo	9.18	Low
Ebonyi	11.22	Low	Osun	11.21	Low
Edo	5.95	Low	Oyo	12.99	Low
Ekiti	10.40	Low	Plateau	29.61	High
Enugu	7.55	Low	Rivers	7.61	Low
FCT	39.01	High	Sokoto	38.28	High
Gombe	32.93	High	Taraba	28.49	High
Imo	10.81	Low	Yobe	45.10	High
Jigawa	35.97	High	Zamfara	48.23	High
Kaduna	24.54	High			

Table 4. The multivariate coefficient of variation of female JAMB applicant for all the geopolitical zones

Zone	North Central	North East	North West	South East	South-South	South West
%MCV	14.80	30.71	29.66	8.40	6.56	10.95
Strength	Low	High	High	Low	Low	Low

4. CONCLUSION

In this paper, we applied the univariate and multivariate coefficient of variation formula proposed by Albert and Zhang [4] on the Joint Admissions and Matriculation Board applicant for the different States and geopolitical zones respectively for both male and female.

Zamfara State recorded the highest variation with %CV of 43.30% for male and %CV of 48.23% for female from 2010 to 2018 in the number of JAMB applicants while Adamawa and the Osun States recorded the least variation with %CV of 7.15% for male and Edo States recorded the least variation with %CV of 5.95% for female.

South West has the least variation with %MCV of 7.13% from 2010 to 2018 in the number of male JAMB applicants while North East has the highest variation with %MCV of 27.97%.

South has the least variation with %MCV of 6.56% from 2010 to 2018 in the number of female JAMB applicants while North East has the highest variation with %MCV of 30.71%.

The Northern States and Zones have a higher disparity rate in the study period while the Southern States and Zones have low disparity rate in the study period. The Northern regions have been known to have more people without a higher education but from the result of this study, the willingness of the people in the Northern regions in attaining a higher education have increased within the study period.

We recommend that more tertiary institutions should be built in the Southern regions to motivate more people to apply.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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