International Journal of Innovative Mathematics, Statistics & Energy Policies
14(3):169-175, July-Sept, 2026

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DOI:10.5281/zenodo.22643744

Multivariate Analysis Of Consumer Spending Patterns Across Selected African Economies: A Principal Component And Factor Analytical Approach

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ABSTRACT
This study investigated consumer spending patterns across nine African countries such as, Egypt, Tunisia, Congo, Ghana, Nigeria, Morocco, Cameroon, South Africa and over a 43-year period using multivariate analytical techniques. Principal Component Analysis (PCA), Factor Analysis (FA), and Item Analysis were applied to extract latent factors, reduce dimensionality, and evaluate internal consistency among variables. The PCA results showed that a single principal component accounted for over 94% of the total variance, suggesting a strong underlying structure in consumer expenditure across these countries. Factor analysis revealed three dominant spending factors, with regional similarities emerging in the loading patterns. Factor 1 had strong loadings on Egypt, Ghana, Congo, and Cameron, suggesting a regional or economic similarity cluster. Nigeria, though loading moderately on Factors 1 and 2, showed highest loading on Factor 3, reflecting a distinct spending pattern possibly due to its population size and oil-reliant economy. High inter-item correlations and Cronbach's Alpha (0.993) confirmed the reliability and cohesiveness of the dataset. The findings highlighted both commonalities and unique consumer behavior characteristics across the selected African economies. The study provides evidence-based insights for regional policy harmonization, market segmentation, and investment decisions in Africa's consumer markets. The study recommended among others, that Policymakers should encourage cross-border policy harmonization in consumer taxation and welfare policy, especially in regions with similar spending profiles.

Keywords: Multivariate, Principal Component Analysis, Factor Analysis, Item Analysis, African Continent.

1.0 INTRODUCTION

In the dynamic global economic landscape, understanding the structure and drivers of consumer spending is critical for policy formulation, investment decisions, and economic planning. In Africa, a continent characterized by diverse economic environments, varied consumer behavior, and developmental disparities, analyzing consumer spending patterns across countries offers a profound insight into their economic trajectory. The complexity and interdependence of consumer behavior in countries such as Nigeria, Egypt, South Africa, Ghana, Tunisia, Morocco, Congo, and Cameroon necessitate robust multivariate approaches to distill the underlying patterns and influences. Principal Component Analysis (PCA) and Factor Analysis (FA) are two essential tools for reducing dimensionality and identifying latent structures in multivariate datasets. These techniques help in revealing dominant components and factors that drive spending behavior while removing redundancy in the data. Applying these methods to African consumer expenditure data reveals insights about how economic, demographic, and regional factors collectively shape spending trends. Moreover, inter-item correlation and reliability metrics such as Cronbach's Alpha serve as internal consistency measures to ensure the robustness of the findings. This multivariate approach transcends simple univariate or bivariate summaries by elucidating systemic interrelationships among consumer data points, thus contributing a refined understanding of African economies' consumption dynamics. The study aligns with the continental aspirations of economic integration and development, particularly under the African Continental Free Trade Area (AfCFTA). It informs national and regional policymakers, development partners, and market analysts about shared consumption drivers, market segmentation opportunities, and collective economic vulnerabilities.

1.1 Consumer Spending Patterns in Africa

Consumer spending refers to the total money spent by households on goods and services. In African economies, consumption is often influenced by income levels, employment rates, inflation, household size, and government subsidies (World Bank, 2020). Researchers like Ajakaiye and Fakiyesi (2009) highlight how fluctuations in income and price stability can impact spending, particularly in developing contexts where disposable income is low and consumption elasticity is high. As a result, it is imperative to apply multivariate approaches.

1.2 Multivariate Analysis

Multivariate analysis allows the simultaneous analysis of more than two variables to understand patterns, groupings, or latent factors (Hair et al., 2019). This is especially useful in economic and behavioral studies where variables are interrelated and cannot be evaluated independently and the Principal Component Analysis is one of the methods of multivariate analysis.

1.3 Principal Component Analysis (PCA)

PCA reduces the dimensionality of a dataset while retaining most of the variance. It has been widely applied in economics to identify the principal drivers of economic behavior (Jolliffe & Cadima, 2016). In African markets, PCA has been applied to cluster nations based on economic or consumption indices (Yartey, 2008). Another method in multivariate analysis that is similar to the PCA is the Factor Analysis.

1.4 Factor Analysis (FA)

FA seeks to model observed variables using latent, unobservable fa ctors (Fabrigar & Wegener, 2012). In the context of African spending patterns, FA can identify underlying factors such as economic stability, inflationary control, or social welfare that impact household expenditures.

1.5 Permanent Income Hypothesis (PIH)

Friedman's PIH (1957) posits that consumers plan spending based on expected long-term income rather than current income. This theory is vital for interpreting the relatively stable consumption patterns despite fluctuating incomes across African countries.

1.6 Life-Cycle Hypothesis (Modigliani & Brumberg, 1954)

This theory argues that individuals plan their consumption over their lifetime, saving in their working years and dis-saving during retirement. Applied to African demographics (e.g., Nigeria and Ghana with youthful populations), this theory helps explain consumption behavior across age brackets.

1.7 Consumer Demand Theory

Rooted in microeconomics, this theory examines how consumers allocate resources based on preferences, prices, and income (Varian, 2014). In multivariate contexts, it serves as a foundation for understanding cross-country differences in consumption baskets.

1.8 Cross-Country Studies

Kumo (2012) applied PCA to explore growth convergence in sub-Saharan Africa and found economic heterogeneity among nations. Similarly, Akpan and Atan (2012) conducted a multivariate analysis on Nigeria's macroeconomic variables, linking inflation and unemployment to consumption behavior.

1.9 Use of PCA in African Contexts

Tapsoba (2014) employed PCA to develop a multidimensional poverty index for West African nations. The findings revealed strong regional clusters driven by education and infrastructure—indirectly influencing spending capacity.

1.10 Factor Analysis in Spending Behavior

In their study of household expenditures in Kenya and Uganda, Ndiritu and Muriithi (2015) used factor analysis to extract major influencing dimensions such as food security, access to credit, and education. Their findings align with the high communalities and Cronbach's alpha found in the present study, suggesting a stable underlying consumption structure.

1.11 Statistical Justification

Hair et al. (2019) recommend Eigenvalues >1 and total explained variance above 60% for strong component retention. The current study reports a first PCA component explaining 94.4% variance and factor analysis explaining 98.8% post-rotation, far exceeding standard thresholds. Similarly, the Cronbach's alpha of 0.9926 confirms internal consistency, surpassing the 0.70 benchmark (George & Mallery, 2016).

1.12 Correlation and Covariance Use

Previous studies by Musonda (2013) confirmed high inter-variable correlations as a condition for PCA and FA. The correlation matrix in this study shows strong relationships (e.g., Morocco-Tunisia = 0.976), validating data suitability for multivariate methods.

1.13 Statement of the Problem

Despite increasing interest in African consumer markets, the existing knowledge is largely fragmented across individual countries and lacks a multivariate synthesis of how consumption patterns align or diverge across the continent. This gap hinders integrated regional planning and the formulation of holistic economic policies tailored to the continent's unique demographic and economic features.

1.14 Aim and Objectives of the Study

The aim of the study is to apply multivariate analytical techniques to uncover and interpret the latent structures underlying consumer spending patterns across selected African countries, while the objectives include to;

1. identify the principal components influencing consumer spending across selected African countries.
2. determine the underlying factors driving consumer expenditure using factor analysis.
3. assess the internal consistency and interrelationships among consumer expenditure indicators across countries.
4. compare similarities and disparities in consumer behavior across the selected African countries.

1.15 Significance of the Study

The study will be useful to policy makers in providing empirical guidance for regional economic planning and cross-country comparisons. It will be beneficial to multinational companies in identifying common consumer clusters. Academically, it will benefit the Researchers in providing clear insight of the robust application of Principal Component Analysis, Factor Analysis and Item Analysis in regional economic research. The research will help African Leaders align with Africa's economic harmonization goals by revealing inter-country consumption similarities.

1.16 Scope of the Study

This study is limited to the multivariate analysis of consumer expenditure data from nine African countries, Egypt, Tunisia, Congo, Ghana, Nigeria, Morocco, Cameroon, South Africa, and a temporal variable (year), over a 43-year period. It applies PCA, Factor Analysis, and Item Analysis for identifying structure, commonalities, and reliability of the data.

2.0 MATERIALS AND METHODS

2.1 Research Design

This study adopts a quantitative, exploratory multivariate research design to examine underlying structures and patterns in consumer spending across selected African economies. The multivariate techniques to be used are: Principal Component Analysis (PCA), Factor Analysis (FA) and Item Analysis.

2.2 Population and Sample

The population of the study is African countries with publicly available historical records of consumer spending indicators while the sample size are the nine African countries selected based on data completeness: Egypt, Tunisia, Congo, Ghana, Nigeria, Morocco, Cameroon, South Africa, and annual time index (Year). The number of observation per country is N=43 years.

2.3 Data Collection and Sources

The Data was collected from the following sources; World Bank Open Data, International Monetary Fund (IMF), Trading Economics and National Statistics Offices.

2.4 Standardization (Z-scores): Since countries have different currencies and magnitudes, all data were standardized before analysis using the formula:

$$Z_{ij} = \frac{X_{ij} - \bar{X}_j}{S_j}$$

where

Z_{ij} is the standardized value for ith observation the jth variable.

X_{ij} is the original value,

S_j is the standard deviation of the jth variable

$\bar{X}_j$ is the mean of the jth variable.

2.5 Analytical Technique

The first method to be applied is the Principal Component Analysis (PCA), the PCA reduces dimensionality by transforming correlated variables into uncorrelated principal components, ordered by the amount of variance they explain.

Mathematical Basis

Given the correlation matrix R, the PCA seeks to solve:

$$R_{ak} = \lambda_k a_k \quad (1)$$

where

λ_k is the eigenvalue for k component,

a_k is the loading or the eigenvector for k component.

Proof =

If we have p variables, the total variance is given as

$$\sum_{i=1}^{p} \lambda_i = trace(R)$$

The proportion of variance for component is given as

$$k = \frac{\lambda_k}{\sum_{i=1}^{p} \lambda_i}$$

From the results, $\lambda_1 = 8.4982$, total variance$= 9$, because there are 9 variables, k becomes

$\frac{8.4982}{9} = 0.944$ or 94.4%.

2.6 Assumptions of PCA and FA

1. Linearity: Relationships among variables are linear.
2. Sampling adequacy: Tested using Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity.
3. Multivariate normality: Especially important for maximum likelihood factor analysis.
4. No multicollinearity: Avoided by checking determinant of correlation matrix and condition index.

3.0 RESULTS

Comparative Tables According to Objectives:

Objective 1: Principal Components Extraction

Component	Eigenvalue	Proportion of Variance	Cumulative Variance (%)
PC1	8.4982	94.4%	94.4%
PC2	0.2330	2.6%	97.0%
PC3	0.1330	1.5%	98.5%

Objective 2: Factor Loadings (Varimax Rotated)

Variable	Factor1	Factor2	Factor3	Communality
Egypt	0.776	0.493	0.308	0.943
Ghana	0.774	0.485	0.389	1.000
Nigeria	0.582	0.514	0.630	1.000
South Africa	0.451	0.774	0.391	1.000

Objective 3: Item Statistics (Cronbach's Alpha = 0.9926)

Variable	Item-Adj Total Corr	Squared Multiple Corr
Tunisia	0.9762	0.9904
Morocco	0.9942	0.9912
Cameron	0.9843	0.9880

Objective 4: Correlation Matrix (Selected Pairs)

Country Pair	Correlation
Tunisia–Morocco	0.976
Congo–Cameron	0.983
Egypt–Ghana	0.957
South Africa–Year	0.929

3.0 DISCUSSION

PCA revealed that the first principal component (PC1) accounted for over 94% of the total variance, indicating a strong, single underlying dimension in the dataset likely reflecting shared economic drivers or policy synchronization across the selected African nation

Factor analysis (Varimax rotation) identified three dominant factors. Factor 1 had strong loadings on Egypt, Ghana, Congo, and Cameron, suggesting a regional or economic similarity cluster. Nigeria, though loading moderately on Factors 1 and 2, showed highest loading on Factor 3, reflecting a distinct spending pattern possibly due to its population size and oil-reliant economy.

The high Cronbach's alpha (0.993) and strong item-total correlations confirmed the internal consistency of the consumer spending indicators. This reliability assures the robustness of cross-country comparisons and validates the coherence of the observed consumption patterns.

Correlation matrix results underscored strong relationships among North African countries (e.g., Tunisia and Morocco: r = 0.976), and also between West and Central African countries (e.g., Ghana and Congo: r = 0.985). This indicates regional consumption similarities possibly influenced by trade linkages or cultural affiliations.

3.2 CONCLUSION

This research concludes that African consumer spending across the sampled countries exhibits a high degree of multicollinearity and shared latent structure, suggesting regional economic synchrony. However, specific countries such as Nigeria and South Africa exhibit distinct expenditure patterns that set them apart from the rest. The multivariate techniques employed provided clarity in understanding complex consumption data and uncovered hidden structures critical for regional economic policy and market strategies.

3.3 RECOMMENDATIONS

The study recommends the following;

1. Policymakers: Encourage cross-border policy harmonization in consumer taxation and welfare policy, especially in regions with similar spending profiles.
2. Economists and Statisticians: Employ PCA and factor analysis in continuous monitoring of regional consumption trends to detect shifts in spending behavior.
3. Investors and Marketers: Leverage consumer spending clusters identified in this study for market segmentation and product positioning strategies in Africa.
4. Regional Economic Bodies: Use findings to enhance integration strategies under the African Continental Free Trade Area (AfCFTA) by aligning fiscal policies in consumer-driven sectors.

REFERENCES

Ajakaiye, O., & Fakiyesi, T. (2009). Global financial crisis discussion series paper 8: The global financial crisis and the Nigerian economy. Overseas Development Institute.

Akpan, E. O., & Atan, A. J. (2012). Effects of exchange rate movements on economic growth in Nigeria. *CBN Journal of Applied Statistics*, *2*(2), 1–14.

Fabrigar, L. R., & Wegener, D. T. (2012). *Exploratory factor analysis*. Oxford University Press.

Friedman, M. (1957). *A theory of the consumption function*. Princeton University Press.

George, D., & Mallery, P. (2016). *IBM SPSS statistics 23 step by step: A simple guide and reference* (14th ed.). Routledge.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). *Multivariate data analysis* (8th ed.). Cengage Learning.

Jolliffe, I. T., & Cadima, J. (2016). Principal component analysis: A review and recent developments. *Philosophical Transactions of the Royal Society A*, *374*(2065), 20150202. https://doi.org/10.1098/rsta.2015.0202.

Kumo, W. L. (2012). Africa's infrastructure: A time for transformation. *African Development Bank*.

Modigliani, F., & Brumberg, R. (1954). Utility analysis and the consumption function: An interpretation of cross-section data. In K. Kurihara (Ed.), *Post-Keynesian economics* (pp. 388–436). Rutgers University Press.

Musonda, M. (2013). Application of principal component analysis in poverty and inequality analysis. *African Statistical Journal*, *16*, 31–49.

Ndiritu, S. W., & Muriithi, B. W. (2015). Household food security and women's empowerment in Kenya and Uganda. *Feminist Economics*, *21*(3), 162–185.

Tapsoba, R. (2014). A multidimensional poverty index for West Africa using principal component analysis. *West African Economic and Monetary Union Journal*, *5*, 75–94.

Varian, H. R. (2014). *Intermediate microeconomics: A modern approach* (9th ed.). W. W. Norton.

World Bank. (2020). *Africa's Pulse: An analysis of issues shaping Africa's economic future* (Issue 21). World Bank Group. https://doi.org/10.1596/978-1-4648-1571-3

Appendix A

year	Egypt	Tunisia	Congo	Ghana	Nigeria	Morocco	Cameron	Southafrica
2022	393.42	34.46	5.92	51.58	268.45	81.7	31.92	256.08
2021	365.24	34.48	6.07	55.5	273.98	84.95	33.02	258.43
2020	321.05	31.48	5.31	49.15	276.22	71.67	29.9	211.1
2019	256.53	30.09	5.36	51.4	353.96	76.11	28.82	248.39
2018	218.71	30.54	5.22	47.98	323.04	75.72	28.64	258.27
2017	213.79	30.34	4.5	45.45	301.07	70.32	25.76	240.35
2016	276.22	31.63	4.49	40.38	329.93	66.2	23.94	204.77
2015	271.5	32.41	4.48	36.24	387.39	65.1	23.53	220.79
2014	253.46	32.92	4.94	39.39	411.96	73.56	26.13	242.81
2013	232.98	33.2	4.67	47.95	379.11	64.02	24.11	256.03
2012	225.28	31.68	4.19	34.55	271.86	59.36	21.72	279.33
2011	178.33	32.02	4.34	33.76	273.66	60.37	22.14	288.36
2010	163.3	29.17	3.85	30.14	246.47	54.77	20.04	260.3
2009	143.94	26.95	3.78	23.18	200.9	54.46	20.44	204.46
2008	117.75	27.53	3.74	27.03	204.13	53.96	19.99	199.28
2007	94.43	23.96	2.97	22.94	184.13	45.8	16.94	211.4
2006	75.84	21.22	2.39	17.11	120.52	39.29	14.86	193.15
2005	64.11	19.94	2.07	8.7	105.85	35.69	13.88	183.7
2004	56.46	19.43	1.65	7.15	80.76	33.71	13.34	162.87
2003	58.63	17.27	0.88	6.22	68.6	29.6	11.51	121.96
2002	62.81	14.52	0.9	5.1	61.44	24.43	8.93	80.91
2001	72.78	13.5	0.94	4.43	44.61	22.69	7.73	88.45
2000	75.74	13.01	0.76	4.2	28.28	23.95	7.42	99.59
1999	68.06	14.01	0.87	6.61	30.91	25.28	8.06	100.07
1998	65.05	13.43	0.89	5.94	33.31	25.2	7.83	100.32
1997	60.53	12.75	0.96	5.75	29.83	24.02	7.19	110.34
1996	52.03	11.94	1.17	5.18	28.95	27.26	7.51	105.35
1995	44.8	11.34	0.99	4.93	23.27	24.57	7.07	111.11
1994	38.7	9.69	0.7	4.02	17.63	22.22	5.87	98.96
1993	34.51	9.06	0.84	4.75	13.03	19.35	10.67	93.93
1992	30.39	9.57	0.8	5.56	21.25	20.81	8.53	95.64
1991	27.32	8.16	1.04	5.49	19.11	20.1	7.66	87.42
1990	30.91	7.82	0.89	5.02	18.68	17.73	8.2	80.97
1989	27.93	6.28	1.26	4.44	13.15	15.16	7.62	65.78
1988	24.76	6.29	1.33	4.41	24.53	14.95	8.36	64.04
1987	28.2	5.87	1.3	4.34	22.22	13.31	8.72	58.65
1986	26.47	5.66	1.1	4.77	22.89	11.93	7.43	43.39
1985	25.23	4.95	1.13	3.78	35.3	9.06	5.5	37.49
1984	22.25	4.84	0.85	3.91	26.19	9.21	4.52	50.11
1983	20.02	4.84	0.84	3.68	20.53	10.45	4.35	57.21
1982	17.84	5.07	0.86	3.62	17.63	10.75	4.07	50.08
1981	13.97	5.17	1.13	3.68	16.17	11.06	4.73	52.79
1980	14.99	5.38	0.8	3.73	15.78	13.14	4.58	47.87