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Metrics of Mediation of Binary Location on Savings - Income Relationship for Middle Income Earners in Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author HCN designed, supervised, directed and proof-read the work. Author AHA structured and administered the questionnaire in the field. Authors AHA and GBG did the collation and the computer analyses as directed by author HCN. All three authors discussed the results from the analyses, reached conclusions and agreed on recommendations for further studies. All authors read and approved the final manuscript.

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Abstract

This study established the place of location (a binary variable) as a mediating variable in the relationship between income and savings of middle income earners in Etsako East and West Local Government Areas of Edo State Nigeria. Due to distinct variability of the population and the uncertainty of its size, stratified random sampling using equal allocation was employed as our sampling design. A total of 924 valid responses (462 from each from both rural and urban middle income dwellers in the two local government areas) were selected and used for the analyses. Linear regression model and the logistic regression model were used to analyze the effects which form the basis of mediation. Because effects of different variables measured in different metrics are combined and compared, standardized coefficients and standard errors were used to test the significance of the mediated effect. Results show that Location is a partial mediator in the relationship between income and savings, and the mediated effect is statistically significant. It was also observed that about 7.5% of the total effect is mediated by location; the size of the mediated effect is 0.13 (medium). We therefore recommend that these metrics for binary mediating variables in mediation analysis should be extended to related cases where the mediating variable will be of three possible ordinal

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outcomes. It is also recommended that this study should be extended to a wider geographical region like the whole of Nigeria, South-South, South-West, South-East, and other geo-political zones of Nigeria.

Keywords: Metrics; mediation; linear regression; logistic regression; standardized coefficients; savings; income and location.

1 Introduction

The earnings of middle income group in Nigeria have been on the increase but there has not been a corresponding effect on their savings. Though middle income group, relative to middle class, is unstable and changes in response to inflationary trend in the country. Studies show that their average monthly income is in the range of #75,000 - #120,000 ($480-640 or roughly $6,000-7,000 p a), [1]. This range is subject to change (increase/decrease) over time and the naira equivalent also fluctuates due to the unstable naira to dollar exchange rate.

Despite the use of inflation and unemployment rates as tools for measuring cost of living, location (rural / urban) is also a pointer to evaluating annual per capita expenditure of families. The question now is, how does location affect the income-savings relationship? According to [2], settlement affects private savings of both rural and urban dwellers. They explained this using the reduced savings of city dwellers due to larger consumption opportunities (city life) when compared to the rural population. In addition, farmers are likely to face larger income uncertainty and less insurance and credit opportunities than urban dwellers, leading to higher saving in rural areas.

Income generation in the rural areas is predominantly from Agriculture due to availability of land, but income from non – agricultural activities are influenced by education, infrastructure, and proximity to urban centers [3]. As a result, there is a drift of middle income earners into urban centers where income generation opportunities are higher.

Low savings means increased interest rate and low investment which in turn leads to decrease in Gross Domestic Product (GDP) of the nation leading to the poor living standard of the people. Factors that may be responsible for this situation are: infrastructure, labour market, quality of business environment, energy sources and rural-urban migration. All these factors are associated with location (these factors determine the classification of an areas as either urban or rural). It is in the light of this that we decided to carry out a study on whether location has any influence on the relationship between income and savings. To achieve reasonable results, mediation analysis and effect size calculations are employed.

Mediation is a hypothesized causal chain in which one variable affects a second variable that in turn affects a third variable. Mediation exists when the effect of independent variable on the dependent variable declines due to a significant presence of the mediating variable (Total effect greater than direct effect).

Estimates of the mediated effect are obtained from coefficients in the following three regression models

$$Y = \alpha_1 + \mathrm{c}X + e_1 \tag{1}$$

$$Y = \alpha_2 + \mathrm{c}X + b\mathrm{M} + e_2 \tag{2}$$

$$M = \alpha_3 + aX + e_3 \tag{3}$$

c' is the direct effect and $a.b$ is the indirect effect [4].

The direct and indirect effects of X on Y sum to yield the total effect of X on Y ($c' + ab$). This total effect can also be obtained from the coefficient of X, c in equation 1 above.

Hence, $c = c' + ab$ (4)

Mediated effect can also be estimated as the difference between the total and the direct effects of X (*c – c')* on *Y*. This is the Judd and Kenny difference of coefficients approach [5].

Where *c'* (direct effect when M is controlled) is no longer significant, we conclude that the mediation is "full or perfect", but where both are significant, we conclude "partial mediation" which is an indication that other indirect effects could be examined and tested . Full mediation is said to occur if c' is equal to zero (that is statistically not significant). Partial mediation is said to occur if *c'* is not statistically equal to zero, and the indirect effect of X on Y is statistically significantly different from zero using the Sobel test.

This paper is aimed at additionally studying effect size and effect of location (urban/rural) (presented as a binary variable of 0, 1) to economic growth through savings of the middle income group.

2 Theoretical Background and Literature

Researchers, such as [6,7,8,9,10,11] and so on, had developed theoretical framework for testing mediation and for inter relationship that exist between income, savings and location.

[6] noted that researchers often test whether there is complete or partial mediation by testing whether c' is statistically significant, which is a test of whether the association between the independent and the dependent variable is completely accounted for by the mediator M. If c is statistically significant and there is significant mediation, then there is a possibility of other mediators. It is often unrealistic to expect that a single mediator would explain completely by an independent variable to a dependent variable relation. [7] are of the opinion that the focus on the significance between the independent and dependent variable, both before and after mediation test, is not justified and can impair theory development and testing. They further argued that attention in mediation analysis should be shifted towards assessing the magnitude (size) and significance of indirect effects. [8] explained the meaning of statistical mediation and proposed a simple method that, apparently, allows identifying mediator variables using the sequential adjustment from several linear regression models.

[9] was of the opinion that effect-size measures offer a means to evaluate both component paths and the overall mediated effect in mediation models. Statistical simulation results indicate acceptable bias across varying parameter and sample-size combinations. The measures are applied to a real-world example using data from a team-based health promotion program to improve the nutrition and exercise habits of firefighters. SAS and SPSS computer codes are also provided for researchers to compute the measures in their own data. [11] was of the opinion that multicollinearity is to be expected in a mediational analysis and it cannot be avoided. His illustration was that if M is a successful mediator, it is necessarily correlated with X due to path a. This correlation, called collinearity, affects the precision of the estimates of the regression equation, (2). If X were to explain all of the variances in M, then there would be no significant variance in M to explain Y. Given that path a is nonzero, the power of the test of the coefficients b and c' is lowered. The effective sample size for the tests of coefficients b and c' is approximately N(1-r^2) where N is the total sample size and r is the correlation between the causal variable and the mediator, which is equal to standardized a. So if M is a strong mediator (path a is large,) to achieve equivalent power, the sample size to test coefficients b and c' would have to be larger than what it will be if M were a weak mediator. [12] illustrated that in simple linear regression analysis with dependent indicator variable the estimates of Y goes out of the limits (0,1) as the value of X deviates (decreases or increases) from what is provided in the analysis. This forms a curvilinear response function (logistic model) which violates the assumptions of normality and constant variance of the error term. They added that maximum likelihood estimate (MLE) should be used for better estimation of parameter.

[13] noted that the existence of urban/rural differences in expected income in Nigeria warrants a rational decision for individuals to migrate from rural to urban areas continuously, notwithstanding the existing

rising levels of unemployment in the urban areas. This scenario not only fuelled by unemployment, low standard of living and poverty, but also raises social vices. An attempt by Government to salvage the situation by providing more employment opportunities in urban areas ignoring the rural areas, as in Nigeria, will continue to stimulate further rural-urban drift.

[1] asserted that even though that about 89% of the Nigeria middle class families would deposit a large sum of money that they do not intend to spend immediately in banks. They are of the view that Nigeria's savings still fall below the requirements of its financial system due to low per capita income, under-investment in productive instruments and investment in unproductive channels. The availability of invisible funds can be a starting point for all investments in the economy, which will eventually translate into economic growth and development.

[14] is of the view that the level of funds mobilization by financial institutions is quite low due to a number of reasons, ranging from low savings deposit rates to the poor banking habits or culture of the people.

Occupational status of individual has significant influence in determining inclusion in the middle class - but not significant for the upper class [15].

3 Methodology

This research is designed to cover the middle income group living in both rural and urban areas of Etsako East and West local Government Areas of Edo state Nigeria. The variables required for this study are savings, income, and location of middle income earners. Here, savings is the outcome variable (y), income as the causal variable, and location as the third variable that may be a mediator. A pilot survey was carried out to estimate the coefficient of multiple determination R^2 and the coefficient of partial determination $R^2_{m.x}$ which form the basis for optimal sample size determination in regression analysis.

Estimated sample size at 100(1-α)% confidence interval can be derived as follows

$$n = \left(\frac{Z\alpha_{/2}}{w}\right)^2 \left(\frac{1-R^2}{1-R^2_{m.x}}\right) + p + 1 \quad [16] \tag{5}$$

where $Z\alpha_{/2}$ is the normal critical value for a two-sided test of size α,

w is the half width of the of the error bound,
R^2 is the coefficient of multiple determination,
$R^2_{m.x}$ is the coefficient of partial determination of m when x is in model (3.11), and
p is the number of variables.

From Table 1b (in Appendix A), $R^2 = \frac{SSR(mx)}{SST(mx)} = \frac{2064.711}{141150.479} = 0.1463$

and from Tables 1b and 1d (in Appendix A),

$SSR(m/x) = SSR(mx) - SSR(x)\ or\ SSE(x) - SSE(mx)$

But $R^2_{m.x} = \frac{SSR(m/x)}{SSE(x)} = \frac{2.18}{12052.948} = 0.000181$

Hence, $n = \left(\frac{Z\alpha_{/2}}{w}\right)^2 \left(\frac{1-R^2}{1-R^2_{m.x}}\right) + p + 1$ will be thus,

$n = \left(\frac{1.64}{0.05}\right)^2 \left(\frac{0.854}{0.9998}\right) + 4 = 923.9 \approx 924$

Calculations from a pilot sample of size 48 (returned from 50 questionnaires sent out), using a 90% confidence interval, $n = 924$. This means that 924 is the optimum value of n which would enable mean savings to be estimated at 90% confidence interval with width of 0.10.

Since there is distinct variability among the population, - population from urban and that from rural areas and the population size is unknown, stratified random sampling using equal allocation was employed as our sampling design. 1000 questionnaires were distributed, (500 in each location), to residents of communities in the two local government areas. After editing for non response to vital questions and wrong response of the 1000 questionnaires distributed, 924 valid responses were selected from all the valid responses (ie 462 each from rural and urban dwellers respectively) and used for the analyses.

That is $\frac{n_h}{n} = \frac{1}{L}$, $n_h = {}^{n}/_{L}$

Where n is the sample size, n_h is the stratum size, and L is the number of strata.

Hence $n_1 = n_2 = \frac{924}{2} = 462$ (for equal allocation).

Generally, the commonly applied method for testing mediation requires the estimation of three regression equations using Ordinary Least Square (OLS) (except omitted variables and interactions are involved or assumptions of normality is not met). But the binary nature of location (0 or 1or rural and urban dwellers respectively) has violated the use of (OLS) in finding the effect of income X on location M. Instead the logistic regression was used. Thus both linear and Logistic regressions are applied in the analyses. This was followed by testing for the significance of the various effects.

When Y is binary and represent the event of interest (response), coded as 0 or1 for failure or success, the logistic regression model is given as:

$$y^* = \ln(o) = ln[p/(1-p)] = \beta_0 + \beta_1 X + \varepsilon \quad (6)$$

o is the odds of the event,
p is the proportion of successes,
X is the independent variable,
β_0 and β_1 are the Y-intercept and the slope, respectively, and
ε is the random error term [17].

Since the mediator is the only dichotomous variable in this study, model (3) will be written as

$$M^* = \beta_1 + aX + \varepsilon \quad (7)$$

where M* is a latent variable.

The scale or variance of M* is not directly observed. To fix the scale of the unobserved M* variable, the residual is normalized to $\pi^2/3$, unlike the usual case of e_2 and e_3 for continuous dependent variables in (1) and (2). Normalization of the residual in logistic regression has an important implication for the estimation of mediation. The reason is that because of fixed variance of the residual in each equation, the scale is made equivalent across equation by standardizing regression coefficient prior to estimating mediation [18].

The standardized coefficient of X is computed as $a' = a \times \frac{s_{x_i}}{s_y}$.

where

s_{x_i} is the standard deviation of x for the ith variable and
s_y is the standard deviation of y [19].

Standard error of standardized coefficient is given as;

$$S_{b_i}^{'} = S_{b_i} \times \frac{s_{x_i}}{s_y} = \sqrt{\frac{1-R_{mult}^2}{(1-R_{m.x}^2)\times(N-K-1)}} \qquad [20]$$

where S_{b_k} is the standard error of unstandardised coefficient b.

N is the sample size and K is the number of variables in the model.

Effect size goes beyond testing the statistical significance of an effect (whether a result is due to chance or sampling variability) but concerned with the consideration of the practical significance of research findings. R^2 effect-size measures assess variance accounted for in mediation models. Since indirect effect is the product of two effects, its size will be the product of partial correlations of paths a and b (R_{med}^2) [9].

$$(R_{med}^2) = r_a r_b = r_{xm.y} \times r_{my.x}$$

One frequently used effect-size measure for mediation is the proportion mediated. This measure indicates what proportion of the total effect is mediated by the intervening variable and also provides a means to assess the relative contribution of single mediators in multiple mediator models by indicating what proportion of the total effect is attributable to individual mediational pathways. It is estimated as; $\frac{ab}{ab+c'}$ or $1 - \left[\frac{c'}{ab+c'}\right]$.

Hypotheses to be tested to establish mediation are:

H_1: there is no significant relationship between income and savings.
H_2: there is no significant relationship between income and location.
H_3: there is no significant relationship between savings and location.
H_4: location is not a significant mediator in the relationship between income and savings.

4 Results

From Appendix B, the total effect of income X on savings Y, (path c) is 0.531 and t*= 19.666 (p-value=0.00). The effect of income X on location M, (path *a*) is 0.031 and $z\ score = 7.2$.

(p-value=0.00).

The effect of income X on savings Y controlling for location M which is indicated as c' is 0.496 with t*= 18.119 (p-value=0.00) and the effect of location M on savings Y controlling for income X which is indicated as b is 4.6419 with t*= 5.226 (p-value=0.00).

Since $c, a, and\ b$ are all significant at $\alpha = 0.05$, we conclude that consistent mediation exist in the relationship between location, income and savings.

Also the significance of both $c\ and\ c'$ and the decrease of the direct effect of income on savings points to the facts that location is a partial mediator in income- savings relation.

For the indirect effect (mediated effect) which is computed as $c - c' = ab \Rightarrow 0.04 \neq 0.14$. This is unrealistic because the effects *a* and *b* are calculated using different metrics. Hence, we use the standardized coefficients and standard errors of *a* and *b* to compute and test for the significance of mediated effect. Thus,

$$a' = a \times \frac{s_{x_i}}{s_y} = 0.031 \times \frac{16.2156}{1.88255} = 0.267$$

And $b' = 0.147$ (Table 2 of Appendix B)

Therefore $a'b' = 0.04 = c - c'$

Standardizing the standard error of *a* and *b,* the formula:

$$S'_{b_i} = S_{b_i} \times \frac{s_{x_i}}{s_y} = \sqrt{\frac{1-R^2_{mult}}{(1-R^2_{m.x})\times(N-K-1)}}$$

For *a*, $S_{a'} = S_{a_i} \times \frac{s_{x_i}}{s_y} = 0.00432 \times 16.2156/1.88255 = 0.0372$

For b, $S_{b'} = \sqrt{\frac{1-R^2_{mult}}{(1-R^2_{m.x})\times(N-K-1)}} = \sqrt{\frac{1-0.316}{(1-0.0288)(920)}}$ =0.0277

Using Sobel approach, $S_{a'b'} = \sqrt{a'^2 S^2_{b'} + b'^2 S^2_{a'}}$

With $t^* = 4.337$ (p-value = 0.00). Therefore we conclude that $a'b'$ (mediated effect) is statistically significant.

The size of the mediated effect (R^2_{med}) = $r_a r_b$

Where $r_a = r_{xm.y} = \frac{r_{xm} - r_{xy}\ r_{my}}{\sqrt{(1-r^2_{xy})(1-r^2_{my})}}$

and

$r_b = r_{my.x} = \frac{r_{my} - r_{mx}\ r_{yx}}{\sqrt{(1-r^2_{mx})(1-r^2_{yx})}}$

Therefore, the effect size, $(R^2_{med}) = r_{xm.y} \times r_{my.x} = .11773 \text{ x } 1.06658 = 0.125 \approx 0.13$. This is a medium level mediation. That is, mediated effect of location on income- savings relation is perceptible and its significance is not influenced by type1 error.

And the proportion mediated is $0.04/(0.04 + 0.496) = 0.075$. In other words, 7.5% of the total effect has been mediated by location.

5 Findings and Conclusion

5.1 Discussion and findings

This study is aimed at measuring the extent to which a binary variable mediate in a relationship between continuous independent and dependent variables. The results from our data show significant relationships among the three variables at play here (savings, income, and location) and indicated a consistent mediation. That is, location (binary variable) is needed to explain income – savings relationship of middle income earners in this locality.

Because the total, and the direct effects are statistically significant,$(c \neq 0, and\ c' \neq 0)$ then, the mediation is partial. Partial in the sense that other variable(s) can as well explain or mediate in income-savings relationship.

For mediated effect to be calculated in this study, where measurements of effects used different metrics, there is therefore the need to standardize the effects to obtain the metrics in a units free scale [20]. The Sobel product of coefficients method was used and this showed conformity with Judd and Kenny difference of coefficient method. The test of mediation shows statistical significance, thus the null hypothesis of location having no influence on income-savings relationship was rejected.

About 7.5% of total effect of the income-savings relationship has been mediated by location in Etsako East and West Local Government Areas of Edo State Nigeria (One's location has 7.5% influence on one's income and savings relationship).

The size of an effect is the magnitude of that effect. It also helps to check the rate of type 1 error committed during hypothesis testing. The size of the mediated effect being medium is an indication that location on income-savings relationship in Etsako East and West Local Government Areas of Edo State Nigeria can be perceived or visible to an attentive observer. Although effect size can be small while test of same effect still show statistical significance, therefore effect size goes beyond significant testing.

5.2 Conclusion

The results of this study show that location plays the role of a mediator in the effect of income on savings in Etsako East and West Local Government Areas of Edo State Nigeria.

The partial mediation observed in this study is an indication that there are other mediating variable(s) apart from location that influence the relationship between savings and income in Etsako East and Etsako West Local Government Areas of Edo State, Nigeria.

The significance of the mediated effect shows that location significantly influence the relationship between savings and income of middle income earners in Etsako East and West Local Government Areas of Edo State.

Since the total effect of income on savings is approximately 53% (C=.531) and the mediated effect is 0.04, we can say that 7.5% (.04/.531) mediated in the model was due to the mediating effect of location. Hence location affects savings from the earnings of middle income earners in Etsako East and West Local Government Areas of Edo State Nigeria to the tune of 7.5%.

Since the effect size is medium, the effect of location on income- savings relation can be perceived or visible to an attentive observer. It can therefore be safe to say that there are other mediators that influence savings - income relationship outside location in these Local Government Areas.

Competing Interests

Authors have declared that no competing interests exist.

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APPENDIX A

Results from the pilot survey

Table 1a. Model summary

Model	R	R square	Adjusted R square	Std error of the estimate
1	.382	.146	.108	16.36444

a. Predictors: (constants), m, x

Table 1b. ANOVA

	Model	Sum of squares	df	Mean square	F	Sig
1	Regression	2064.711	2	1032.356	3.855	.028
	Residual	12050.768	45	267.795		
	Total	14115.479	47			

a. Dependent variable y
b. Predictors:(constants), m, x

Table 1c. Model summary

Model	R	R square	Adjusted R square	Std error of the estimate
1	.382	.146	.108	16.18705

(a) Predictors: (constant), x

Table 1d. ANOVA

	Model	Sum of squares	df	Mean square	F	Sig
1	Regression	2062.531	1	2062.531	7.872	.007
	Residual	12052.948	46	262.021		
	Total	14115.479	47			

(a) Dependent variable y
(b) Predictors:(constant), x

APPENDIX B

Results of the estimated regression models and correlation coefficients of the data: savings, income, and location.

Table 2. Summary estimates of normal regression and correlation analysis

Equation	Unstd. effect	Std. effect	Std. error	SSR	R^2	Correlation(r)
$Y=\alpha_1+$ c$X+\ e_1$	c =.531	c=.544	.027	68436.127	.296	r_{mx}=.242
$Y=\alpha_2+$ c $'X+b$M$+e_2$	c'=.496	c'=.509	.027	73120.267	.316	r_{xy}=.544
$Y=\alpha_2+$ c $'X+b$M$+e_2$	b=4.641	b=.147	.888			r_{my}=.270

$$S'_{b_k} = \sqrt{\frac{1-R^2_{mult}}{(1-R^2_{m.x})\times(N-K-1)}} \quad R^2 = 0.316$$

$$SSR(m/x) = SSR(mx) - SSR(x)\ or\ SSE(x) - SSE(mx)$$

But $R^2_{m.x} = \frac{SSR(m/x)}{SSE(x)} = \frac{4684.139}{162658.058} = 0.0288.$

Therefore, $S_{b'} = \sqrt{\frac{1-0.316}{(1-0.0288)(920)}}$ =0.0277

Regression of location (M) on income(X) M*=$\beta_1 + aX + \varepsilon$

Table 3.1. The logistic procedure (with stata SE 9.1)

m	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
x	.0310933	.0043206	7.20	0.000	.0226252	.0395614
cons	-3.053082	.4282914	-7.13	0.000	-3.892517	-2.213646

Table 3.2. Logit (N=924): Factor change in odds (Odds of: 1 vs 0)

m |	b	z	P>|z|	e^b	e^bStdX	SDofX
x |	0.03109	7.197	0.000	1.0316	1.6557	16.2156
cons |	-3.053082	-7.13	0.000			

. fitstat

Measures of Fit for logit of m

Log-Lik Intercept Only: -640.468 Log-Lik Full Model: -612.912

D(922): 1225.824 LR(1): 55.112

Prob > LR: 0.000

McFadden's R2: 0.043 McFadden's Adj R2: 0.040

Maximum Likelihood R2: 0.058 Cragg & Uhler's R2: 0.077

McKelvey and Zavoina's R2: 0.072 Efron's R2: 0.057

Variance of m*: 3.544 Variance of error: 3.290

Count R2: 0.584 Adj Count R2: 0.169

AIC: 1.331 AIC*n: 1229.824

BIC: -5070.248 BIC': -48.283

Thus, $S'_{b_k} = S_{b_k} \times \frac{s_{xk}}{s_y}$

$$S_{a'} = 0.00432 \times \frac{16.2156}{1.88255} = 0.0372$$

The results of the standard error for mediated effect using Sobel approach is as follows:

$$S_{a'b'} = \sqrt{a'^2 S_{b'}^2 + b'^2 S_{a'}^2} = \sqrt{0.000055022 + 0.000030064385}$$
$$= 0.009224$$

The hypothesis to be tested is; $H_o: a'b' = 0$ Vs $H_a: a'b' \neq 0$,

Using the test statistic $t^*_{ind} = \frac{\beta_{ind}}{s_{\beta_{ind}}}$

Which is $t^*_{ind} = \frac{0.04}{0.009224} = 4.337$

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