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# Assessing Sierra Leone's Consumption Function: A Cointegration and an Error Correction Model Approach

Ibrahim Abubakarr Bah<sup>1</sup>

## Abstract

This study uses Cointegration and an Error Correction Model to investigate the responsiveness of household consumption to changes in income in Sierra Leone covering the periods 1980 to 2020. The study relies on annual time series data on consumption and gross domestic product from the World Bank's World Development Indicators database. In the empirical model, consumption depends entirely on income. The results show that in the short-run, 85 percent of additional income goes toward consumption and that income is greater than consumption in the short-run with an adjustment value of 75 percent annually. In the long-run, the results show a significant marginal propensity to consume of 1.02 meaning that an additional 1 Leone is fully put into consumption. The long-run marginal propensity to consume does confirm results from previous studies that show relatively higher marginal propensities to consume in the long-run for low-income countries compared to middle- and high-income countries. An important policy implication of this study is that any increase in spending by the government to boost aggregate demand can also significantly increase consumption.

**Keywords:** *Marginal Propensity to Consume, Consumption, Income, Cointegration, Error Correction Model, Sierra Leone*

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## 1. Introduction

Many researchers have over the decades examined how changes in the incomes of individuals affect their expenditures. Some have used micro-level data to examine the consumption patterns of individuals while many others have used aggregate data to investigate the consumption function in different countries and or regions.

Alimi (2015) estimated the short and long-run consumption functions of Nigeria and South Africa and finds that in Nigeria, the short and long-run marginal propensities to consume are 0.9 and 0.95 respectively. This suggests that in the long-run for example, on average, 950 Naira is consumed for an additional 1,000 Naira increase in income. The MPCs for South Africa were relatively lower. Bonsu and Muzindutsi (2017) estimated the consumption function in Ghana. Their findings revealed that long-run marginal propensity to consume in Ghana is 0.79, meaning that for every one cedi change in income, consumption changes by 79 percent.

Other authors also sought to infer from Keynesian macroeconomics that the consumption function is concave; as income increases, consumption increases but at a slower rate. In a related study, Gong et al. (2012) showed that when absolute risk tolerance is presumed in the model, the consumption function is concave. This means that the marginal propensity to consume (MPC) is relatively higher when income is low and vice versa.

This study contributes to the macroeconomic literature by investigating the consumption function in Sierra Leone to determine the fraction of total output that is consumed by private individuals. This is done by specifying a simple macroeconomic model with consumption depending solely on income. This study is significant because policymakers regard consumption as a key indicator of economic performance. In the expenditure measure of national income, an increase in incomes of individuals is expected to increase spending on consumption goods which in turn will increase aggregate expenditure.

## 2. Data Description

The data for this study is based on Sierra Leone and is from the World Bank's World Development Indicators database. The sample data consists of 41 annual observations on consumption and gross domestic product covering the period 1980 to 2020.

Consumption is in constant Sierra Leone Leones (SLL) and measures the market value of final goods and services including licensing and permit fees, durable goods, imputed rent and non-profit institutions serving households in Sierra Leone within a year. However, this measure of consumption excludes purchases of houses. Gross Domestic Product measures the market value addition in the production of goods and services in Sierra Leone and is measured annually. It only includes the value addition by residents within Sierra Leone and is in constant Leones (SLL). It includes taxes on products less subsidies not included in the value of the goods/services. This GDP measure does not exclude depreciation of assets or natural resources. Both consumption and GDP data are in trillions of Leones.

Figure 1 presents a graphical representation of the trends in consumption and GDP between 1980 and 2020 measured in billions of Leones. It shows a high correlation between the two, meaning that GDP and consumption more often than not move in the same direction.

**Figure 1:** Graphical Representation of the Association between Consumption and GDP

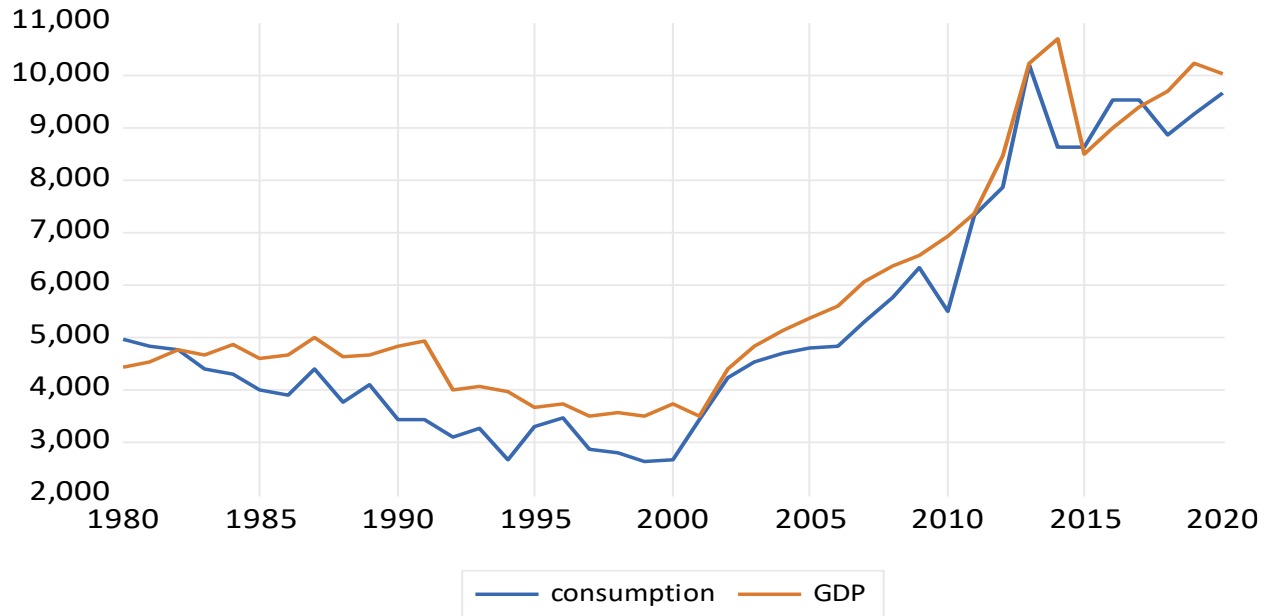


Table 1 presents the summary statistics of consumption and GDP. This includes the number of observations, mean, minimum, maximum, and standard deviations of the series. Both GDP and consumption are in billions of Leones.

**Table 1:** Summary Statistics of Sample Data

Variables	Obs	Mean	Median	Max	Min	Std Dev
Consumption	41	5251.254	4503.267	10169.13	2606.494	2316.268
GDP	41	5806.505	4809.929	10684.25	3479.977	2238.178

From Table 1, the mean value of consumption is 5 trillion and 251 billion Leones while that of GDP is 5 trillion and 806 billion Leones. The maximum value of both variables is in the tens of trillions of leones.

### 3. Methodology

I specify a Keynesian consumption function in the form

$$C_t = \beta_0 + \beta_1 Y_t + U_t \quad (1)$$

From Equation (1),  $C_t$  is consumption in year  $t$  while  $Y_t$  is Income in year  $t$ . In our model, the proxy for Income is gross domestic product.  $\beta_0$  is the intercept in our model while the slope parameter  $\beta_1$  measures the responsiveness of consumption to a unit change in income. In other words,  $\beta_1$  is the marginal propensity to consume and theoretically ranges from 0 to 1. The error component  $U_t$  accounts for other unobserved factors that affect consumption including people's preferences, interest rates, and other random shocks to the economy.

### 3.1. Test for Stationarity

To estimate the model, both series should be stationary at level form. Therefore, this study examines the stationarity of the series by using the Augmented Dicky-Fuller (ADF) test. This test allows for examining the stationarity of individual series. The Null hypothesis of non-stationarity is tested at the 1 percent, 5 percent, and 10 percent levels. This study tests for stationarity of consumption and GDP at level form and in differences form.

If the series are stationary in their level form [I(0)], then an estimation of equation (1) in its original form will yield a consistent estimate of the marginal propensity to consume for Sierra Leone.

If the series are not stationary at level form, but are both stationary at first difference [I(1)] or second difference [I(2)], then estimating the differenced equation yields consistent estimates. However, this will not yield the marginal propensity to consume (MPC) as predicted by the economic theory.

### 3.2. Cointegration Test and Error Correction Model

If the residual from estimating equation (1) is stationary at level [I(0)], then it means that both series are cointegrated, and thus estimating the series at their level form will yield consistent estimates (Engle & Granger, 1987). To test for cointegration, the study follows the Augmented Engle-Granger test for cointegration as proposed by Engle and Granger (1987). Firstly, the non-stationary series in their level forms are estimated to generate the residual from the model. Then the residual is tested using the ADF method to check for the presence of unit root. If the null hypothesis of unit root is rejected, then the series are said to be cointegrated.

If the series are cointegrated, then the parameter estimate  $\beta_1$  from equation (1) represents the static long-run MPC. Another intuitive way of estimating the long-run model is by the following model:

$$C_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 C_{t-1} + V_t \quad (2)$$

$\alpha_2$  is the responsiveness of current consumption to consumption in the previous period. From equation (2), long-run MPC =  $\alpha_1 / (1 - \alpha_2)$ .

Long-run equilibrium however does not mean that a model is in short-run equilibrium. In Engle and Granger (1987), the Granger Representation Theorem states that for two cointegrated series, their relationship can be expressed in an Error Correction Model. Thus, in the short-run, changes in consumption depend on changes in GDP and the lagged error term. The error correction model is specified below:

$$\Delta C_t = \gamma_0 + \gamma_1 \Delta Y_t + \gamma_2 U_{t-1} + \varepsilon_t \quad (3)$$

$\gamma_1$  is the estimate for the short-run MPC while  $\gamma_2$  measures the speed of adjustment to short-run equilibrium. Therefore, this study estimates equation (3) to examine the short-run relationship between consumption and income.

## 4. Results

I present the results of the study in this section starting with the results from the tests for stationarity using the ADF method. Table 2 presents the results from testing consumption, GDP, and the residual from estimating equation (1) for stationarity. From the table, both consumption and GDP are non-stationary at level form. The ADF statistics are insignificant at the 1 percent, 5 percent,

and 10 percent levels meaning that we fail to reject the null hypothesis of a unit root. In contrast, both consumption and GDP are stationary at their first differences. The ADF statistics of both first differenced series, when tested without trend, with trend, and with trend and intercept, are significant at the 1 percent significant level. Therefore, the null hypothesis of a unit root is rejected.

The residual series got from estimating equation (1) is stationary at level form. The ADF statistics are significant meaning the null hypothesis of non-stationarity is rejected at the 1 percent level.

**Table 2:** ADF Unit Root Test

VARIABLES	LEVEL			FIRST DIFFERENCE		
	None	Intercept	Intercept and Trend	None	Intercept	Intercept and Trend
	t-statistic	t-statistic	t-statistic	t-statistic	t-statistic	t-statistic
Consumption	1.0396	0.0904	-1.7704	-7.2862***	-7.4755***	-8.1235***
GDP	1.5133	0.2020	-1.3405	-5.3077***	-5.5107***	-5.7051***
Residual	-5.6076***	-5.5455***	-5.4506***			

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Since consumption and GDP are integrated of the same order  $[I(1)]$ , and the residual from the non-stationary series is stationary at level form  $[I(0)]$ , then a cointegrating relationship exists between consumption and GDP. If two series are cointegrated, we can also express their relationship using an error correction mechanism. Table 3 presents results for the consumption function at levels using equation (1), long-run MPC using equation (2), and short-run MPC using equation (3).

**Table 3:** Estimation Results of Consumption Function for Sierra Leone

Variables	Levels (1)	Long run (2)	Cointegration (3)	Short run ECM (4)
GDP	1.0058*** (0.0390)	0.8164*** (0.1534)	1.0294*** (0.0384)	
D(GDP)		0.2053 (0.1548)		0.8546*** (0.1711)
Consumption(-1)				
Residual(-1)				-0.7557*** (0.1784)
Constant	-589.0023** (242.3504)	-566.0887** (243.6675)	-767.5204*** (240.0447)	-5.6487 (86.1267)
Number of Observations	41	40	40	40
R-squared	0.9446	0.9527	0.95029	0.4351
Durbin Watson	1.5713	2.1054		2.1954

Standard errors in parentheses

\*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

In order to confirm the significance of the long-run MPC estimate, a cointegration regression of equation (1) is also estimated using a fully modified ordinary least squares method.

In model (1), estimated with the levels equation, the MPC is 1.0058. This means that on average, a 1 Leones increase in income (GDP) leads to a 1.0058 Leones increase in consumption and this is statistically significant at the 1 percent level. The R-squared is 0.94 suggesting that 94% of the variation in consumption is explained by changes in GDP. The Durbin-Watson statistic is 1.57 and satisfactory since both series are cointegrated. In model (2), the coefficient for GDP is constant while that of lagged consumption is insignificant. Nonetheless, the long-run MPC =  $\frac{0.8164}{1-0.2053} = 1.0273$ . This confirms that in the long-run, a 1 Leones increase in income on the average leads to a 1.02 Leones increase in consumption. However, from model (2), the significance of the long-run MPC cannot be determined from the regression results. In model (3), the result of a cointegrating regression using fully modified ordinary Least Squares is presented. The long-run MPC is 1.0294, meaning that in the long-run, on average, a 1 Leones increase in income increases consumption by 1.02 Leones and this result is significant at the 1 percent level. In model (4) which presents estimates of an ECM model, the short-run MPC is 0.8546 and it is significant at the 1 percent level. On average, for every 100 Leones increase in income, 86 Leones is consumed in the short-run. The coefficient of the lagged residual, -0.7557, is the error correction term and it is negative and significant meaning that a long-run relationship exists between consumption and income (GDP). The term measures the deviation from the long-run relationship. It means that 75.57% of the disequilibrium in the short-run adjusts within a year.

The results from this study do not exactly match the predictions of the theory but an MPC approximated to 1 in itself is within the upper boundary of the Keynesian MPC.

## **5. Discussion and Conclusion**

The results confirm that there is almost a one-to-one relationship between income and consumption. A change in income leads to an equal change in consumption in the long-run. Diacon and Maha (2015) found that the MPC is much higher for low-income countries. Sierra Leone is a low-income country, so it is not surprising to get an MPC of 1. Alimi (2015) estimated the MPC for Nigeria, a country in the same region as Sierra Leone and which shares significant historical and economic ties with Sierra Leone. The long-run MPC for Nigeria was 0.95 while the short-run MPC is 0.9. The short-run MPC for Nigeria, 0.9 is higher than that of Sierra Leone while its long-run MPC is relatively lower compared to that of Sierra Leone. Nonetheless, the results from this study confirm results from some previous studies that marginal propensities to consume are relatively higher in low-income countries.

This study is set out to provide policymakers with a grasp of the consumption function in Sierra Leone without the use of elaborate models and estimation techniques. The study aims at providing a solid background for future research on the subject. One policy implication of this study is that a government stimulus package that boosts aggregate demand significantly increases consumption, and that can have tradeoffs in the form of higher inflation rates.

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