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**Do non-communicable diseases influence sustainable development in Sub-Saharan Africa? A panel autoregressive distributive lag (ARDL) model**

**Short title:** NCDs and sustainable development

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## Key messages

- Prevalence of non-communicable diseases in Sub-Saharan Africa is rapidly increasing. Consequently, the burden of NCDs, measured by disability-adjusted life years, has nearly doubled since 1990.
- NCDs negatively and significantly affect sustainable development in the long run. The main NCDs –cardiovascular diseases, diabetes and chronic lung disease, ischemic heart disease that are responsible for significant shares of the disease burden also strongly negatively impact sustainable development in the region.

- It is imperative that countries urgently adopt strategies, such as the WHO "best-buys" for policymakers, to reduce the current trend of NCDs prevalent in the sub-region, if they are to follow the sustainable development trajectory.

**Keywords:** Non-communicable diseases, disability-adjusted life years, sustainable development, adjusted net savings, panel ARDL, Sub-Saharan Africa.

**JEL Classification:** I15, Q01, E21, C23, O55

**Abstract**

The burden of non-communicable diseases (NCDs) in Sub-Saharan Africa has been on the surge during the last two decades. This study examines the relationship between NCDs, measured by disability adjusted life years (DALYs), and sustainable development in Sub-Saharan African (SSA) countries. We adopt a panel Autoregressive Distributed Lag model to evaluate the association between NCDs and sustainability of development, alternately measured by adjusted net savings and gross domestic savings, in 24 SSA countries, from 1990 to 2017. The results show that NCDs adversely affect sustainable development in the long run. The findings demonstrate an urgent need to mitigate the rapidly rising burden of NCDs. We argue that reducing the current trend of NCDs in the sub-region is necessary for countries to be on a sustainable development trajectory.

## 1 Introduction

Non-communicable diseases (NCDs) are the largest cause of death in the world, accounting for over 71% of global deaths (World Health Organisation, 2018). The main NCDs are cardiovascular diseases accounting for 17.9 million deaths, followed by cancers (9.0 million), respiratory diseases (3.9 million), and diabetes (1.6 million). Early estimates showed that the number of people suffering from the major NCDs is expected to rise (Mathers and Loncar, 2006). Although NCDs were predominantly the leading cause of death in developed countries, the focus has shifted to developing countries, over 80% of global deaths from NCDs occur in developing countries. Specifically, 80% of deaths from cardiovascular, 90% of deaths from chronic obstructive pulmonary diseases and 75% of deaths from all cancers occur in developing countries (Fuster et al., 2011; World Health Organisation, 2011, 2013).

In Sub-Saharan Africa (SSA), the burden of disease continues to be dominated by infectious diseases. However, the trend is clearly changing with the disability-adjusted life-years (DALYs)[1] due to NCDs continually and rapidly rising since 1990, while infectious diseases DALYs are on the decline (Global Burden of Disease Collaborative Network, 2020). Figure 1 illustrates the trend in NCDs DALYs in SSA from 1990 to 2019. It shows that the leading cause of NCDs in the sub-region in 2019 was cardiovascular diseases which increased by 68%, from 16,089,280 DALYs in 1990. Rapid unplanned urbanisation and changes in lifestyle associated with economic development have contributed significantly to the rise in NCDs prevalence, amidst the growth in population in the region (Gouda et al., 2019; Marquez and Farrington, 2013).

***(Insert Figure 1 here)***

The current and potential burden of NCDs is a cause of global concern. NCDs tend to persist over a long term contributing to loss of economic productivity, diversion of resources from other activities and substantial cost to families and individuals (Maher et al., 2012; Mayosi et al., 2009). Conceptually, one DALY is the equivalent of losing one year in good health because of either premature death, diseases, or disability. The Commission on Macroeconomics and Health guides that each life year should be valued at approximately three times annual earnings. It is evident that the increasing NCDs-DALYs in SSA signify losses of earnings in increasing amounts, a challenge to sustainable development. However, the association between NCDs and sustainable development in SSA is not explicitly available for policymakers to comprehend the magnitude of an emerging NCDs epidemic.

Thus, our study contributes to the existing literature by examining the association between NCDs and sustainable development in SSA. Specifically, we investigate the extent to which mortality and morbidity from NCDs correlate with sustainable development in the short-and long-run. This study is important because it enables us to draw lessons and inform the NCD policy-development process in SSA countries and other low- and middle-income countries (LMICs) with similar characteristics.

The bulk of the evidence on the economic impact of NCDs is from high-income countries while in LMICs it is generally scarce. For instance, in a systematic review of studies on the global impact of NCDs on macroeconomic productivity, only four were from the World Health Organisation (WHO) Africa region: Kenya, Nigeria, South Africa and Tanzania (Muka et al., 2015). The South African study used the comparative risk assessment methodology developed by the WHO to assess the prevalence and burden of diabetes and found that 5.5% of the population had diabetes which increased with age, and 10-14% of the NCD disease burden in adults (30+ years) were attributable to diabetes (Bradshaw et al., 2007). The Kenyan study, on the other hand, investigated the total burden of disease from infectious diseases and cardiovascular illnesses in coastal rural Kenya using data from the Health and Demographic Surveillance System (Etyang et al., 2014). They found that NCDs were the second leading cause of DALYs, after HIV/AIDS. The Tanzania study investigated the cost of treating stroke by interviewing community participants and reviewing cost data from project documents, and found that average productivity loss per patient was higher in the urban district compared to the rural district (Kabadi et al., 2013). In Nigeria, they investigated the determinants of returning to work for stroke survivors and found that the chance of returning to work was lower for post-stroke duration of a year or less (Peters et al., 2013). None of these studies evaluated the economic burden of NCDs on sustainable development, which is the main objective of our study.

Others have assessed the financial burden of treating and managing NCDs at household and health system levels, also mainly set in developed countries (Muka et al., 2015; Thakur et al., 2011). For instance, Muka et al.'s (2015) systematic review of the global impact of NCDs on healthcare spending found only 16 studies (out of 153) that focused on LMICs, of which only three were in Africa. Two of the Africa studies examined the direct cost of treatment and management of stroke from a health system perspective in Senegal (Touré et al., 2005) and Tanzania (Kabadi et al., 2013). Yet, indirect costs, such as work loss, work replacement, reduced productivity from illness and the cost to the carers of the sick, are equally important when assessing the burden of diseases like NCDs. Indeed, the third study accounted for direct and indirect costs and found that diabetes cases recorded by countries of the WHO African Region in 2000 resulted in a total economic loss of USD25.51 billion (Kirigia et al., 2009).

A major study that assessed the burden of NCDs in SSA uses the Global Burden of Disease Study to calculate NCDs-DALYs (Gouda et al., 2019). The NCD-DALYs measure the disease burden at the population level by summing years of life lost due to premature mortality and years of life lived with disability, providing an insight into the extent of labour supply and productivity losses. We take this analysis further and evaluate the relationship between NCD-DALYs and sustainable development in SSA.

Another strand of literature investigates the determinants of sustainable development by estimating the impact of economic and social variables. For instance, studies set on the Asian continent have found that per capita income, financial development, inflation rate and minerals depletion have a significant effect on sustainable development (Koirala and Pradhan, 2019). Similarly, in Kenya, energy efficiency is an important determinant of sustainability in the short run while household consumption and unemployment rate are significant determinants both in the short and long run (Kaimuri-Kyalo and Kosimbei, 2017).

Studies that have evaluated the association between health-status and adjusted net savings have used life expectancy as a proxy for health-status and found it to be an important determinant (Gnègnè, 2009;

Hess, 2010). However, life expectancy captures the average population health. It is imperative to use a health-status variable that represents the burden of disease, such as NCD-DALYs, to understand the extent of the effect of these diseases on sustainable development. Bloom et al. estimated the economic cost of NCDs, measured by DALYs, in China and India for the period 2012 – 2030, and found that the total cost of the five major NCDs will be USD 27.8 trillion for China and USD 6.2 trillion for India (Bloom et al., 2013). While their study uses the prevalence of NCDs as the health-status variable, it examines the economic impact based on the forecasts of future disease prevalence.

Our study analyses the relationship between NCDs and sustainable development using panel Autoregressive Distributed Lag (ARDL) model on 24 SSA countries. We find that NCDs, measured by DALYs, have a negative effect on sustainable development in the long run but not in the short run. We further examine the relationship between sustainable development and 22 NCDs separately. Although the results are mixed, we found that several NCDs, such as alcohol use disorder, breast cancer, liver cancer, diabetes mellitus, among others adversely affect sustainable development in SSA in the long run. These findings reinforce the importance of reducing NCDs in the sub region.

The rest of the paper is organised as follows. Section 2 discusses the pathways though which NCDs affect sustainable development. Section 3 describes the methods for estimating the relationship between NCDs and sustainable development and the sources of data. The empirical results are presented and discussed in section 4, while section 5 concludes the paper.

**2 Pathways through which NCDs affect sustainable development**

To analyse the pathways, it is important to explain the definition of sustainable development adopted in this study. It is "… development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). That is to say, societal welfare depends on that society's comprehensive wealth, which is made up of produced capital ($K_P$) (machinery, structures and equipment), natural capital ($K_N$) (agricultural land, protected areas, forests, minerals and energy) and intangible capital ($K_H$) which includes human, social and institutional capital (World Bank, 2011, 2012, 2018). Changes in comprehensive wealth enable us to measure the sustainability of development. However, it is not possible to obtain data on an annual basis for all the forms of capital in comprehensive wealth. The suggestion is to use the adjusted net savings (ANS), which is the gross national savings adjusted for the annual change in volume of all forms of comprehensive capital[2] (World Bank, 2011).The ANS is rooted in the traditional Gross National Income (GNI) which, in principle, shows the distribution of consumption, savings and investment in a society[3] as follows:

$$ANS = (GNI - C + NCT) - \delta K_P + \delta K_H - \delta K_N - \delta N_K \quad (1)$$

where GNI, $K_P, K_H$ *and* $K_N$ are as previously defined; $C$ is total private and public consumption, $NCT$ is net current transfers, $N_K$ is negative capital that includes damages from carbon dioxide emissions from fossil fuel and damages from exposure of the population to air pollution use, and $\delta$ is depreciation/appreciation rate. The operation in brackets equates to Gross National Savings (GNS); it comprises of all items that increase a country's savings over and above the remaining GNI after subtracting consumption. An economy is on a sustainable path if savings are higher than the total depreciation of all the forms of capital (Pearce and Atkinson, 1993). Compared to gross domestic product (GDP), adopting ANS as a proxy for sustainable development is more desirable as it reflects changes in comprehensive wealth over time (Koirala and Pradhan, 2019). GDP treats the production of goods and services and the value of asset liquidation as part of the product of a country, which means a country can post growth in GDP even though it was depleting its natural resources; such economic progress is not sustainable.

Figure 2 illustrates the main channels through which NCDs affect sustainable development. The direction of arrows signifies the route of the mechanisms, from one economic entity to another.

***(Insert Figure 2 here)***

NCDs affect gross national savings through household savings and firm investments. The mechanism starts when NCDs force people into early retirement and thus reduce the overall labour market participation in an economy while increasing the dependent population relative to the working population. This potentially reduces savings rates during active years because people anticipate that early retirees, due to NCDs, will most likely have shorter post-retirement life expectancy. This results in declining aggregate savings, increasing long-term interest rates and declining investment, and eventually decreasing stock of produced capital.

Additionally, as working people are forced into early retirement due to NCDs, they leave with their long-earned experience and expertise, which increases the firm's cost of replacing them in the form of hiring and training, and the gap left before new hires acquiring the same level of experience lost. Also, the population attitude towards a shortened life expectancy due to NCDs could potentially discourage undertaking investments in education and other human capital development because of the expected shorter periods of payoffs in the labour market.

Furthermore, when workers die prematurely from NCDs, the workforce is permanently reduced and their contribution to national output is removed. Also, productivity declines when working-age people suffer from NCDs; the illness impedes individual's ability to work harder and longer and to think clearly (Grossman, 1972). Productivity losses also arise when workers are absent due to illness from NCDs and absent while caring for the sick, particularly children. Moreover, NCDs in children could lower education attainment levels thereby affecting future labour earnings and potentially lowers savings. For example, childhood obesity, a strong predictor of adult obesity, leads to less skill formation and therefore lower productivity in adulthood and ultimately lower labour earnings (Cawley, 2004; Cawley and Spiess, 2008; Sabia, 2007). Lower wages potentially result in lower consumption, savings, and investment, which could translate into lower rates of growth in national income.

Additionally, NCDs pose a burden in the form of increased health expenditures on all economic agents. At the household level, NCDs increase consumption of healthcare, especially for multi-morbidity cases, and impose a greater financial burden on individuals (Lee et al., 2015). This forces households to cut back on consumption of non-health goods and/or liquidate assets, thus increasing the risk of financial insecurity and reducing the standard of living. At the firm level, firms face reduced turnover due to decreased aggregate demand, and incur higher costs in employee health benefits and early retirement cost pressures on healthcare insurance providers. All these channels divert resources away from other productive activities that could produce non-health utility generating goods and services.

At the government level, the chronic nature of NCDs implies that governments increasingly provide healthcare services to the sufferers. For instance, the rapid increase in treatment rates for major medical conditions in the 1990s is attributed to increases in prevalence of diabetes, cancer and mental illness (Howard et al., 2010). In a fixed budget scenario, increasing healthcare spending implies reduction in resources available for other investments such as infrastructure and education, yet public investment is a major driver of economic activity especially in developing countries (Agénor and Moreno-Dodson, 2006).

## 3. Methods

### 3.1 Economic model

Our study follows the neoclassical growth model extended to incorporate human capital (Bloom et al., 2004). The model can distinguish human capital by education and health status, hence can explicitly show the contribution of health-status to national income. We therefore postulate a production technology defined as:

$$Y = AK^{\alpha}L^{\beta}e^{h} \tag{2}$$

where $Y$ is output, $A$ is total factor productivity, $K$ is physical capital, $L$ is labour, and $h$ is human capital, which includes education and health status.

### 3.2 Data and Variables

This study adopts an unbalanced panel data covering 24 countries in SSA over the period 1990 – 2017. The number of countries is limited by data unavailability for some countries in SSA during the years under study. The data for macroeconomic variables used in the study are mainly from the World Bank World Development Indicators, unless otherwise indicated. Table A1 in the Appendix contains the list of countries used in the study.

The dependent variable is sustainable development, represented by adjusted net savings (ANS), which is also referred to as the true rate of savings in a country after considering expenditures on education, depletion of natural resources and damages caused by pollution (World Bank, 2012). ANS is often used as a measure of sustainable development (Greasley et al., 2014; Kaimuri-Kyalo and Kosimbei, 2017; Koirala and Pradhan, 2019), because it suggests that a country can sustain its wealth and level of consumption if savings each year, are sufficient to cover the depreciation of man-made and natural resources. A positive value for the ANS implies that consumption potential of future generations will not be compromised by the current generation (World Bank, 2018). Data for this variable is measured as a proportion of gross national income (GNI). Additionally, we use the ratio of gross domestic savings (GDS) to GDP as an alternative measure of sustainable development, as adopted by Hess (2010), to assess the robustness of our results.

The main explanatory variable of interest in this study is the human capital in the form of health status. We express the effect of health status using the burden of NCDs, measured by Disability-Adjusted Life Years (DALYs). The WHO defines DALYs as the number of years lost due to ill-health, disability or premature death within a given population. Thus, the overriding objective of the study is to examine how ANS could be influenced by NCD-DALYs. We obtained annual data on DALYs attributed to NCDs per country for 1990 – 2017 from the global burden of disease estimates published by the Institute of Health Metrics and Evaluation (IHME) (Global Burden of Disease Collaborative Network, 2020). DALYs data is measured in number of years. We also control for the impact of labour supply on sustainable development using the average share of the population aged 15-64 years. Additionally, we control for macroeconomic variables adapted from empirical literature on the determinants of sustainable development and were found to be significant determinants. These include real GDP per capita, broad money, foreign direct investment (FDI), gross national expenditure (GNE) and current account balance (CAB).

### 3.3 Empirical Model

There are several econometric models used in previous studies for analysing panel data, such as pooled OLS, fixed effects and random effects (Koirala and Pradhan, 2019). However, our study adopts Autoregressive Distributed Lag (ARDL) model, as developed in (Pesaran et al., 1997; Pesaran et al., 1999), to examine the association between NCD-DALYs and sustainable development because the other three models are unable to capture the dynamic nature of the data. This can result in serious bias if the dynamics are heterogeneous across cross sectional units (Brañas-Garza et al., 2011). Besides, the ARDL model can be applied to examine both short-run and long-run relationships regardless of whether the variables under study are stationary in levels or in first difference (Pesaran and Shin, 1999). Nevertheless, well-known co-integration approaches developed by (Engel and Granger, 1987; Johansen, 1995; Johansen and Juselius, 1990) require all variables in a model to be integrated of order one (Akıncı et al., 2015; Shrestha and Bhatta, 2018). Furthermore, the ARDL model produces unbiased and consistent results even for studies where the sample size is small (Nagawa et al., 2020). The empirical model is expressed as:

$$\Delta lnANS_{it} = \sum_{j=1}^{p} \delta_{ij} \Delta lnANS_{i,\,t-j} + \sum_{j=0}^{q`} \Lambda_{ij} \Delta lnX_{i,t-j} + \theta_i \{ lnANS_{i,\,t-1} - (\beta_{0i} + \beta_{1i} lnX_{i,t-1}) \} + \varepsilon_{it} \quad (3)$$

where $lnANS$ is the natural logarithm of adjusted net savings, $lnX$ is a set of independent variables in natural logarithms including the NCD-DALYs indicator, $\delta$ and $\Lambda$ represent the short-run coefficients of lagged dependent and independent variables respectively, $\beta$ denotes the long-run coefficients, $p$ and $q$ are the optimal lags of the lagged dependent and independent variable respectively, $\theta$ is the speed of adjustment coefficient which shows the speed at which equilibrium is restored when disequilibrium occurs, and the subscripts $i$ and $t$ represent the country and time period, respectively.

**3.4 Estimation strategies**

Testing for unit root is not necessary for ARDL regression analysis so long as the variables are integrated of order zero and one (Pesaran et al., 1997; Pesaran et al., 1999; Pesaran and Smith, 1995). However, we perform stationarity test to ensure that none of the variables is integrated of an order greater than one using panel unit root tests developed by (Im et al., 2003) and (Choi, 2001), also known as the Fisher type, as both allow for unbalanced panel data. The null hypothesis is that all series in the panel have a unit root, while the alternative hypothesis is that all series are stationary.

Choosing an appropriate lag length is an important step in the estimation of panel ARDL model to account for the problem of non-normality, autocorrelation and heteroskedasticity. For panel ARDL model estimation, the unrestricted model and any of the standard information criterion are used for deciding the choice of lags for each country per variable. Subsequently, the most common lag for each variable across the countries is used to represent the lags for the model.

There are three different estimators for ARDL analysis, namely the mean group estimator (MG) (Pesaran and Smith, 1995), the pooled mean group (PMG) estimator developed by (Pesaran et al., 1999) and the dynamic fixed effects (DFE) estimator. The MG estimator assumes that the regression coefficients differ across countries in both the short run and the long run. It thus calls for estimating separate regressions for each country. However, the PMG estimator imposes a common long run relationship across countries while allowing for heterogeneity in the short run coefficients and intercepts. The main feature of the DFE model is that it allows for country-specific intercepts, but assumes that the speed of adjustment, and the short run and long run coefficients, are homogeneous for all countries.

We estimate Equation 3 with each of the three estimators and then apply the Hausman test to ascertain if there is a significant difference between them. The null hypothesis for this test is that the difference between PMG and MG or PMG and DFE estimator is not significant, suggesting that the coefficients are homogeneous across countries in the long run. The alternative hypothesis is that the difference between PMG and MG or PMG and DFE is significant. If we fail to reject the null hypothesis then the PMG estimates are more efficient than MG or DFE. Otherwise, the MG or DFE specification will be considered more appropriate.

## 4 Results and discussion

### Descriptive statistics

Table 1 shows a summary of the variables used in the current study, along with their descriptive statistics. The average log of adjusted net savings in SSA during the period 1990 – 2017 is 4.339, while that of GDS is 3.458. Comparing the sample means with the respective standard deviations, the variation for lnANS is lower than lnGDS. The overall mean for log of NCD-DALYs is 14.14.

***(Insert Table 1 here)***

The correlation matrix for the variables used in the study are presented in Table 2. In general, collinearity is likely to exist between two independent variables if the absolute value of their correlation coefficient exceeds 0.8 (Gujarati et al., 2013; Kennedy, 2008; Nagawa et al., 2020; Price and Bohara, 2013). The correlation matrix shows that none of the independent variables is highly correlated with another. Hence, multicollinearity is not a major problem to invalidate the simultaneous inclusion of any of our explanatory variables in the regression analysis.

***(Insert Table 2 here)***

**Unit Root Tests**

As mentioned earlier, we adopted Im, Pesaran and Shin (IPS) and the Fisher Augmented Dickey Fuller (ADF) unit root tests to examine the stationarity properties of the variables used in our study. Table 3 presents the results for the level variables and Tables 4 shows the result for the first differences. Concerning the level variables, both tests strongly point to the existence of stationarity with constant and trend at 1% significance level for all the variables, except NCD-DALYs, broad money and population, which contain unit root. Nevertheless, considering the same tests in first difference the overwhelming evidence is that the first differences do not contain unit root. Given that there is a mixed level of integration among the variables, the use of panel ARDL model becomes appropriate compared to the conventional co-integration approaches.

***(Insert Table 3 here)***

***(Insert Table 4 here)***

**Cointegration Test**

To ascertain whether there is a long run relationship among the variables across all countries, we use a variety of panel cointegration tests: the Kao test, Pedroni test and Westerlund test. The null hypothesis for each of these tests is that there is no cointegration. The results shown in Table 5 suggest that the null hypothesis of no cointegration can be rejected at a 1% significance level for three out of the five statistics related to Kao's cointegration test. The Pedroni and Westerlund conintegration tests reject the null hypothesis of no cointegration at 1% and 10% significance level, respectively. Given the results of these cointegration tests, we conclude that the variables used in the current study are cointegrated. Consequently, we can estimate a panel ARDL error correction model and interpret the coefficients of the variables in levels, as the long run effects on the dependent variable.

***(Insert Table 5 here)***

**Panel ARDL Regression Analysis**

To examine the relationship between NCDs and sustainable development in SSA, we estimate an error correction-based panel ARDL model using Equation (3) and natural log of adjusted net savings (lnANS) as the dependent variable. The lag structure for the model selected by Akaike Information Criterion (AIC), which was also confirmed by Bayesian information criterion (BIC), is ARDL (1, 0, 0, 0, 0, 0, 0, 0), where the dependent variable is lagged once, and the rest of the variable are not lagged. Table 6 shows the results of the PMG, MG and DFE estimations, together with the Hausman test to determine the best estimator among them. Comparing the three estimators, the Hausman test indicates that the null hypothesis of long run homogeneity restriction among the countries included in the sample cannot be rejected. This implies that the PMG estimator is more appropriate for examining the long run and short run relationships between the dependent and explanatory variables than the MG and DFE estimators.

According to the PMG results in column two of Table 6, NCD-DALYs have a negative and significant effect on adjusted net savings in the long run but no significant effect in the short run. That is, all things being equal, a 1% increase in NCD-DALYs reduces adjusted net savings by 14.980% in the long run. This is consistent with other findings that NCDs are chronic in nature contributing to loss of economic productivity as well as diverting resources from other activities to treat the chronically sick, in the long run (Maher et al., 2012; Mayosi et al., 2009; Thakur et al., 2011).

Additionally, GDP per capita growth has a positive and significant effect on adjusted net savings in the long run. Ceteris paribus, a 1% increase in GDP per capita growth leads to 7.626% increase in adjusted net saving in the long run, suggesting that countries with higher GDP growth rates have higher savings than low GDP growth countries. This finding is consistent with Friedman’s permanent income hypothesis (Friedman, 1957). According to the theory, when individuals are faced with an increase in their current income above the anticipated level of permanent income, they may save and invest the supplemental income in order to offset any potential decline in future income.

Surprisingly, the level of financial development, measured by the ratio of money supply to GDP (broad money), has a negative effect on adjusted net savings in the long run, but the impact is positive and significant at 10% in the short run. Furthermore, the current account balance has a positive and significant effect on adjusted net savings in the short run, while the effect is insignificant in the long run. Gross national expenditure has a significant contributory effect on adjusted net savings in both the short run and long run. Holding all other factors constant, a 1% increase in gross national expenditure reduces adjusted net savings by 0.319% in the short run and 34.420% in the long run. This outcome is consistent with the Keynesian model of consumption and saving which postulates that savings are negatively correlated with consumption expenditure. The ratio of working age population to total population has a positive and significant effect on adjusted net savings in the long run. The results indicate that a 1% increase in the ratio of working-age population increases adjusted net saving by 49.90% in the long run. This is consistent with the life-cycle hypothesis as working-age people tend to be net producers and savers (Ando and Modigliani, 1963), although the full contributory potential of the growth in this age-group may depend on the economic system and policies in place (Bloom and Canning, 2008). The coefficient of the error correction term, which indicates the speed of adjustment takes a negative value and is significant at 1% level.

***(Insert Table 6 here)***

We further estimate an error correction-based panel ARDL model using the natural log of gross domestic savings (lnGDS) as the dependent variable. Table 7 shows the results of the PMG, MG and DFE estimations, together with the Hausman test to determine the best estimator among them. Again, the Hausman test suggests that the PMG estimator is more appropriate than the MG or DFE estimator. The PMG results reported in column two of Table 7 indicate that NCD-DALYs negatively affect gross domestic savings in the long run but the effect is statistically insignificant in both the short run and long run.

As expected, GDP per capita growth significantly contributes positively to gross domestic savings in the long run, implying that a country's per capita income growth has a significant effect on its sustainable development. Similarly, the results indicate that financial development and foreign direct investment have a positive and significant effects on gross domestic savings in the long run, but the impact of these variables is not significant in the short run. On the contrary, an increase gross national expenditure adversely affects gross domestic savings significantly at 1% level in both the short run and long run. The error correction term is negative and statistically significant at 1%, suggesting a stable long run relationship between the variables.

***(Insert Table 7 here)***

We also examined the association between sustainable development and 22 major NCDs separately, using both lnANS and lnGDS as dependent variables, while controlling for the other explanatory variables. The results are reported in Tables 8 and 9, respectively. The results show that, breast cancer and liver cancer adversely affect sustainable development in the long run, in the category of cancers (neoplasms), while hypertensive heart disease and ischemic stroke are the main ones that negatively affect sustainable development in the cardiovascular diseases' category. Although prevalence of substance abuse disorders is relatively low and rising slowly in SSA (see Figure 1), these results show that alcohol use disorders, a subset of substance abuse disorders, is negatively associated with adjusted net savings in the long run. This suggests that higher prevalence of alcohol use disorders is potentially detrimental to sustainable development in SSA.

***(Insert Table 8 here)***

***(Insert Table 9 here)***

**4.1 Discussion**

Our analysis demonstrates that NCD-DALYs adversely affect sustainable development in SSA. This finding is consistent with the neoclassical growth theory augmented with human capital, demystified by early writers on the topic of health and wealth, and increasingly tested with empirical data (Bhargava et al., 2001; Bloom and Canning, 2000; Bloom et al., 2004; Kabajulizi et al., 2017). Specifically, NCDs are of a chronic nature, they contribute to loss of economic productivity, diversion of resources from other activities and substantial cost to families and individuals. Households have to tap into their savings and/or borrow money to meet the increasingly higher and persistent healthcare expenditure (Murphy et al., 2020; Wang et al., 2016). Reduced savings and increased debt result in declining growth in future capital for investment (see channels in Figure 3). Furthermore, years of life lost due to premature mortality from NCDs suggests a cumulative reduction in the labour force in the long run because it takes time to replace skilled and experienced labour. Even for those countries with NCDs that cause fewer deaths globally, years of life lost due to premature mortality is significantly negatively correlated with the countries' wealth (Bollyky et al., 2015).

Our results have also shown that NCDs that are responsible for significant shares of the disease burden negatively affect sustainable development in SSA. This is partly explained by inadequate access to cost effective interventions for prevention and/or treatment of the major NCDs. For instance, treatments for coronary heart disease and stroke that have helped reduce mortality by two-thirds in high-income countries are not readily available in poor countries (Ezzati and Riboli, 2012). Generally, health systems in resource-constrained countries, such as SSA, are ill-equipped to identify, treat and follow up the affected persons (Hogerzeil et al., 2013).

The WHO guidelines for prevention and control of NCDs (World Health Organisation, 2013) have since been augmented with a list of "best buys" for policymakers (World Health Organisation, 2017). However, a recent study showed countries in SSA were in the bottom 20 on the list of implementation rate, having implemented between 5-26% of the policies, compared to 71-87% for the top 20, mostly upper-middle-income and high-income countries (Allen et al., 2020). There is evidence suggesting that prevalence of the major NCDs could significantly reduce through public sector planned and coordinated efforts to modify risk factors such as adoption of a healthy diet, increasing physical activity, reduction in tobacco use and alcohol abuse (Global Burden of Disease 2015 Risk Factors Collaborators, 2016).

Interventions aimed at modifying the behavioural and metabolic risk factors constitute low-cost activities for countries to adopt, and they significantly reduce the burden of NCDs (Juma et al., 2018; Newdick, 2017; World Health Organisation, 2017). Our study serves to increase awareness of the economic consequences of NCDs and the need to modify risk factors. We posit that a multi-sector approach to NCD policy formulation and implementation is essential for prevention and treatment, if countries are to be on the path to sustainable development.

We are cognisant of the criticisms labelled against the use of DALYs, the measure for our main explanatory variable, to estimate the global burden of disease. It is argued, that the difference between women's and men's health needs, and the gender difference in cause specific morbidity and mortality, may not be ably captured by DALYs; the difference goes beyond merely disaggregating the data (Sundby, 1999). This is likely to affect equity in resource allocation for action against NCDs; yet limited public resources should be directed to the greatest need (Tapager et al., 2020). One suggestion is to estimate the burden of NCDs using the quality-adjusted life years (QUALYs) lost to morbidity and mortality from NCDs (Ock et al., 2015). However, the QUALYs method is also limited by the value judgements attached to utility measures in estimating the quality-adjusted-life-years, they produce varying results across populations, rendering it difficult to compare the burden across countries. Currently, DALYs is the most comprehensive measure to estimate the burden of disease, periodically updated by the IHME, for comparison over time, across age groups, and among populations across countries.

Additionally, some researchers have criticised the use of ANS as a measure for sustainable development (Arrow et al., 2012; Boos, 2015; Ferreira and Vincent, 2005), as it could be influenced by shifts in terms of trade (TOT) in open economies (Boos, 2015; Boos and Holm-Müller, 2012). Although, there are suggestions to use the present value of future TOT on long term trends of TOT to mitigate the shifts (Vincent et al., 1997), generating long-term trends is still an empirical challenge. Despite the shortcomings, ANS, is able to predict the direction in changes between current and future consumption levels, particularly for developing countries (Ferreira and Vincent, 2005).

A final issue concerns the composition of human capital. Our analysis was limited by data availability for all countries in the sample for the variables that could represent human capital, besides health status. For instance, our attempt to use some of the known measures of education, such as secondary school enrolment, returned many missing values and was thus dropped from the regression. Work experience, such as measured in Bloom et al (2004), could also be included in the human capital variable if data is available.

**5 Conclusions**

Our study set out to assess the relationship between NCDs and sustainable development in SSA. We adopted the ARDL model on a panel of 24 SSA countries, to estimate the short- and long-run effects of NCD-DALYs on sustainable development. We used NCD-DALYs as a proxy for the NCDs burden while sustainable development was alternately measured by ANS and GDS. We find that NCD-DALYs adversely affect sustainable development in the long run. The findings from our study emphasise the urgent need for governments in SSA to speed up the NCDs policy implementation to avert a potential NCDs epidemic.

**Notes**

1 DALYs are calculated by summing years of life lost due to premature deaths and years of life lived with the disability. One DALY represents one lost year of healthy life (GBD 2017 DALYs and HALE Collaborators, 2018).

2 Calculation of ANS and how each component is derived, is in the World Bank publication: Estimating the World Bank's Adjusted Net Savings: Methods and Data (World Bank, 2018).

3 The Life Cycle Hypothesis (Ando and Modigliani, 1963) posits that savings are positively related to income growth. In early life, individuals are net borrowers, and owing to higher productivity in mid-life, they pay off earlier debts and save and invest for retirement, while in later years their income decreases, and they live off the savings.

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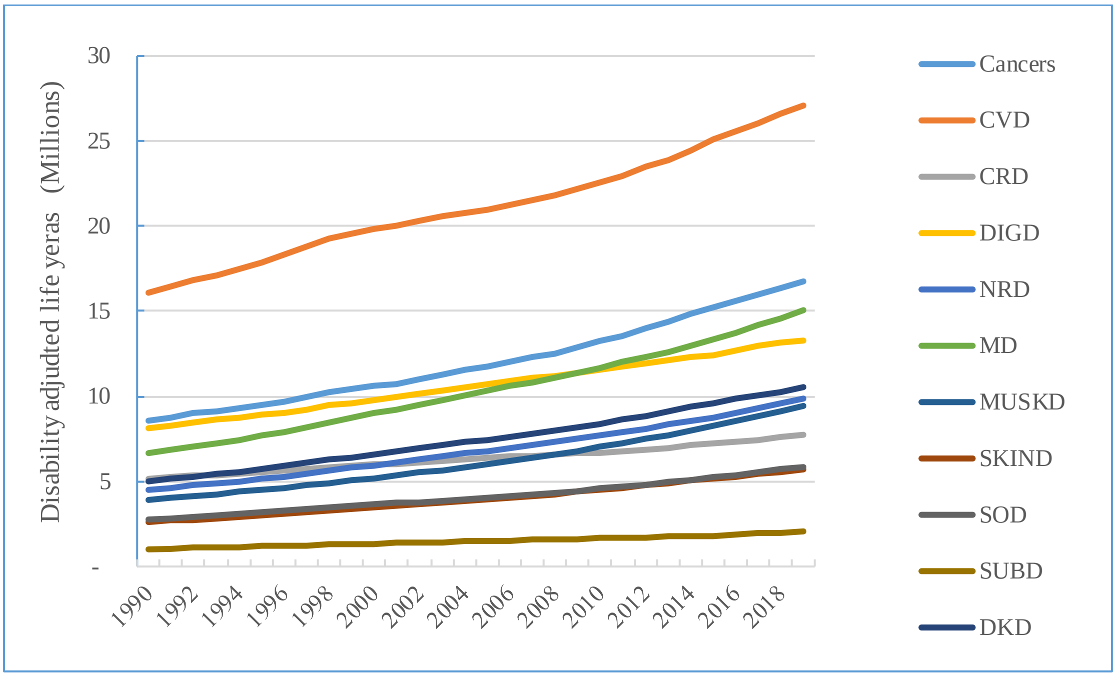
Figure 1: Number of disability-adjusted-life-years by type of non-communicable disease in Sub-Saharan Africa: 1990 - 2019




Data source: Global Burden of Disease Collaborative Network (2020)

Note: CVD = Cardiovascular diseases, CRD = Chronic respiratory diseases, DIGD = Digestive diseases, NRD = Neurological disorders, MD = Mental disorders, MUSKD = Musculoskeletal disorders, SKIND = Skin and subcutaneous diseases, SOD = Sense organ diseases, SUBD = Substance use disorders, DKD = Diabetes and kidney diseases

Figure 2: Pathways through which NCDs influence sustainable development: A conceptual framework

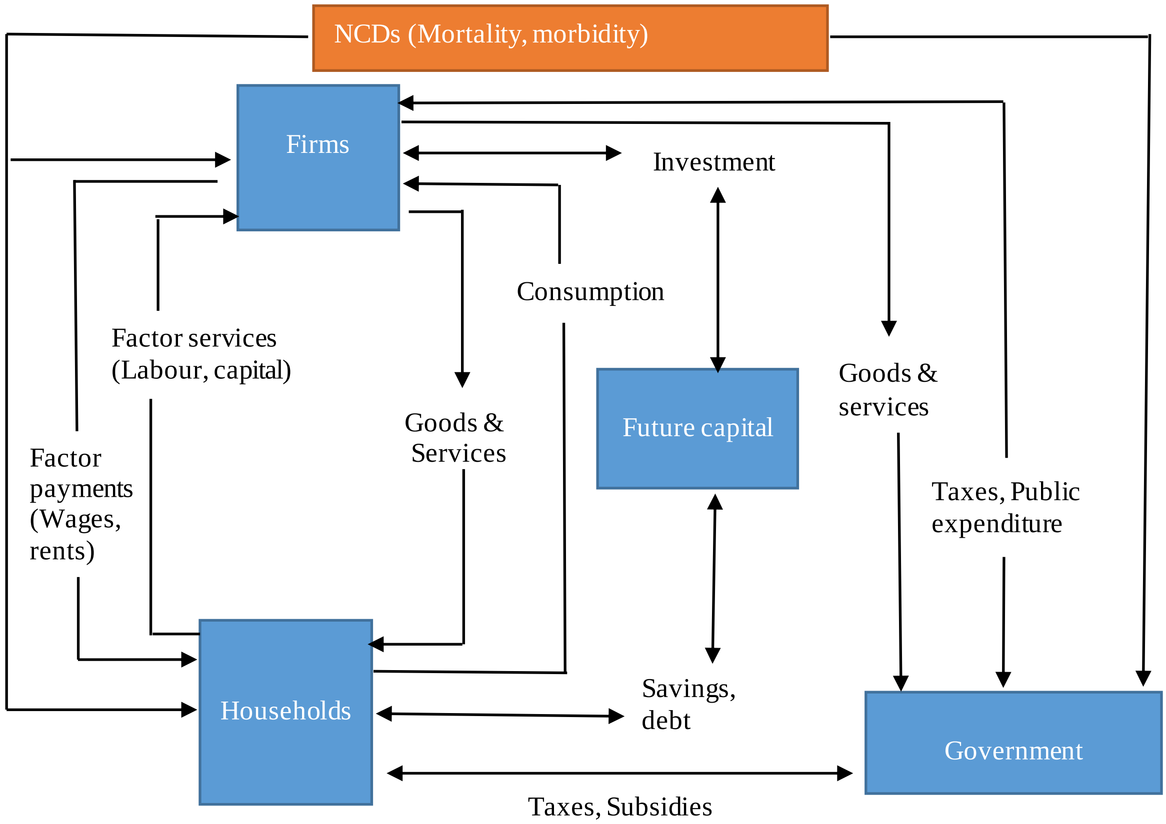


**Table 1: Descriptive statistics**

| Variable | Definition of Variables | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|---|
| lnANS | Adjusted net savings, excluding particulate emission damage (% of GNI) | 652 | 4.339 | 0.306 | 0 | 4.80 |
| lnGDS | Gross domestic savings (% of GDP) | 672 | 3.458 | 0.460 | 0 | 4.455 |
| lnDALYs | Non-communicable Diseases-Disability Adjusted Life Years (in years) | 672 | 14.145 | 1.294 | 11.473 | 17.153 |
| lnGDGrowth | GDP per capita growth (annual %) | 672 | 3.434 | 0.195 | 0 | 3.941 |
| lnBroadMoney | Broad money (% of GDP) | 666 | 3.084 | 0.468 | 1.638 | 4.392 |
| lnCAB | Current account balance (% of GDP) | 652 | 4.102 | 0.214 | 0 | 4.507 |
| lnFDI | Foreign direct investment, net inflows (% of GDP) | 672 | 2.462 | 0.262 | 0 | 3.895 |
| lnGNE | Gross national expenditure (% of GDP) | 672 | 4.665 | 0.126 | 4.055 | 5.031 |
| lnPopulation | Working age population ages 15-64 (% of total population) | 672 | 3.971 | 0.063 | 3.850 | 4.185 |

Note: All the variables defined above are in natural logarithm

**Table 2: Matrix of correlations**

| Variables | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| (1) lnANS | 1.000 | | | | | | | | |
| (2) lnGDS | 0.179 | 1.000 | | | | | | | |
| (3) lnDALYs | 0.085 | 0.094 | 1.000 | | | | | | |
| (4) lnGDPGrowth | 0.099 | 0.078 | 0.102 | 1.000 | | | | | |
| (5) lnBroadMoney | 0.124 | 0.027 | 0.017 | 0.064 | 1.000 | | | | |
| (6) lnCAB | 0.201 | 0.285 | -0.057 | 0.069 | 0.019 | 1.000 | | | |
| (7) lnFDI | -0.049 | 0.036 | 0.044 | 0.136 | 0.147 | -0.263 | 1.000 | | |
| (8) lnGNE | -0.028 | -0.753 | 0.061 | -0.008 | 0.105 | -0.475 | 0.131 | 1.000 | |
| (9) lnPopulation | 0.071 | 0.287 | -0.074 | 0.090 | 0.632 | 0.131 | 0.137 | -0.260 | 1.000 |

Note: See Table 1 for the description of the variables.

**Table 3: Stationarity test of the variables**

| | IPS | | Fisher - ADF | |
|---|---|---|---|---|
| Variable | Constant | Trend | Constant | Trend |
| lnANS | -5.143*** | -8.499*** | 9.881*** | 11.366*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnGDS | -4.578*** | -7.001*** | 8.118*** | 8.052*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnDALYs | 8.087 | 3.147 | 2.311** | -2.053 |
| | (1.000) | (0.999) | (0.010) | (0.980) |
| lnGDPGrowth | -11.692*** | -12.719*** | 43.820*** | 39.203*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnBroadMoney | 0.480 | -4.933*** | 0.698 | 5.496*** |
| | (0.684) | (0.000) | (0.243) | (0.000) |
| lnCAB | -6.334*** | -7.906*** | 13.433*** | 11.115*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnFDI | -6.591*** | -8.830*** | 12.388*** | 14.721*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnGNE | -4.593*** | -6.7542*** | 6.433*** | 5.749*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnPopulation | 5.890 | 4.119 | 9.402*** | -1.373 |
| | (1.000) | (1.000) | (0.000) | (0.915) |

Notes: *** and ** denote the rejection of the null hypothesis of non-stationarity of the variables in levels at 1% and 5%, respectively. Relevant p-values are in parentheses.

**Table 4: Stationarity test of the first difference of the variables**

| | IPS | | Fisher - ADF | |
|---|---|---|---|---|
| Variable | Const | Trend | Const. | Trend |
| lnANS | -15.409*** | -15.485*** | 86.188*** | 71.724*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnGDS | -15.306*** | -15.420*** | 80.869*** | 66.550*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnDALYs | -6.001*** | -7.651*** | 10.164*** | 9.481*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnGDPGrowth | -17.565*** | -17.562*** | 123.317*** | 107.133*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnBroadMoney | -13.415*** | -13.813*** | 56.328*** | 48.096*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnCAB | -14.891*** | -14.864*** | 80.774*** | 67.238*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnFDI | -15.678*** | -15.761*** | 92.933*** | 76.832*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnGNE | - 15.087*** | -15.129*** | 78.118*** | 63.569*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| lnPopulation | -1.411* | -3.613*** | 1.738** | 2.177** |
| | (0.079) | (0.000) | (0.043) | (0.015) |

Notes: ***, **, and * denote the rejection of the null hypothesis of non-stationarity of the variables in first differences at 1%, 5% and 10% significance level, respectively. Relevant p-values are in parentheses.

**Table 5: Co-integration tests**

| Kao | | Pedroni | | Westerlund | |
|---|---|---|---|---|---|
| Variable | Statistic | Variable | Statistic | Variable | Statistic |
| Modified DF. | 0.859<br>(0.195) | Modified PP | 4.039***<br>(0.000) | Variance ratio | -1.570*<br>(0.058) |
| Dickey-Fuller | -0.834<br>(0.202) | Phillips-Perron | -5.913***<br>(0.000) | | |
| Augmented DF | -3.719***<br>(0.000) | Augmented DF | -5.560***<br>(0.000) | | |
| Unadjusted MDF | -15.130***<br>(0.000) | | | | |
| Unadjusted DF | -9.620***<br>(0.000) | | | | |

Notes: *** and * indicate the rejection of the null hypothesis of no cointegration at 1% and 10% significance level, respectively. Relevant p-values are reported in parentheses.

**Table 6: Panel ARDL Regressions: Dependent Variable – Adjusted Net Savings**

| | Pooled Mean Group | Mean Group | Dynamic Fixed Effects |
|---|---|---|---|
| Variables | Coef. | Coef. | Coef. |
| **Long Run** | | | |
| lnDALYs | -14.980*** | -13.690 | -0.639 |
| | (4.989) | (20.730) | (6.457) |
| lnGDPGrowth | 7.626* | 4.138 | 17.840*** |
| | (3.992) | (7.248) | (6.718) |
| lnBroadMoney | -11.220*** | 5.371 | 1.513 |
| | (2.151) | (6.435) | (1.513) |
| lnCAB | -2.253 | 31.440* | 3.125 |
| | (4.963) | (17.280) | (7.086) |
| lnFDI | -0.482 | 4.891 | -2.159 |
| | (2.551) | (5.696) | (3.163) |
| lnGNE | -34.420*** | -1.813 | -51.260*** |
| | (10.060) | (23.050) | (8.350) |
| lnPopulation | 49.900** | 188.800 | -38.090 |
| | (19.960) | (151.200) | (39.843) |
| **Short Run** | | | |
| Error correction | -0.005*** | -0.0130*** | -0.010** |
| | (0.001) | (0.001) | (0.004) |
| ΔlnDALYs | 1.030 | 3.000* | 0.748 |
| | (0.917) | (1.569) | (0.552) |
| ΔlnGDPGrowth | -0.035 | -0.002 | -0.137* |
| | (0.057) | (0.024) | (0.081) |
| ΔlnBroadMoney | 0.110* | 0.063 | 0.068*** |
| | (0.060) | (0.057) | (0.0675) |
| ΔlnCAB | 0.129* | -0.222 | -0.041 |
| | (0.074) | (0.136) | (0.061) |
| ΔlnFDI | -0.002 | -0.063 | -0.089* |
| | (0.0.28) | (0.060) | (0.051) |
| ΔlnGNE | -0.319* | -0.235 | 0.211 |
| | (0.164) | (0.166) | (0.335) |
| ΔlnPopulation | 0.082 | 13.900 | -2.781 |
| | (1.889) | (13.250) | (2.397) |
| Constant | 1.349*** | -4.360 | 3.999* |
| | (0.238) | (5.366) | (2.135) |
| Observations | 614 | 614 | 614 |
| Hausman specification test | 4.410 | | 0.730 |
| | [ 0.731] | | [ 0.100] |

Notes: The dependent variable is the natural log of adjusted net savings. Estimations are done using the xtpmg command in Stata. The lag structure selected is ARDL (1, 0, 0, 0, 0, 0, 0, 0) based on AIC and the order of variables is: adjusted net savings, DALYs, GDP per capita growth, broad money, current account balance, foreign direct investment, gross national expenditure and population (all in natural logs). ***, ** and * indicate significance of the regression coefficients at the levels of 1%, 5% and 10%, respectively. The values in parentheses represent the standard errors for PMG and MG estimators, and robust standard errors, clustered at the country level for the DFE estimator. For the Hausman test, the chi-square test statistics are reported with the corresponding p-value in parenthesis.

**Table 7: Panel ARDL Regressions: Dependent Variable – Gross Domestic Savings**

| | **Pooled Mean Group** | **Mean Group** | **Dynamic Fixed Effects** |
|---|---|---|---|
| Variables | Coef. | Coef. | Coef. |
| **Long Run** | | | |
| lnDALYs | -0.0656 | 8.074 | 0.367** |
| | (0.0706) | (8.232) | (0.152) |
| lnGDPGrowth | 0.624*** | -0.468 | 0.118 |
| | (0.090) | (0.668) | (0.127) |
| lnBroadMoney | 0.224*** | -1.423 | -0.027 |
| | (0.041) | (1.619) | (0.057) |
| lnCAB | -0.086 | 9.287 | -0.133 |
| | (0.137) | (9.648) | (0.083) |
| lnFDI | 0.329*** | 2.057 | 0.179*** |
| | (0.061) | (2.107) | (0.065) |
| lnGNE | -2.999*** | -7.853 | -1.799*** |
| | (0.165) | (5.425) | (0.426 |
| lnPopulation | 0.466 | 0.398 | -1.572** |
| | (0.422) | (6.806) | (0.646) |
| **Short Run** | | | |
| Error correction | -0.338*** | -0.744*** | -0.598*** |
| | (0.071) | (0.105) | (0.129) |
| ΔlnDALYs | 2.232 | 4.330 | -0.534 |
| | (2.058) | (4.671) | (0.669) |
| ΔlnGDPGrowth | -0.066 | -0.048 | -0.088* |
| | (0.041) | (0.043) | (0.052) |
| ΔlnBroadMoney | -0.006 | 0.024 | -0.023 |
| | (0.067) | (0.132) | (0.048) |
| ΔlnCAB | -0.012 | -0.257 | -0.000 |
| | (0.097) | (0.293) | (0.026) |
| ΔlnFDI | -0.114 | -0.151 | -0.095** |
| | (0.074) | (0.144) | (0.037) |
| ΔlnGNE | -1.392*** | -0.256 | -0.651*** |
| | (0.339) | (0.342) | (0.219) |
| ΔlnPopulation | -1.592 | -10.550 | -2.070 |
| | (2.186) | (11.98) | (2.405) |
| Constant | 4.400*** | -4.749 | 7.586*** |
| | (0.922) | (11.450) | (2.431) |
| Observations | 614 | 614 | 614 |
| Hausman specification test | 3.780 | | 0.410 |
| | [0.805] | | [0.100] |

Notes: The dependent variable is the natural log of gross domestic saving. Estimations are done using the xtpmg command in Stata. The lag structure selected is ARDL (1, 0, 0, 0, 0, 0, 0, 0) based on AIC and the order of variables is: gross domestic savings, DALYs, GDP per capita growth, broad money, current account balance, foreign direct investment, gross national expenditure and population (all in natural logs). ***, ** and * indicate significance of the regression coefficients at the levels of 1%, 5% and 10%, respectively. The values in parentheses represent the standard errors for PMG and MG estimators, and robust standard errors, clustered at the country level for the DFE estimator. For the Hausman test, the chi-square test statistics are reported with the corresponding p-value in parenthesis.

**Table 8: Effect of Major Non-communicable diseases on Adjusted Net Savings (PMG)**

| Variables | Long run Coef. | Short run Coef. |
|---|---|---|
| Alcohol use disorders | -0.100*** | -4.784 |
| Alzheimer's' disease | -0.048 | -1.223 |
| Asthma | -0.019 | -0.684 |
| Breast cancer | -0.040* | -0.994 |
| Cervical cancer | -0.023 | -1.379 |
| Chronic kidney disease | 0.038 | -0.700 |
| Drug use disorders | 0.037 | -0.778 |
| Liver cancer | -0.222*** | 0.669 |
| Mental disorders | -0.017 | -10.029 |
| Diabetes mellitus | -0.065** | -1.706 |
| Chronicobstructivepul | -0.056 | -2.065 |
| Cirrhosis and chronic liver | 0.162*** | -1.041 |
| Colon and rectum cancer | -0.043 | -0.291 |
| Headache disorders | -0.168*** | 3.388 |
| Hypertensive heart disease | -0.108*** | -1.799 |
| Ischemic heart disease | 0.058** | -2.133 |
| Ischemic stroke | -0.095** | -1.937 |
| Leukemia | 0.003 | 0.378** |
| Parkinson's disease | -0.092*** | -1.678 |
| Prostate cancer | -0.035 | 0.080 |
| Rheumatic heart disease | -0.024 | -1.617 |
| Stomach cancer | 0.070** | -1.568 |
| Number of Observations | 614 | 614 |

Notes: The table above contains the PMG results of the estimated long run and short run effects of the major non-communicable diseases on adjusted net savings after controlling for GDP per capital growth, broad money supply, current account balance, foreign direct investment, gross national expenditure, and adult population in each of the separate regressions. All the variables are in natural logarithm. ***, **, and * indicate significance at 1%, 5% and 10%, respectively.

**Table 9: Effect of Major Non-communicable diseases on Gross Domestic Savings**

| Variables | Long run Coef. | Short run Coef. |
|---|---|---|
| Alcohol use disorders | -0.037 | -1.559 |
| Alzheimer's' disease | 0.267*** | -0.543 |
| Asthma | 0.006 | 0.762 |
| Breast cancer | -0.072** | 0.149 |
| Cervical cancer | 0.260*** | 0.407 |
| Chronic kidney disease | -0.074 | 0.464 |
| Drug use disorders | 0.036 | -0.942 |
| Liver cancer | -0.106*** | 0.559 |
| Mental disorders | 0.044 | -1.788 |
| Diabetes mellitus | 0.121 | 1.267 |
| Chronicobstructivepul | 0.037 | -0.612 |
| Cirrhosis and chronic liver | -0.060 | 1.021* |
| Colon and rectum cancer | 0.061 | 0.496 |
| Headache disorders | -0.072 | -1.765 |
| Hypertensive heart disease | -0.029 | 0.214 |
| Ischemic heart disease | 0.047 | -0.752 |
| Ischemic stroke | -0.009 | 0.144 |
| Leukemia | -0.050 | 0.400 |
| Parkinson's disease | -0.001 | 0.368 |
| Prostate cancer | 0.161*** | -0.962 |
| Rheumatic heart disease | -0.032 | 0.099 |
| Stomach cancer | 0.038 | 0.197 |
| Number of Observations | 614 | 614 |

Notes: The table above contains the PMG results of the estimated long run and short run effects of the major non-communicable diseases on gross domestic savings after controlling for GDP per capital growth, broad money supply, current account balance, foreign direct investment, gross national expenditure, and adult population in each of the separate regressions. All the variables are in natural logarithm. ***, **, and * indicate significance at 1%, 5% and 10%, respectively.

**Table A1: List countries used in the study and their average ANS, GDS and NCD DALYs: 1990 - 2017**

| Country | Average Adjusted Net Saving | Average Gross Domestic Saving | Average DALYs |
|---|---|---|---|
| Benin | 4.378 | 3.467 | 14.007 |
| Botswana | 4.667 | 4.047 | 12.402 |
| Burundi | 3.933 | 2.667 | 14.136 |
| Cameroon | 4.416 | 3.710 | 14.846 |
| Comoros | 4.416 | 2.989 | 11.561 |
| Republic of Congo | 3.517 | 4.233 | 13.421 |
| Gabon | 4.394 | 4.246 | 12.404 |
| Ghana | 4.325 | 3.336 | 15.034 |
| Guinea | 4.282 | 3.426 | 14.355 |
| Guinea-Bissau | 4.307 | 3.010 | 12.596 |
| Kenya | 4.393 | 3.415 | 15.343 |
| Madagascar | 4.461 | 3.536 | 14.993 |
| Malawi | 4.272 | 3.199 | 14.607 |
| Mali | 4.426 | 3.388 | 14.645 |
| Namibia | 4.572 | 3.505 | 12.626 |
| Niger | 4.389 | 3.412 | 14.475 |
| Nigeria | 4.571 | 4.021 | 16.863 |
| Senegal | 4.430 | 3.354 | 14.359 |
| Sierra Leone | 4.169 | 2.779 | 13.862 |
| South Africa | 4.387 | 3.701 | 15.976 |
| Tanzania | 4.497 | 3.589 | 15.663 |
| Gambia | 4.237 | 3.178 | 12.441 |
| Togo | 4.348 | 3.358 | 13.655 |
| Uganda | 4.317 | 3.435 | 15.221 |

Note: All the variables are in natural logarithm