

El Serafy User costs and their implications for macroeconomic policy in Africa's mineral rich economies

"[N]atural resources are not purchased from Mother Nature who produced them so that their valuation must inevitably be artificial and controversial... the national accounts ought not to show the using up of assets whose creation has not first been recorded in the accounts... Nature is not recognised as a factor of production by economists or national accountants and nature's production of resources is not, and perhaps could never be, recorded in the accounts."

Derek Blades (1989)

Abstract

Many of Africa's economies are mineral based. Their sustainability and their macroeconomic vulnerability to market fluctuations are accordingly matters of direct concern. This thesis asks how much of the proceeds of mining in such countries can be safely spent each year. Using El Serafy's approach to the 'proper' definition of National Income, it recomputes Net Domestic Product in 11 mineral-based African economies and tests for their macroeconomic sustainability. The study finds a disturbingly poor level of sustainability in several of them; with aggregate expenditures in excess of the levels posited under efficient resource rent management given the El Serafy User cost approach. The study estimates the budget deficit and national debt as a proportion of net national product adjusted for mineral resource depletion in each country and evaluates the outcome by comparison with standard 'rules of thumb' concerning 'acceptable' fiscal deficits and national debt levels. The outcome reveals that using GDP as an anchor as opposed to an 'appropriate' measure that adjust for mineral resource depletion by policy-makers may lead to the implementation of sub-optimal economic policies which are detrimental for sustainable income growth and development. The findings from the study therefore highlight the need for more efficient resource management as well as the development of a 'properly defined' national income which corrects for resource depletion to inform sustainable fiscal policy.

Keywords: national income, El-Serafy User cost, sustainability, mineral resources,

JEL Codes: Q01. Q32. Q58.

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List of Abbreviations

ANRC	African Natural Resource Centre
ANNI	Adjusted Net National Income
ANS	Adjusted Net Savings
ADB	African Development Bank
ASBI	Adjusted Sustainable Budget Index
SWF	Sovereign Wealth Fund
GDP	Gross Domestic Product
GNI	Gross National Income
GS	Gross Savings
IMF	International Monetary Fund
NDP	Net Domestic Income
NDY	Net Domestic Income
NY	National Income
SBI	Sustainable Budget Index
SNA	System of National Accounts
SWF	Sovereign Wealth Fund
UN	United Nations
WB	World Bank
WCED	World Commission on Environment and Development

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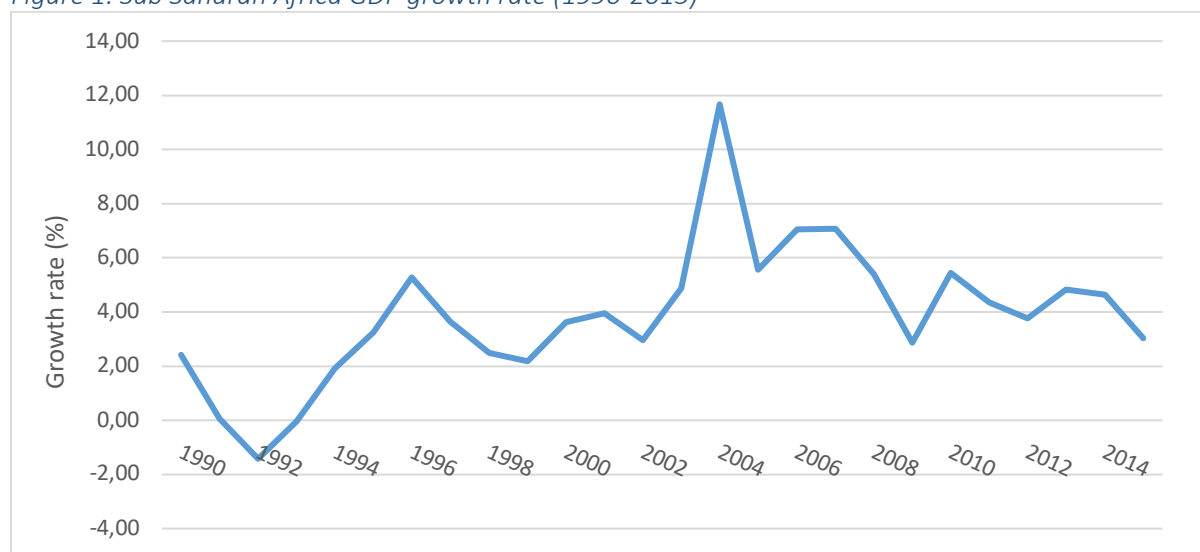
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Introduction

Africa is in a considerably better social and economic situation today than it was at the start of the century. In the last 10 to 20 years, sub-Saharan Africa has made considerable progress forward and is now one of the world's fastest growing continents (World Bank, 2015). The GDP growth rate of the sub-Saharan African region has averaged about 5% per year since 2002, and at times exceeded that, as illustrated below. Over the next ten years, the GDP growth rate is forecast to average about 6% a year (World Bank, 2015).

Figure 1: Sub Saharan Africa GDP growth rate (1990-2015)



Source: World Bank: World Development Indicators

This recent strong performance was mainly the result of a commodity price boom as well as some considerable improvements in macro-economic policy. A look at public debt for example shows that almost all African countries outperform European Union nations (World Bank, 2015). Economic growth has also led to significant human development outcomes. Since the early 2000s, Africa's poverty rate fell from 58% to 43% (World Bank, 2015). Furthermore, life expectancy has increased, infant mortality has significantly decreased, real income per capita has increased by more than 30%, urbanization has increased, the number of people living below the poverty line has decreased and numerous small and medium enterprises that provide jobs for the local population have sprung up across the continent (World Bank, 2015). Political violence and conflict are widespread and corruption is still prevalent in many African countries. Numerous concerns have arisen over the sustainability of this economic rise and there is reason to investigate the validity of these concerns.

Many of Africa's economies are based on natural resources. Some (minerals) are non-renewable, such as oil, diamonds and gold, while others (fish/timber/soil) are renewable, but risk being harvested or used unsustainably. A critical question is, therefore, how much can a country spend each year without leaving itself impoverished in the future? Neo-classical economic theory has addressed this for over forty years (since the RES symposium edition of 1974), and it can be argued that economics in general has worried about such issues since the time of Malthus. However, in order to shift this from a discussion or an expressed concern, to an actual policy, the problem has to be quantified. Although the extraction of their mineral resources lowers the resource stock available to future generations of Africans as well as causing a permanent reduction in the various economies' income generating capacity, such a loss is not recognised as asset depreciation in the standard national accounting frameworks.

The appropriate method of introducing such depreciation was extensively discussed in the early 1990s, but since the United Nations System of National Accounts of 1993, the discussion has died down. The UN opted to use satellite accounts rather than computing a "properly defined" national income. However, for purposes of macroeconomic policy, a "proper definition" of NDP or NDY, which corrects for resource depletion is needed. Such a "properly defined" national income could then become the basis for informed sustainable fiscal policy. This thesis demonstrates the process and consequences of such computations in 11 mineral-based African economies.

Much of fiscal policy concerns the magnitude of an "acceptable" budget deficit or an acceptable rate of growth in national debt. Thus there is a common rule of thumb that a deficit equivalent to 3% of GDP is acceptable. The question being asked here is: does it matter whether the local resources used in producing the final goods and services that went into that GDP were renewable or not? In attempting to answer this question we revisit the issue of developing appropriate fiscal frameworks in a mineral rich economy.

The appropriate fiscal response to resource endowments depends to a great degree on how much longer they are expected to last. If many more years are expected, then the concern is short run smoothing, i.e. addressing the impacts of resource price fluctuations on the fiscus. However, the closer the date at which the resource is expected to be exhausted, the more the policy maker's problem becomes long term sustainability, i.e. how to provide for the years when the resource is no longer there.

Many (developed) countries, following the lead of the 1993 UN System of National Accounts, have begun compiling satellite accounts. While the interpretation of these has been significantly improved (see the 2008 System of National Accounts; chapters 12 and 29), the real message of this data may have been missed by policy makers. This is especially true in low-income, mineral-rich African economies which may not have developed such accounts. A simple test can be used to reveal the extent to which policy makers have internalised the message of the satellite accounts. This would take the relationship between an economy's fiscal deficit before borrowing and its nominal NDY as conventionally recorded, and compare it to the relationship between the country's fiscal deficit and its National Income as calculated using the El Serafy method (which follows Hicks's view of income as the time derivative of wealth). Such a comparison would provide a mechanism to test the fragility of economies (or the risk their fiscal policies entail in the face of commodity price fluctuations). A more complete indicator of an economy's exposure to fluctuating commodity prices would be the relationship between National Debt and Net Domestic Product as computed in these two manners. Such tests will underlie the remainder of the paper.

Literature Review

The questions "*what is income?*" and "*how sustainable is current consumption?*" has preoccupied policymakers and economists for a long time. Economic theory has for a long time emphasized the "*maximise present value criterion*" which involves maximising the present discounted value of current and future utility from consumption (Arrow et al., 2004). The optimal level of consumption is derived from solving the optimization problem. According to this criterion, consumption today is considered excessive if it is greater than the level of present consumption recommended by the optimal consumption path (Arrow et al., 2004). A number of key factors such as the discount rate influences the optimal consumption path where a higher value for the discount rate means that less weight is given to future utility *ceteris paribus*.¹

¹ There is no consensus among economists on what is the correct value for the discount rate. Ramsey (1982) contended that the suitable value of the discount factor must be zero in a deterministic world. The implication is that the utility of future generations should carry the same weight as that of the current generations. However, the use of zero discount factor rate was shown to lead to paradoxes and consequently negative social welfare implications (Koopmans, 1960; Lind, 1982; Portney and Weyant, 1999)

An alternative criterion for evaluating whether consumption is excessive or deficient is the “sustainability criterion” which underlines the ability of the economy to provide non-declining welfare or living standards for its citizens. The terms “sustainable” and “sustainable development” became very popular after the release of the report by the World Commission on Environment and Development (WCED) in 1987 also known as the Brundtland report (named after the chairperson of the commission). The Brundtland report’s (WCED, 1987) approach to sustainable growth is broad; “growth that meets the needs of the present without compromising the ability of future generations to meet their own needs and the management of human, natural and financial assets to increase long term economic wellbeing”. An economy that experiences rapid expenditure growth funded by extraction of mineral resources, and does so without increasing its overall stock of wealth by investing in physical and human capital, will not be able to sustain its economic growth in the long-run. It also risks sacrificing the wealth of the future generations to finance current consumption and in so doing fails to meet the Brundtland definition of sustainability.

Natural Resource Accounting is based mainly on John Hick’s (1939) definition of ‘*sustainable income*’ and Repetto and Cruz’s (1989) concept of ‘*wasting assets*’. The sustainable income of an economy is the level of consumption that can be sustained forever without diminishing the net wealth of the nation (Arrow et al., 2004). It is important to understand that this definition does not mean that the stock of natural assets must remain constant, but rather that their ability to generate a stream of income for the future stays unchanged. With substitution between the different forms of capital (natural, manufactured, human) sustainable income may be understood to entail that the total stock of capital and not that of the individual components remains the same.

Unlike with renewable resources such as wood, optimal resource use programs are not easy to devise for exhaustible resources such as minerals. This is why their capacity to generate the same stream of income and employment for the future generations is reduced with depletion due to commercial exploitation. As such it is vital that future generations are compensated for the consumption of natural assets by investing some of the resource rents in other forms of capital assets (manufactured and human) that are capable of providing the same stream of economic gains in the future.

Good policymaking needs good information on the capacity of the economy to provide the same stream of economic gains in the future. Blades (1989) argued that the United Nation's System of National Accounts then in place gave little aid to resource planners and decision makers. Four years later, the UN adopted satellite accounting to mitigate this deficiency². Despite being adopted by the United Nations, satellite accounts have not become universal, nor have the policy lessons they offer been fully recognized. Nowhere has this problem been clearer than in Africa's recent growth surge, so much of which was driven by mineral commodities.

Prior to the end of the prolonged commodity boom that led up to the 2008 recession, much was made of the rapid growth in GDP demonstrated by many African countries. The continent's rising GDPs were held to be heralds of a new dawn, an up-turn that was reversing the downward economic trends that had typified so many of the continent's economies since the end of the colonial era.

Unfortunately, the rapid fall in commodity prices that ensued as the global recession took hold showed the limitations of these high hopes and the weak foundations on which some had been based. Although commodity prices have since begun to recover, the lessons of the price shocks have not necessarily been built into the fiscal policies of the economies most affected.

In the 1990s, attempts to measure sustainability were popular and numerous studies attempted to provide a good measure of sustainability for single countries or a selection of countries. These included Repetto et al. (1989) for Indonesia, Cruz and Repetto (1991) for Costa Rica, van Tongeren et al. (1993) for Mexico, Bartelmus et al. (1993) for Papua New Guinea, Pearce and Atkinson (1993) and Serôa da Motta and Young (1995) for Brazil, and Hamilton and Atkinson (1996) for a number of countries.

The World Bank (1997) carried out the most comprehensive study attempting to provide an indicator of weak (i.e. Solow/Hartwick) sustainability. This study covered 103 countries in

² The trouble is that the satellite accounts do not directly help anyone wanting to use fiscal rules of thumb – the information has first to be converted into a properly calculated national income. Not only are satellite accounts not universally used; but even when they are in place, they aren't designed to be used by fiscal policy makers. The information may be there, but the way it is presented is not obviously helpful. It is vital to have a measure, which incorporates the information from the satellite accounts and is easy to interpret and use by policy makers.

total, over a 25-year period. Of special interest is Extended Genuine Saving II, which the World Bank defines as Gross Saving plus current government spending on education minus fixed capital consumption minus resource rents from natural capital extraction minus CO₂ damages. The natural resource rents were computed for items such as copper, silver, tin, hard coal, phosphate, oil, zinc, natural gas, iron, bauxite, brown coal, lead, and nickel. The findings from this study are that the world as whole and high-income countries in particular pass the test of weak sustainability due to high investments in human and manufactured capital. It further suggest that entire sub-Saharan African region exhibited signs of unsustainability during 1980s and 1990s. Neumayer (2000) critically examined the World Bank (1997) study and argued that its conclusions critically depended on its methodology. He stated that there were three competing methods for computing natural resource rents, and that the one used by the Bank was inferior to at least one of them, namely the El Serafy method.

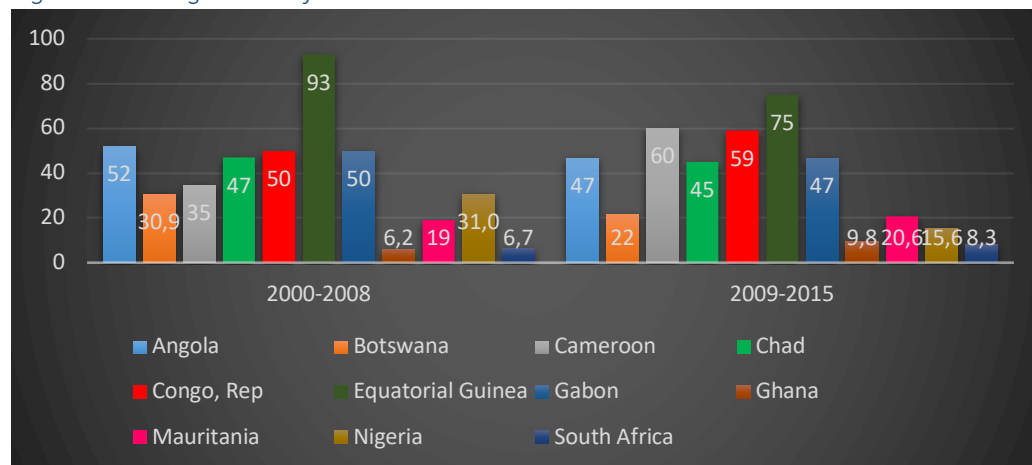
Macroeconomic analysis usually focuses on GDP growth as the principal measure of economic performance; however, as is now widely established, GDP gives an incomplete picture of an economy's true situation and the welfare of its inhabitants. Other indicators, while harder to quantify, can provide valuable information on the state of an economy. This is particularly true for countries with a large endowment of mineral resources, as in the case of many sub-Saharan African countries. GDP and comparable measures describe the value of total production in the economy without accounting for changes to the capital stock (which should be captured in Net Domestic Product or in National Income). If the national accounting aggregates were comprehensively defined, then such changes would also include the exhaustion of non-renewable resources, damages to the ecosystem, the accumulation of human capital, and new mineral discoveries. In resource-rich economies, these subtleties have vital implications for the sustainability of long-term growth and the design of fiscal policies.

The relationship between natural resources and economic success has long confounded economists. Despite having considerable natural resources, many African countries are still among the poorest nations in the world and have not been able to embark on a sustainable long-run economic growth path or to implement the stable fiscal policies necessary to continue on such a path. It isn't just that, as Collier et al. (2010) showed, in low-income resource rich countries corruption is often prevalent, literacy levels low , infant mortality rates high, and access to water and electricity inadequate, but that even in the development

literature the role of natural resources ranges from highly beneficial to deeply undermining. While there is no doubt that mineral riches prompted the economic ‘take-offs’ of the USA and the dominions, in post-colonial Africa, the weak empiric relationship between resources and economic performance suggests that context-specific factors in each country may promote its ability or inability to harness its resource wealth.

Despite efforts towards diversification, the mining sector continues to be the backbone of many sub-Saharan economies. This sector is by a number of measures the largest contributor to GDP, makes up a considerable amount of government revenues and generates the bulk of export earnings. The importance of mineral production to our sample of African economies is shown in Figures 2-4 below. In the sample of countries studied, the key driver behind the mining sector growth and earnings has largely been oil. There have also been significant contributions from ores such as coltan and iron ore, and minerals such as copper, manganese, nickel, tin, and zinc. In non-oil producing countries like Botswana and South Africa it has been diamonds and platinum (and coal and gold) respectively. The appropriate use of mineral resources is of the utmost importance for sustainable growth and development. Countries like Botswana, Ghana and South Africa have received widespread praise for the manner in which their mineral revenues have been managed (through investment in infrastructure, education, health-care and financial assets). To some extent, these countries managed to limit the “Dutch Disease” and the “Mineral Curse”. The story is different in countries such as Angola, Chad, Cameroon, Congo, Equatorial Guinea, Gabon and Nigeria. In these economies, resource curse characteristics such as the sluggish growth of non-mining exports, high inflation, high unemployment rates and growing income inequality have become the norm.

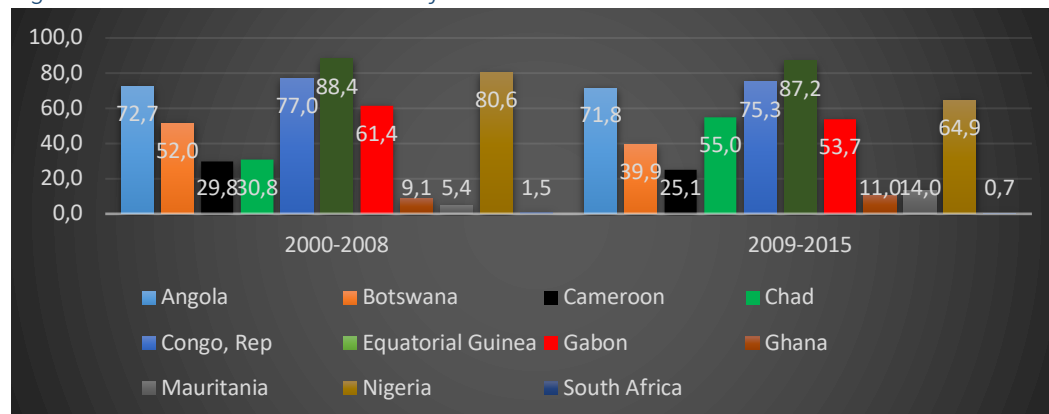
Figure 2: Mining as a % of GDP



Source: United States Geological Survey, IMF International Financial Statistics, World Bank

As Figures 2, 3 and 4 show, mineral resources are major contributors to economic activity.

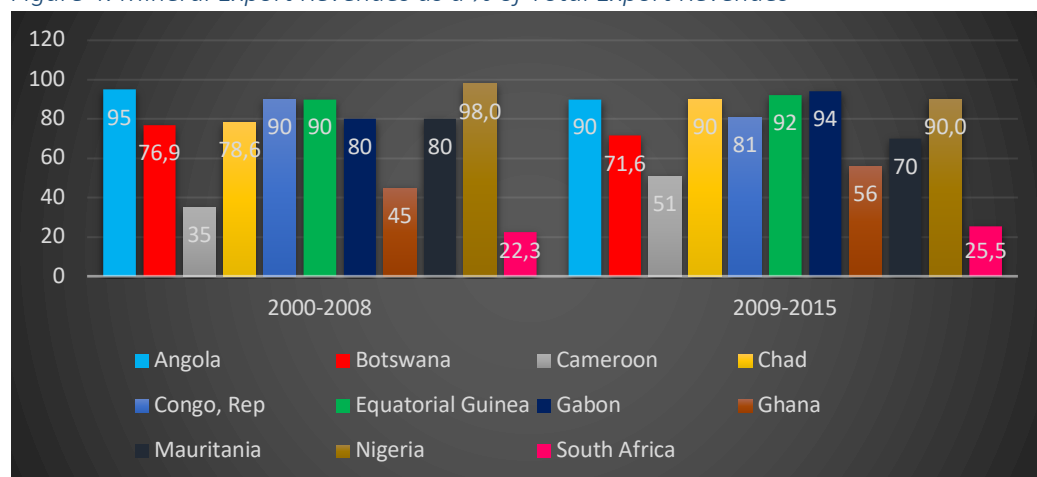
Figure 3: Mineral Revenues as a % of Government Revenues



Source: United States Geological Survey, IMF International Financial Statistics, World Bank

Although government revenues from minerals peaked prior to the global financial crisis and declined in its aftermath, they have shown signs of recovery since 2015.

Figure 4: Mineral Export Revenues as a % of Total Export Revenues



Source: United States Geological Survey, IMF International Financial Statistics, World Bank

The concentration of export earnings in these countries is very high as illustrated in the graph above. Such high earnings concentration levels make these countries particularly vulnerable to terms of trade shocks. It is a commonplace that commodity prices are more volatile than those of manufactured goods are. This outcome is seen in the well documented observation that many resource-dependent countries experience more generalised macroeconomic volatility and have a strong tendency towards procyclicality (Hausmann and Rigobon, 2003; Van der Ploeg and Poelhekke, 2009).

Ramey and Ramey (1995) make the point that such volatility has adverse implications for long-term economic growth and welfare, and their sustainability. Unsurprisingly, the economic

landscape in these countries has been changing in the aftermath of the global financial crisis. Figures 2-4 suggests that the peak of the contribution of mining to government revenue and the share of GDP accounted for by this sector may have passed. Several factors may be responsible for this declining trend:

- The global financial crisis and its after effects resulted in a massive decline in the demand for primary commodities, lowering their prices and leading to the abandonment of some mining projects (African Natural Resource Centre, 2016).
- The mining industry in a number of countries had reached maturity in terms of production. Diamond production in Botswana reached its highest level in the mid-2000s and has since then been in decline. In South Africa, De Beers recently closed its largest underground operations at the Kimberly mines after operating there for more than 120 years (African Natural Resource Centre, 2016).
- Lastly, the implementation of policies aimed at diversifying national economies resulted in faster growth in the non-mining sector relative to the mining sector (African Natural Resource Centre, 2016).

Nonetheless, the mining sector remains crucial to many sub-Saharan economies.

It is in this environment that wealth accounting is used to identify and analyse patterns of natural capital depletion in Angola, Botswana, Cameroon, Chad, Congo (Brazzaville), Equatorial Guinea, Gabon, Ghana, Mauritania, Nigeria and South Africa, and their implications for long-term growth and development in these countries. This analysis uses El-Serafy's approach to determine the resource base depreciation because of mining in these countries. A focus of the analysis will be the ratio of Adjusted Net Savings to Gross National Income. This measure indicates the degree to which the present depletion of natural resources is compensated by the reinvestment of natural resource rents in the produced and human capital (the essence of Solow/Hartwick weak sustainability). This has significant consequences for intergenerational equity in the exploitation of natural resources and welfare.

Research questions and findings

The primary research questions addressed in this study are:

- i) What is the estimated El-Serafy User cost generated through mineral resource extraction in each of the selected sample of sub-Saharan African countries?

- ii) What is the current adjusted net national savings rates in these countries, and what are the implications of these rates for long-term sustainable income growth and development?
- iii) How do an economy's fiscal deficit before borrowing, and its nominal National Income as conventionally recorded, compare to the country's fiscal deficit and its true National Income (as calculated using the El Serafy method which follows Hicks's view of income as the time derivative of wealth)? The relationship between national debt and Net Domestic Product as computed in the aforementioned manners will also be calculated.
- iv) Is the fiscal balance sustainable and what should be the appropriate fiscal policy in a low-income economy that is mineral-rich?
- v) What challenges remain and what policy recommendations towards sustainable mineral resource revenue management for low-income mineral-rich African economies can be suggested?

The study's findings reveal a disturbingly poor level of sustainability in several low-income mineral resource-rich African countries, namely Angola, Cameroon, Chad, Congo (Brazzaville), Equatorial Guinea, Gabon, and Nigeria. The high GDP growth rates experienced by these countries (especially prior to the global financial crisis) hide a decrease in the overall stock of capital. The depleting stock of natural capital in these countries has not been adequately compensated for through investment in human and manufactured capital. Instead, the exploitation of mineral resources has created an unsustainable surge in current consumption expenditure at the expense of long-term sustained economic growth. Using a measure of net national product that is adjusted for mineral resource depletion as an anchor for defining the size of an acceptable deficit reveals that GDP typically understates the magnitude of a budget deficit and overstates the magnitude of a budget surplus. Similarly, national debt when expressed as a percentage of the adjusted measure of national income reveals that several of these mineral-rich economies are more vulnerable to fluctuating commodity prices than the conventional measures will suggest.

Data Sources and Methodology.

This study uses data collected from the United States Geological Survey, the World Bank, the International Monetary Fund, National Statistics Agencies and Financial Authorities. The data comprises information on GDP, specific mineral rents, sector shares (minerals and mining as percentage of GDP), and estimates of yearly mineral production, Budget Deficit, and National Debt for a sample of 11 selected sub Saharan African countries for the period 1990-2015. These countries are Angola, Botswana, Cameroon, Chad, Congo Brazzaville, Gabon, Ghana, Equatorial Guinea, Mauritania, Nigeria and South Africa.

Adjusted Net Savings

Adjusted Net Savings = Gross Savings – Fixed Capital Depreciation + Investment in Human Capital – Depletion of Natural Capital – Pollution Damages

‘Adjusted Net Savings’ is an aggregate that offers policy makers a relatively clear and simple indicator of the level of sustainability of an economy’s investment policies. Standard measures of savings and investments give incomplete pictures of a nation’s investment patterns because they tend to be restricted to physical i.e. man-made/manufactured capital. A more inclusive indicator, which incorporates other types of assets, also provides a more accurate picture of an economy’s national investment level (Bolt et al. 2002; Naikal, 2015).

In the current system of national accounts, only physical capital is included within fixed capital formation, which is the sole measure of investment and of the overall stock of wealth in the national accounts (Bolt et al. 2002; Naikal, 2015). Similarly, the conventional calculation of the net savings rate only includes the depreciation of manufactured capital. The ANS framework takes the wider view that both **human** and **natural** capital should be included when assessing the total assets of an economy. From this perspective, any increase in educational expenditure or development of labour force skills will increase the value of human capital and should therefore be considered an investment. Similarly, the over-exploitation of a non-renewable resource or the depletion of a mineral resource such as diamonds decreases the value of that resource stock remaining *in situ*. This represents a disinvestment in the future productive capacity and welfare of the country.

Barbier et al. (1994) describe Adjusted Net Savings (ANS) as a reasonably accurate indicator of the degree to which a country passes the Hartwick-Solow rule of weak sustainability. However, it is worth noting that although the demands of neo-classical sustainability are described as 'weak', there are some strong assumptions underlying it. The main assumption is that all types of capital (human, physical, natural) are in fact substitutable as production inputs. This is a strong assumption even though they are not assumed to be perfect substitutes, i.e. to have a straight line isoquant with an infinite elasticity of substitution. Rather they are cobb-douglas in shape – i.e. having an elasticity of substitution of one. The logic of this is that one just wants to remain on the same isoquant – as a resource become scarce its value rises, as another becomes more abundant its prices should fall (Solow, 1974 and 1986; Pezzey and Toman, 2005). The model market value of the capital needs to be remain constant, not the number of physical units. In this way one can move smoothly along a curved isoquant and sustain a given level of production. To give a hypothetical example, if South Africa's physical capital stock decreased by about ten percent and human capital stock increased by ten percent, the net opportunity cost for future generations is zero. Whether or not this is in fact true remains a contentious issue and this study does not attempt to settle this debate. The interpretation of ANS as a measure of sustainability is as follows:

Positive ANS: This indicates that the country is investing for future generations by accumulating assets (increasing the overall capital stock) that would be used to generate income for the economy in the future and enable long-term sustainable economic growth.

Negative ANS: This indicates that a country is depleting its overall stock of capital as it reduces its natural asset base, and its growth path is therefore unsustainable.

Conventional assessments of Adjusted Net Saving use five primary components:

- **Gross Savings:** Gross National Income less final consumption expenditure (public and private) plus net current transfers.
- **Current Education Expenditure (Human Capital Investment):** Standard national accounting measures only count as investment the portion of total education

expenditure that goes towards fixed capital accumulation, such as the construction of schools. The contribution of human capital (knowledge, experience, skills) to production is hard to deny but is not considered an asset even within the extended definitions of savings (excluding ANS) used. Sub-Saharan economies like most nations of the world, increase their human capital stock largely through expenditure on their educational system. There exist numerous approaches to measuring investment in human capital, which include the cost-based approach, the income-based approach and the outcomes approach. It is true that there is no universally accepted method of calculating the change in the human capital stock within and across countries (Jorgensen and Fraumeni, 1992), although there is a growing consensus that conventional savings rates should be adjusted to account for changes in the value of human capital. In the context of an Adjusted Net Savings framework that considers human capital an integral and indispensable component of the nation's asset base, expenditure on its formation and development cannot be simply classified as consumption. This is why recurrent educational expenditure such as salaries and wages, books and teaching materials are included in this current educational term. A limitation of using this cost-based measure for investment in human capital is that it excludes private educational expenditure. One has to acknowledge that accurate data on private educational expenditure is difficult to acquire in many developing sub-Saharan countries. The data on current educational expenditure came from UNESCO and the World Bank; and had some missing elements. Where the data set was incomplete, the educational expenditure of the preceding year is used to estimate the missing data. For example, if there is no educational expenditure data for 2000 but there is data for 1999, the ratio of educational expenditure as a percentage of GDP in 1999 is adjusted by the ratio of GDP to GNI for 2000 to give educational expenditure as a percentage of GNI for 2000.

- **Depreciation of Physical Capital:** This is the decrease in the value of manufactured or fixed capital. The data was taken from the World Bank: World Development Indicators. Depreciation data for all the countries in the study were unavailable from 2009 to 2015 and had to be estimated. Available data on depreciation as a percentage of GNI was regressed against the log of GNI per capita. This regression was then used to estimate the unavailable depreciation data: $Dep/GNI = B_0 + B_1 * \ln(GNI \text{ per capita})$,

which in turn was used to calculate the depreciation in nominal terms. There are nonetheless some limitations associated with the use of this data. The accounting conventions on which depreciation is estimated for tax purposes may be unrelated to the actual physical depreciation in a machine or plant and thus lead to inaccurate estimates of the depletion of the existing physical capital stock.

- **Damage caused by CO₂ emissions:** This item expands the notion of an economy's asset base even further to include unpolluted air. The data on estimated CO₂ emissions is published in the World Development Indicators Database of the World Bank. The marginal social costs of CO₂ emissions are consensus estimates, derived from Frankhauser (1994), of global damages to human health, crops and infrastructure incurred per metric ton of CO₂ emitted over the century that each ton would remain in the atmosphere. The social cost is the present value of the yearly flows of damages. It is worth noting that under the "*polluter pays principle*", emitting countries are charged for the global damages imposed by their CO₂ emissions. Furthermore, countries suffering from climate change are entitled to a clean environment (Hamilton and Clemens, 1999). However, there are limitations associated with the use of this data. It is established that rising levels of carbon dioxide increase plant growth rates. In addition to this is the fact that the impact of rising CO₂ levels are not spread evenly across the globe. In some areas, expected rainfall is set to rise, and in others, it is set to fall. Simply taking an average impact over a continent and imposing this on individual counties is not easy to justify and seem somewhat inaccurate.
- **Depreciation of Natural Resources:** This covers two elements, namely non-renewable (minerals) and renewable resources. The first aspect relevant to this study is the reduction in the value of sub-soil mineral deposits through mining. The second is the extraction of fish stocks, forests and other biological resources at rates beyond sustainable levels. Although satellite accounts for fisheries and forestry are becoming more common, they do not give usable data on sustainable yields. For the purpose of this analysis, renewable resources are excluded and the emphasis is specifically on mineral resources.

Despite the fact that mineral resource extraction lowers the stock available to future generations, the standard income measures fail to classify it as a cost of production.

That it is an opportunity cost was recognised Hotelling (1932), but he did not indicate how it should be estimated. At present there are three competing methods for computing resource rents: the World Bank's (NPV), El-Serafy's and Repetto's.

The World Bank's Method for Computing Resource Rents

In this method, resource rents are measured as the market value of the extracted resource less the average extraction cost. In theory, the net price should be computed as market price less marginal extraction cost. However, since such marginal cost are difficult to estimate, the World Bank has adopted the average extraction cost as a proxy. The procedure is used for all types of mineral resources including crude oil, base metals, precious metals and gemstones. The formula for resource rents is given below:

$$(P - AC) \cdot R$$

Source: Neumayer (2000)

- P is the resource price
- AC is average cost
- R is resource depletion

Rents are usually valued at total Hotelling rent, albeit calculated using the more available average cost as a proxy for the theoretically correct marginal cost, i.e the resource rent over any time period will be the net price of the resource (P - AC) multiplied by the amount produced (R). The only negative externalities considered are CO₂ emissions which are valued at 20 US\$ per metric tonne of carbon (Fankhauser, 1994).

From the formula, it is clear that this method does not account for resource discoveries. However, given that exploration expenditure tend to be recorded under investment expenditure (rather than as production costs of the mining sector) in standard national accounting there may be no need to correct for resource discoveries (World Bank, 1997).

The Repetto (Net Price) Method for Computing Resource Rents

Also called the net price method, this procedure for computing resource rents was postulated by Repetto (1988). He follows Hotelling (1932) in treating the rent per unit of production as (P-MC), and in recognizing that the terminal point in the dynamic programming problem is set by the financially feasible amount of the resource that can be profitably extracted. This

method assumes that all net revenue from mining is ascribed to the depletion of the ore body and none of it is ascribed to value added by other factors of production i.e. the net profit from resource extraction represents total hotelling rents (Crowards, 1996). This implicitly assumes that marginal costs from resource extraction remain constant. Thus, to maximise resource rents, increases in rent per unit as the stock size decreases will be set equal to the discount rate (Crowards, 1996). The resource rent formula is specified as

$$(P - MC) \cdot (R - D)$$

Source: Neumayer (2000)

- P is the resource price
- MC is marginal cost
- R is annual production
- D is resource discoveries

This approach is consistent with national accounting practices and theoretical growth models such as Hartwick (1990) in that it allows for the calculation of a capital consumption allowance that is rooted in a net product measure. Levin (1991) and Landefeld & Hines (1985) recommend this measure and take it further to develop operational accounting procedures for measuring depreciation using the net price method. However, it must be noted that there is still a lot of controversy surrounding the treatment of resource discoveries.

Repetto's method is not without its critics. Despite its theoretical correctness, one of these is the use of (constant) marginal cost rather than average cost. Hartwick (1990) objects that as long as marginal cost are assumed to be constant (instead of increasing) as the resource stock becomes depleted, the estimated extraction costs will tend to exceed the '*true extraction costs*' resulting in an overestimation of the depreciation term. A second is that new resource discoveries and the subsequent asset revaluations can cause sudden and large fluctuations in Adjusted Net National Product (Serôa da Motta and Young, 1995). Finally, El Serafy (1989) and Neumayer (2000) observe that with the net price method, resource depreciation cancels out the income generated by mining. All the receipts from production are considered capital consumption and as such, net income is zero. With respect to national income, it is as though the mineral never existed. This interpretation is misleading and is the reason that El Serafy based his approach on the Hicksian definition of income.

The El Serafy (User cost) Method for Computing Resource Rents

This method follows the Hicks's basic view that income is the time derivative of wealth³. El Serafy (1989) proposes that the proceeds from current resource extraction be split into two components:

- *True income* which is the value added from mining;
- *A residual term* equal to the amount that would have to be reinvested at the prevailing interest rate in order to generate a perpetual income stream equal to the true income.

In this analysis, the 'El Serafy' method will be used to compute resource rents for the eleven countries so as to ascertain whether they meet the preconditions for weak sustainability, or are unsustainable, and to formulate the appropriate policy recommendations.

To calculate the User cost for resource depletion according to the El Serafy method, four different terms are needed:

- P-AC (net price of the resource);
- R, Production (Resource Depletion);
- r, the real discount rate (the discount rate used in this analysis is 4% p.a.);
- n, the number of years of reserves remaining at current production rates and assuming current extraction technologies (reserves to production ratio).

It is important to calculate resource rents for each category of mineral resource. Resource rents can be defined broadly as Unit Rents × Production where the Unit Rents = Unit Price – Unit Cost. The El-Serafy formula for User cost can be expressed as:

$$(P - AC) \cdot R \cdot \left[\frac{1}{(1 + r)^{n+1}} \right]$$

Source: Neumayer (2000)

³Hicks (1939) provided a theoretical definition of income and discussed how government agencies and economists approximate this definition. Hicks defined income as the maximum amount that can be consumed in a given period without decreasing real wealth. He further engaged in the discussion of three approximations to this central definition. The first approximation defines income as the maximum amount that can be spent on consumption while keeping nominal wealth constant. The second defines income as the maximum amount that an individual can consume in a given period (t) and still expect to consume the same amount in all subsequent periods (t+n). The third approximation defines income as the maximum amount that individuals can consume in a given period and still expect to consume the same amount in real terms in the future.

It may be worth discussing the derivation of the formula above in order to understand conceptually and theoretically how this method differs from others used to estimate resource rents.

Assuming that resource receipts accrue at the end of the period, the value of a resource stock at the start of the period can be expressed as:

$$\begin{aligned} \mathbf{W}_0 &= [R_1(P_1-C_1)/(1+r)] + \{R_2(P_2-C_2)/(1+r)^2\} + \dots + \{R_T(P_T-C_T)/(1+r)^T\} \\ &= \sum_{t=1}^T \{R_t(P_t-C_t)/(1+r)^t\} \end{aligned} \quad (1)$$

Let V represent a constant income payment which will be replicated *ad infinitum*. The resulting stream's present value at the start of the period is X_0 : i.e.

$$\begin{aligned} \mathbf{X}_0 &= V/(1+r) + V/(1+r)^2 + V/(1+r)^3 + X/(1+r)^4 + \dots \\ &= \sum_{t=1}^{\infty} V/(1+r)^t \end{aligned} \quad (2)$$

Now assuming that $R_t = R$, $P_t = P$ and $C_t = C$ for all t and using $N = R(P-C)$ for net receipts and $d=1/(1+r)$, expression (1) and (2) can be rewritten as

$$\mathbf{W}_0 = N [d + d^2 + d^3 + d^4 + \dots + d^T] \quad (3)$$

$$\mathbf{X}_0 = V [d + d^2 + d^3 + d^4 + \dots] \quad (4)$$

Note that for $r > 0$ this implies $d < 1$

Multiplying the left hand and right hand side of equations (3) and (4) by the term d gives

$$d\mathbf{W}_0 = N [d^2 + d^3 + d^4 + d^5 + \dots + d^{T+1}] \quad (5)$$

and subtracting (5) from equation (3) gives $W_0 - dW_0 = N[d - d^{T+1}]$ so that

$$W_0 = N [d - d^{T+1}]/[1-d] \quad (6)$$

Rewriting equation (4) for a finite time horizon n gives $\mathbf{X}'_0 = V [d + d^2 + \dots + d^n]$ where n is an arbitrary real finite number. Proceeding as before gives $\mathbf{X}'_0 = V [d - d^{n+1}]/(1-d)$; letting $n \rightarrow \infty$ makes the term d^{n+1} vanish so that $\mathbf{X} = \lim_{n \rightarrow \infty} (\mathbf{X}') = dV/[1-d]$ which is the present value of a constant infinite income stream.

Assuming a perfectly competitive economy, if the constant infinite income stream depends solely on the ownership of the mineral stock, then the present value of the infinite income stream must be equal to the value of the mine at the start of the period: $W_0 = X_0$

Using equation (5) and (6) gives $N [d - d^{T+1}]/[1-d] = dV/[1-d]$. Collecting like terms together and substituting $1/(1+r)$ for d gives $N - V = N/(1+r)T$.

Finally by substituting $N = R(P-C)$ one gets $R(P-C) - X = R(P-C)/(1+r)^T$ and the expression for the El-Serafy User cost (Depreciation): $D_N = R(P-C)/(1+r)^T$.

This is an estimate of the total Hotelling Rent (only an estimate, since Hotelling used marginal rather than average extraction cost) that the resource could provide. Following Keynes's terminology, it is called the User cost of resource depletion as it indicates the share of resource receipts that should be considered as capital depreciation.⁴

With this method, an explicit correction term for resource discoveries is not needed because discoveries and new technologies that affect effective reserves enter the formula via changes to n , and the formula is recalculated for each year.

The logic behind the formula for the El Serafy method is that sustainability need not require that all resource rent be invested (as Hartwick (1997) suggested) but that a portion can be consumed. While the earnings from the resource stock will end at some finite point, sustainable income by definition must last forever. Therefore, a finite cash flow has to be converted into an infinite one. Sustainable income is that part of resource receipts which if received infinitely would have a present value just equal to the present value of the finite stream of resource receipts over the lifetime of the resource. That is if each year's resource rents were used to purchase an infinitely long-lasting annuity, sustainable income would be the annual pay out from that annuity.

The User cost or depreciation term is the difference between the net resource receipts and sustainable income. This method thus leads to a fairly simple rule for calculating the

⁴Keynes (1936) used the term in relation to capital and defined it as the maximum net value of the capital equipment if it had been conserved rather than being used. The application of User cost in the context of mining was placed in the appendix to Ch6 of the GT. It grew in popularity and become commonly used in studies analyzing of exhaustible resource. Examples of such studies include Schramm, 1986.

depreciation term for a mineral resource as User cost, and the associated real income from resource extraction.

An advantage of using the El Serafy method is that it does not presume efficient resource pricing, i.e resource rent growing at the rate of interest according to Hotelling's rule. This is because the El-Serafy method does not depend on an optimisation model. It is an "after the fact" approach thus making it more flexible than competing resource rent calculation methods (World Bank, 2013). Consequently, future resource receipts have to be discounted and the El Serafy method requires the selection of a discount rate r .

For any given asset lifetime, the choice of interest rate is of significant importance. If the remaining lifetime of the mineral resource, n , or the discount rate, r , is quite small, then User cost value will be relatively large. With a long resource extraction horizon and high discount rate, nearly all net receipts count as income.

Butterfield (1992) argues that the El Serafy approach confuses an "*income measure*" with a "*product measure*" by asserting that "*User cost*" does not measure "*natural capital consumption*" thereby implying that gross product and not net product should be adjusted. In so doing, the El Serafy method violates the income-product identity. The counter-argument to this is that an unadjusted GDP should be calculated following the standard accounting procedures and GDP adjusted with User cost should also be computed and the latter will serve as a more reliable measure of sustainable income (Harris & Fraser, 2002).

The second criticism of this method is that its assumption that unit rents and extraction levels remain constant over time is unrealistic. This assumption means that User cost estimates would stay fixed while extraction cost and prices vary over time (Dasgupta, 1995). Harris and Fraser (2002) counter argue that El Serafy's approach, like other methods, aims to generate some approximation to the true measure. The procedure is constantly updated in each accounting period so that the set of assumptions is not strictly followed to over time.

Computing resource rents according to the 'El Serafy'-method

In the following section, resource rents have been computed using the 'El Serafy'-method.

Table 1: Share of Single Mineral Resources as a percentage of Total Resource Rents

Share of Crude Oil & Natural Gas (% of Rents)	1990-1999	2000-2008	2009-2015
Angola	99.4	97.5	96.2
Cameroon	70.0	60.3	52.1
Chad	0.0	98.5	97.2
Congo Brazzaville	90.3	97.5	98.9
Equatorial Guinea	95.0	96.0	97.0
Gabon	90.3	87.8	85.4
Ghana	0.0	0.2	29.4
Mauritania	0.0	9.6	19.9
Nigeria	99.8	99.6	95.2
Share of Iron Ore (% of Rents)			
Mauritania	100	90.2	57.6
Share of Gold (% of Rents)			
Ghana	100	95.9	70.3
Mauritania	0.0	0.1	22.5
South Africa	29.9	16.2	17.5
Share of Coal (% of Rents)			
South Africa	57.6	35.3	57.5
Share of Platinum (% of Rents)			
South Africa	12.5	48.1	24.7
Share of Diamonds (% of Rents)			
Angola	0.0	2.4	3.8
Botswana	90.2	93.3	96.7
Diamonds	0.0	3.8	0.3
South Africa	0.0	0.3	0.2

Source: United States Geological Survey, IMF International Financial Statistics, World Bank

Table 1 shows that for Angola, Cameroon, Chad, Congo (Brazzaville), Equatorial Guinea, Gabon and Nigeria the dominant resource is oil & natural gas. For Botswana the dominant resource is diamonds, Ghana has gold and Mauritania is dominated by iron-ore extraction. South Africa has the most diversified mineral base in the sense that it is not heavily reliant on any particular one.

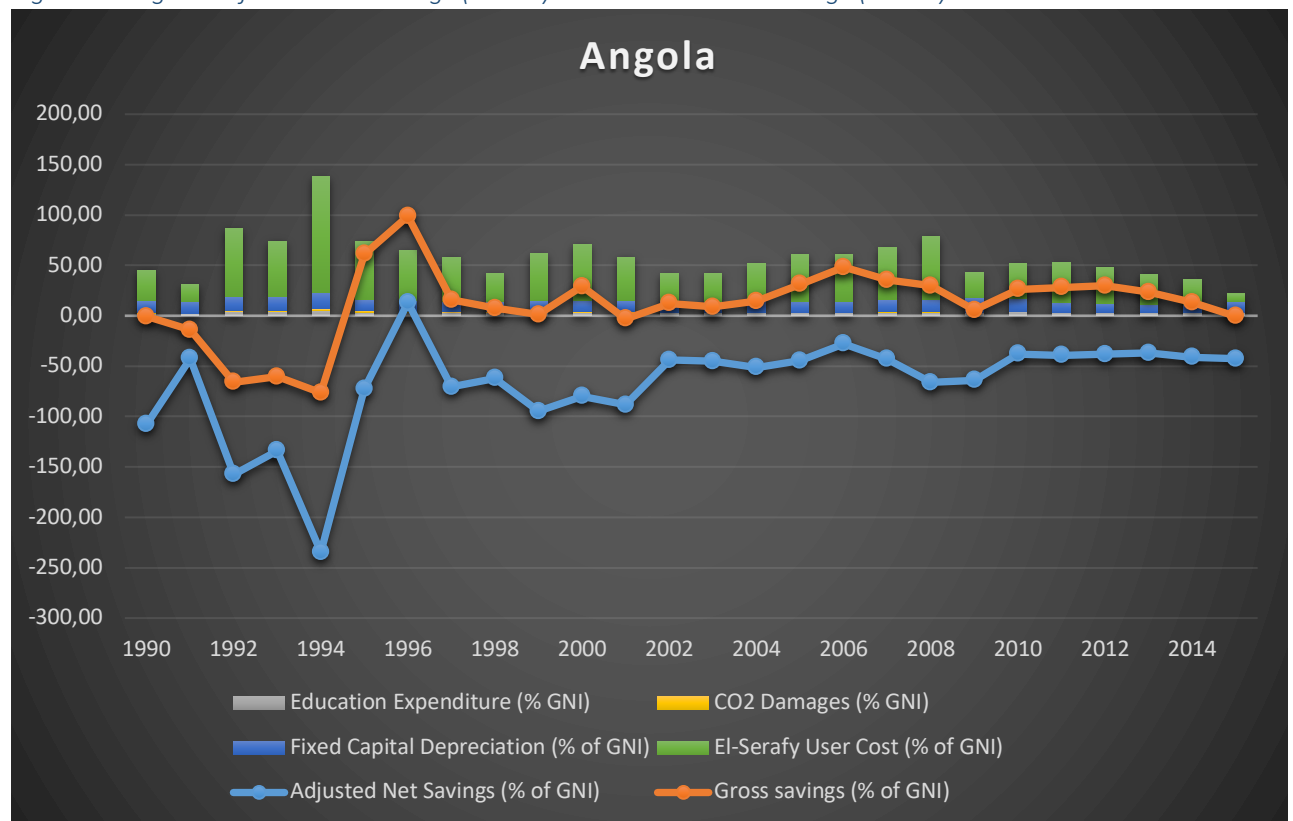
Before moving on to the analysis, it is important to acknowledge a number of methodological issues. First, data limitations affect the reliability of the analysis for mineral resources. For example, Gabon ranked as the fourth largest world producer of manganese and Cameroon the seventh largest producer of pumice in 2014 (John, 2014; Loyd, 2014). Nigeria, in addition to producing oil and natural gas, also produced and exported other minerals, such as tantalum

and nickel. Even though their contribution is undeniable, these minerals could not be in the calculations because the data was unreliable or deficient. The second and perhaps most important issue is that the results significantly underestimate the total stock of wealth for our sample of countries as other categories of natural capital such forests and agricultural land are excluded from the analysis due to data unreliability and unavailability. In the remainder of this paper, the term natural resources will be used interchangeably with mineral resources.

Results

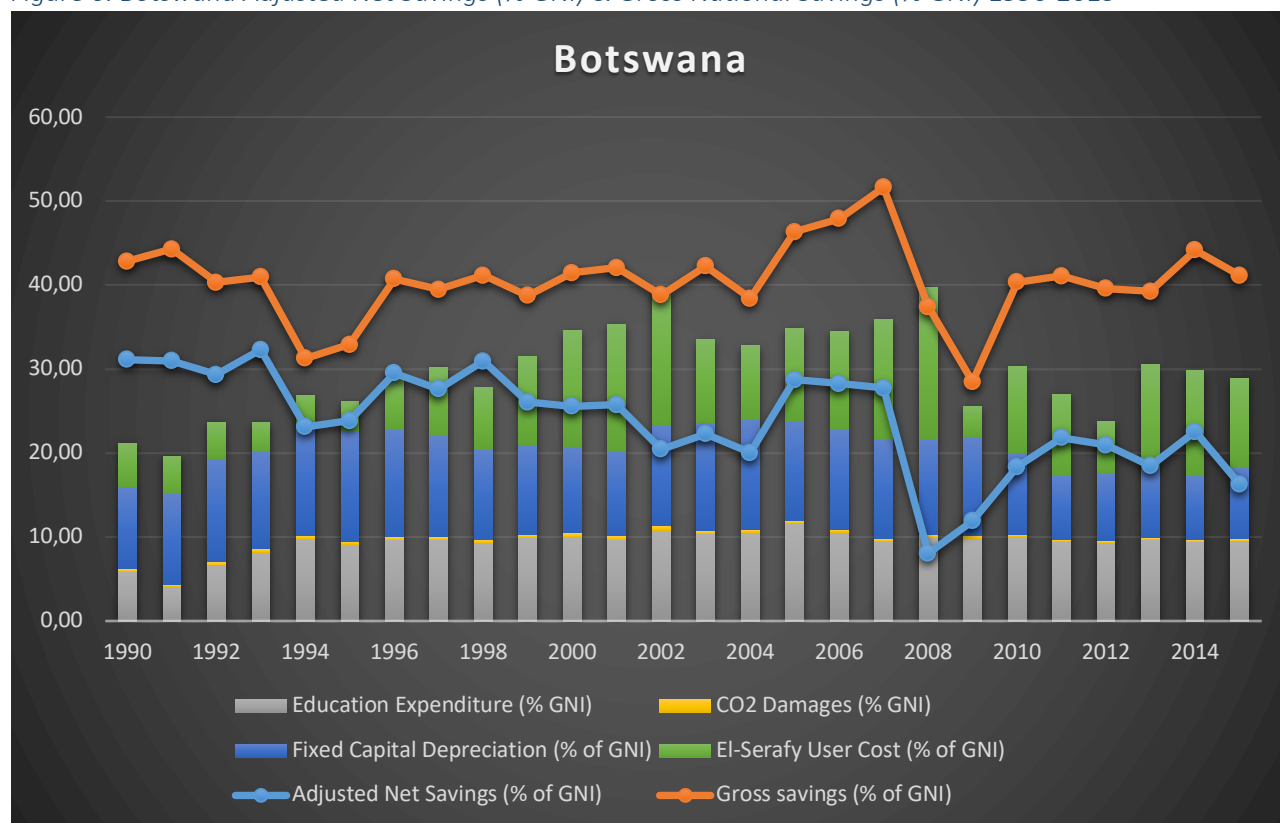
After the estimates of the User cost from mineral resource extraction have been calculated, Adjusted Net Savings are estimated for the sample of 11 countries and the results illustrated in the following graphs

Figure 5: Angola Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



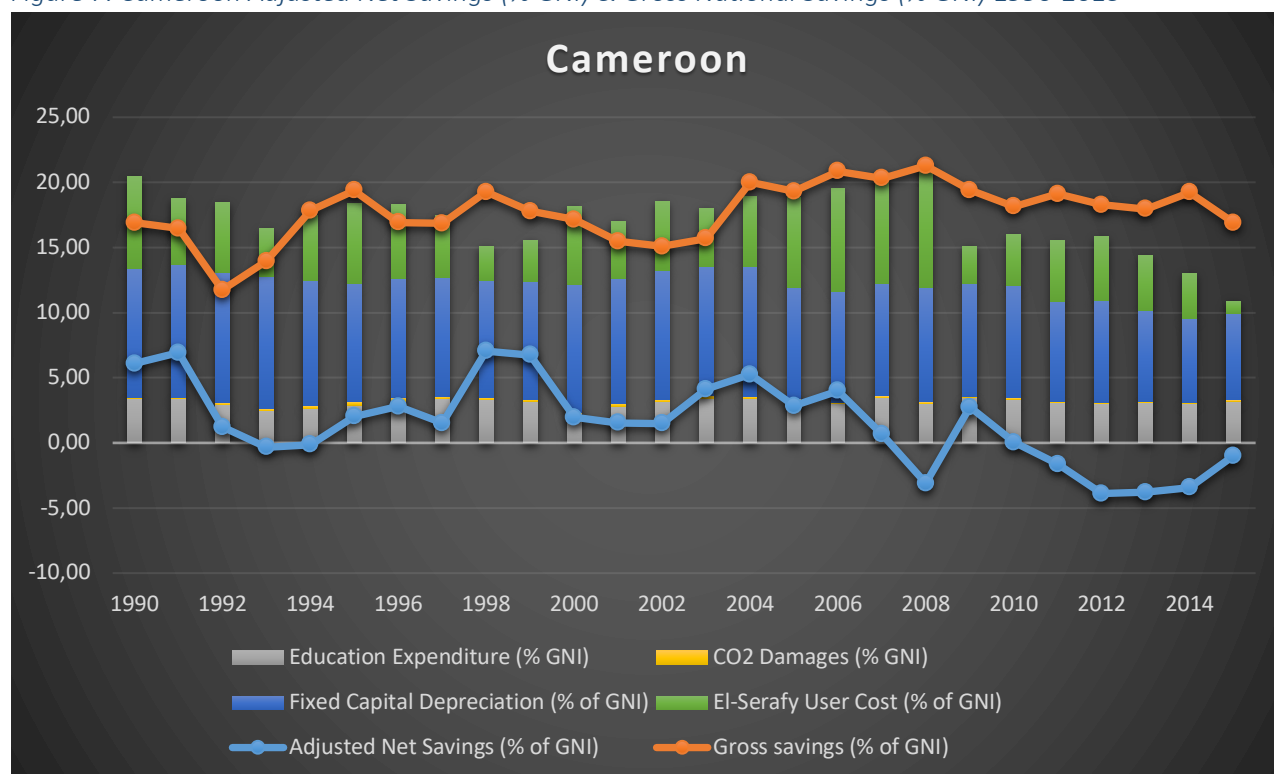
Source: Author's Own Calculation

Figure 6: Botswana Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



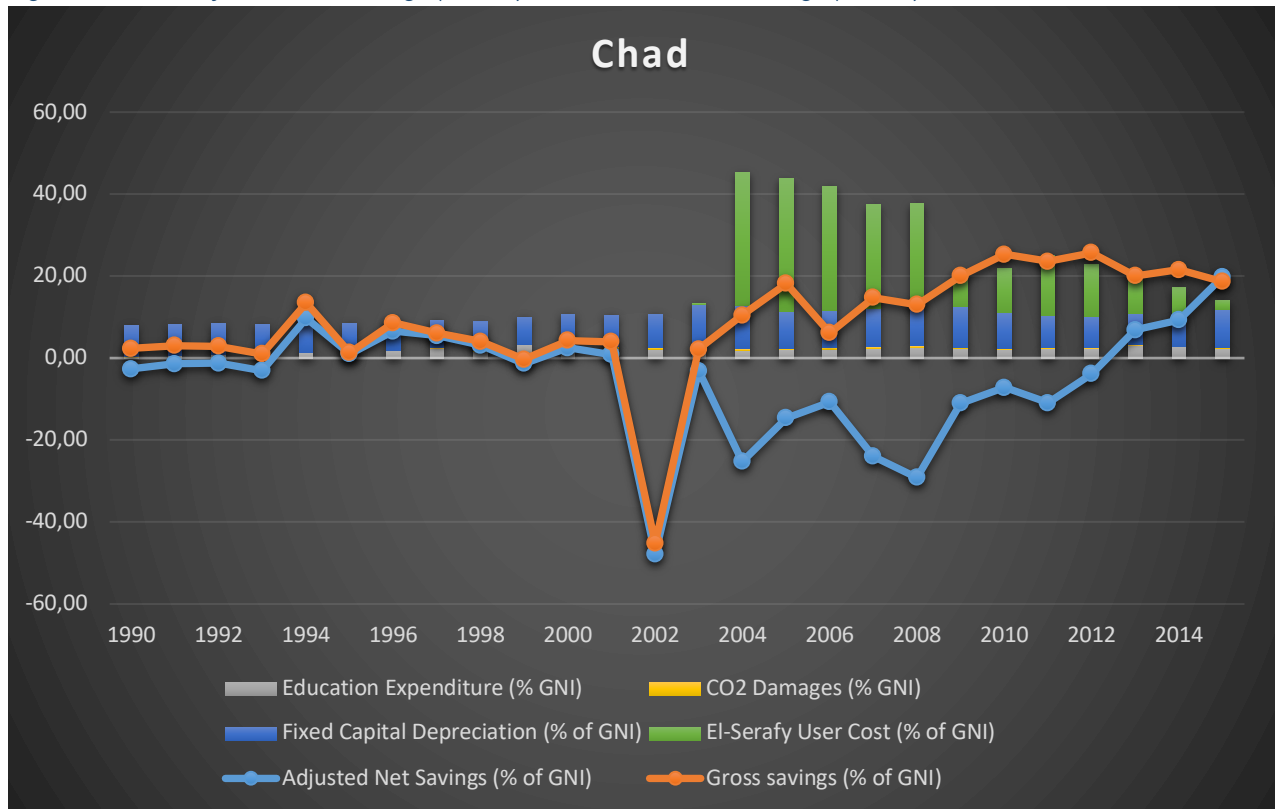
Source: Author's Own Calculation

Figure 7: Cameroon Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



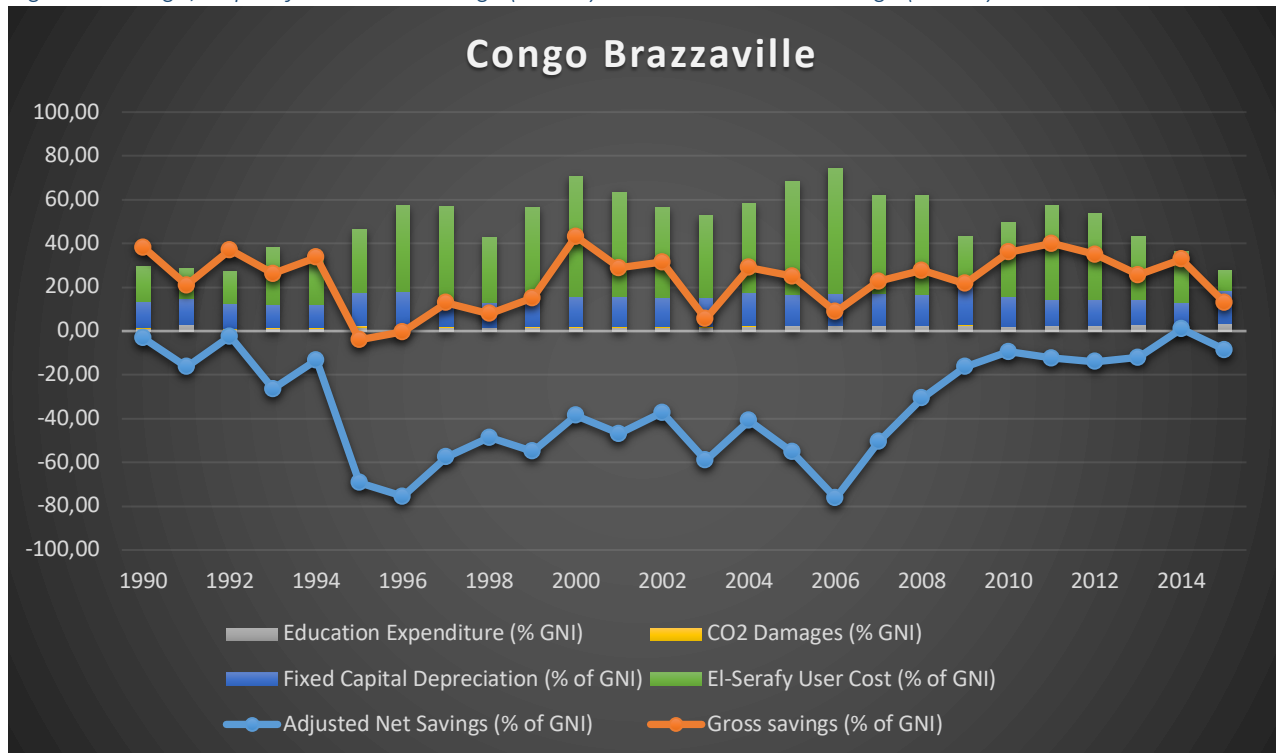
Source: Author's Own Calculation

Figure 8: Chad Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



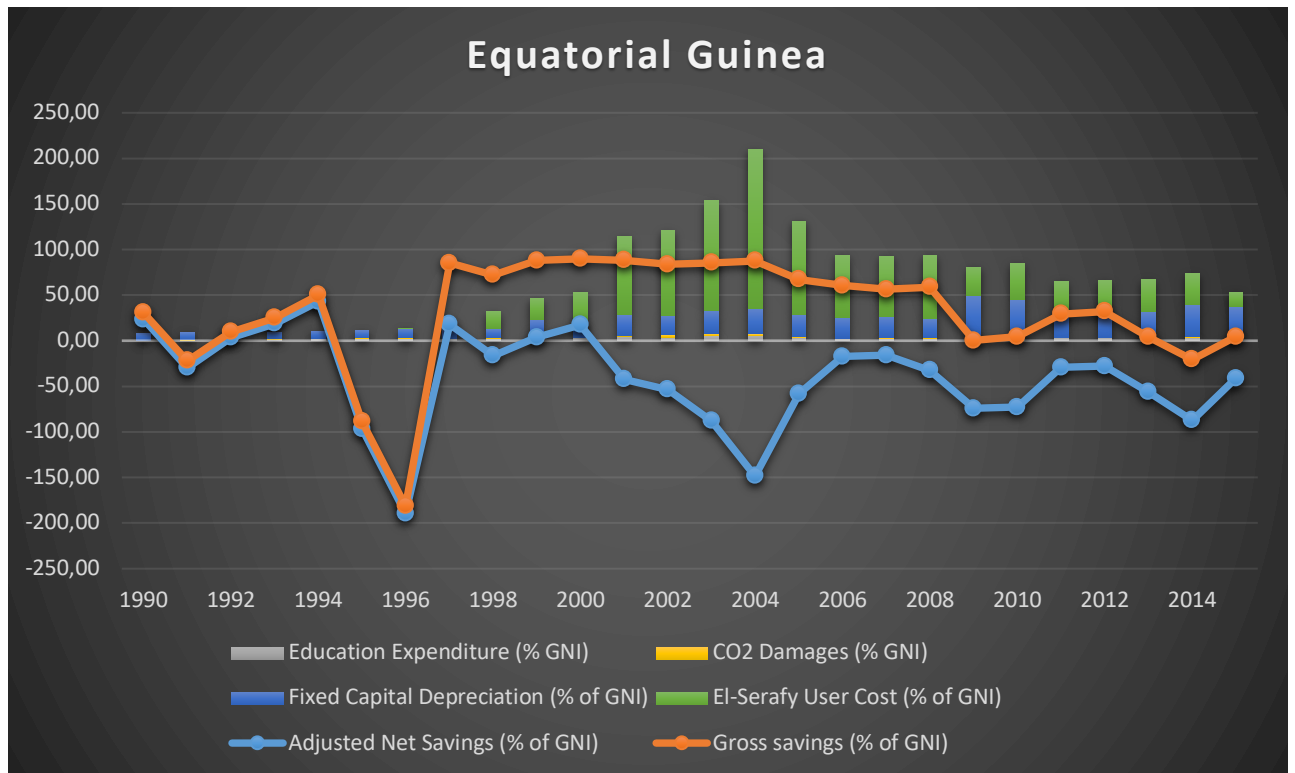
Source: Author's Own Calculation

Figure 9: Congo, Rep Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



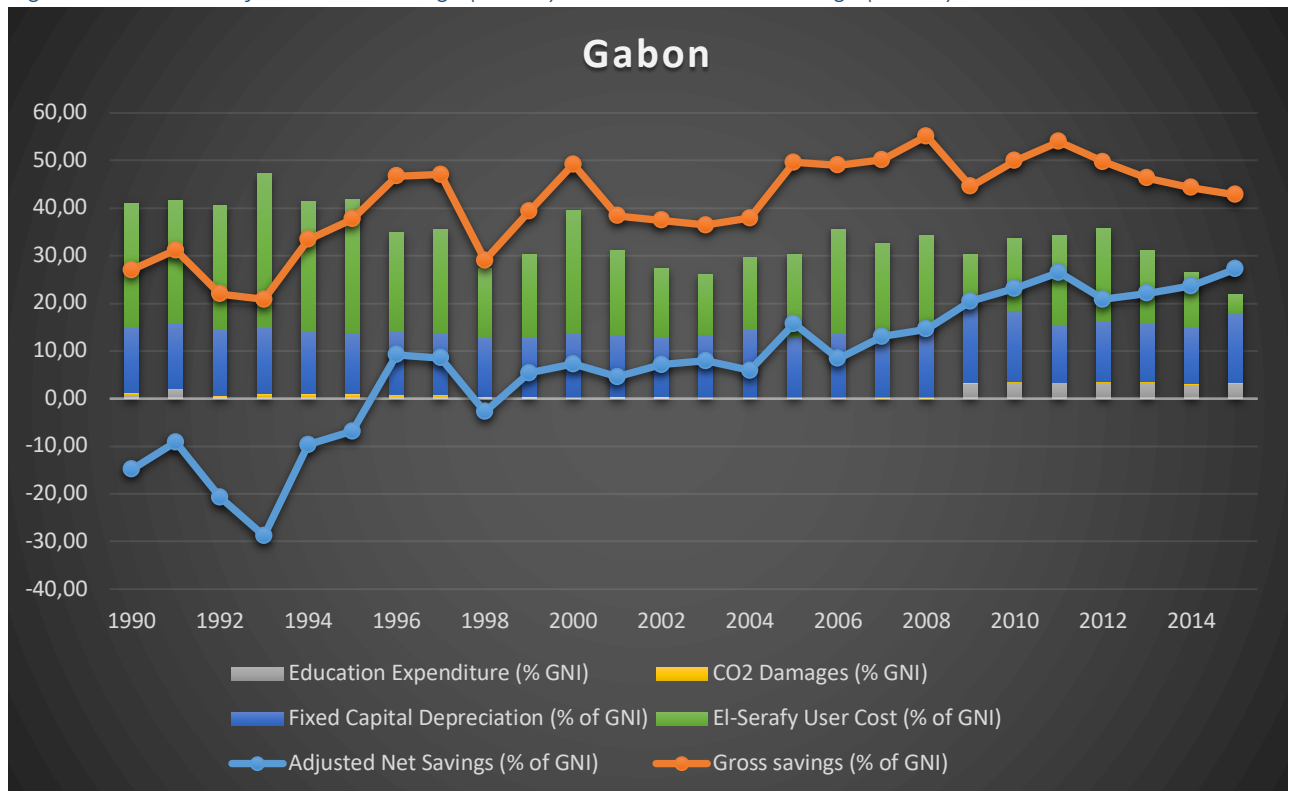
Source: Author's Own Calculation

Figure 10: Equatorial Guinea Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



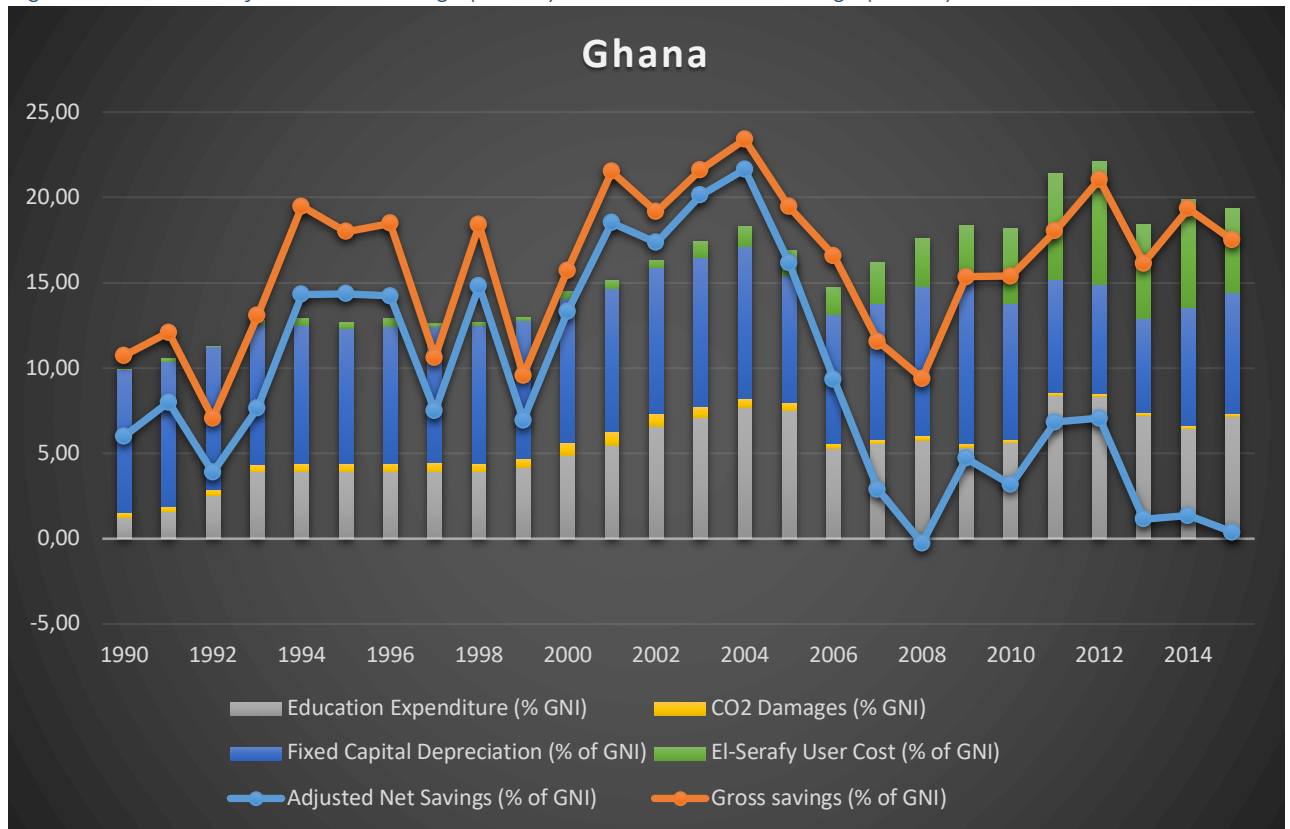
Source: Author's Own Calculation

Figure 11: Gabon Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



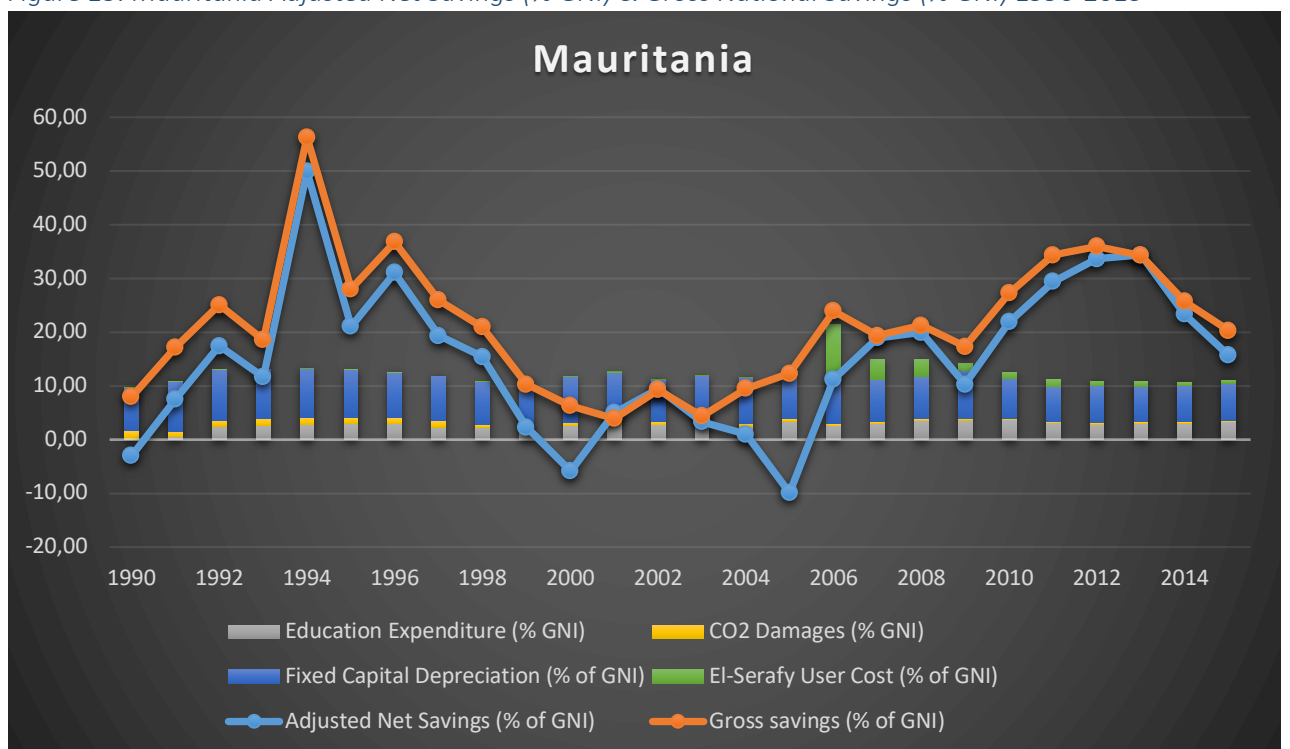
Source: Author's Own Calculation

Figure 12: Ghana Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



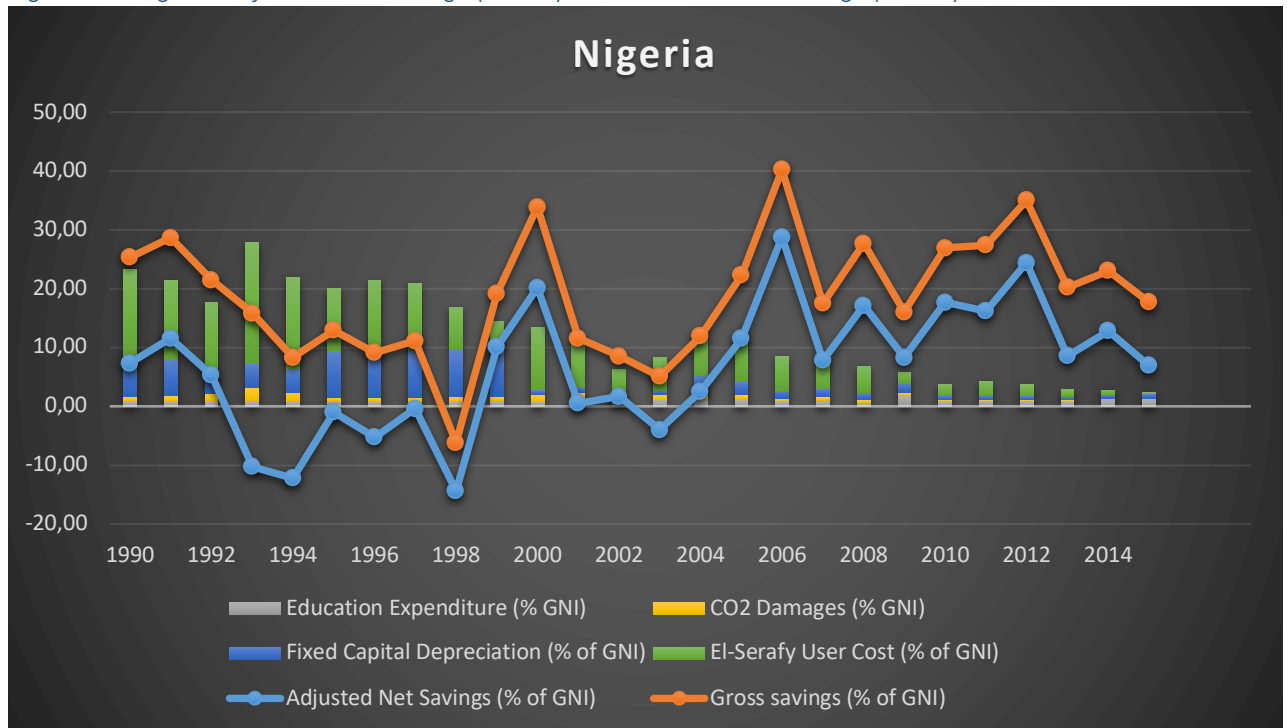
Source: Author's Own Calculation

Figure 13: Mauritania Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



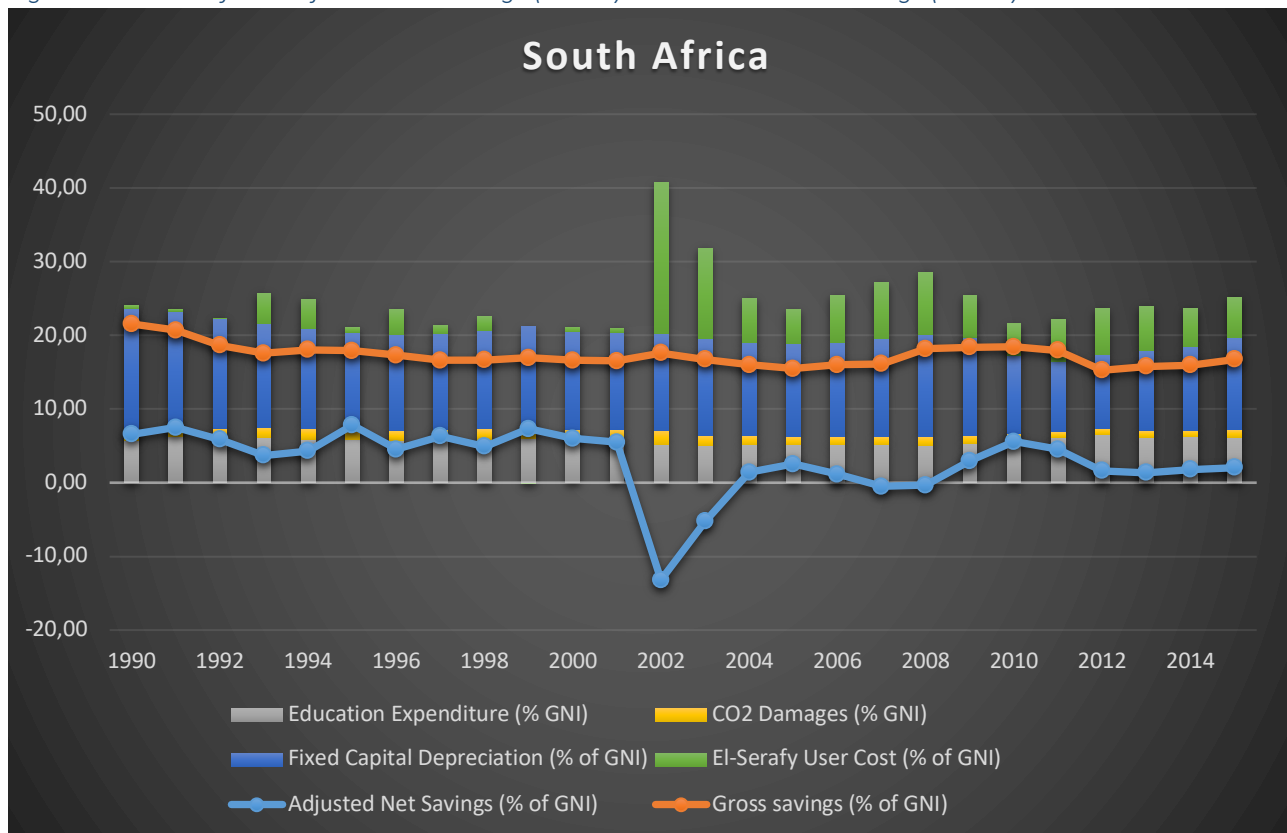
Source: Author's Own Calculation

Figure 14: Nigeria Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



Source: Author's Own Calculation

Figure 15: South Africa Adjusted Net Savings (% GNI) & Gross National Savings (% GNI) 1990-2015



Source: Author's Own Calculation

The figures above indicate that Botswana, Cameroon, Gabon, Ghana, Mauritania and South Africa experienced a consistently positive gross savings rate. This did not necessarily translate into persistently positive Adjusted Net Savings. On the other hand, Angola, Chad, Congo, Equatorial Guinea and Nigeria experienced a few years of negative gross savings rate.

The countries with high reserves to production ratios (**n**) rarely display negative ANS. Such appears to be the case for Botswana, Cameroon, Ghana and South Africa. This is not surprising because a high **n** decreases the User cost from mineral depletion as a smaller share of the resource stock is consumed, assuming a constant production level.

For Mauritania and Nigeria, the ANS rates seem to move quite closely with the GS rates, but there are a number of years where the GS rate is positive but ANS rate is negative. In the case of Angola, Chad, Congo and Equatorial Guinea, the figures show that there is a large gap between their GS and ANS. These countries are also similar in that there are several years where the GS rate is positive but the ANS rate is negative to a considerable degree. An explanation for this is the fact that they all have low reserves to production ratios. Furthermore, during the price commodity boom their production increased considerably but the size of their reserves stayed constant and in some cases declined, resulting in a fall of their reserves to production ratio (**n**). Thus, the estimated User cost from resource depletion was high. Asheim (1994) and Pezzey and Withagen (1995) showed that a positive ANS is a necessary but not sufficient condition for weak sustainability. However, persistently negative rates of ANS must lead to declining future welfare. If a persistent negative ANS rate is a relatively good indicator of unsustainability, there is a need for some formal definition of this. Following Neumayer (2000) but altering his approach slightly, we define a persistently negative savings rate as having experienced negative ANS rates for more than seven years for the period 1990-2015 though not necessarily consecutively.

Out of maximum of 25 possible years, the frequency of persistently negative adjusted savings is as follows:

Table 2: Frequency of persistently negative saving rates

Country	Number of Years
Botswana	0 Years
Ghana, Mauritania	1-3 Years
Cameroon, South-Africa	4-6 Years
Gabon, Nigeria	7-9 Years
Angola, Chad, Congo (Brazzaville), Equatorial Guinea	>=10 Years

Source: Author's Own Calculations.

From Table 2, we can conclude that six out of the eleven countries in this study have experienced persistently negative savings and can therefore be classified as weakly unsustainable. The persistence of negative ANS for Angola, Chad, Congo Brazzaville and Equatorial Guinea certainly highlights the need for better resource management in the future. These countries have not been able to capitalize on the considerable opportunities given to them through their natural resource endowments to build up and maintain their physical and human stock of capital in exchange for the exhaustion of their stock of natural capital. Botswana, on the other hand, has enjoyed consistently positive Adjusted Net Savings; with its high ratios of reserves to production, there seems little indication of unsustainability. The widening of the gap in recent years between GS and ANS in Botswana, Cameroon, Ghana and Nigeria suggests that some amount of the national wealth that is consumed is in excess of what should be the case under efficient resource rent management as suggested by El Serafy User cost approach.

Strictly speaking, it is incorrect to define sustainability purely in terms of savings. The crucial factor in determining sustainability is investment and not savings (Neumayer, 2000). Savings equals investment only in the special case where government expenditure is zero and there is no economy in the world where this is the case. If there are no taxes and government expenditure is non-zero then savings is the sum of investments and government expenditure. With taxes present in the economy, savings equals investments plus government expenditure plus taxes.

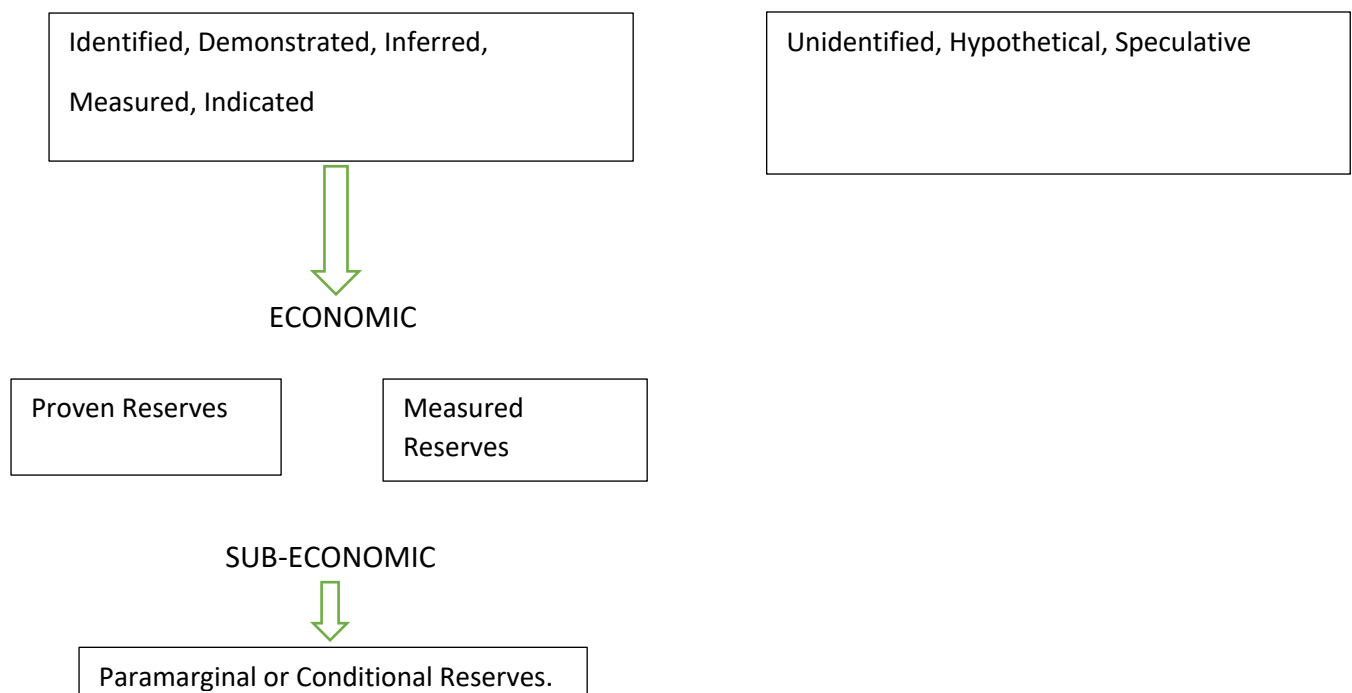
A simple test can be used to reveal why a “proper definition” National Income which corrects for resource depletion is needed for low-income resource-rich economies. This looks at the relationship between an economy’s fiscal deficit before borrowing and its nominal NY as conventionally recorded, and compares it to the relationship between the country’s fiscal deficit and its National Income as calculated using the El Serafy method. A more complete indicator of an economy’s exposure to fluctuating commodity prices could be the relationship between national debt and Net Domestic Product as computed in these two manners. Using a measure of net national product that adjust for mineral depletion as an anchor for defining the size of an acceptable deficit reveals that GDP typically understates the true magnitude of a budget deficit and overstates the true magnitude of a budget surplus. Similarly, national debt when expressed as a percentage of the adjusted net national income reveals that several mineral-rich economies are more vulnerable to fluctuating commodity prices than the conventional measures would suggest (refer to Appendix 9 for the graphs). Thus, the common rule of thumb that a fiscal deficit equivalent to 3% of GDP or a debt to GDP ratio that does not exceed 60% is acceptable may lead to misjudgements of the true state of the economy. Consequently, the economic policies implemented by the governments in these countries may be flawed and lead to sub-optimal outcomes for current and future generations. In the next section, which discusses fiscal policy in the context of a mineral-based economy, we construct a number of first order approximation measures that focus on investments and should provide an indication of the fiscal fragility of these economies.

[What is the appropriate Fiscal Policy in low-income resource-rich African countries?](#)

Mineral economies are unique and different from non-mineral economies because of their reliance on mineral revenues for budget stability and their dependence on the mining sector to boost sustainable economic development and growth. Despite this basic similarity, there are significant variations between resource-rich countries, ranging from the relative magnitude of the resources’ contribution to the economy, the maturity of the resource sector, its ownership and taxation structure, the government's financial position and the size of the reserves. The last point may be the most important because it determines the focus of fiscal policy. The first practical problem with reserves is how to appropriately define them. Numerous approaches has been used over time, but the one which is clearly defined and internationally understood is that used by U.S. Government’s Bureau of Mines. It provides the

following definitions: “reserves” are the known amounts of a mineral that can be profitably produced at current prices and with the current level of technology (Omayra et al., 2013). New discoveries and new technologies (as well as changes in demand that are reflected by changes in the price of the product) can influence the extent of economic reserves. These are the stocks of the resource sometimes known as its “proven reserves”. As the degree of knowledge of the precise dimensions of the ore body diminishes, one moves to the terms “indicated reserves” and then “inferred reserves”. The extent of the proven reserve of a mineral may be influenced in other ways than by demand and supply. For example, a tax system which imposes a royalty on proven but unexploited reserves leaves miners with an incentive not to confirm reserves that are believed to exist. In Zambia, the government estimates that about \$2 billion of possible mining tax revenue is lost through tax avoidance (International Monetary Fund, 2017).

Table 3: Classification of Mineral Resource Reserves



It follows then that the appropriate fiscal response to resource endowments depends to a great degree on how much longer they are expected to last (the size of the reserves properly defined). The length of time remaining to resource depletion will determine whether the focus will be on short-run smoothing or long-term sustainability, as previously mentioned.

Numerous theorists have identified a combination of concerns about short-run and long-term strategies. Short-run price volatility in natural resource markets has been identified by Auty (1997, 2000 and 2004), Barnett and Ossowski (2003), Cashin et al. (2003), Eifert et al. (2003), Collier (2010 and 2012), Daniel et al. (2013), Geiregat and Yang (2013). Long term sustainability has mainly been a concern of weak sustainability theorists such as Solow (1974, 1986) and Hartwick (1977).

A reasonable estimate of whether existing reserves are likely to last long is crucial and should be at the core of fiscal policy frameworks in mineral-based economies. The attraction of the El Serafy method is that it incorporates the vital element of a resource extraction horizon in the computation of resource rents and how much of it is safe to consume. If the remaining lifetime of the mineral resource n is quite small, then User cost value will consequently be relatively large. With a long resource extraction horizon, nearly all net receipts count as income, which allows the government to invest these proceeds into a sinking fund that will smooth the fiscus.

Although sustainability is an important concern for all countries, adjusting fiscal policy to a future environment without mineral resources is a less immediate concern for those economies with long resource horizons. The main short-run concern for these economies usually involves managing the volatility of resource revenues caused by price fluctuations. On the other hand, countries with shorter resource horizons need to focus more immediately on how government expenditure can be sustained once resource revenues are exhausted. It follows that managing the volatility in resource prices should be the most important objective of fiscal policy in countries that rely heavily on the revenues generated from the extraction of natural resources and have a long resource horizon. For countries with shorter resource horizons and larger uncertainties about production volumes, an alternative approach to control for resource price volatility is needed (Barnett and Ossowski, 2003). The optimal level of the non-resource fiscal balance should be based on the individual economy's capacity to absorb revenues without this leading to high inflation and a large current account deficit (Daniel et al., 2013). A major benefit of this approach is that it provides a direct link to fiscal sustainability by setting a target for the non-resource fiscal balance that can be sustained even after resource revenues get depleted (Daniel et al., 2013). Fiscal policy in this scenario is very similar to that which a country reliant on foreign aid should plan for when it is

anticipated that aid will stop in the medium to long term. In the event that resource revenues are higher than budgeted, the excess must be saved rather than spent. For the same reason, the government can draw down on its financial assets when budgeted revenues fall short of what is expected. Examples of countries that implement such fiscal frameworks include Norway, Timor-Leste and Papua New Guinea.

One option to ensure fiscal sustainability is the “annuity approach”. This entails saving all resource revenues. Expenditure is then confined to the interest generated from these savings. These saved resource revenues are commonly referred to as stabilisation or sovereign wealth funds. These funds should complement fiscal policy rather than trying to substitute it; their funding should come from budget surpluses and not borrowing. Consequently, resource funds should not be granted autonomous spending authority. They can be allowed to exercise different mandates such as providing a means to carry out intergenerational savings or stabilizing government spending. Ideally, countries with very poor institutional capacity should possess just one resource fund as the management of several resource funds is likely to be very difficult. Norway provides an example of the successful implementation of this approach. Each year the government budget is credited with approximately 4% of the value of saved oil revenues. Although this approach has worked well in Norway, a number of academic scholars have argued that it is unlikely to be successful for developing countries especially in sub-Saharan Africa which suffer from capital scarcity and large infrastructure investment needs. According to Collier (2012) the classical sovereign wealth fund is inappropriate for “poor countries” because in capital inadequate economies it is inappropriate to accumulate long-term foreign investments and the central objective should be to develop domestic infrastructure. Similarly, Van der Ploeg (2009) argued that an international sovereign wealth fund is not appropriate for a capital scarce country as it is too conservative, in that it prevents any short-term increases in consumption. This criticism is grounded on the fact that the sovereign wealth fund model is based on the permanent income hypothesis (developed by Milton Friedman 1957) which is one of the key foundations of modern-day consumption theory. Sovereign wealth funds perform a wide-ranging set of functions and exist in some of the world’s richest countries (e.g., Canada, Norway, and the United States) as well as in some of the poorest (e.g. Nigeria and Ghana).

An alternative strategy to the annuity approach is to use the proceeds from the sale of mineral resources to purchase manufactured capital and improve the socio-economic conditions of the citizens (Geiregat and Yang, 2013; Helbling, 2013). The rate of return of productive government expenditure is likely to be much higher for countries with significant infrastructure and human capital needs compared to the rate of return on financial assets (Daniel et al., 2013). An increase in government expenditure finance by resource revenues on high-quality public infrastructure is very likely to boost economic growth and decrease the reliance of the economy on resource revenues for fiscal stimulus. It is quite clear that such an outcome depends heavily on the effectiveness of public spending. Should public spending be poorly managed, it is obvious that the welfare of future generations will be seriously compromised.

In order to ensure that a state's expenditure matches its long-term average revenues, the fiscal authorities can implement rules that account for yearly fluctuations in resource prices. Such smoothing in estimating the structural proceeds that can be expected in an average year allows the authorities to determine how much of the proceeds can be safely spent through the annual budget. It is still possible that structural revenues will change very sharply following unexpected price changes (Daniel et al, 2013).

The Sustainability of the Budget

There is consensus that resource-rich countries must invest the revenues from the exploitation of mineral resources into increasing their stock of wealth by accumulating other assets. These other assets (human, financial and manufactured capital) will then help generate income for the economy in the future when the minerals resource is exhausted.

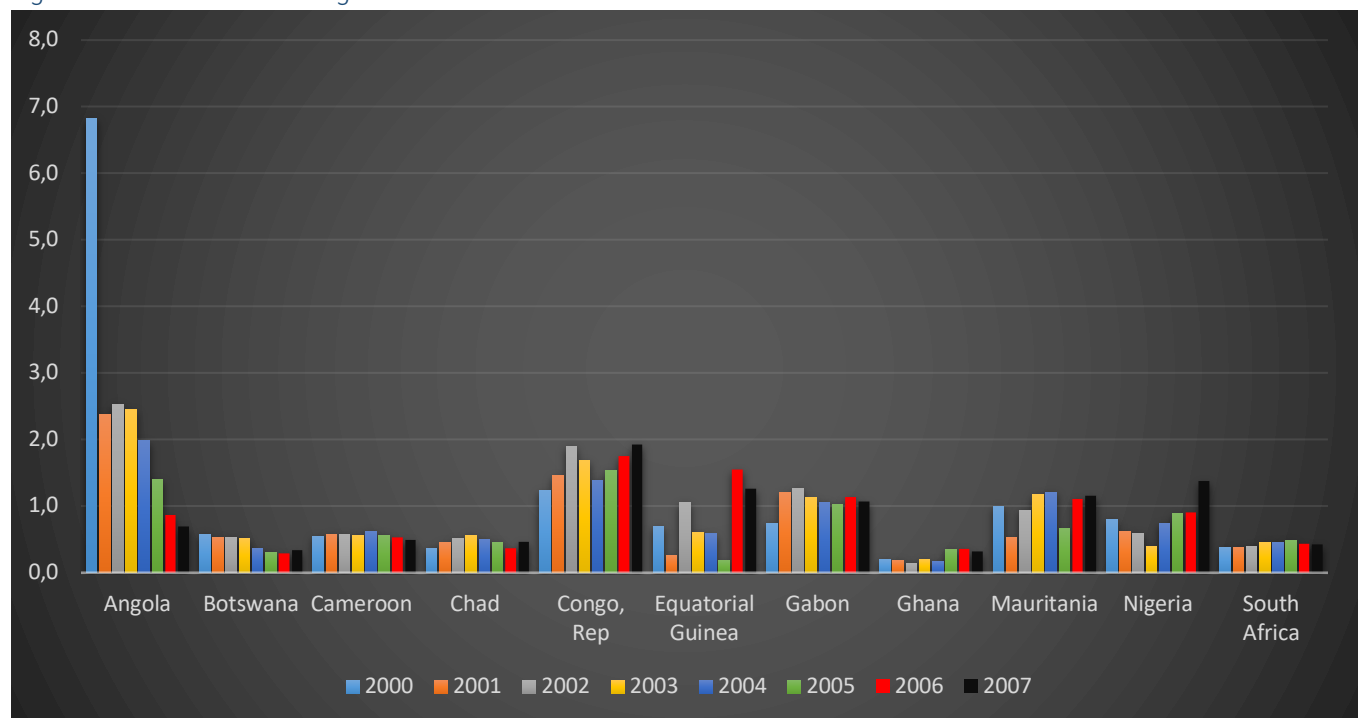
The Hartwick-Solow Rule developed by Hartwick (1977) and Solow (1974, 1986) offers a rule of thumb for assessing sustainability in resource-rich countries. This states that a non-declining level of consumption can be sustained if the value of investments equals the value of rents on extracted resources at each point in time.

Few African countries have adopted and implemented mineral revenue policy management that follows this approach. Botswana is usually praised for its good mineral revenue management and asset accumulation policies. Their finance policy framework stipulates that mineral revenues should be used to finance investment in other types of capital (African

Natural Resource Centre, 2016). This is to ensure that the country's asset base does not diminish and to provide the basis for alternative income-generating streams or mechanisms when the mineral resource becomes exhausted. The corollary from the asset-preservation principle is that non-investment (recurrent) expenditure must be financed from non-mineral sources. In Botswana mineral revenues are not separated from the rest of the budget but rather paid in to a Sinking Fund. The proceeds from the fund are used to smooth the fiscal balance when diamond prices fluctuate adversely.

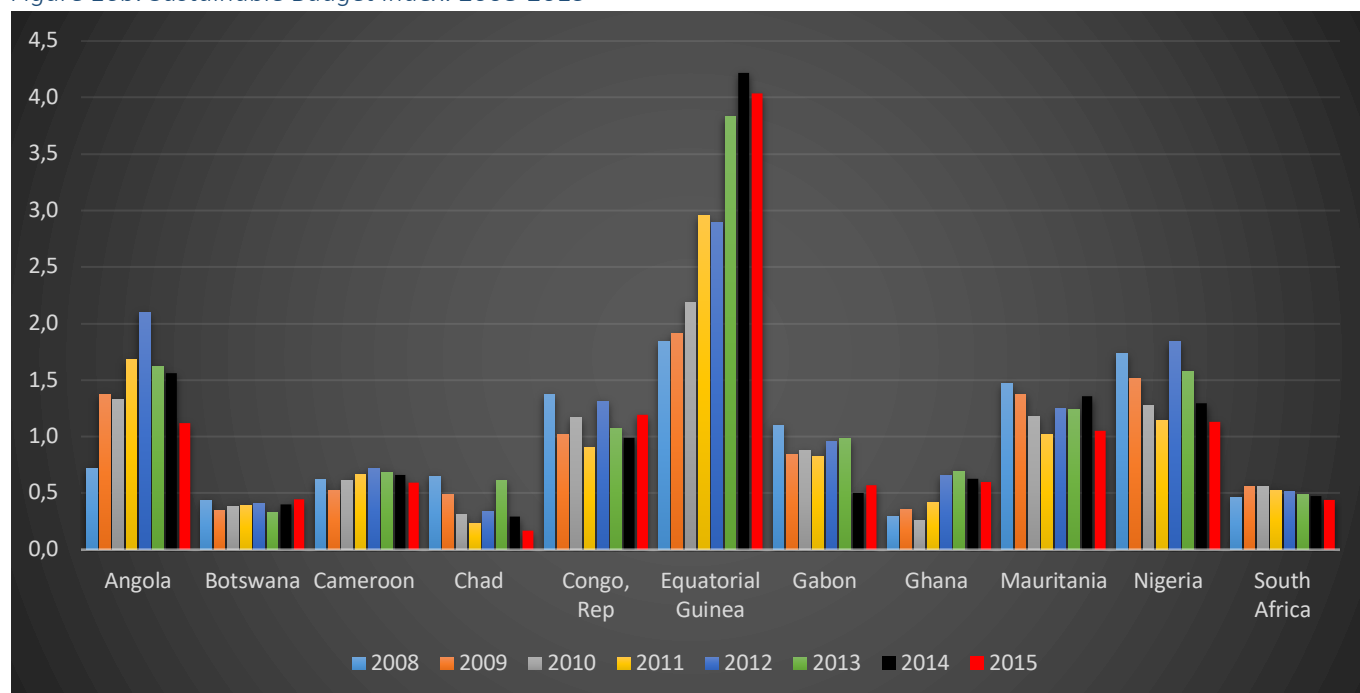
Historically, the implementation of the asset-replacement principle has been monitored through the Sustainable Budget Index, defined as the ratio of recurrent spending to non-mineral revenues. An SBI value of less than one suggest that the proceeds from the extraction of mineral resources is being spent on public investment or saved and then interpreted as (weakly) sustainable. An SBI value greater than one indicates that recurrent expenditure is being (partly) financed from mineral revenues, which is then interpreted as (weakly) unsustainable. In calculating the SBI, government expenditure is adjusted so that current educational and health spending is classified as investment in human capital and excluded from recurrent spending. We extend the SBI measure to the other mineral economies to get a first-order approximation of fiscal sustainability following Hartwick's rule:

Figure 16a: Sustainable Budget Index: 2000-2007



Source: Authors Own Calculations based on data from National Financial Authorities

Figure 16b: Sustainable Budget Index: 2008-2015

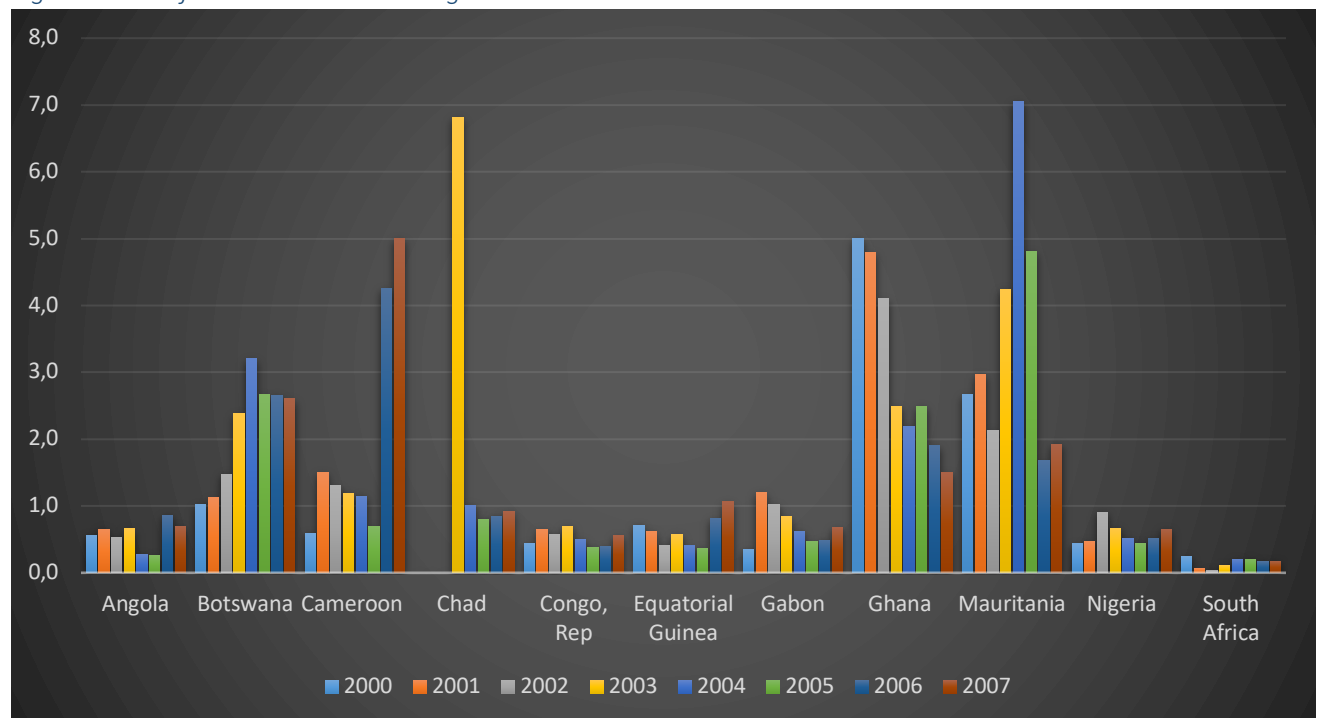


Source: Authors Own Calculations based on data from National Financial Authorities

The first-order approximation of the Hartwick-Solow rule to the sample of countries yields interesting results. The SBI for most countries has been greater than one, especially in Angola (13 years), Mauritania (12 years), Congo (12 years) and Equatorial Guinea (12 years). Chad (2 years) and Cameroon (7 years) surprisingly display relatively low signs of budget unsustainability. Botswana stands out as being highly sustainable with 0 years. Ghana and South Africa are mid-table with 4 years each. Marginal increases in the share of health and education in total expenditure is an important explanation of why the SBI has been on average below one in the “weakly sustainable economies”. Even though the Hartwick-Solow rule provides an easy rule of thumb, it is certainly not optimal for a low-income mineral-based economy. Collier and Venables (2008) show that the optimal growth path for these countries involves setting aside some of the resource rents for consumption. Their study however does not specify what should be the optimal consumption/investment ratio of resource rents. This leads us back to the El Serafy method and the beauty of its underlying logic. According to El Serafy, sustainability need not require that all resource rent be invested but that a portion can be consumed. While the earnings from the resource stock will end at some finite point in the future, sustainable income by definition must last forever. Thus, sustainable income is that part of resource receipts which if received infinitely would have a present value just equal to the present value of the finite stream of resource receipts over the lifetime of the resource.

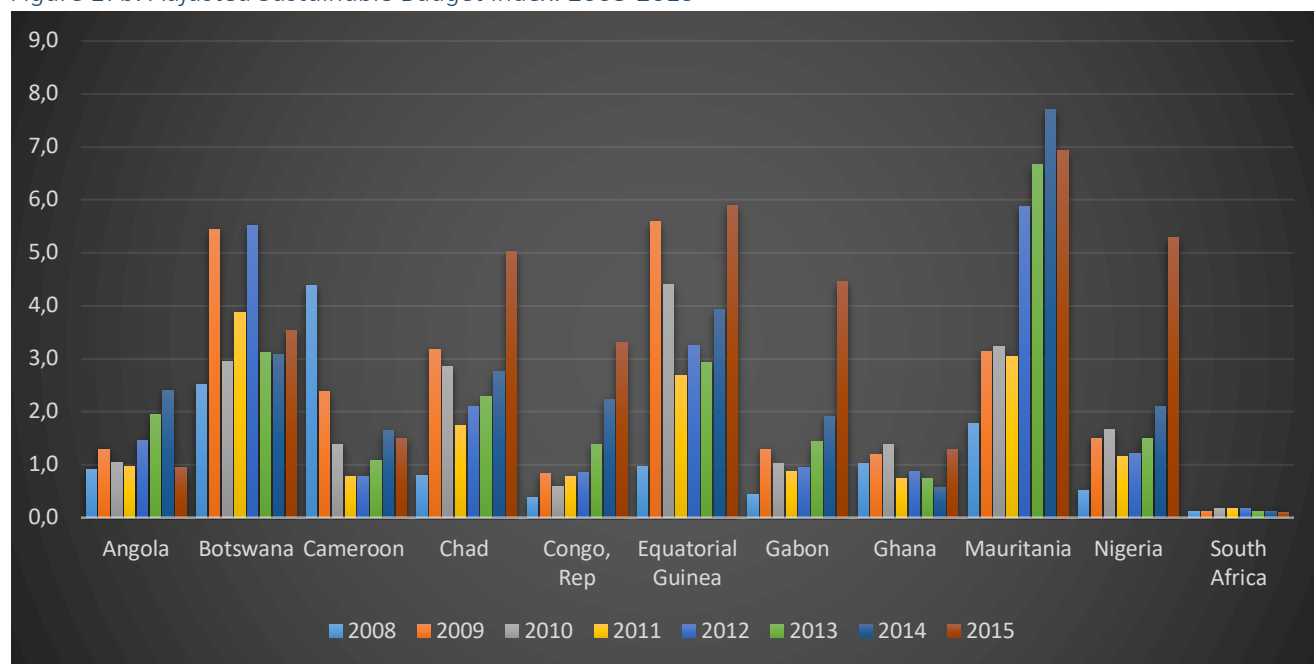
Given that we have already calculated the User cost from mineral extraction, we can estimate the sustainable income from resource rent extraction, which is the difference between total resource rents and User cost. We construct a relatively simple indicator called the Adjusted Sustainable Budget Index to test the fragility of fiscal policies in these economies. This simple test can be used to reveal the extent to which policy makers have internalised the message of the satellite accounts (where these accounts have been constructed) or failed to derive possible insights due to the absence of these satellite (mineral) accounts. The Adjusted Sustainable Budget Index is defined as the ratio of net investment expenditure to sustainable income as defined using the El Serafy method (which follows Hicks's view of income as the time derivative of wealth). An ASBI value greater than one suggest that the sustainable portion of resource rents is invested in other assets, human or physical, and thus is interpreted as (weakly) sustainable. An ASBI value of less than one indicates that current consumption is being (partly) financed from sustainable income which is then interpreted as (weakly) unsustainable. As with the calculation of the SBI, government expenditure is adjusted so that current educational and health spending is classified as investment in human capital and excluded from current consumption expenditure.

Figure 17a: Adjusted Sustainable Budget Index: 2000-2007



Source: Authors Own Calculations based on data from National Financial Authorities

Figure 17b: Adjusted Sustainable Budget Index: 2008-2015



Source: Authors Own Calculations based on data from National Financial Authorities

Prior to the global financial crisis, several economies had ASBI values below one and thus appeared to display signs of budget unsustainability. These “*high risk*” countries included Angola (8 years), Congo (8 years), Nigeria (8 years), South Africa (8 years), Equatorial Guinea (7 years), Gabon (6 years) and Chad (4 years). There was a declining trend in Ghana’s ASBI but it never dropped below one. Cameroon did not display any clear trends as the ASBI values fluctuated a little but fell below one only twice. On the other hand, Botswana and Mauritania displayed no signs of budget unsustainability either before or after the global financial crisis. In the aftermath of the 2008 global financial crisis, the ASBI of the “*high risk*” economies appears to display an increasing trend. This may be attributed to the fall in mineral commodity prices and the slow-down in economic growth that pushed the governments of most of these countries to reduce their current consumption expenditure, diversify their exports base and manage their resources rents more appropriately. The unexpected finding from this analysis is the fact that Botswana and South Africa display diametrically opposite trends when these economies arguably have better fiscal frameworks relative to the rest of their mineral-exporting peers. We would expect these two economies to display not exact but similar trends. We suspect that the El Serafy User cost term for mineral resource extraction in South Africa may have been underestimated. This would have inflated the estimated sustainable income of resource rent and resulted in understating the ASBI value.

The ASBI also has its limitations. Firstly, it aggregates capital (physical and human) and does not provide an indication of the distribution of sustainable income expenditure between the different types of capital. The productivity of the different types of capital and consequently their economic impact is different at specific periods for these economies. South Africa suffers from a shortage of highly skilled workers and experiences (youth) unemployment although it is among the top countries with a high level of human capital investment.

Discussion and Policy Implications

The economic performance of resource-rich African countries has not been consistent and to some extent can be considered disappointing as many struggled to manage windfall gains from a primary commodities price boom efficiently. A number of theories have been developed to explain the failure of mineral-rich economies to capitalize on their natural resource endowments and achieve long-term sustainable growth and development. The first factor is the quality of institutions, which in turn affect the quality of the economic policies that tend to be put in place (Auty, 1997). The fact that resource-poor countries typically outperform resource-rich countries seems to be a robust finding. Robinson et al. (2006) produced one of the most comprehensive studies on the relationship between an abundance of resource revenues, political accountability and the quality of institutions in the economy. Their argument and empirical evidence suggest that governments that do not have to introduce socially tolerable and consistent systems of taxation but can instead finance themselves through resource revenues have reduced incentives to be accountable and responsive to their citizens. Consequently, they do not have a stake in the development of a thriving market-based, non-resource economy that is otherwise required to establish a taxable economic base and secure the fiscal sustainability of the state. Table 3 shows that with the exception of Botswana and South Africa, all the countries in this study had very poor scores for the index of institutional quality and furthermore share other adverse institutional features, as illustrated in table 3 (World Bank, 2015). In contrast, governments in non-resource countries have an incentive to promote the development of a market-based economy as it generates a multitude of corporate and individual taxpayers, providing a steady and stable source of revenue for the state. Auty (1997) analysed the economic and institutional performance of resource-deficient and resource-rich countries and his findings are in line with those of Robinson et al.

In the Robinson et al. (2006) model, the existence of resources and associated rents increases the utility of holding political power for too long. As a result, political horizons across a range of policy issues are short-sighted and sub-optimal from a social welfare perspective. Most of the resource revenues are directed towards the single purpose of keeping political power. One manifestation of this is a bloated public sector, which has a stake in keeping the status quo and is paid off through the rents emanating from the resource sector. Unsurprisingly, a number of prominent studies (Auty, 1997 and 2004; Collier, 2010) have found a strong evidence that resource abundance is associated with higher levels of corruption. Seven out of eleven countries, namely Angola, Cameroon, Chad, Congo-Brazzaville, Equatorial Guinea and Nigeria in our study, rank among the most corrupt in the world according to the World Bank's Governance Quality Index (2015). Secondly, mineral commodity prices tend to be highly volatile which renders mineral economies fragile due to their heavy reliance on them. Cairncross (1962) and Prebisch (1964) were among the first to highlight the adverse impact of primary commodity prices on the economies of exporting countries.

The rent-seeking and broader political economy literature on the resource curse helps explain the prevalence of poor public investments financed by resource-related public revenue windfalls. Torvik (2009) suggest that one of the biggest issues concerning resource-rich countries is why massive domestic investments in some of them have not resulted in greater growth gains. Gelb (1988) estimated that more than half of the bonus gains from the rise in oil prices in the 1970s were invested in domestic projects. Any of the leading growth models would have predicted that following such significant public investment strong and sustainable economic growth would have occurred but this was not the case for several of the countries in this study. A number of reasonable arguments that have been advanced to explain why the expected growth failed to happen. In a study of the response by the Nigerian government to positive terms of trade shocks during the oil boom, Gavin (1993) found that the government largely invested in projects with high prestige and political gains but which made little economic sense. Nigeria is not the only country to behave like this. The tendency to invest in projects with negative social surplus is typical of many resource-rich African governments. Auty (2004), using a staple trap model, finds that most mineral exporting countries tend to be severely distorted by sub-optimal patterns of resource rent absorptions during periods of high

price volatility caused by overly ambitious government attempts to increase employment and other misjudgements in expenditure priorities.

Several studies have also highlighted the strong relationship between resource abundance and conflict or war. Collier and Hoeffler (1998 and 2004) argue that resource-rich countries face conflict for two main reasons. First, the resource rents are used to buy weapons and pay the soldiers. Secondly, because resources often have a winner-takes-all quality with big payoffs for the winner and a limited need for cooperation with losers in the future to extract rents, resources trigger fierce struggles over control. A good example is the Democratic Republic of Congo that has suffered from social and political instability since its independence in the 1960s. The governments of Chad, Cameroon and Nigeria have launched large-scale military operations against the Islamist terrorist group Boko Haram since 2012. Significant government expenditure has been directed towards buying military equipment and paying soldiers involved in the war. The cumulative military expenditure from 2012 -2015 for Chad, Cameroon and Nigeria was \$1.8, \$1.7 and \$10.9 billion US dollars respectively.

The approach of the Brundtland report (WCED, 1987) to sustainable growth is broad: “growth that meets the needs of the present without compromising the ability of future generations to meet their own needs and the management of human, natural and financial assets to increase long term economic wellbeing”. An economy that experiences rapid expenditure growth funded by the extraction of mineral resources without increasing its overall stock of wealth by investing in physical and human capital will not be able to sustain its economic growth in the long-run. Furthermore, such an economy runs the risk of sacrificing the wealth of future generations to finance current consumption, i.e. it fails even the Brundtland definition of sustainability.

A growth strategy that is sustainable needs to account for the temporal and inter-generational dimensions of resource wealth by ensuring that current growth does not come at the expense of future growth. It is important to acknowledge that the discovery of new mineral resources or an increase in the stock of reserves of existing mineral resources can also play a positive role.

Adopting and implementing policies that increase savings and maximize rents from mineral resources, sustaining human capital investment, and putting in place transparent and

consistent fiscal policies will be vital to building a government's policy credibility and expand the available space for public investment or free up resources to build fiscal reserves.

For sustainable economic growth to be achieved it is also important that the revenues from mineral resources are reinvested into different types of productive capital. This requires a strong policy framework grounded by clear policy commitments. According to the World Bank (2013) such policy commitments should include

- (i) efforts to promote efficient resource extraction with a view to maximizing resource rents;
- (ii) a fiscal regime for the resource sector that enables the government to recover an equitable share of resource rents;
- (iii) well-designed investment that uses resource rents to generate sustainable returns over the long term.

Challenges to Efficiently Managing Resource Rents

The implementation of '*best practice*' policies in mineral-based economies requires economic and political reforms that can prevent stakeholders seeking to capture a disproportionate share of mineral rents. This is very challenging especially as it has been shown that economies with low reserves to production ratios tend to be more likely to implement economically beneficial reforms which will help, diversify the economy (Auty, 2004; Eifert et al., 2003). On the other hand, countries with high reserves to production ratios tend to procrastinate on economic transformation reforms. The latter will use their minerals as collateral to secure loans to maintain current consumption patterns with the hope that the prices of their minerals will return to earlier high levels. One of the main issues that was highlighted earlier is the difficulty of finding accurate information on mineral resource stocks. In this study, it was necessary to gather mineral resource stocks from different sources as no source had data consistently for the period examined for the entire sample of countries. With the exception of Botswana and South Africa, there are no comprehensive data or statistics on wealth accounting nor even a pretence by the governments of Angola, Cameroon, Congo (Brazzaville), Equatorial Guinea, Gabon, Ghana, Mauritania and Nigeria to create and regularly update accounts so as to show the evolution of the stock of mineral resources. As a first step

towards sustainable mineral resource management, the national authorities of these countries should develop resource accounts for their existing stock of minerals and ensure that these accounts are updated at regular intervals and in line with international best practices. Implementing this as well as the other recommendations of the United Nations SEEA would help to preserve, protect and enhance each country's national wealth, thus building a foundation for the prosperity of both present and future generations.

Another difficulty with efficiently managing resource rents in order to achieve sustained economic growth involves determining the right proportion of the resource rents to invest and consume. The ultra-prudent approach is that all the resource rents should be invested and none should be consumed. This view is extreme and difficult to implement in real life, especially for developing countries which suffer from infrastructural constraint and a relatively high [youth] unemployment rate. The El Serafy method used in this study offers some guidance on how possibly to deal with this investment-consumption trade-off. Sustainability need not require that all resource rents be invested (as Hartwick suggested in 1997); a portion can be consumed. Sustainable income is that part of resource receipts which if received infinitely would have a present value just equal to the present value of the finite stream of resource receipts over the lifetime of the resource. Therefore, the amount of resource rents available to invest is the sustainable income from the resource rents. When assessing different investment opportunities, the marginal returns offered by different types of public investment should be the determining factor. Cameroon, Chad and Congo, for example, suffer from a considerable lack infrastructure in the form of roads and railway lines, which is typical of many African countries. These deficiencies suggest that increased investment in road infrastructure will generate strong economic returns. Yet even though shortages of physical capital (roads) are certainly constraining development, on the other hand and in the medium term especially, the absorptive capacity of these countries is likely to be low and an overemphasis on these forms of capital may result in unproductive investments. Therefore, the time path for the use of revenues needs to be carefully thought out. One possibility is to keep at least some part of the revenues in a sovereign wealth fund in the short term, as is done by many of the oil-rich Middle-East Arab countries. As table 4 shows, six out of eleven of the countries in this study have created a sovereign wealth fund whose objective is to accumulate assets that parallel the hypothetical ones in the El Serafy

calculation. According to Collier (2012), the classic sovereign wealth fund is inappropriate for low-income resource-rich countries because in capital inadequate economies, accumulating long-term foreign investments is not warranted and the central objective should be to develop domestic infrastructure. Similarly, Van der Ploeg (2008) argued that an international sovereign wealth fund is not appropriate for a capital-scarce country as it is too conservative in that it prevents any short-term increases in consumption. The opposing view is that it will be detrimental to the economy if an SWF can only invest domestically, because it will not be performing one of its major functions, which entails reducing Dutch disease pressures and thus would add to macroeconomic instability. Secondly, the SWF is exposed to domestic political pressures where special interest groups would push the implementation of investment projects, which very often have minimal economic justification (African Natural Resource Centre, 2016).

While it is true that establishing an SWF with a well-defined mandate could be considered to be taking a step in the right direction, countries need to push even further and implement reforms that will improve the quality of institutions, which play a key role in the management of resource revenues. Good institutions are crucial because they ensure that investment projects are carefully selected, implemented and subsequently evaluated. This is why good governance and fiscal transparency should also be major priorities for resource-rich African countries. For these economies to achieve fiscal transparency, it is imperative that they follow good practices such as establishing an open budget process, making data on mineral resources publicly available and making sure that the data are of good quality.

Conclusion

Although many African countries are richly endowed in mineral resources and heavily reliant on them for economic welfare, the over-exploitation of these resources and the inadequate management of the associated revenues poses a threat for the sustainability of their income growth and development. The key policy question raised from this analysis is: how can these mineral rich economies embark on a sustainable resource revenue management and income growth path? Given the heterogeneity of mineral rich economies, it may seem unfeasible to formulate a single policy prescription that is consistent across the set of countries. This is true to a certain extent. However, the El Serafy approach which we

computed, notwithstanding country specific factors enables policy makers to estimate the portion of the revenues from resource extraction, which they can safely spend without diminishing the welfare of the future generations. It does not end here. The estimated User cost can be used to adjust *standard measures* of national income for the depletion of natural capital and in the process contribute in establishing a 'properly defined' national income which corrects for resource depletion to inform sustainable fiscal policy in these countries. Other complementary efforts on the part of the governments in these economies establishing an open budget process, fiscal transparency, developing mineral resources accounts (where they do not exist) which should be publicly accessible and regularly updated. Knowing the capacity constraints of many African governments and their difficulty in undertaking coherent sustainable resource management, this cannot be left entirely to policy makers and economic planners. It is equally contingent on extractive companies to understand that it is to their commercial advantage that minerals are exploited sustainably and the rents managed efficiently by government in order to provide an enabling environment for sustained income growth and development.

Appendix 1: Data Sources

Angola

Crude Oil and Natural Gas production figures source: OPEC Database, World Bank Database, USGS Mineral Yearbook. Diamond production estimates from the Kimberley Process Website, U.S Geological Survey Mineral Commodity Summaries and the US Bureau of Mines 1987.

Botswana

Diamonds production figures source: Botswana Mineral Accounts Report, Statistics Botswana and Economic Accounting of Mineral Resources in Botswana, U.S Geological Survey Mineral Yearbook.

Cameroon

Crude Oil production figures source: “Banques des Etats de l’Afrique Centrale” database, World Bank Database, USGS Mineral Yearbook, U.S Geological Survey Mineral Commodity Summaries and the U.S Bureau of Mines 1987.

Chad

Crude Oil production figures source: “Banques des Etats de l’Afrique Centrale” database, World Bank Database, USGS Mineral Yearbook, U.S Geological Survey Mineral Commodity Summaries and the U.S Bureau of Mines 1987.

Congo Brazzaville

Oil & Natural Gas production data source: OPEC Database, U.S Geological Survey Mineral Yearbook, “Banques des Etats de l’Afrique Centrale” database.

Equatorial Guinea

Crude Oil & Natural Gas production figures data source: OPEC Database, “Banques des Etats de l’Afrique Centrale” database.

Gabon

Crude Oil & Natural Gas production figures data source: OPEC Database, “Banques des Etats de l’Afrique Centrale” database. Other major mineral is manganese but reliable production figures were unavailable.

Ghana

Crude Oil, Diamonds and Gold production figures data source: World Bank Database, US Geological Survey Mineral Commodity Summaries, and US Bureau of Mines 1987.

Mauritania

Crude Oil, Copper, Gold and Iron-ore production figures data source: the Mauritania Natural Wealth for a Sustainable Future Report, United States Geological Survey Minerals Yearbook, US Geological Survey Mineral Commodity Summaries and US Bureau of Mines 1987.

Nigeria

Oil & Natural Gas production figures data source: the OPEC Database, the United States Geological Survey Minerals Yearbook, US Geological Survey Mineral Commodity Summaries and US Bureau of Mines 1987.

South Africa

Data on Coal, Gold, Platinum and Diamond production data source: Statistics South Africa, the South African Chamber of Mines, the South African Department of Trade & Industry and the Kimberley Process Website.

Appendix 2: Budget Sustainability Index

Table 2a: Frequency of SBI greater than one suggesting the Budget is weakly sustainable

Country	Number of Years	Average value
Angola	13 years	1.92
Botswana	0 years	0.42
Cameroon	7 years	0.60
Chad	2 years	0.43
Congo, Rep	12 years	1.37
Equatorial Guinea	11 years	1.88
Gabon	8 years	0.96
Ghana	4 years	0.37
Mauritania	12 years	1.11
Nigeria	9 years	1.12
South Africa	4 years	0.47

Source: Author's Own Calculations.

Table 2b: Frequency of ASBI less than one suggesting Budget is weakly sustainable

Country	Number of Years	Average value
Angola	11 years	2.0
Botswana	0 years	5.9
Cameroon	4 years	3.7
Chad	5 years	4.7
Congo, Rep	13 years	1.8
Equatorial Guinea	8 years	4.3
Gabon	9 years	2.3
Ghana	4 years	4.1
Mauritania	0 years	8.2
Nigeria	9 years	2.5
South Africa	16 years	0.3

Source: Author's Own Calculations.

Appendix 3: Institutional Quality Index for selected African countries

Table 3a Index of Institutional Quality, 1995

Country	Voice Accountability	Political stability	Effective governance	Regulation burden	Rule of law	Control of Corruption	Overall index
Angola	-1.28	-1.98	-1.31	-1.38	-1.49	-1.14	-8.58
Botswana	0.86	1.01	0.56	0.65	0.58	0.82	4.49
Cameroon	-0.94	-0.96	-1.08	-1.12	-1.44	-1.33	-6.87
Chad	-0.99	-1.00	-0.64	-1.23	-1.26	-1.38	-6.49
Congo, Rep	-0.83	-1.22	-1.17	-1.23	-1.04	-0.86	-6.35
Equatorial Guinea	-1.52	-0.13	-0.96	-1.44	-1.28	-1.26	-6.60
Gabon	-1.10	-0.20	0.12	0.14	-0.65	-0.32	-2.02
Ghana	-0.21	-0.23	-0.12	-0.34	-0.23	-0.34	-1.48
Mauritania	-0.57	0.37	-0.12	-0.40	-0.50	-0.56	-1.79
Nigeria	-1.55	-1.06	-0.92	-0.97	-1.29	-1.19	-6.98
South Africa	0.84	-0.38	1.02	0.52	0.09	0.73	2.82

Source: World Bank (1995)

Table 3b Index of Institutional Quality, 2005

Country	Voice Accountability	Political stability	Effective governance	Regulation burden	Rule of law	Control of Corruption	Overall index
Angola	-1.23	-0.89	-1.14	-1.26	-1.43	-1.30	-7.24
Botswana	0.59	1.06	0.65	0.67	0.64	1.16	4.78
Cameroon	-1.03	-0.18	-0.91	-0.93	-1.21	-1.18	-5.45
Chad	-1.31	-1.44	-1.38	-1.24	-1.51	-1.51	-8.39
Congo, Rep	-1.08	-1.17	-1.27	-1.31	-1.47	-1.04	-7.35
Equatorial Guinea	-1.68	-0.39	-1.43	-1.43	-1.46	-1.61	-8.01
Gabon	-0.67	-0.81	0.33	-0.15	-0.45	-0.83	-2.58
Ghana	0.20	0.17	-0.19	-0.13	-0.12	-0.37	-0.43
Mauritania	-0.91	-0.23	-0.29	-0.37	-0.71	-0.56	-3.08
Nigeria	-0.87	-1.67	-0.89	-0.76	-1.35	-1.16	-6.70
South Africa	0.65	-0.16	0.64	0.70	0.11	0.57	2.51

Source: World Bank (2005)

Table 3c Index of Institutional Quality, 2015

Country	Voice Accountability	Political stability	Effective governance	Regulation burden	Rule of law	Control of Corruption	Overall index
Angola	-1.18	-0.50	-1.00	-0.91	-1.08	-1.39	-6.06
Botswana	0.44	1.04	0.50	0.44	0.60	0.85	3.86
Cameroon	-0.95	-0.99	-0.77	-0.92	-0.98	-1.07	-5.68
Chad	-1.34	-0.97	-1.46	-1.21	-1.18	-1.36	-7.53
Congo, Rep	-1.02	-0.53	-1.02	-1.20	-1.08	-1.20	-6.04
Equatorial Guinea	-2.00	-0.21	-1.42	-1.35	-1.46	-1.77	-8.19
Gabon	-0.71	-0.73	0.02	-0.80	-0.55	-0.89	-3.67
Ghana	0.50	-0.03	-0.25	-0.03	0.14	-0.20	0.13
Mauritania	-0.89	-0.64	-1.03	-0.87	-0.87	-0.92	-5.21
Nigeria	-0.37	-1.93	-0.96	-0.85	-0.96	-1.08	-6.15
South Africa	0.65	-0.21	0.26	0.28	0.09	0.03	1.10

Source: World Bank (2015)

Appendix 4: Sovereign Wealth Funds

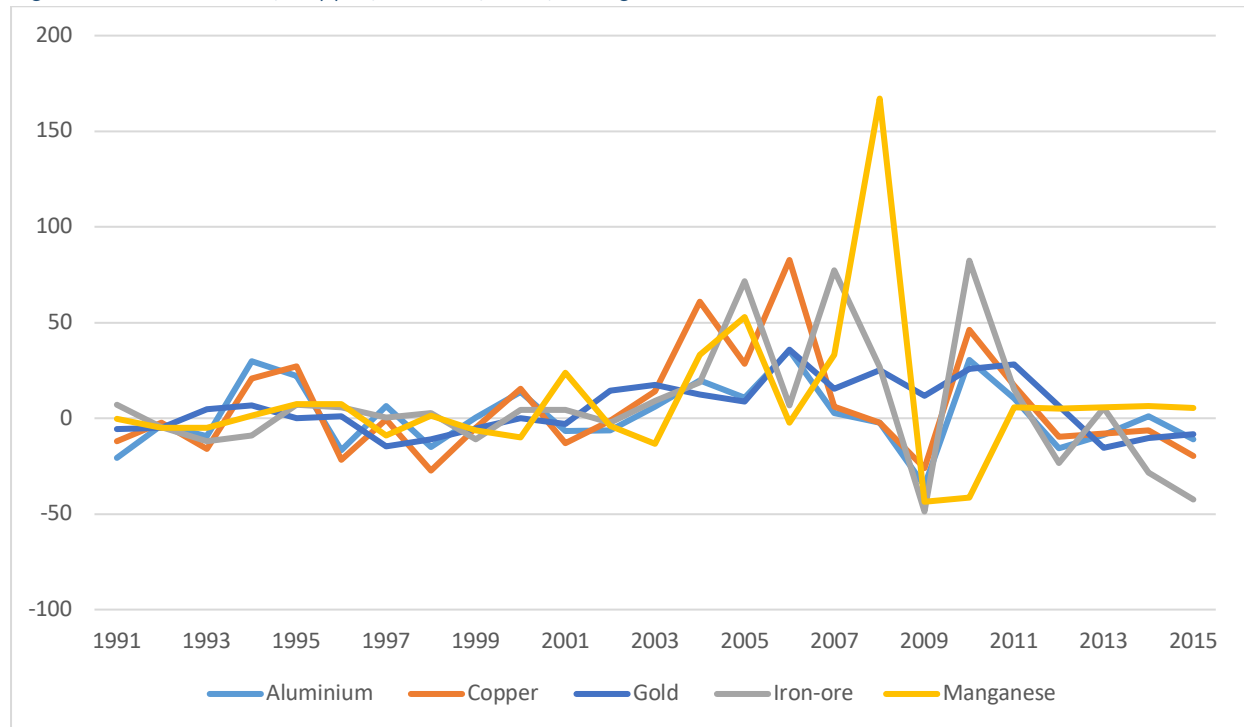
Table 4: Sovereign Wealth Funds in sub-Saharan Africa

Country	Fund Authority	Inception	Source of funding
Angola	Angola Sovereign Fund	2012	Oil
Botswana	Pula Fund	1996	Diamonds
Equatorial Guinea	Fund for Future Generations	2002	Oil
Gabon	Sovereign Fund of Gabon	1998	Oil
Ghana	Ghana Stabilization Fund	2011	Oil
	Ghana Heritage Fund	2011	Oil
Nigeria	Nigerian Sovereign Investment Authority	2011	Oil

Source: International Working Group on Sovereign Wealth Funds (2008)

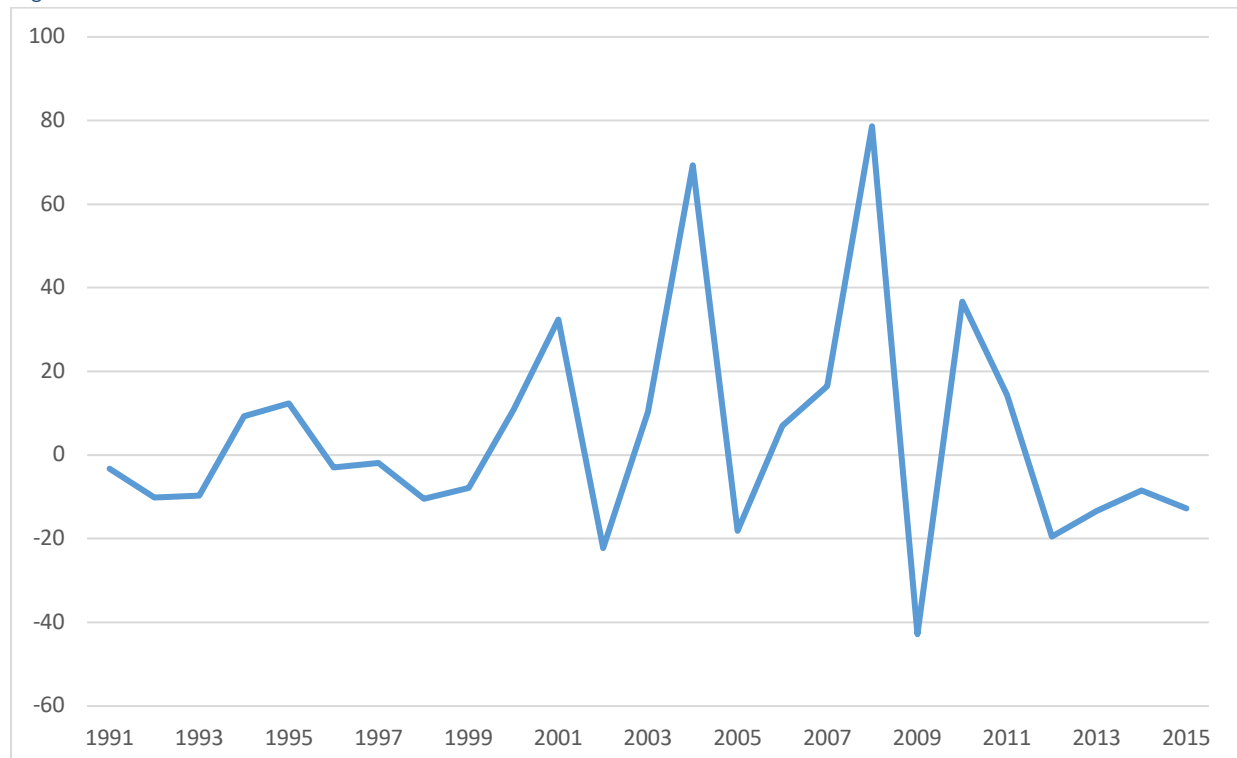
Appendix 5: Mineral Commodities Yearly Prices Fluctuations

Figure 18a: Aluminium, Copper, Iron-ore, Gold, Manganese Price Fluctuations



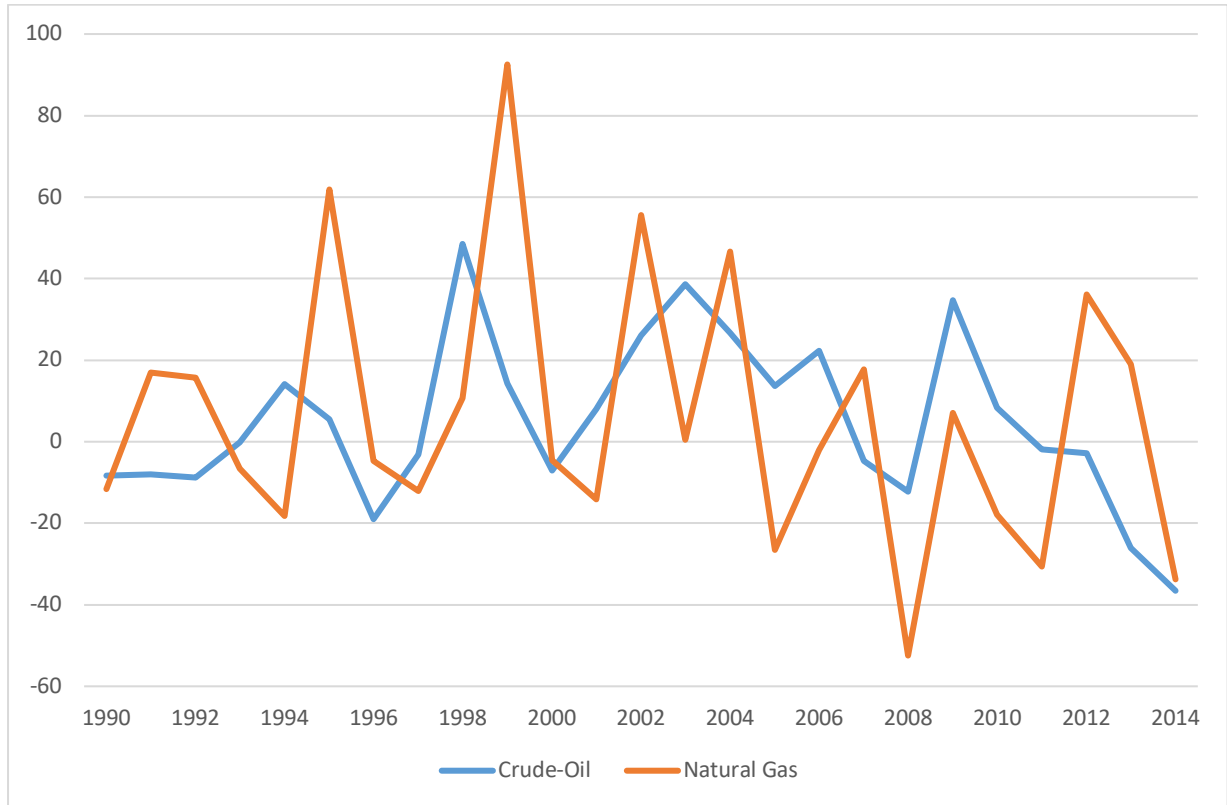
Source: International Monetary Fund: World Economic Outlook

Figure 18b: Coal Price Fluctuations



Source: International Monetary Fund: World Economic Outlook

Figure 18c: Crude Oil and Natural Gas Price Fluctuations



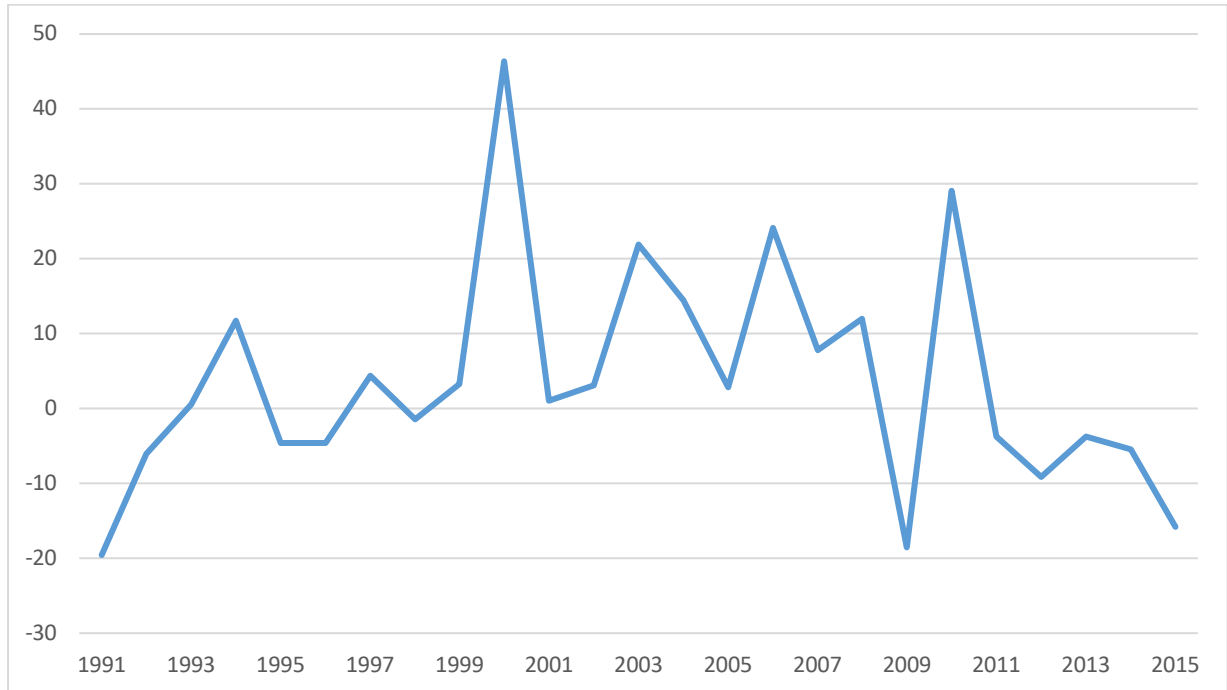
Source: International Monetary Fund: World Economic Outlook

Figure 18d: Diamonds Price Fluctuations



Source: International Monetary Fund: World Economic Outlook

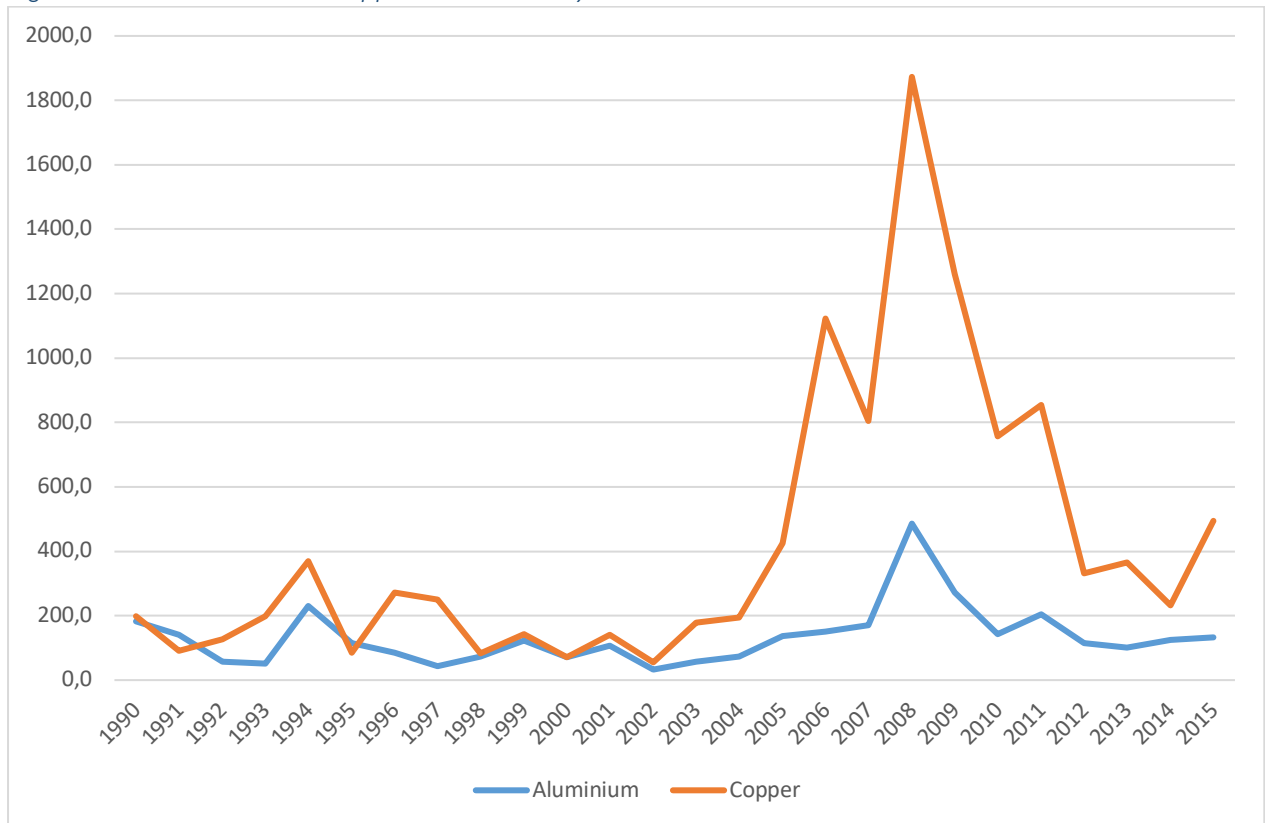
Figure 18e: Platinum Group Metals Price Fluctuations



Source: International Monetary Fund: World Economic Outlook

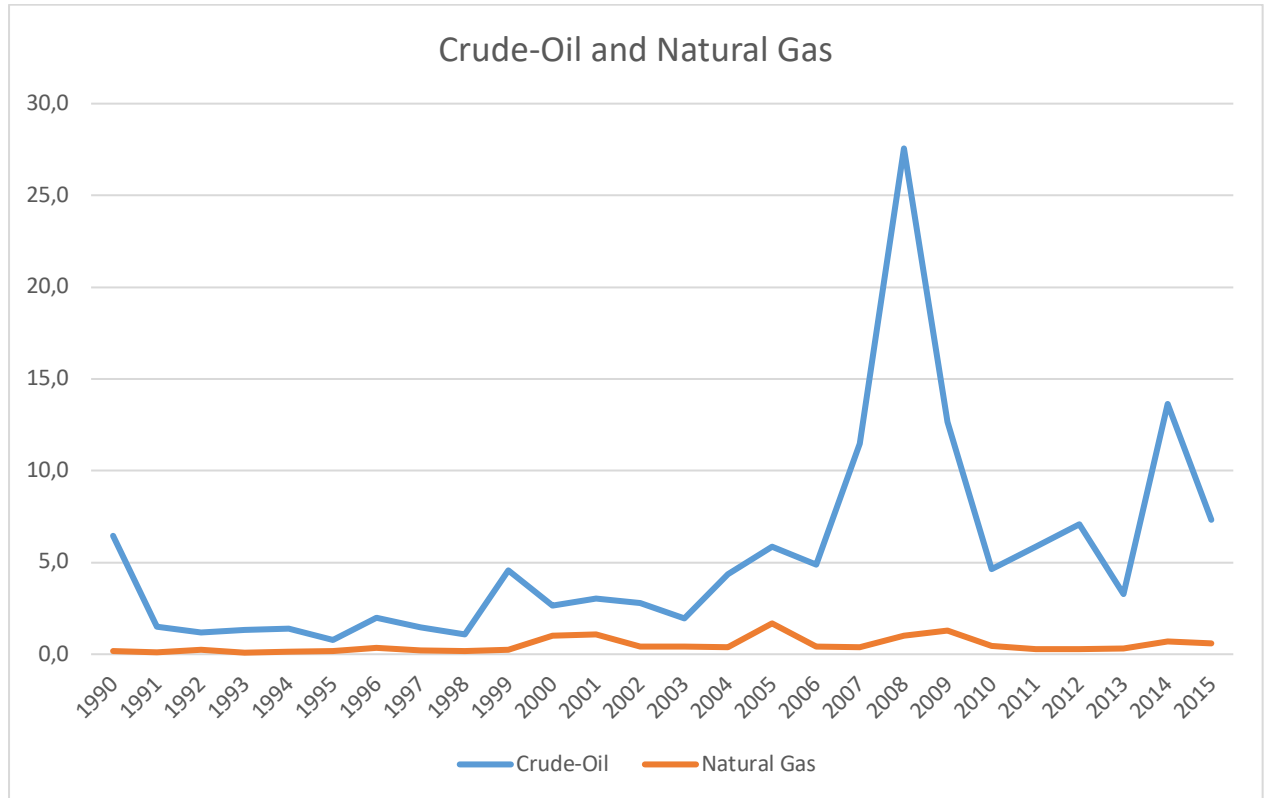
APPENDIX 6: Mineral Commodities Annualized Price Volatility

Figure 19a: Aluminium and Copper Price Volatility



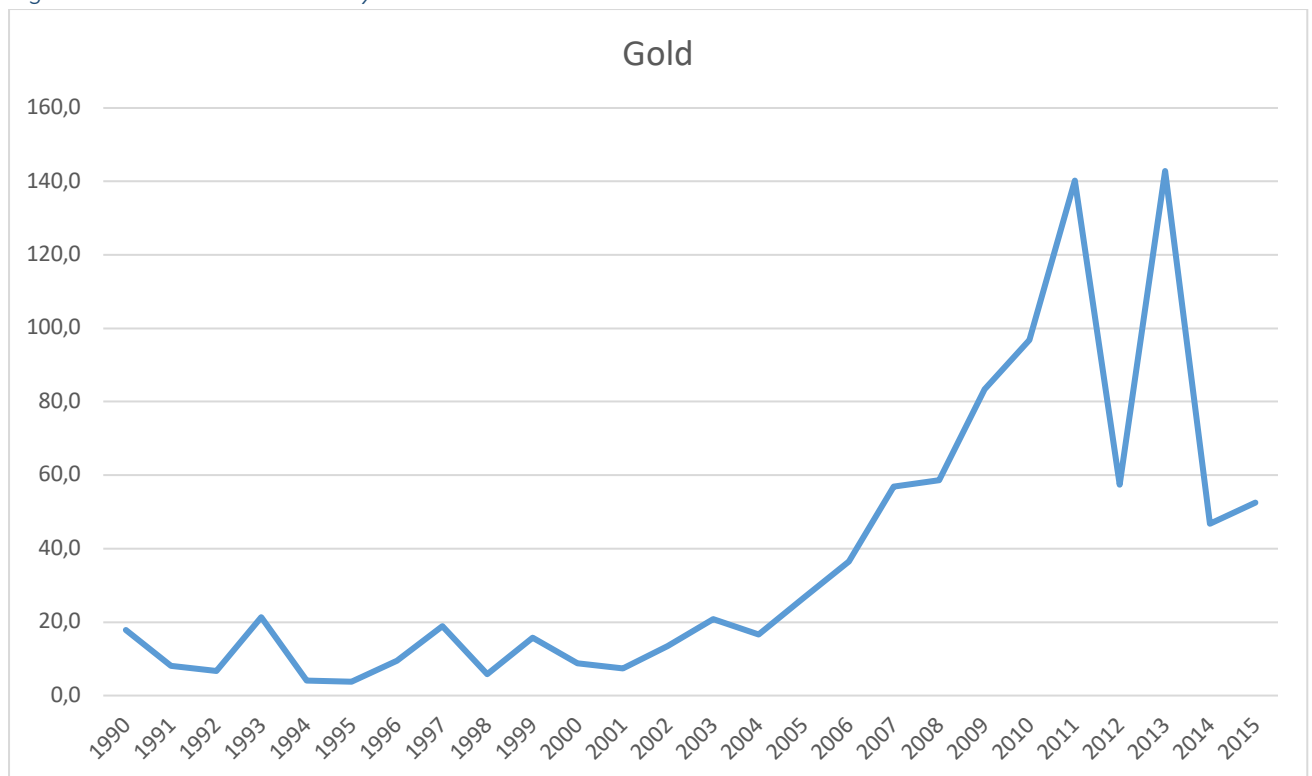
Source: International Monetary Fund: World Economic Outlook

Figure 19b: Crude Oil and Natural Gas Price Volatility



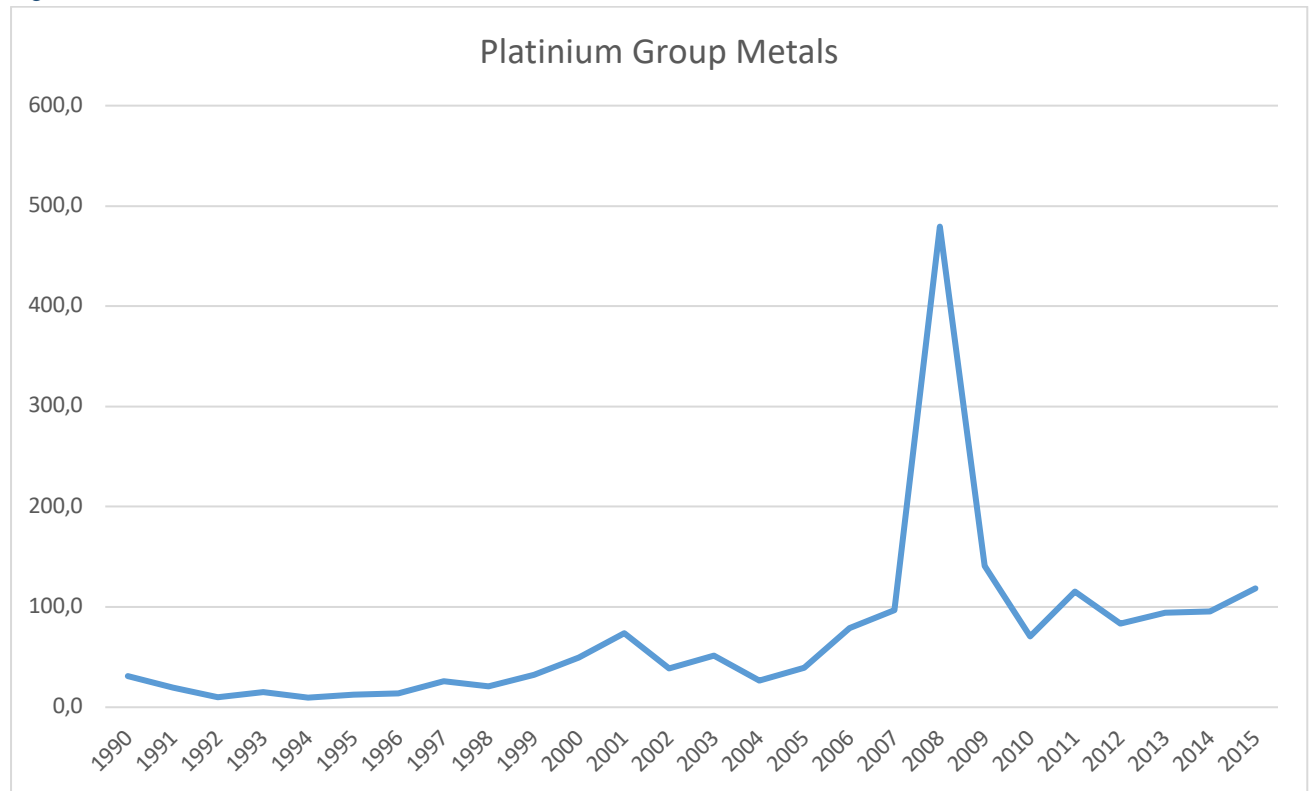
Source: International Monetary Fund: World Economic Outlook

Figure 19c: Gold Price Volatility



Source: International Monetary Fund: World Economic Outlook

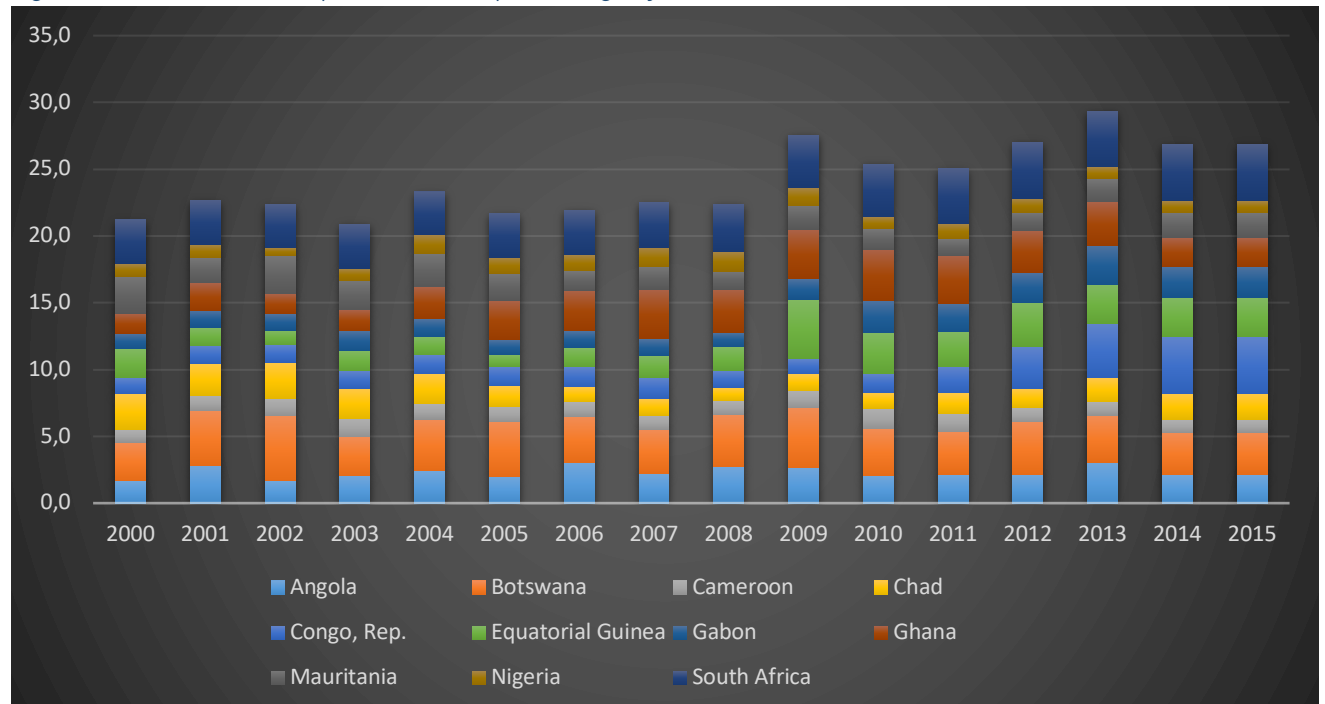
Figure 19d: Platinum \$/Oz Price Fluctuations



Source: International Monetary Fund: World Economic Outlook

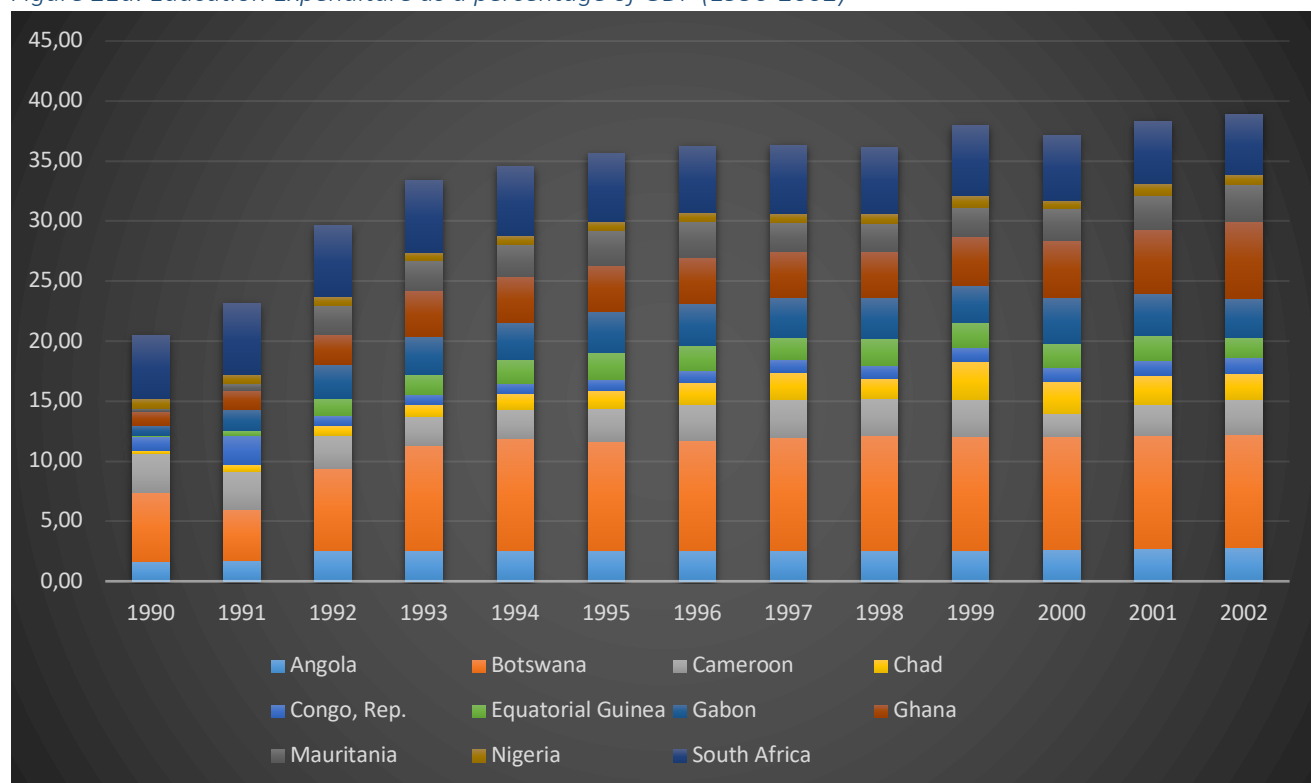
Appendix 7: Public Health and Education Expenditure

Figure 20: Public Health Expenditure as a percentage of GDP



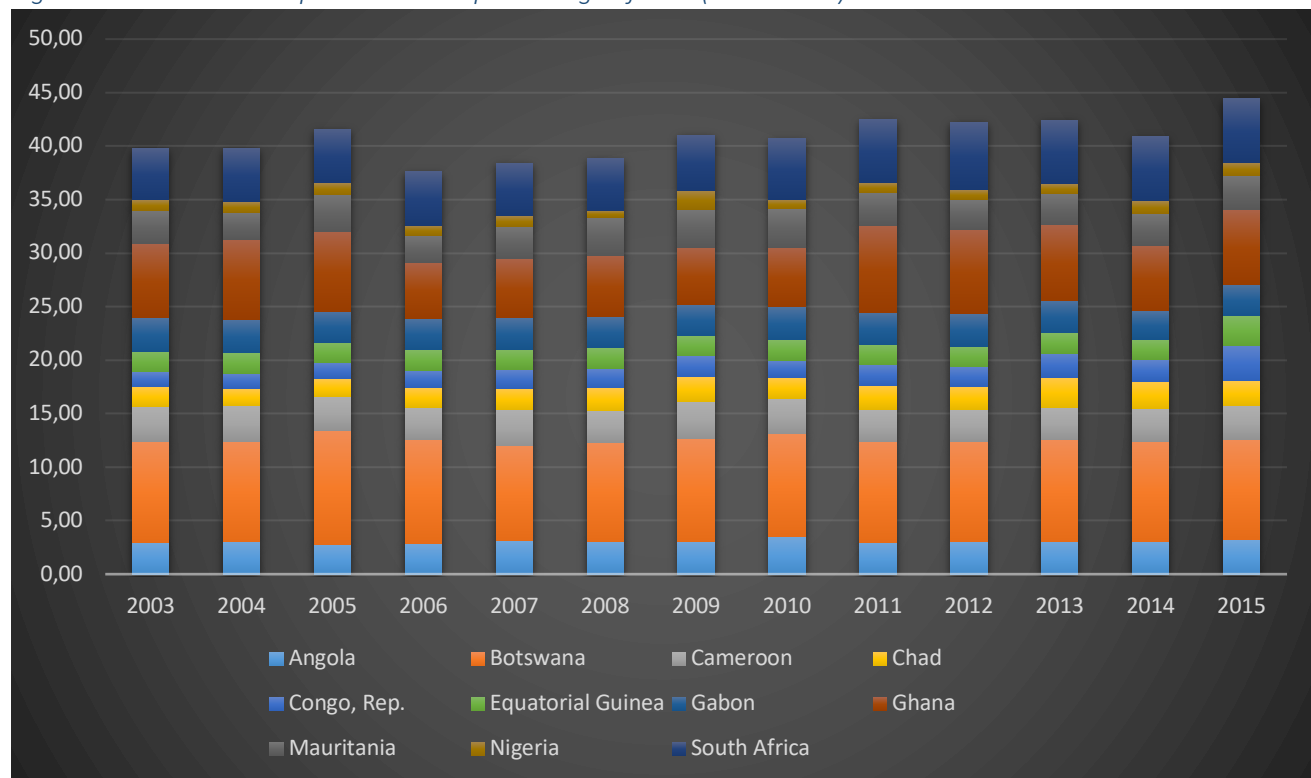
Source: World Bank: World Development Indicators, Domestic National Accounts

Figure 21a: Education Expenditure as a percentage of GDP (1990-2002)



Source: World Bank: World Development Indicators, Domestic National Accounts

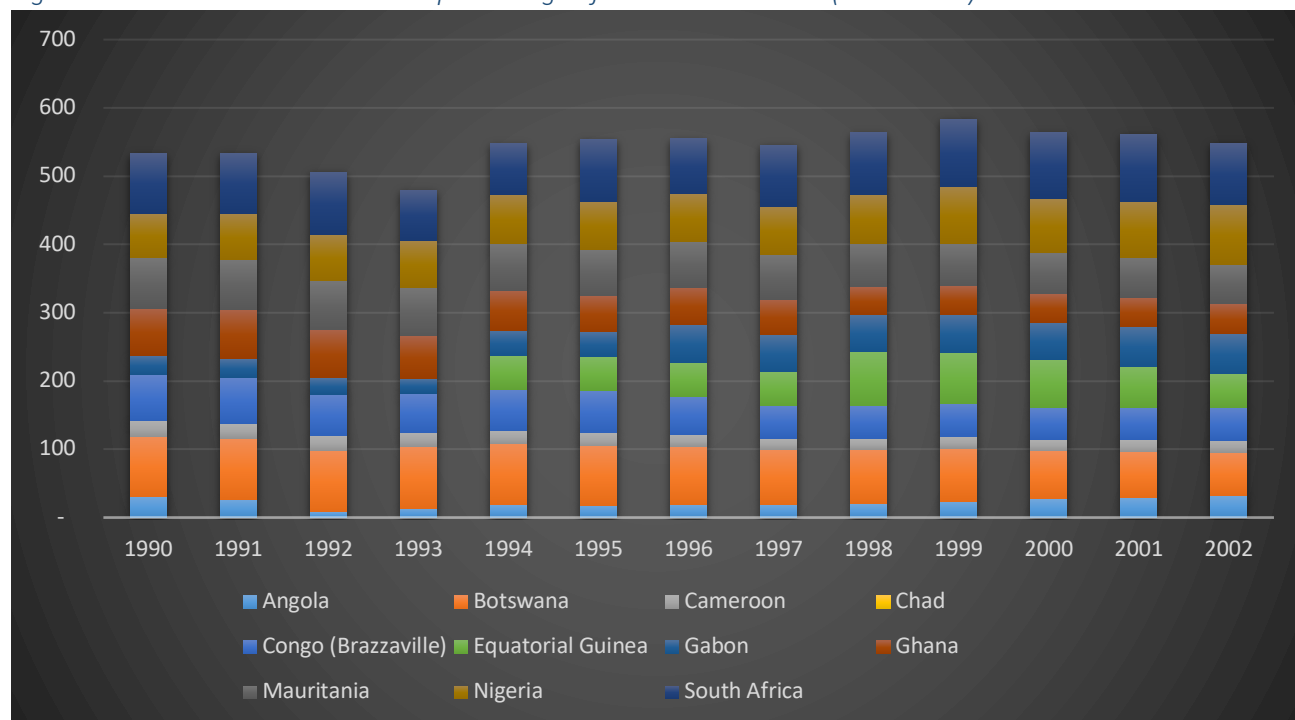
Figure 21b: Education Expenditure as a percentage of GDP (2003-2015)



Source: World Bank: World Development Indicators, Domestic National Accounts

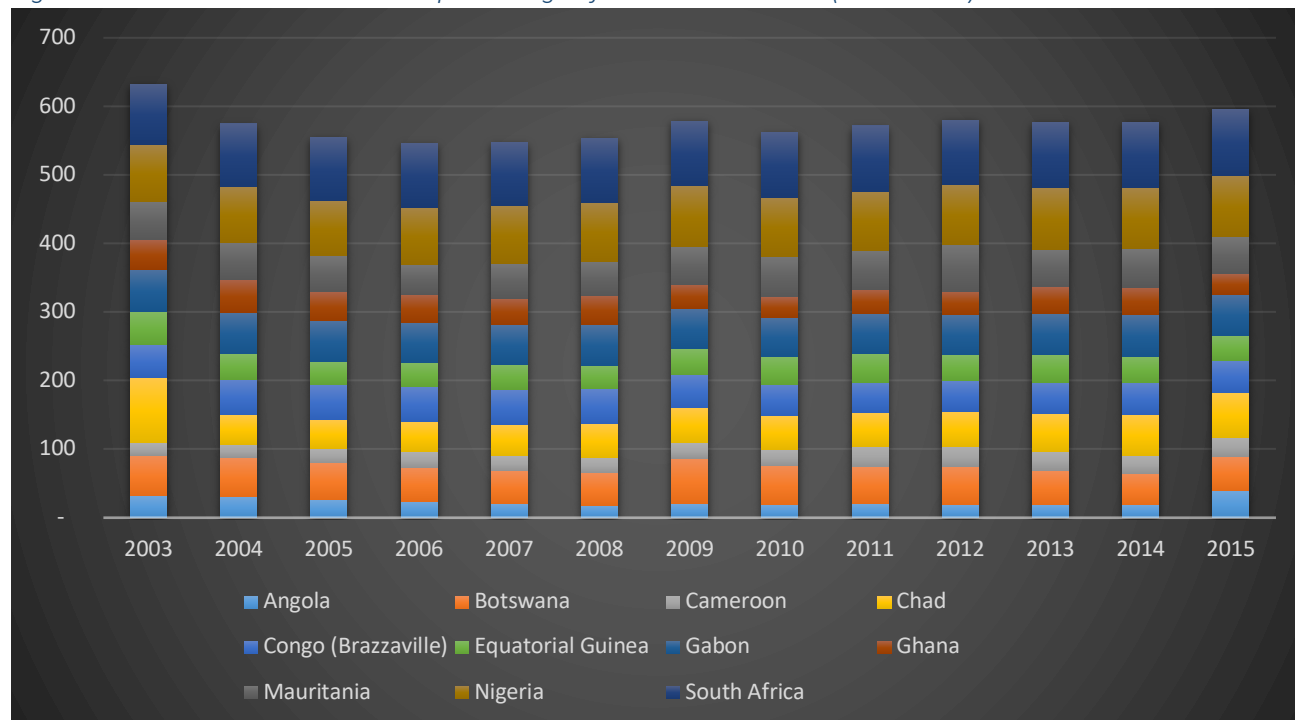
Appendix 8: Sustainable income as a percentage of Resource rent

Figure 22a: Sustainable income as a percentage of total resource rent (1990-2002)



Source: Author's Own Calculations.

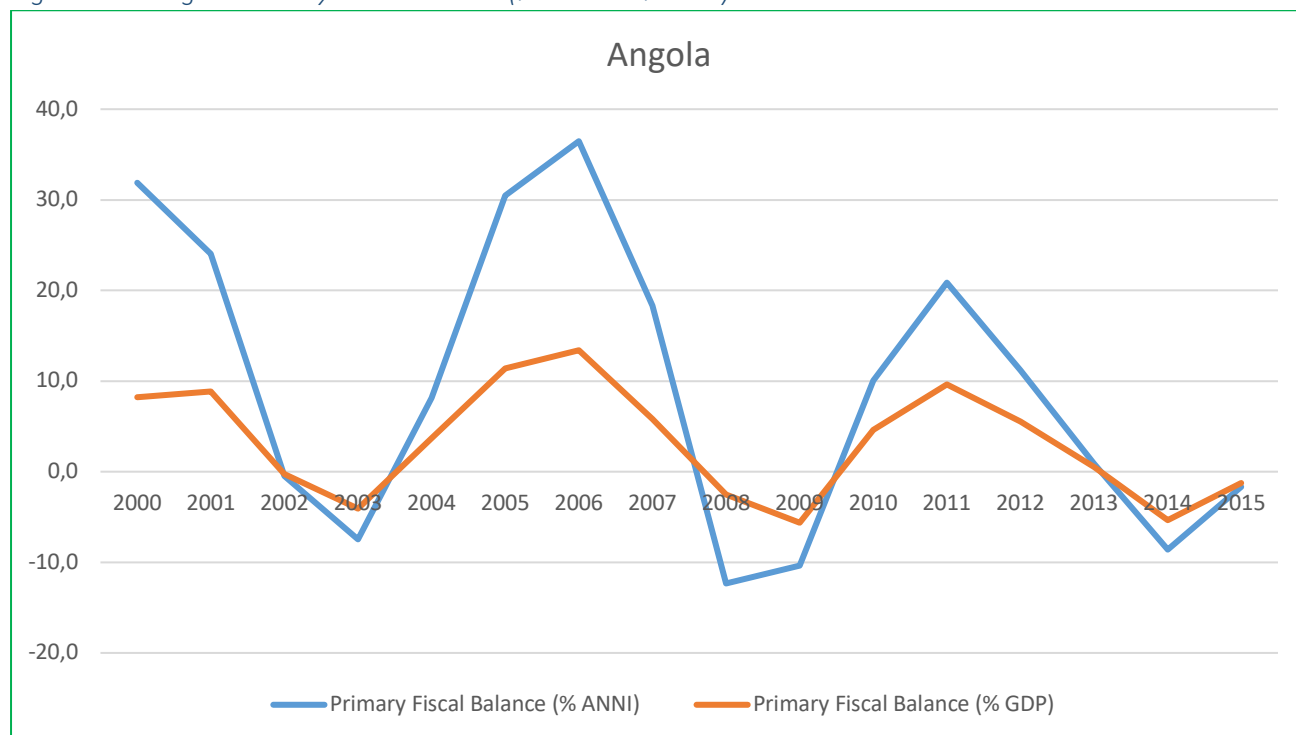
Figure 22b: Sustainable income as a percentage of total resource rent (2003-2015)



Source: Author's Own Calculations.

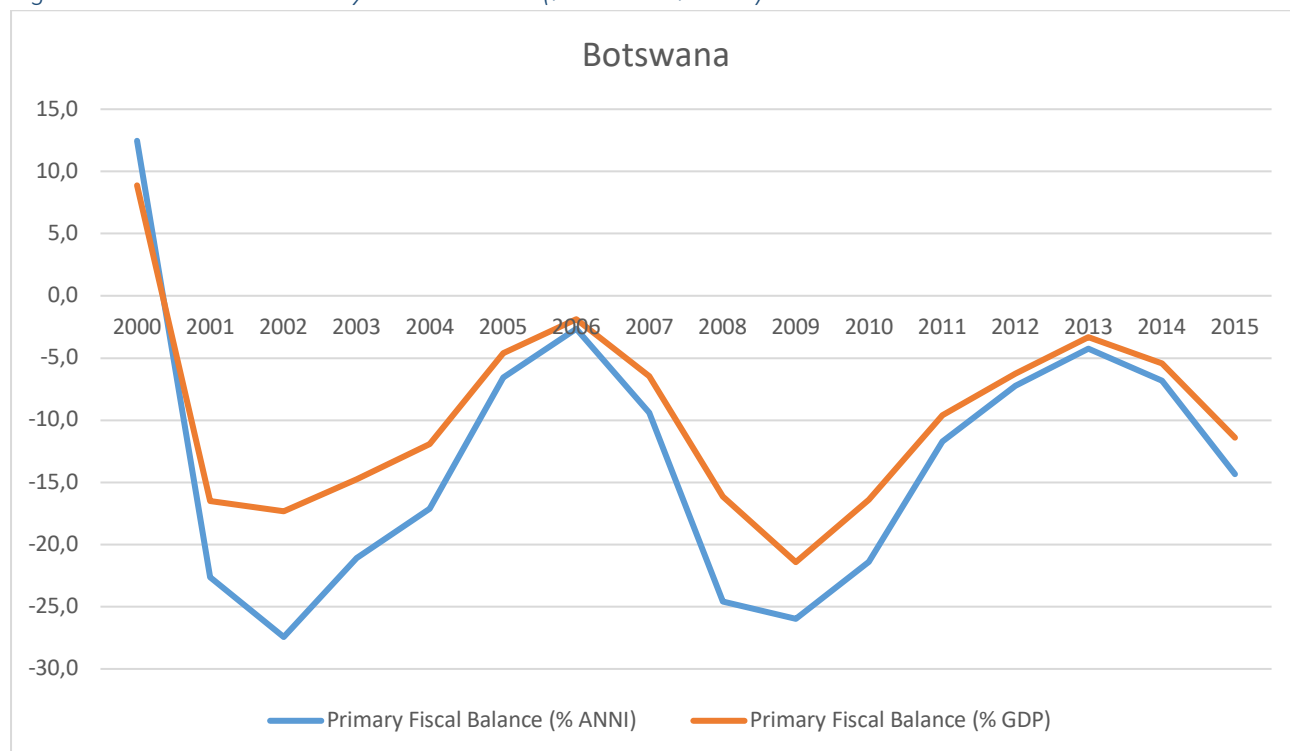
Appendix 9: Primary Fiscal Balance

Figure 23a: Angola Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



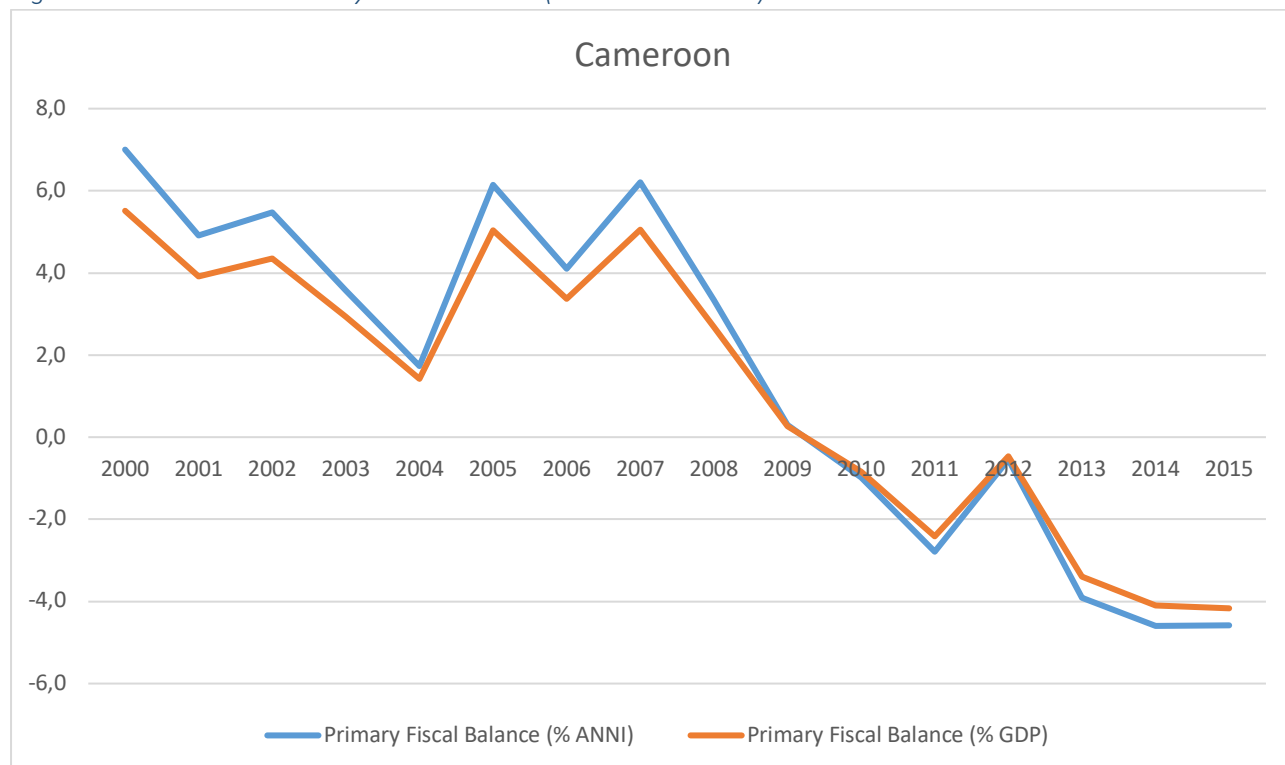
Source: Author's Own Calculations, International Financial Statistics

Figure 23b: Botswana Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



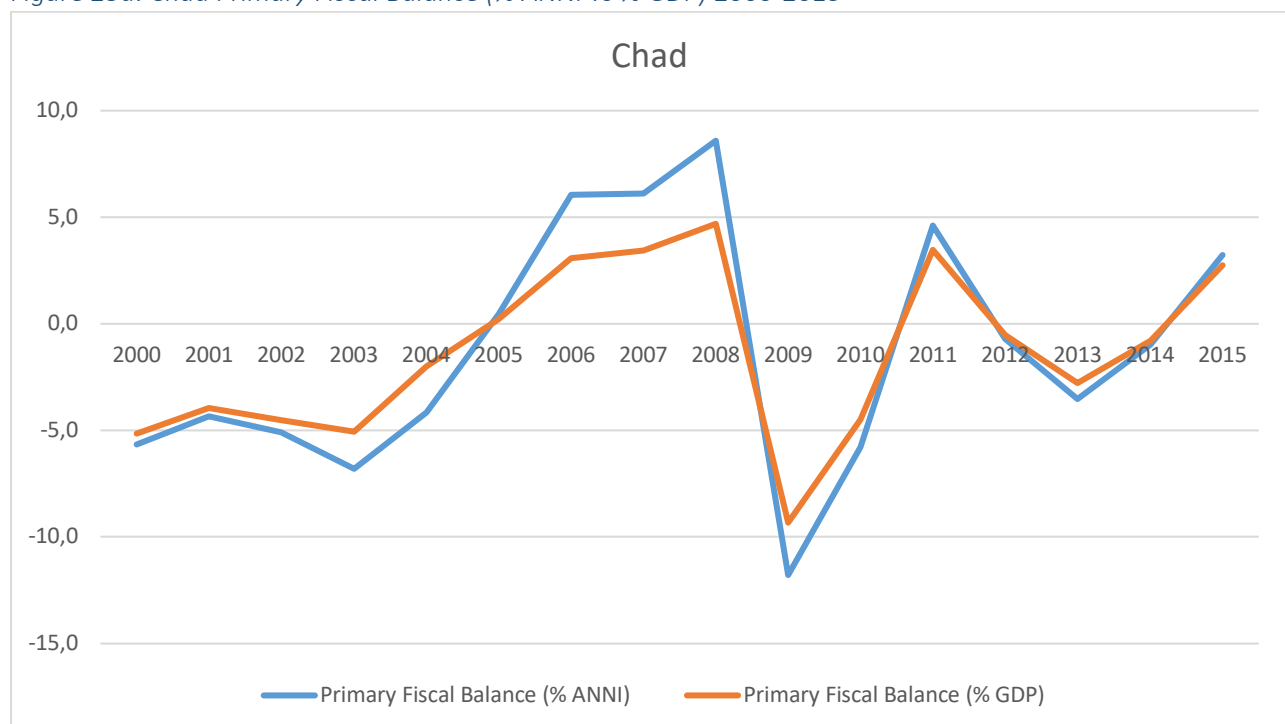
Source: Author's Own Calculations, International Financial Statistics

Figure 23c: Cameroon Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



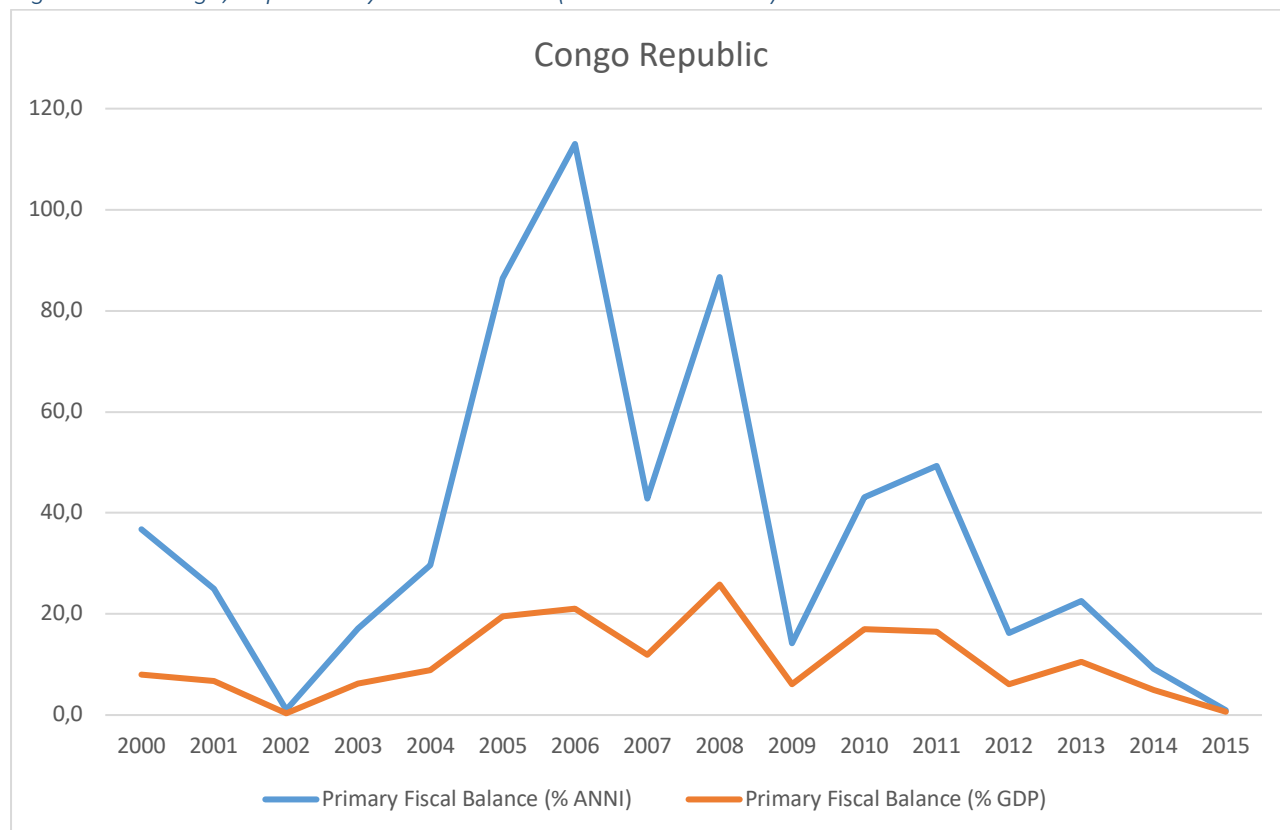
Source: Author's Own Calculations, International Financial Statistics

Figure 23d: Chad Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



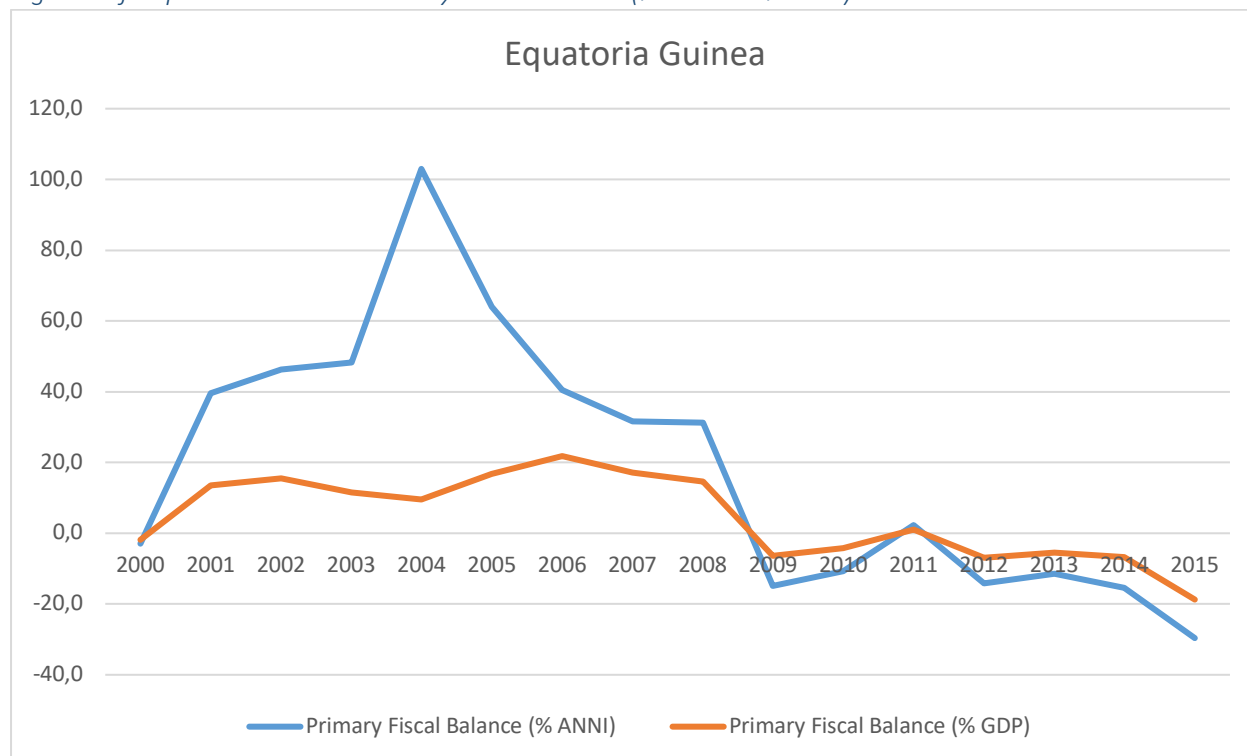
Source: Author's Own Calculations, International Financial Statistics

Figure 23e: Congo, Rep Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



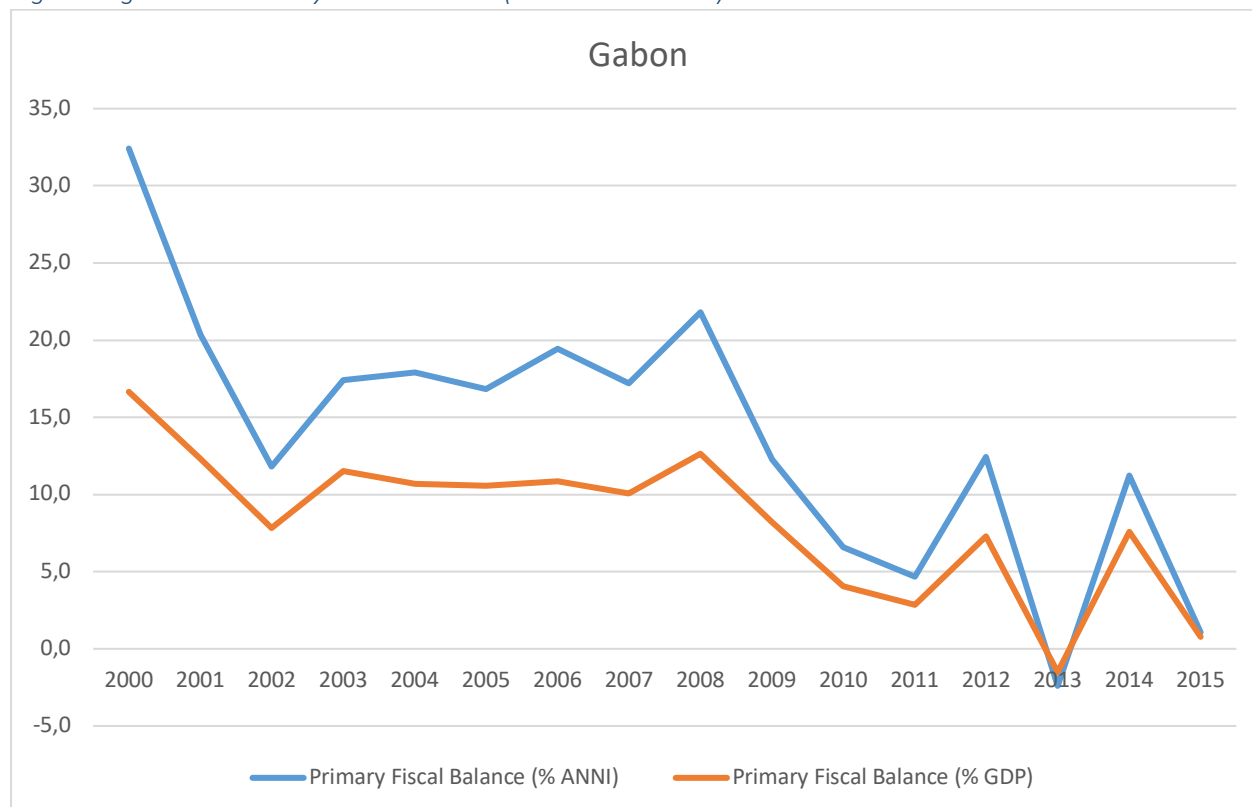
Source: Author's Own Calculations, International Financial Statistics

Figure 23f: Equatorial Guinea Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



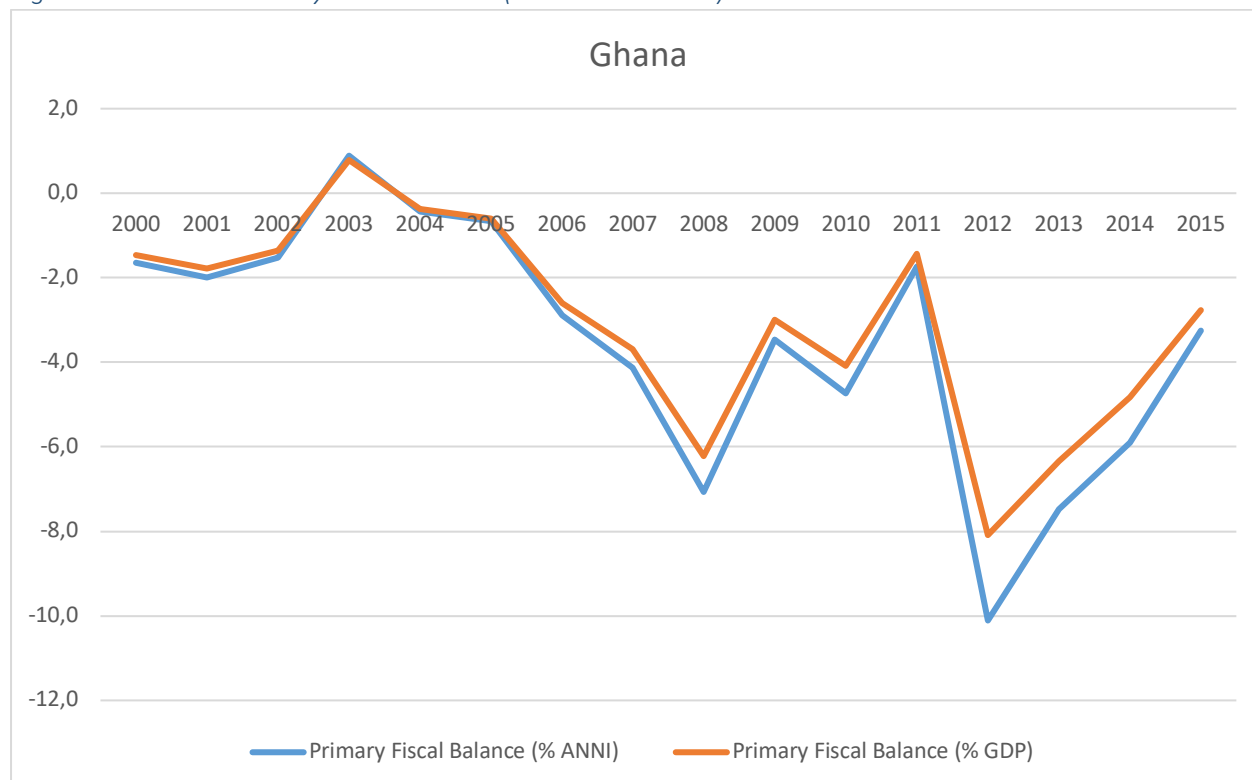
Source: Author's Own Calculations, International Financial Statistics

Figure 23g: Gabon Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



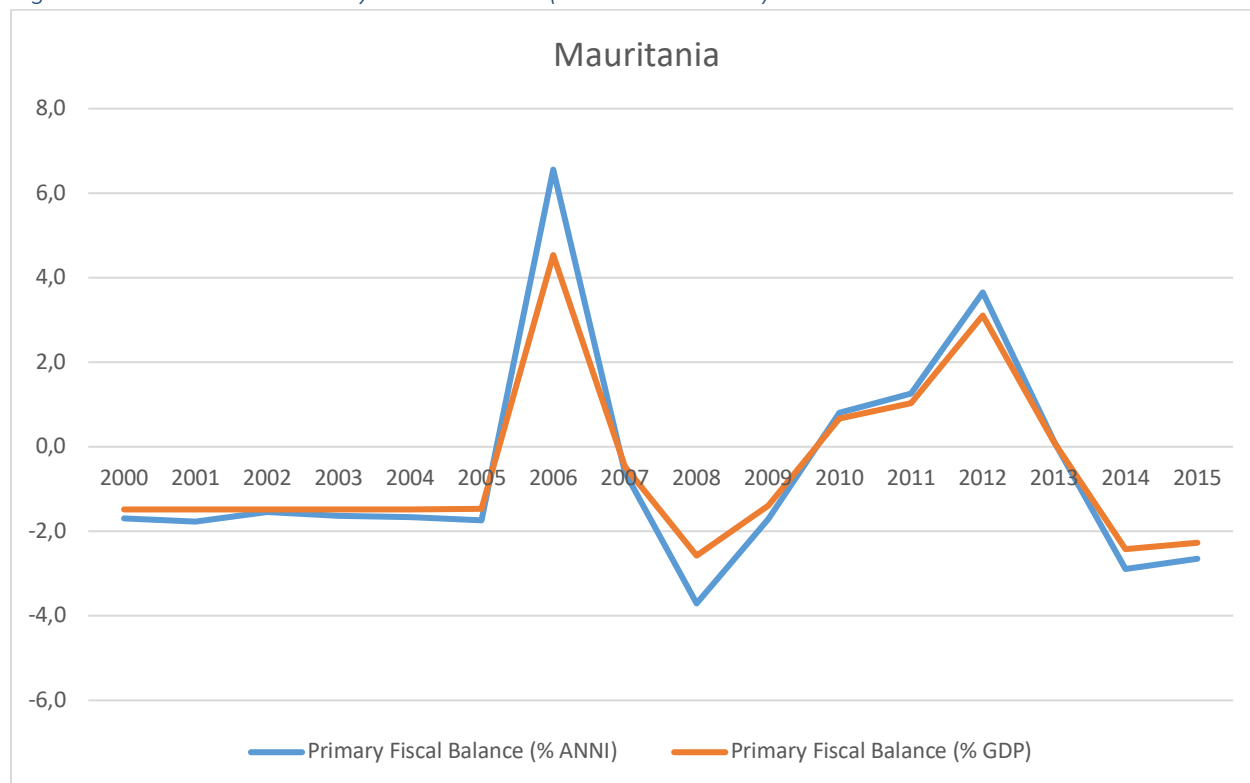
Source: Author's Own Calculations, International Financial Statistics

Figure 23h: Ghana Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



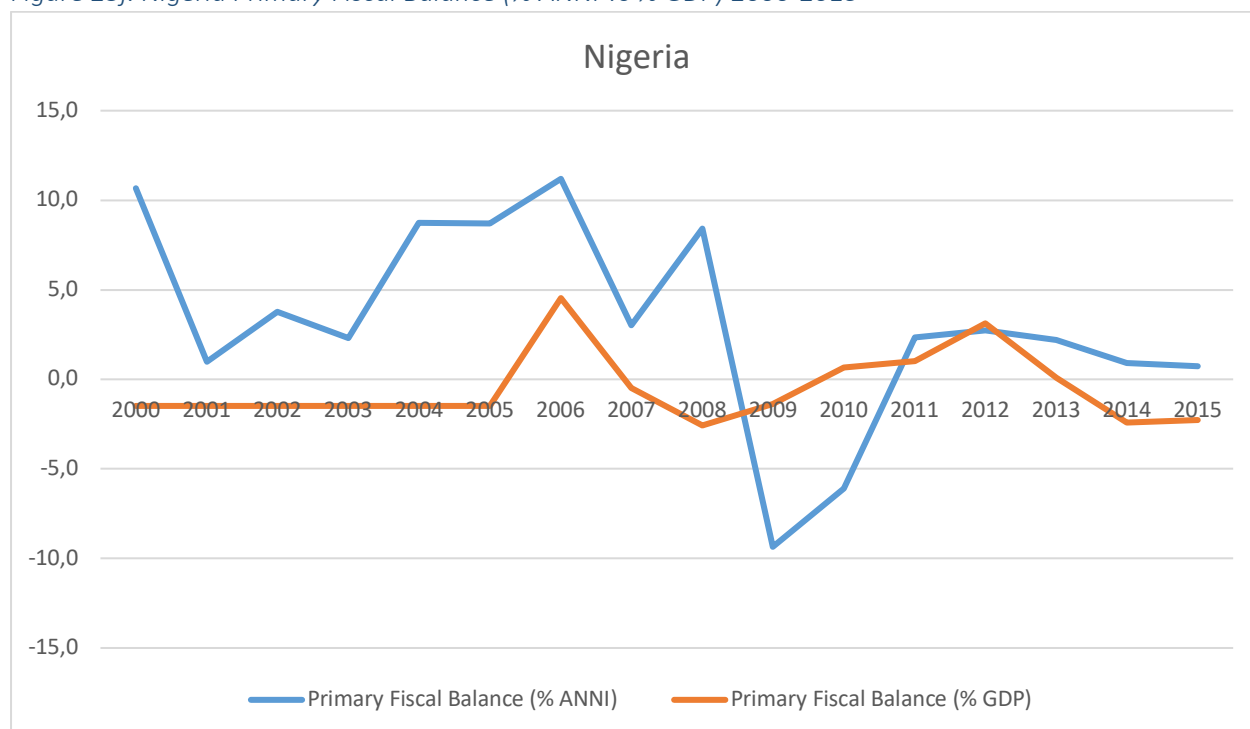
Source: Author's Own Calculations, International Financial Statistics

Figure 23i: Mauritania Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



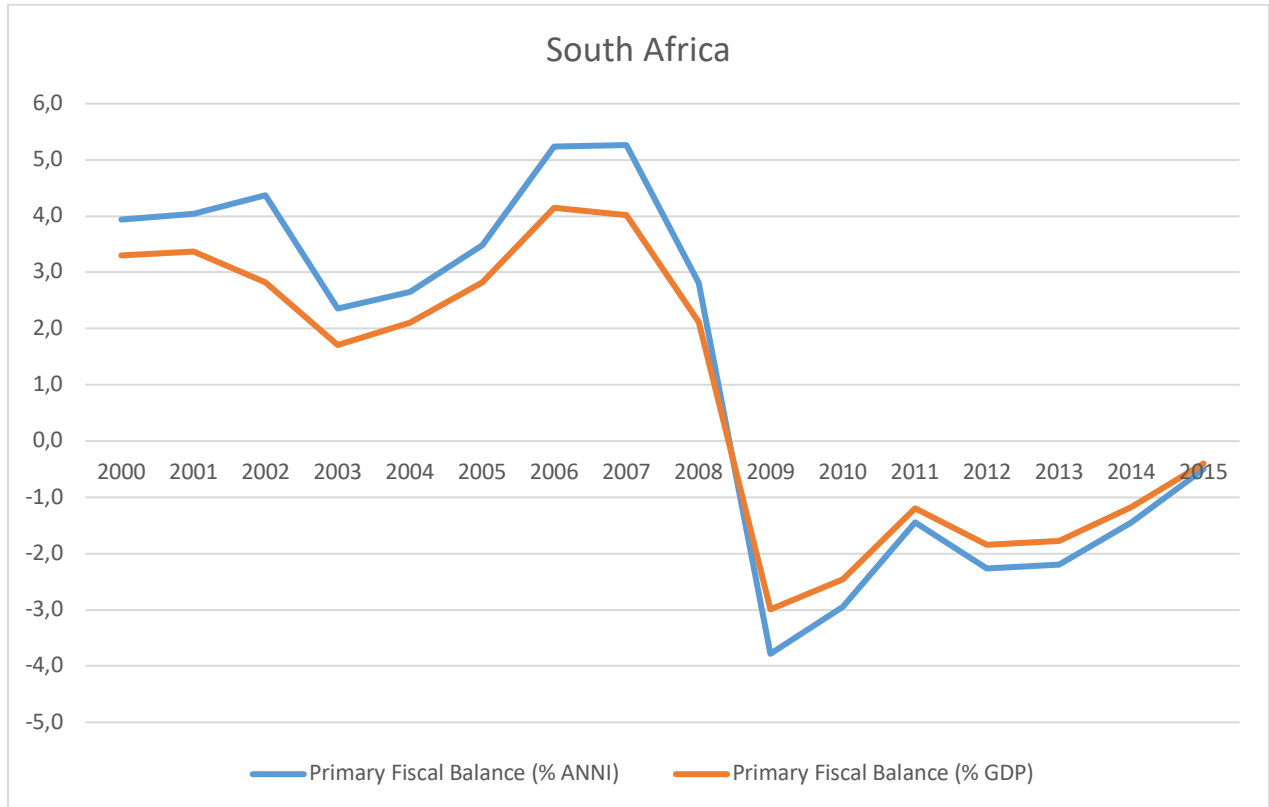
Source: Author's Own Calculations, International Financial Statistics

Figure 23j: Nigeria Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



Source: Author's Own Calculations, International Financial Statistics

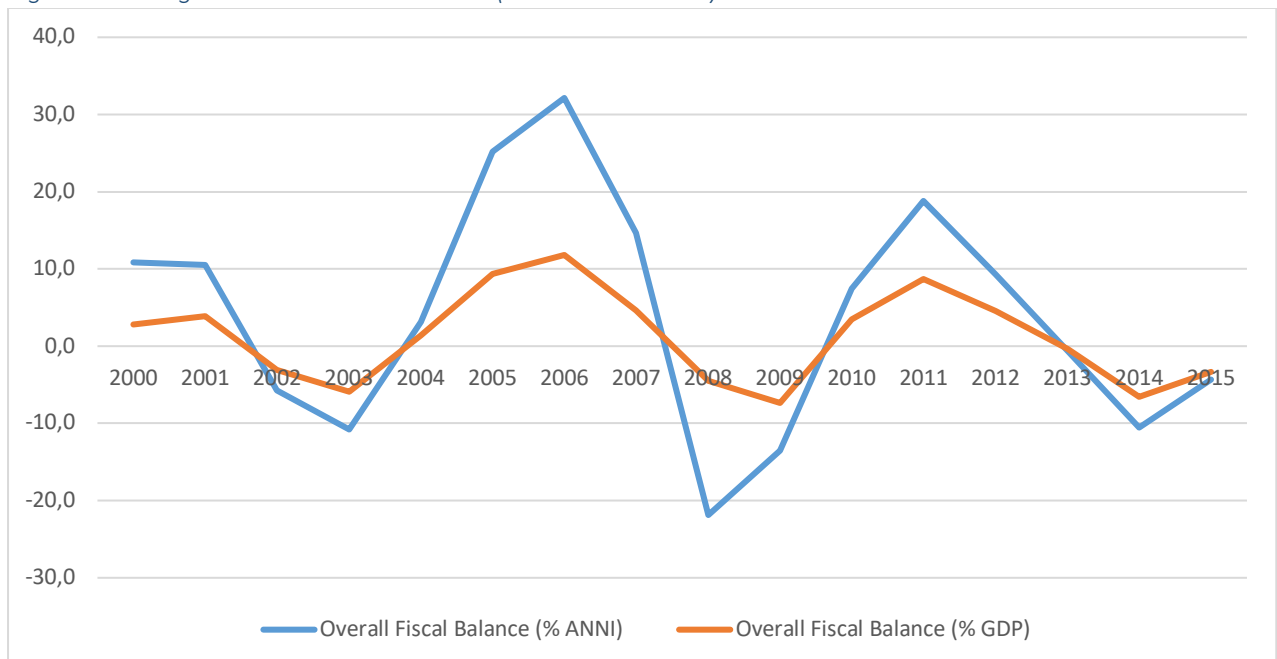
Figure 23k: South Africa Primary Fiscal Balance (% ANNI vs % GDP) 2000-2015



Source: Author's Own Calculations, International Financial Statistics

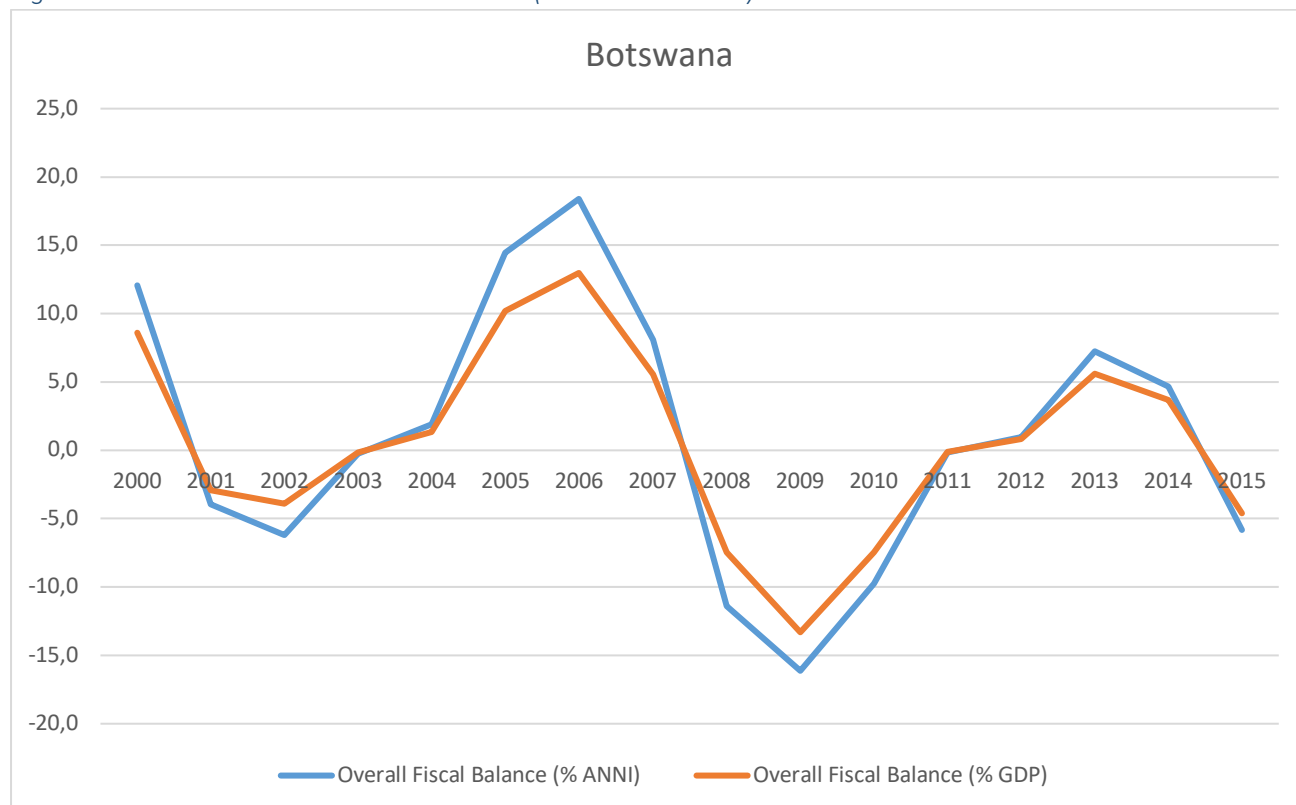
Appendix 10: Overall Fiscal Balance

Figure 24a: Angola Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



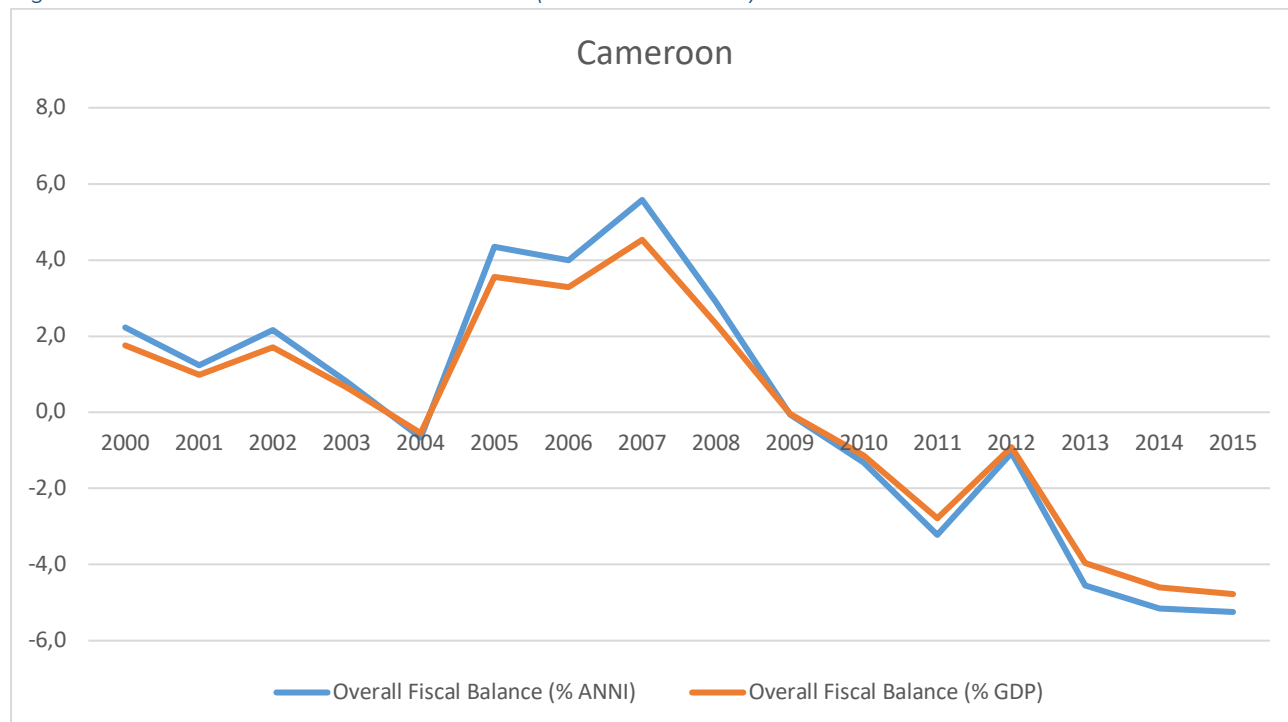
Source: Author's Own Calculations, International Financial Statistics

Figure 24b: Botswana Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



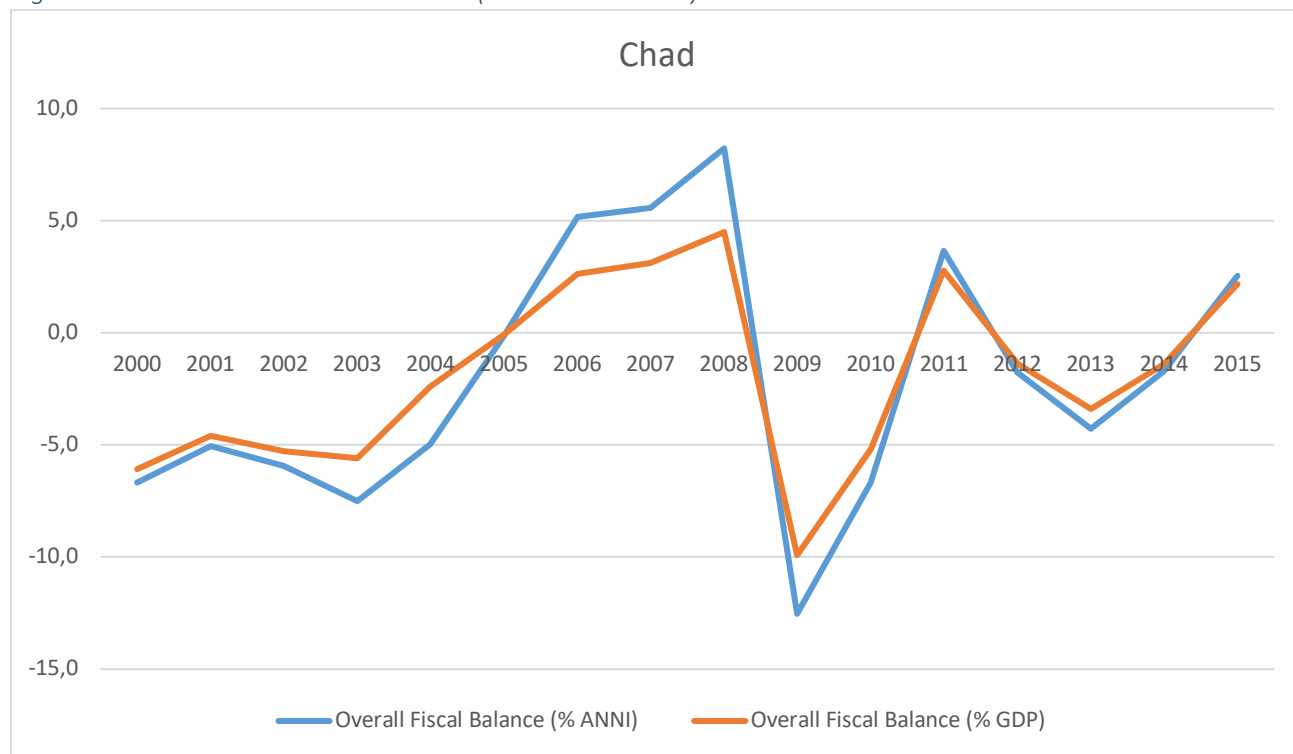
Source: Author's Own Calculations, International Financial Statistics

Figure 24c: Cameroon Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



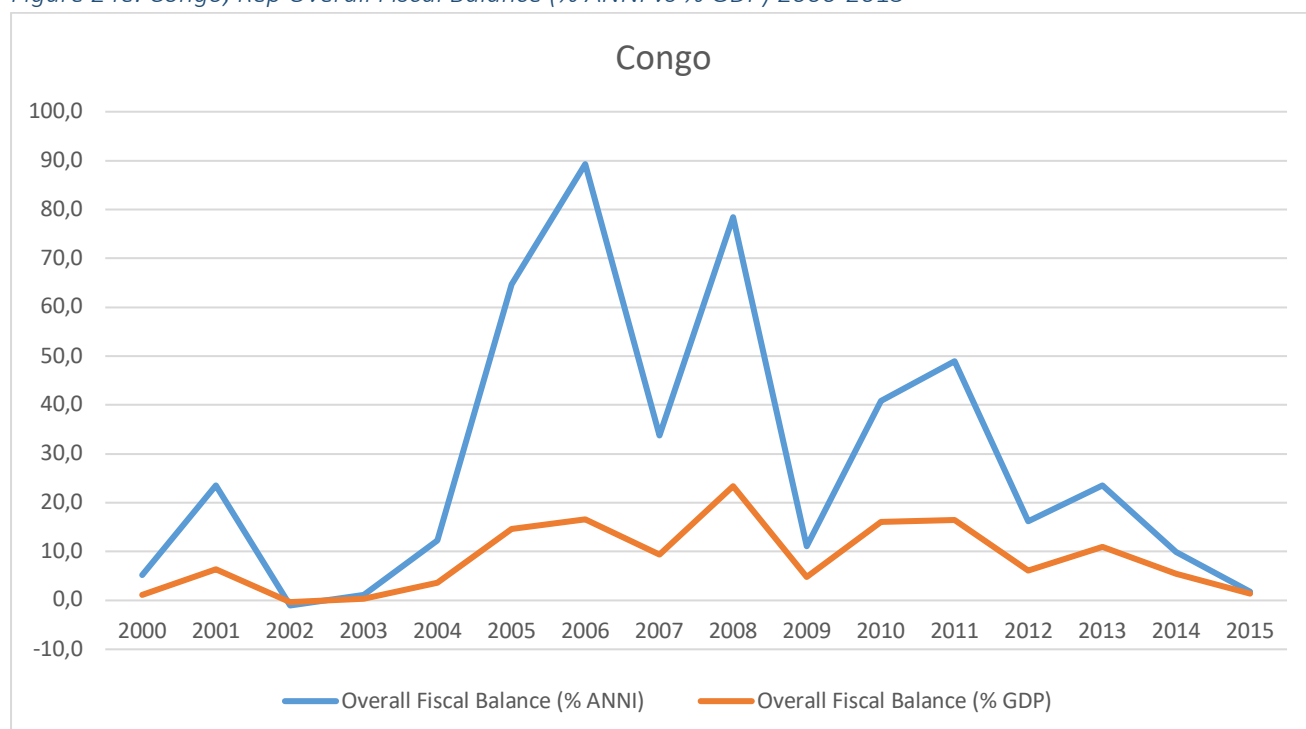
Source: Author's Own Calculations, International Financial Statistics

Figure 24d: Chad Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



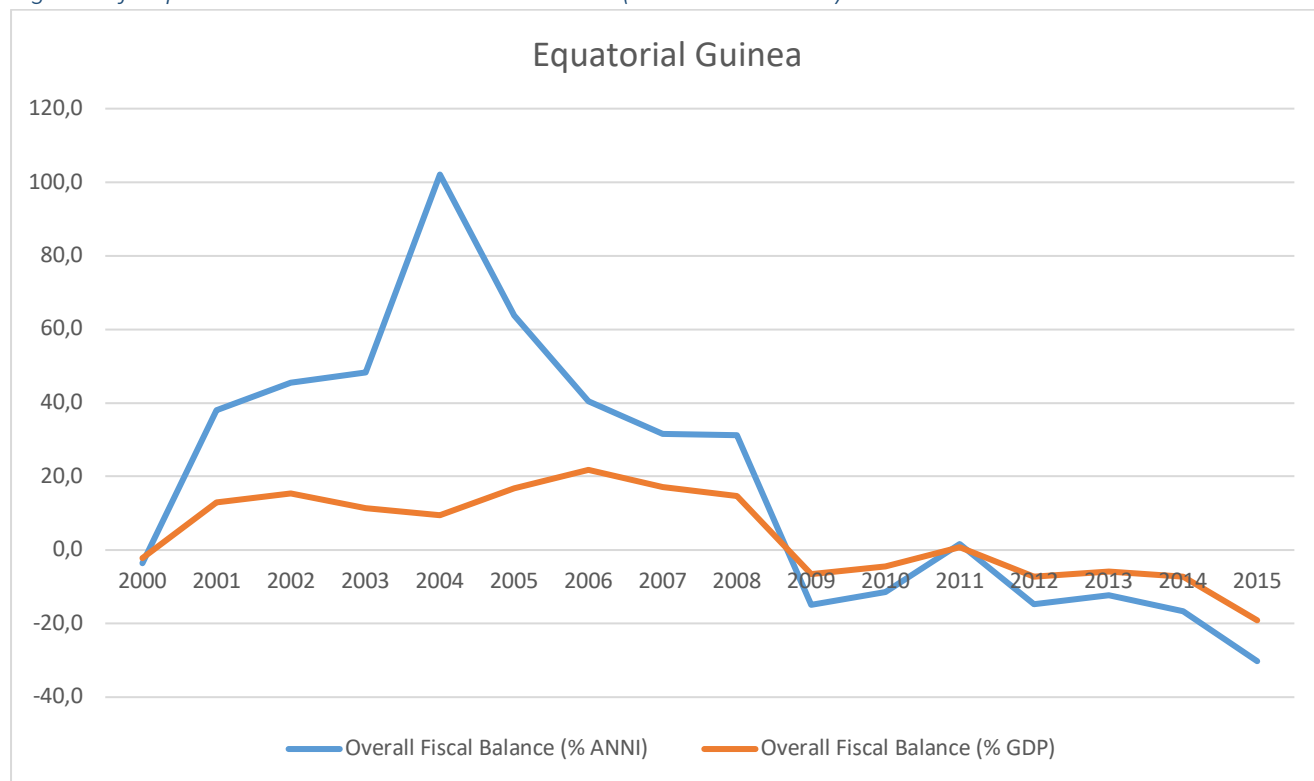
Source: Author's Own Calculations, International Financial Statistics

Figure 24e: Congo, Rep Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



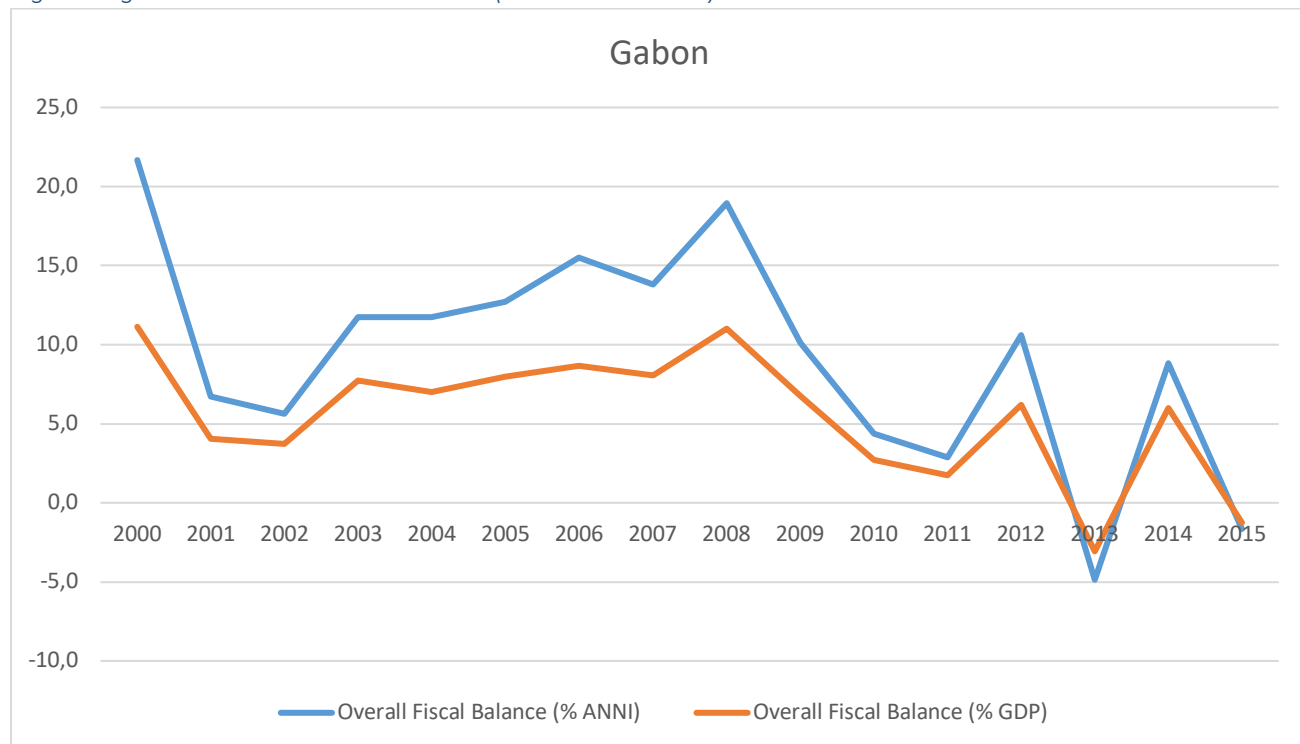
Source: Author's Own Calculations, International Financial Statistics

Figure 24f: Equatorial Guinea Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



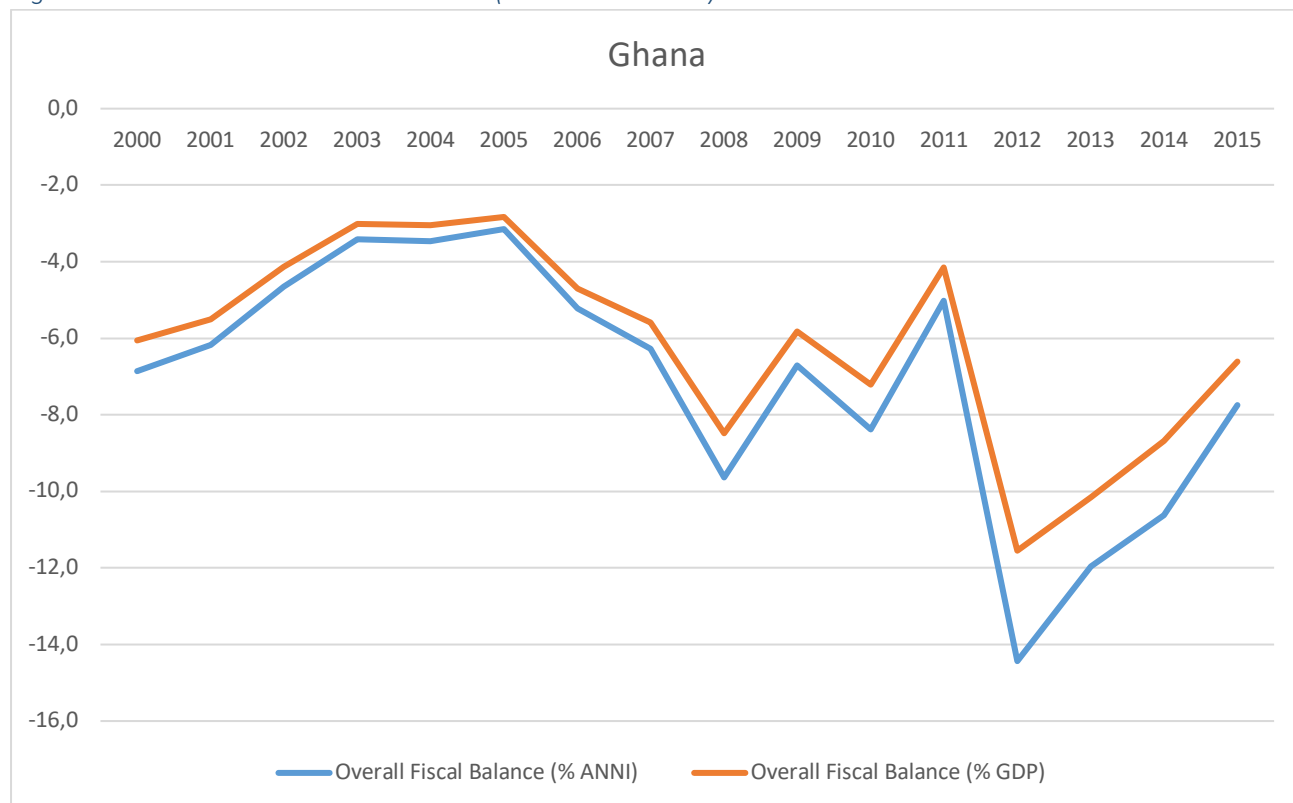
Source: Author's Own Calculations, International Financial Statistics

Figure 24g: Gabon Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



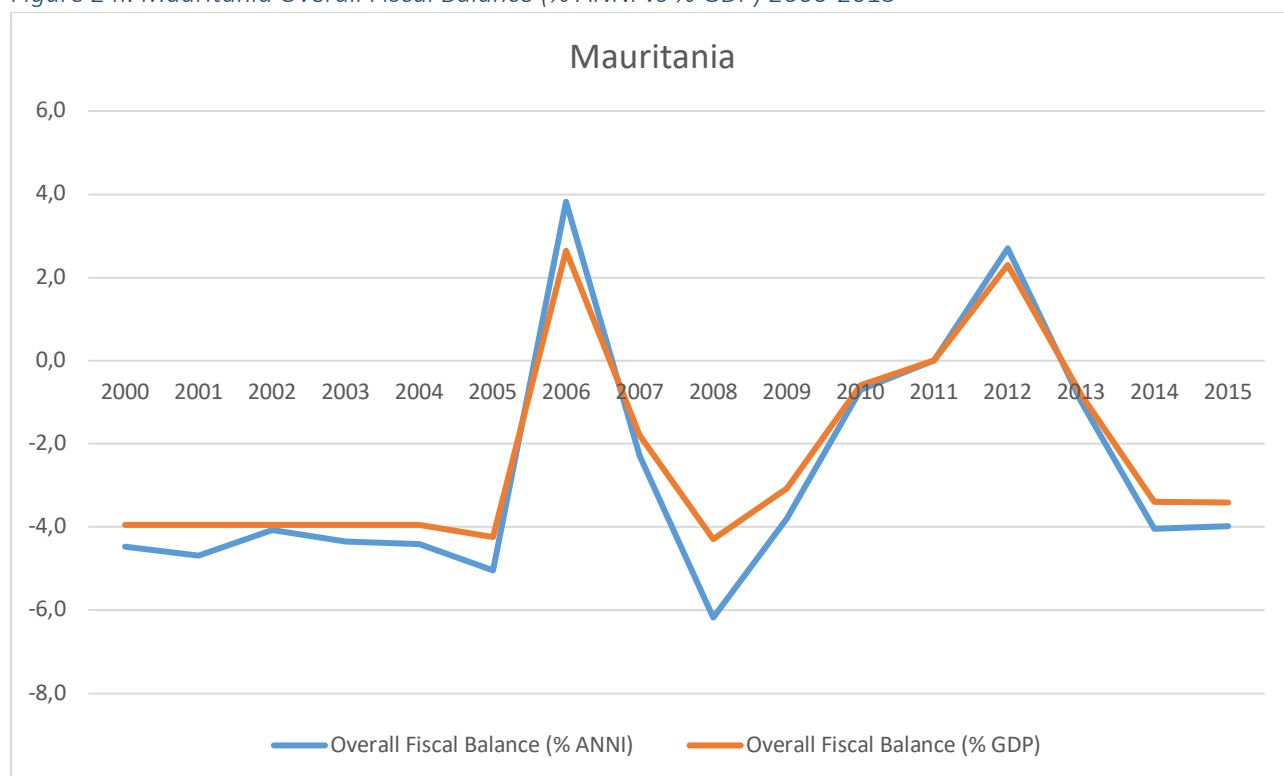
Source: Author's Own Calculations, International Financial Statistics

Figure 24h: Ghana Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



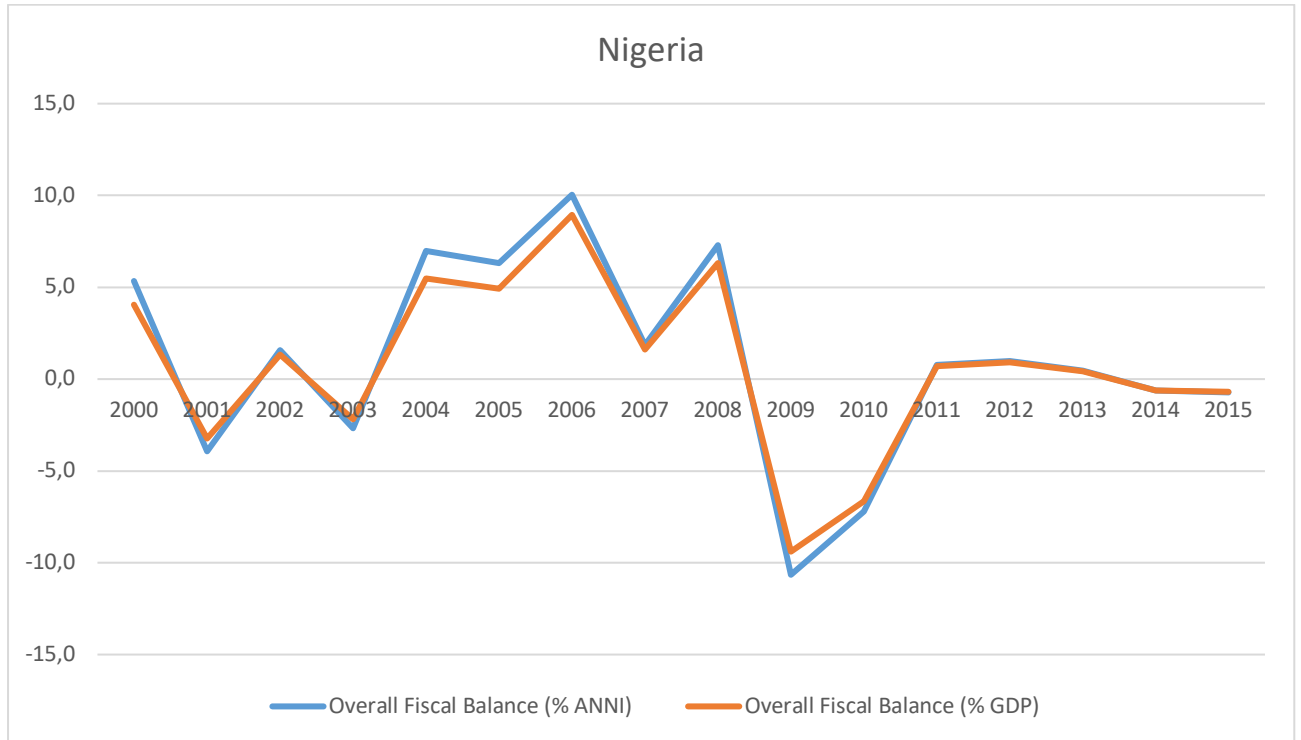
Source: Author's Own Calculations, International Financial Statistics

Figure 24i: Mauritania Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



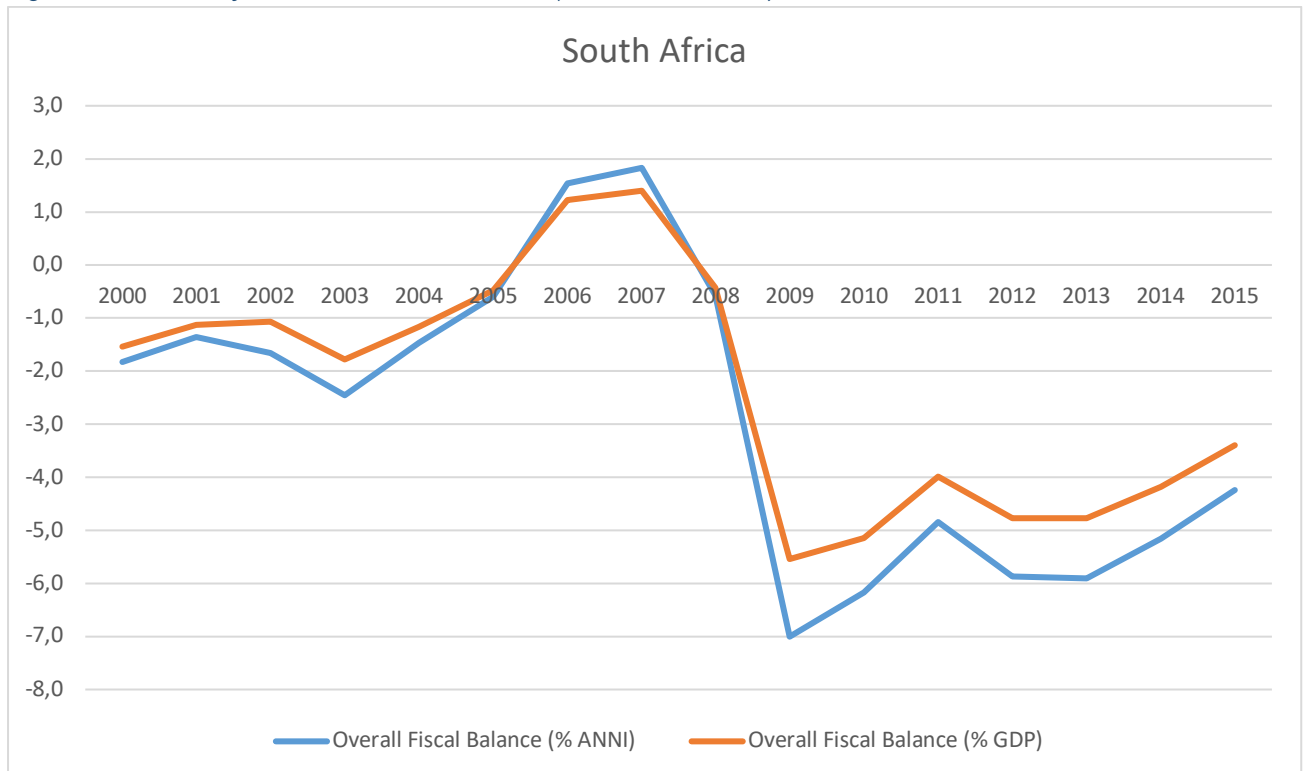
Source: Author's Own Calculations, International Financial Statistics

Figure 24j: Nigeria Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



Source: Author's Own Calculations, International Financial Statistics

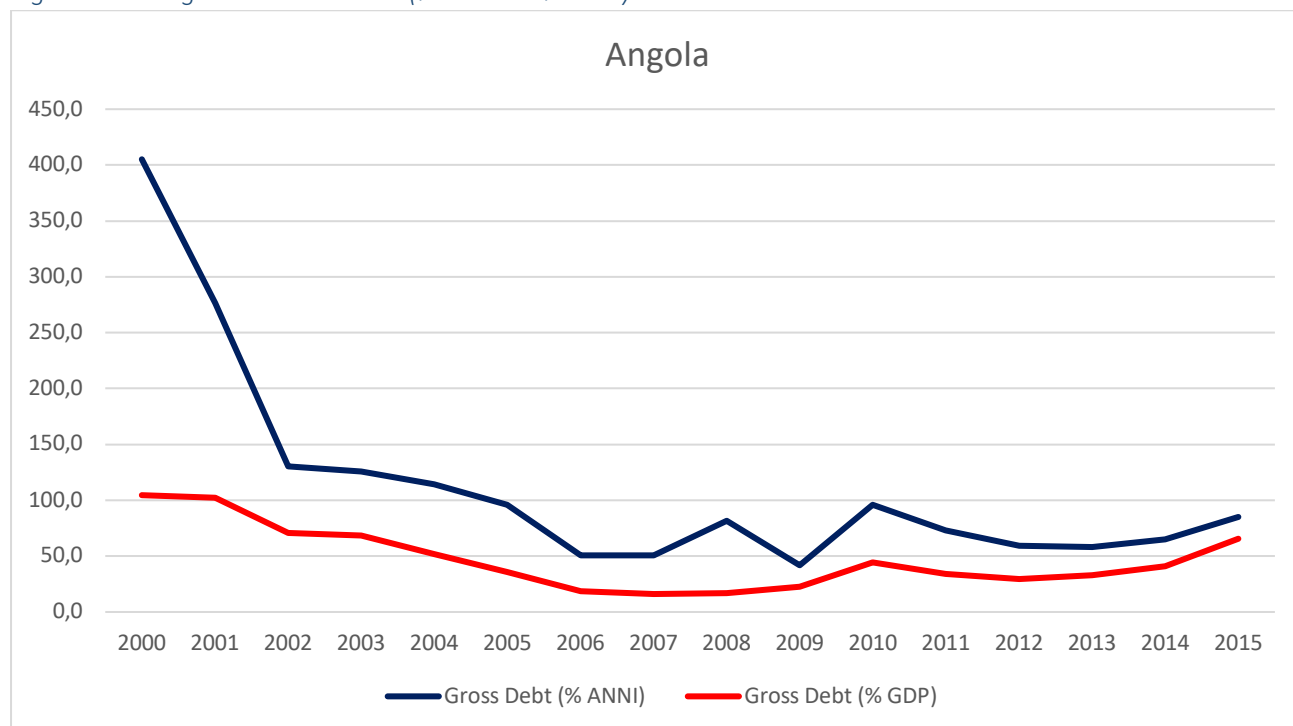
Figure 24k: South Africa Overall Fiscal Balance (% ANNI vs % GDP) 2000-2015



Source: Author's Own Calculations, International Financial Statistics

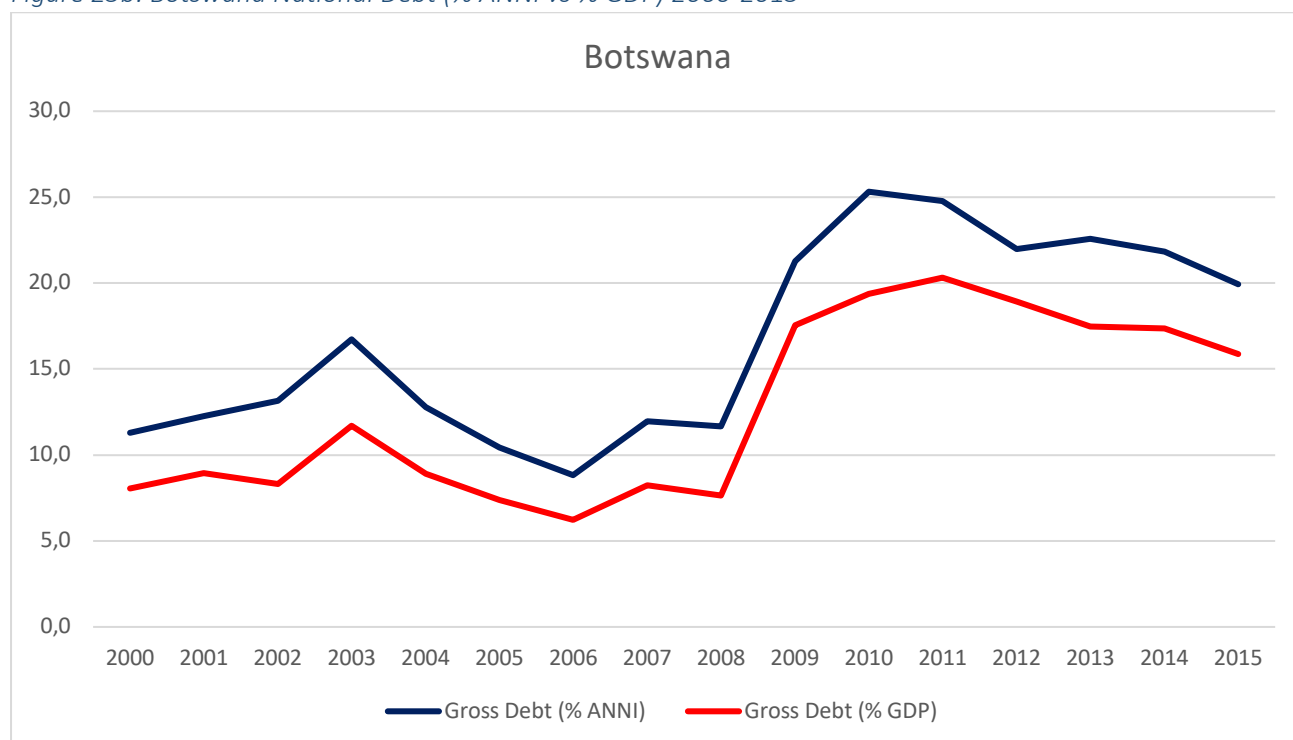
APPENDIX 11: National Debt

Figure 25a: Angola National Debt (% ANNI vs % GDP) 2000-2015



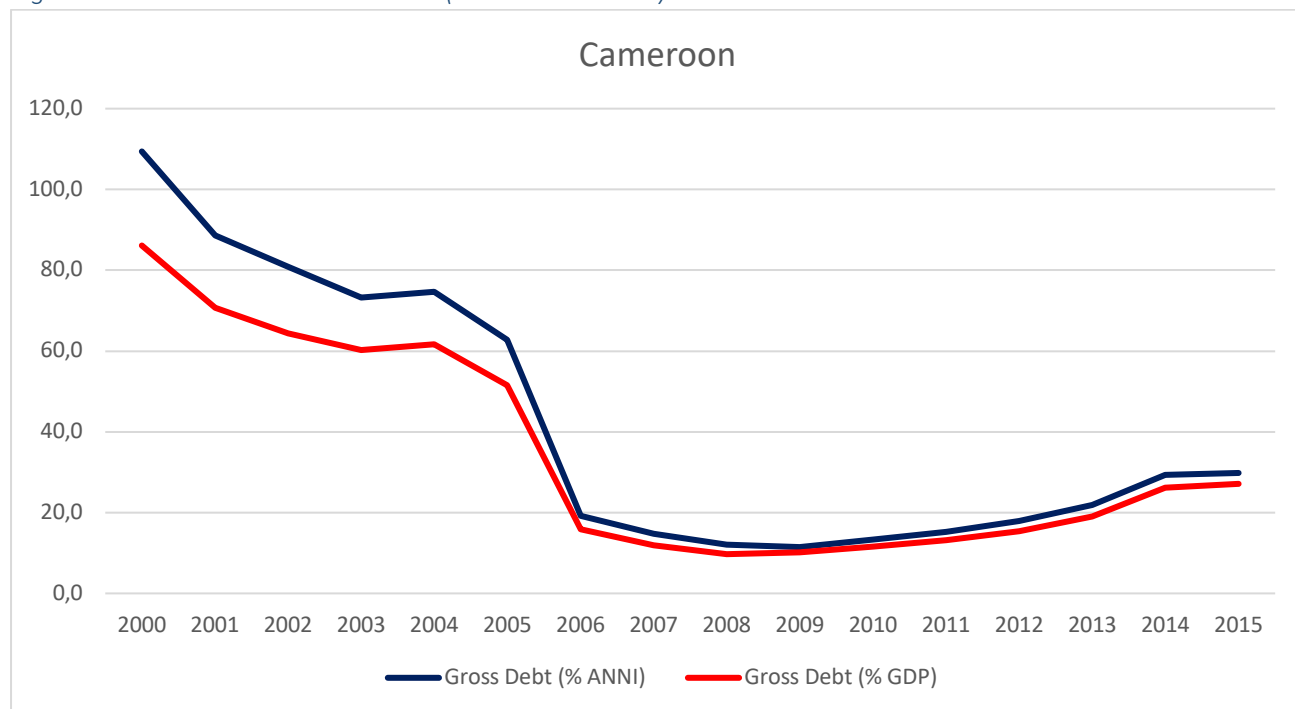
Source: Author's Own Calculations, International Financial Statistics

Figure 25b: Botswana National Debt (% ANNI vs % GDP) 2000-2015



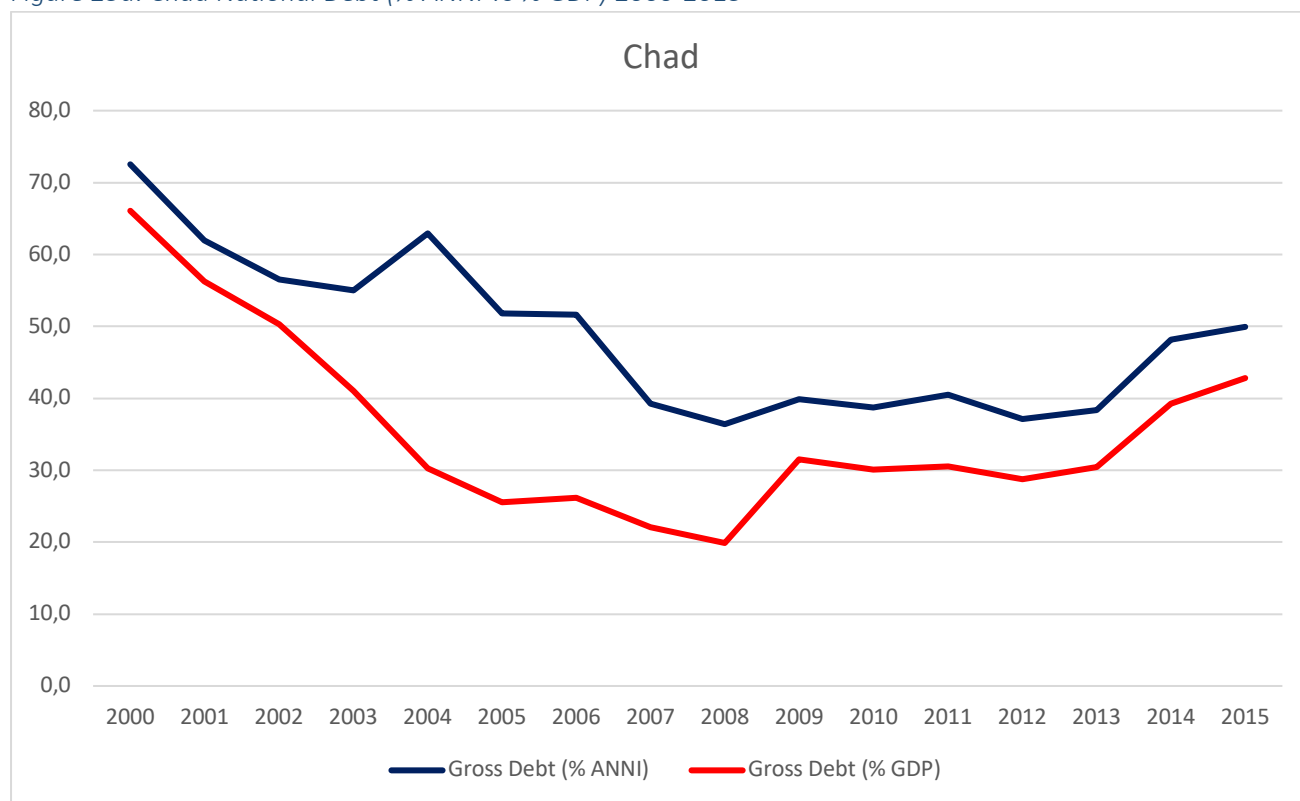
Source: Author's Own Calculations, International Financial Statistics

Figure 25c: Cameroon National Debt (% ANNI vs % GDP) 2000-2015



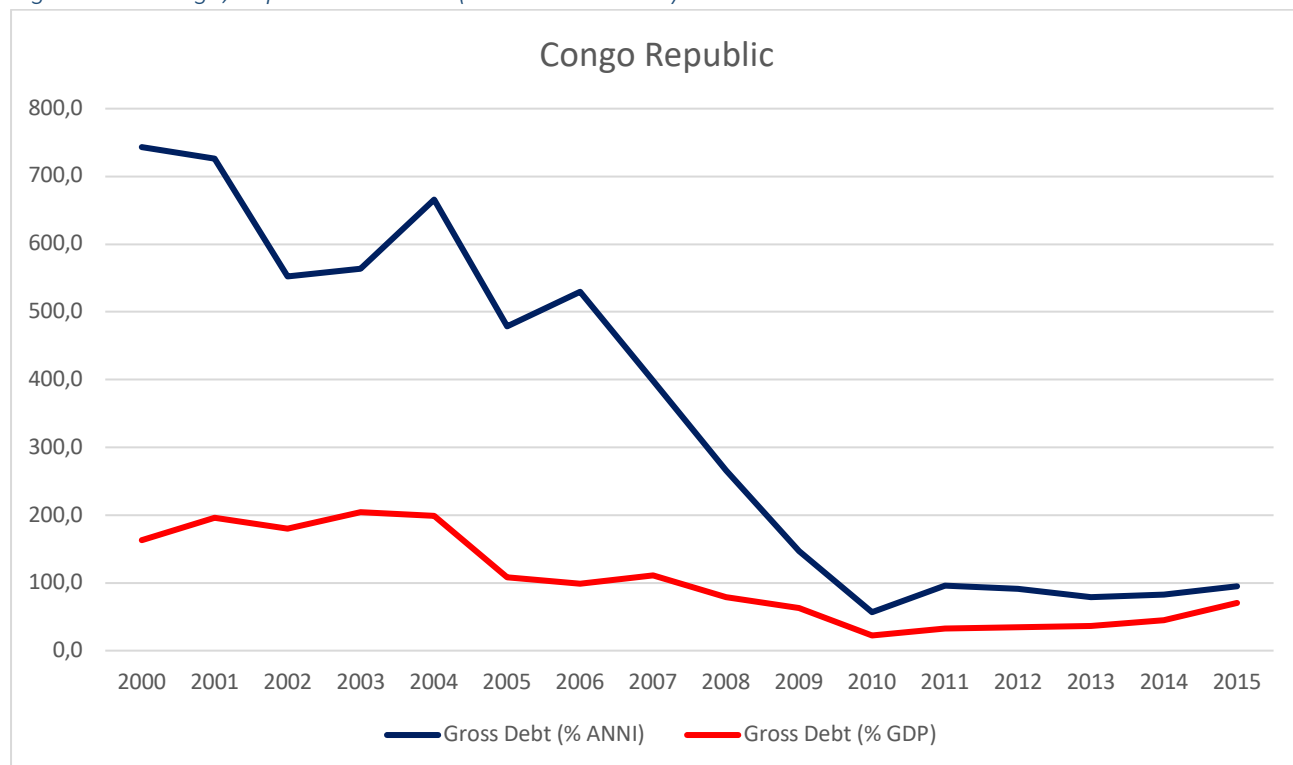
Source: Author's Own Calculations, International Financial Statistics

Figure 25d: Chad National Debt (% ANNI vs % GDP) 2000-2015



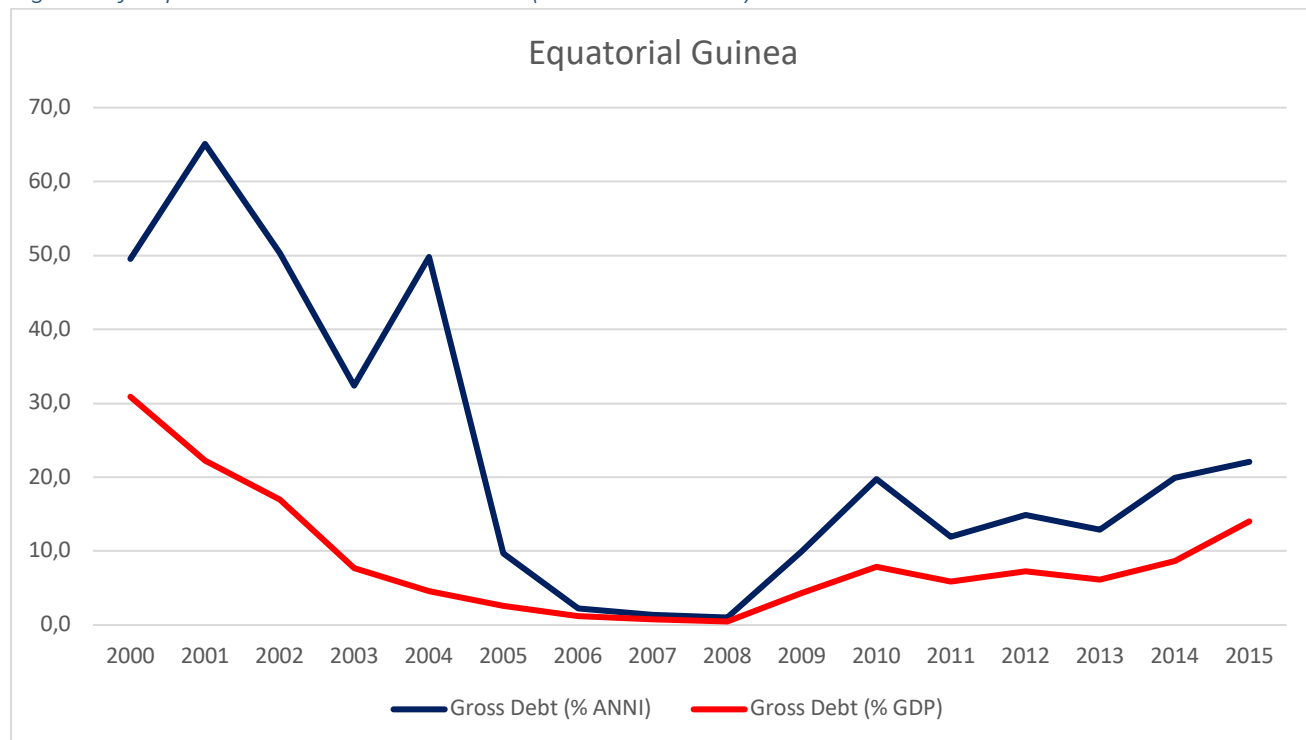
Source: Author's Own Calculations, International Financial Statistics

Figure 25e: Congo, Rep National Debt (% ANNI vs % GDP) 2000-2015



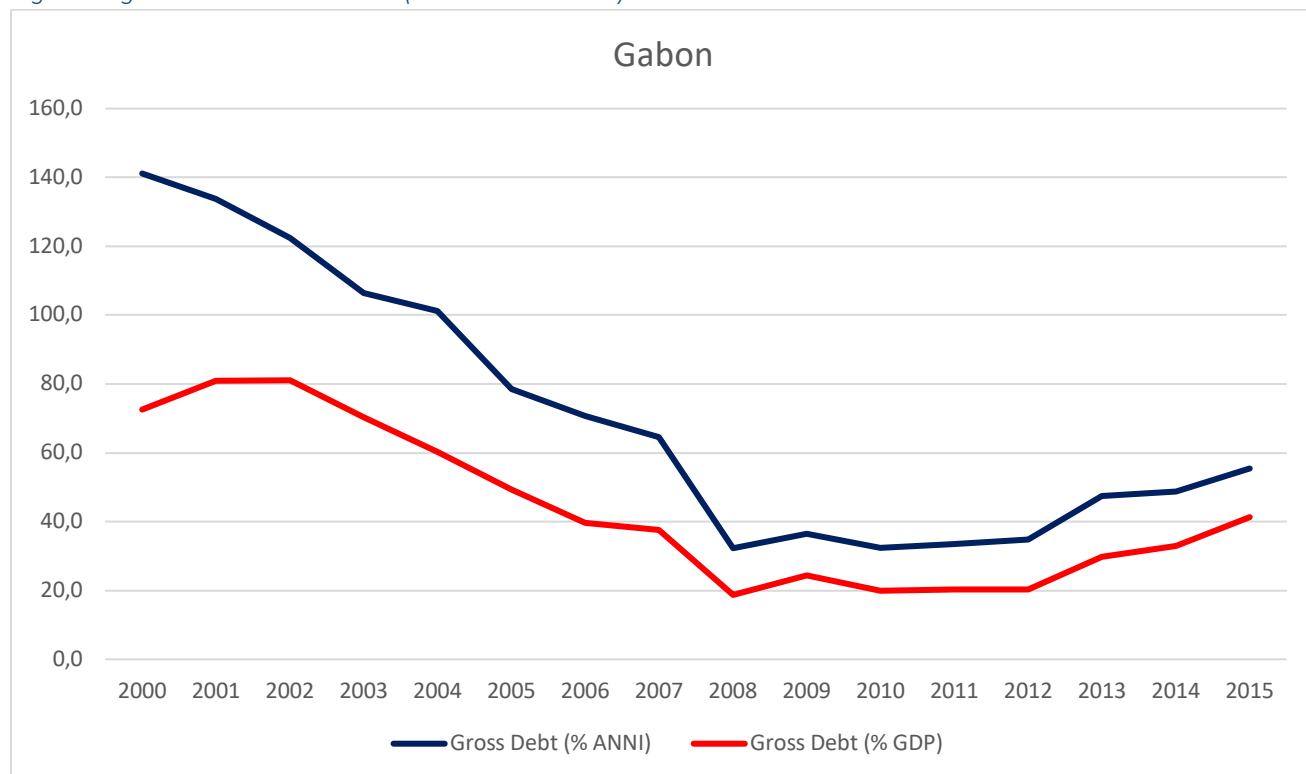
Source: Author's Own Calculations, International Financial Statistics

Figure 25f: Equatorial Guinea National Debt (% ANNI vs % GDP) 2000-2015



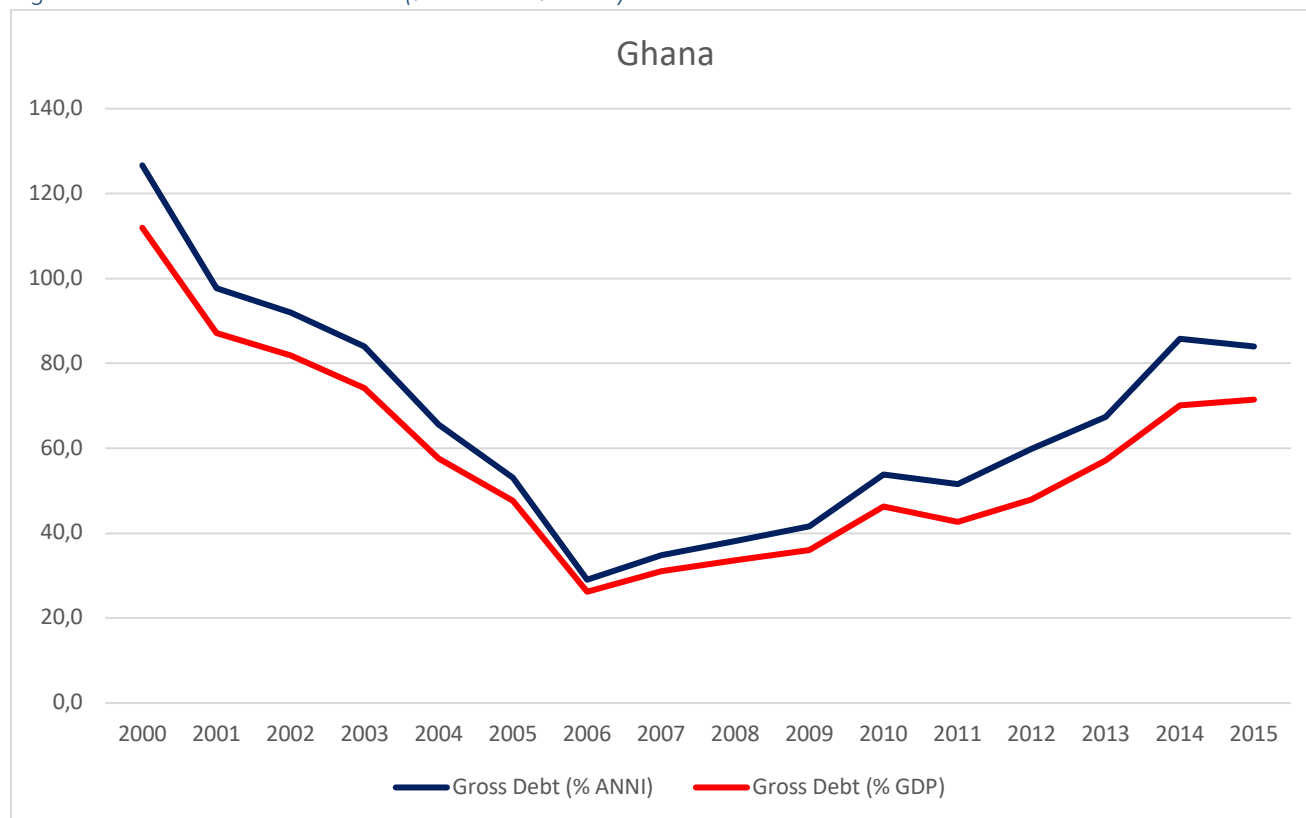
Source: Author's Own Calculations, International Financial Statistics

Figure 25g: Gabon National Debt (% ANNI vs % GDP) 2000-2015



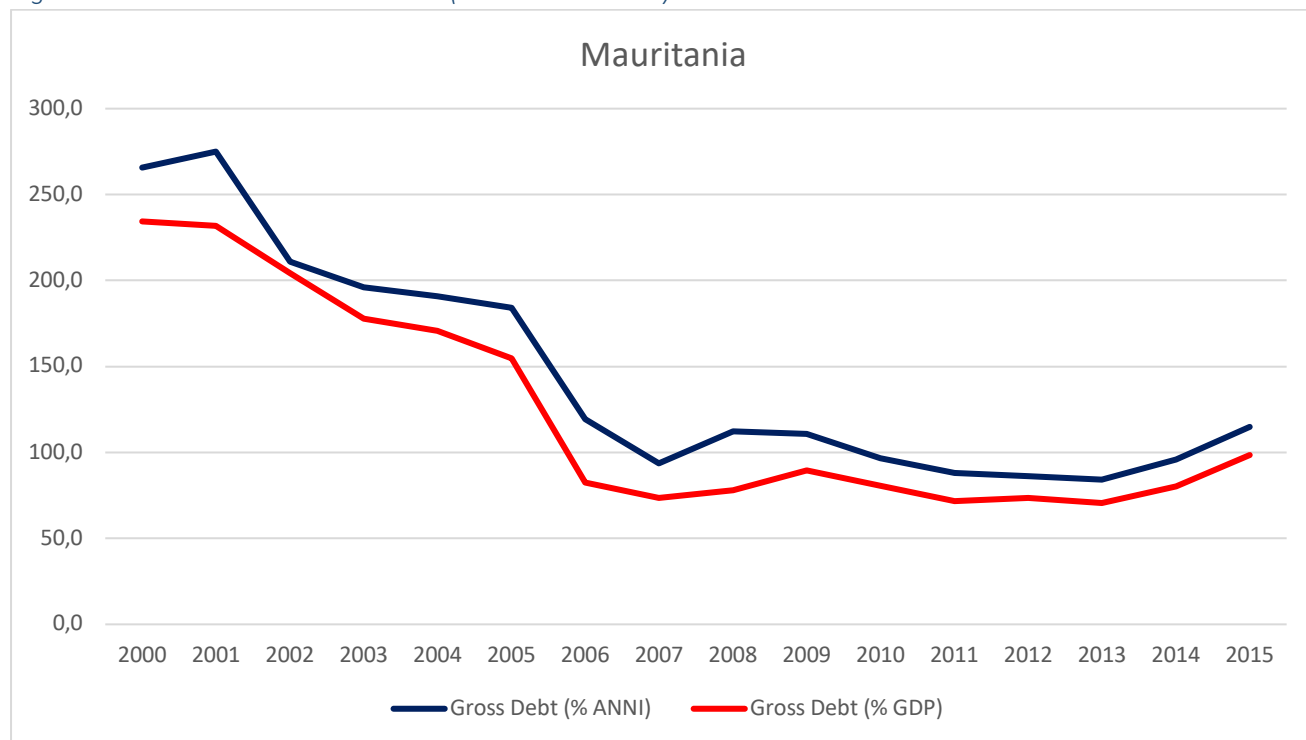
Source: Author's Own Calculations, International Financial Statistics

Figure 25h: Ghana National Debt (% ANNI vs % GDP) 2000-2015



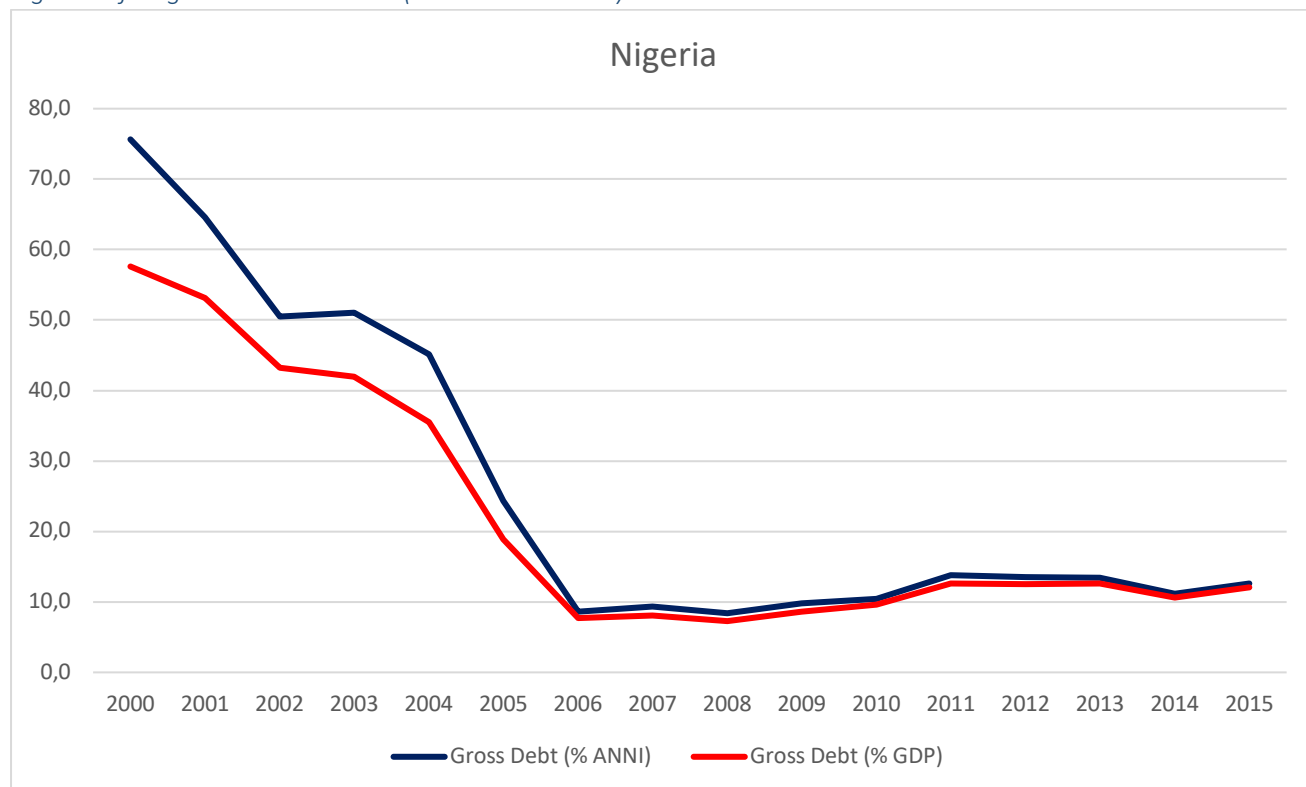
Source: Author's Own Calculations, International Financial Statistics

Figure 25i: Mauritania National Debt (% ANNI vs % GDP) 2000-2015



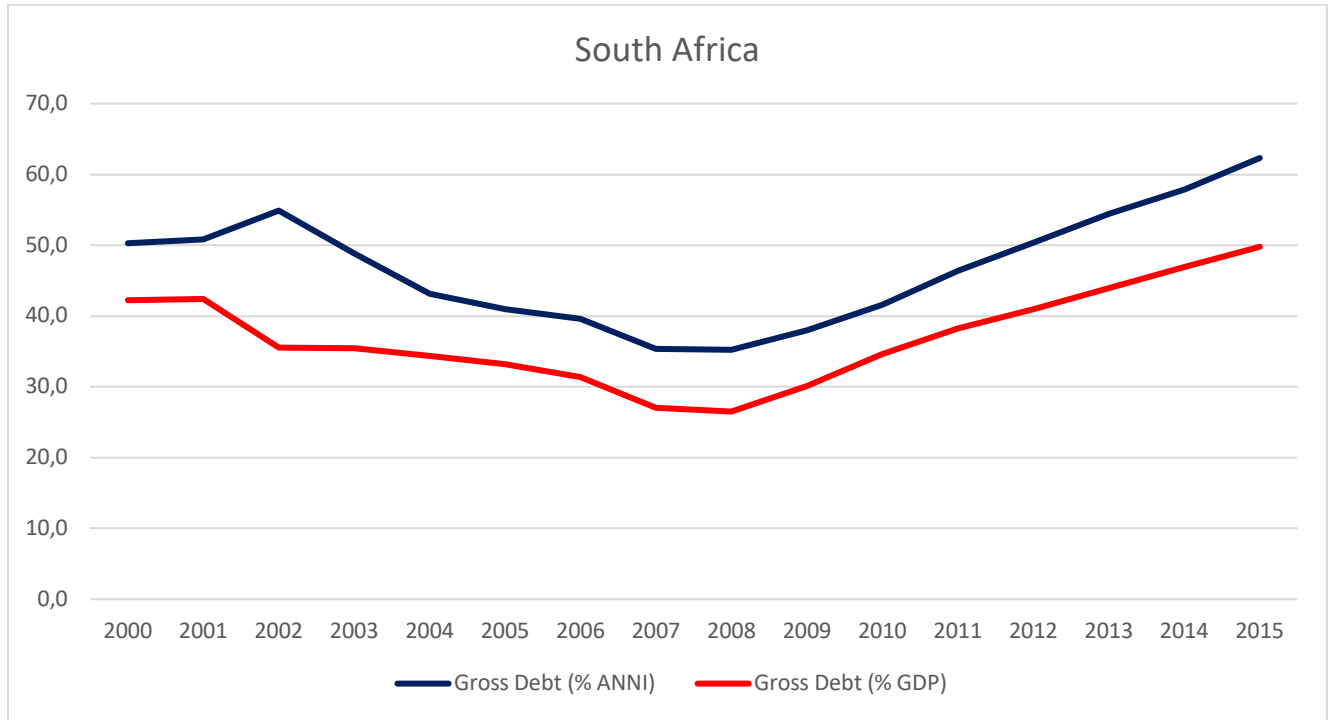
Source: Author's Own Calculations, International Financial Statistics

Figure 25j: Nigeria National Debt (% ANNI vs % GDP) 2000-2015



Source: Author's Own Calculations, International Financial Statistics

Figure 25k: South Africa National Debt (% ANNI vs % GDP) 2000-2015



Source: Author's Own Calculations, International Financial Statistics

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