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Extending The Debt-Health Trade-Off in the Era of the Green Transition

A Fixed Effects Panel Regression Analysis of Public Debt, Public Health Expenditure and Renewable Energy in Sub-Saharan Africa, 2004-2021



Abstract

This thesis investigates whether the transition to renewable energy influences the trade-off between public debt and health expenditure in Sub-Saharan Africa (SSA) from 2004 to 2021. Panel data from 38 SSA countries are analyzed using four fixed effects regression models, testing two separate interaction terms. The first combines public debt, electricity access and renewable energy consumption to assess whether renewable energy access moderates the debt-health trade-off found in previous literature. The second interaction term focuses on a simpler interaction between public debt and renewable energy consumption.

The findings contrasts from existing literature, showing a positive association between public debt and health expenditure in most models. However, when interacted with renewable energy, debt shows a negative and statistically significant relationship with health expenditure, suggesting that investment in renewable energy under debt overhang may crowd out health budgets. By contrast, the three-way interaction shows a positive effect, although close to zero which gives questionable interpretations. Overall, the results point to a conditional relationship: the fiscal space for health may expand or shrink depending on how governments prioritize debt and energy. While modest in size, the effects highlight the importance of resource allocation in shaping development outcomes under debt constraints.

Keywords: *Public Debt, Health Expenditure, Sub-Saharan Africa, Debt Overhang Theory, Development Trade-Offs*

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LIST OF ABBREVIATIONS

AFDB African Development Bank

COP Conference of the Parties

GDP Gross Domestic Product

HIPC Heavily Indebted Poor Countries

IDA International Development Association

IEA International Energy Agency

IMF International Monetary Fund

ODA Official Development Assistance

OECD Organisation for Economic Co-operation and Development

SAP Structural Adjustment Program

SDG Sustainable Development Goals

SSA Sub-Saharan Africa

WDI World Development Indicators

1. INTRODUCTION

Ever since the debt crisis in 1980 that swept across Latin America and parts of Sub-Saharan Africa, it became clear that the market for loans to developing countries was flawed. Some scholars argued that many developing nations were caught in a "debt trap" (Krugman, 1988; Onuoha, 2023) where the cost of servicing debt undermined these nations' ability to achieve long-term development. This concern remains relevant today, but the global green energy transition has added a new dimension to the debate. At COP29 in 2024, African leaders emphasized that there is a need to address the debt crisis when it comes to enabling *climate resilience* across the continent, while also focusing on a just transition (UN Economic Commission for Africa, 2024). Their claim is that long-term development goals cannot be sustained with short-term financing solutions, which is why the African Development Bank (AFDB) encourages member states to consider reforms to the global financial system, as addressing Africa's debt challenges requires significant structural changes (AFDB, 2024). As climate finance has become a growing theme within sustainable development, it also raises the question of if green energy expansions divert resources away from essential social investments like the health sector or for education.

Additionally, fueled by the pressures of climate change, framing *growth* within the language of sustainability has become an imperative for both governments and markets. Within this context, access to energy stands as a core pillar of modern development. Energy takes various forms and historically, energy as *fuel* from coal and oil are linked to early industrialization to power machinery and transportation. It worked as the foundation for mechanized production and economic expansion. However, energy as *electricity* subsequently evolved to being the modern benchmark in the energy discussion. In recent years, the focus has shifted further. It is no longer solely about expanding electricity access, but about ensuring that electricity is produced from renewable sources to meet environmental goals. This contemporary energy discussion and global aim is often referred to as the green energy transition.

In Sub-Saharan Africa (SSA), access to electricity has doubled in the 21st century, rising from 25.7 percent of the population in 2000 to 51.5 percent in 2022 (World Bank Indicators). This period has also witnessed an ideological shift in global energy systems, where renewable energy is increasingly positioned as both the environmentally and economically preferable path. This

positioned electricity access from renewable sources within the discourse of sustainable development - both as an enabler to economic growth and a contributor to increased living standards.

According to the International Energy Agency (IEA) by 2024, global investments in clean energy had grown to nearly twice the amount invested in fossil fuels. Yet, this shift is not without conflict. The European Commission acknowledged that despite Africa's great potential for renewable energy sources, the continent receives only 3% of global energy investment, leaving 600 million people in Africa without electricity.

A hindering factor affecting both electricity access and thus development, are monetary enablers. Expanding electricity access and scaling up renewables are two global goals requiring substantial financing. As countries in SSA increasingly turn to bilateral and multilateral loans to fund development, this raises critical questions about whether this type of development initiatives drives debt levels, and if so, if it enables or restricts investments in other vital public goods such as healthcare. Seemingly, this growing focus on sustainable energy places countries in SSA at a potential trade-off as expanding access to renewable energy sources to meet climate goals may require public debt, yet rising debt levels can constrain public spending in essential sectors like healthcare. This debt-health trade-off is the central analytical focus of this research.

1.1. Aim of study and research question

To summarize these potentially conflicting challenges, while debt can secure crucial projects increasing the share of renewable energy, it can divert investments in social spending. The general question that arises from this discussion is how climate finance effectively can contribute to energy transition while still ensuring that social spending priorities are not compromised. The foundation of this study is built on the assumption that these variables interact, leading to the creation of an interaction term to capture their combined effect. There is much research on public debt from a range of perspectives, but not as much on the effects of renewable energy on the trade-off between debt servicing and health expenditure. This study builds on insights from prior research showing that public debt can both support and constrain development objectives, depending on fiscal space and governance context. To comprehend this potential trade-off, the research question guiding this thesis is as follows;

Does renewable energy influence the trade-off between public debt and health expenditure in Sub-Saharan Africa?

1.2. Scope

This study focuses on Sub-Saharan Africa. The research question is operationalized with a dataset covering the period 2004 to 2021. This time frame is chosen primarily due to data availability. Due to time constraints, only one area of public expenditure will be analyzed. The dependent variable in the study will be health expenditure. This study's focus aligns with the quantitative scope of earlier studies (Fous, 2008; Said and Sani, 2020), both of which examine health expenditure in relation to public debt.

2. BACKGROUND

Understanding the trade-off between debt and public health expenditure in SSA requires examining the historical processes that shaped debt accumulation in the region. This chapter traces the development of public debt in Africa, from the end of colonial rule to Bretton Woods institutions, and considers how climate finance, and renewable energy, has introduced a new dimension to development in the 21st century.

2.1. Conceptualizing neocolonialism within the origins of public debt in Africa

The origins of public debt in Africa cannot be understood without first recognizing the economic structures inherited from colonial rule. Many African countries gained their independence during the 1950s and 60s, but post-independence saw another chapter of dependence arising amid economic globalization, namely "neocolonialism". The idea of neocolonialism shaping the global financial landscape is not a new understanding of this era. After gaining independence from Britain in 1957, Kwame Nkrumah, the first African-born president of Ghana, stated in his book "Neo-Colonialism: The Last Stage of Imperialism" from 1965, that;

"The essence of neo-colonialism is that the State which is subject to it is, in theory, independent and has all the outward trappings of international sovereignty. In reality its economic system and thus its political policy is directed from outside."

Further, Nkrumah argues that with time, the neo-colonial control has become unidentifiable with particular states but is exercised by a consortium of financial interests. These investments from foreign capital rather results in increasing global inequality, than resulting in development of the less developed countries. Nkrumah although does not mean to exclude foreign capital in less

developed countries, but wants to prevent this financial power to impoverish these countries (Nkrumah, 1965, p.4-6). Another way he describes this financial power, or neocolonialism, is partly as a form of "Western financial monopoly" (Nkrumah, 1965, p.42).

2.2. Bretton Woods and SAPs

This Western financial monopoly has on one hand contributed to development, while being questionable. After the second world war and with countries starting to decolonize, countries in the global north increasingly sought to integrate newly independent nations into the global economic system, partly to prevent them from aligning with communist ideologies. Terms such as “developing countries” and “third world” started to arise, defining nations through their levels of poverty and economic challenges (Okeke, 2001).

With intention to support post-war reconstruction in 1944, two institutions central in the new international economic order was created at the Bretton Woods Conference: The International Monetary Fund (IMF) and the World Bank. These institutions extended their reach to developing countries, by giving loans to less developed countries to support economic reforms in favor of liberalization and the international free market, enabling participation from banks in the global north as well (Cheru, 2002). Through these institutions, *multilateralism* became a mechanism to ensure continued global economic prosperity and improved living standards. By the 1980s, these loans had escalated to such extent that debt-servicing became too difficult. With the aim to aid indebted countries and foster development, the Bretton Woods institutions established Structural Adjustment Programs (SAP), a tool to enforce the economic policies outlined in the Washington Consensus (Skosireva and Holaday, 2010; Loewenson, 1993). Through enforcing these macroeconomic policy packages, SAPs, they aided to liberalize markets by limiting the role of government's, promoting privatization, deregulating markets and establishing market-driven pricing.

Nations seeking assistance from these institutions were commonly required to implement SAPs, the set of macroeconomics policies. During the late 1980s, over 257 SAPs were implemented in 38 countries in Sub-Saharan Africa. The SAP aimed to foster economic growth, but beyond this development indicator, some scholars claim that SAPs led to negative implications on other indicators such as health. For example, according to Loewenson (1993), SAPs often led to cuts in health sector expenditure as developing countries were encouraged to reduce public spending and boost exports to adjust their economies to support debt repayments. The IMF and the World

Bank did however adjust their policies after criticism, and the aim was to mitigate negative impacts on health, while being more responsive to the developing countries needs. As a result, the Highly Indebted Poor Countries (HIPC) was adopted to address the debt burden caused by external debt services. This enabled heavily indebted developed countries granted debt relief if eligibility conditions were met, but conditions that also have been debated (Cheru, 2012; Skosireva and Holaday, 2010).

2.3. Critical interpretations of the development of debt

Simultaneously, the perception of "dependency" grew. Stemming from Latin American social science, dependency theory offers a perspective on development which originated in the 1960s which continues the line of critique by Nkrumah by emphasizing how economic subordination continues through global financial structures that favor the interests of former colonial powers. The theory posits that developing countries had, despite legal independence, become economically subjugated to wealthier nations, limiting their policy autonomy and economic sovereignty. While this theory is not tested in this study, it relates to historical background of the study which enriches the discussion from a global political economy perspective.

Frank (1966) argued that underdevelopment in the Global South is not a natural stage of progress, but rather the result of historical and structural exploitation by wealthier nations. Frank's core-periphery model argues that global capitalism creates a system where developed nations are positioned in the 'core' by accumulating wealth through exploiting countries positioned in the 'peripheral'. This exploitation is facilitated by unequal trade, aid and investment relationships, which hampers independent development and instead reproduces dependency. According to Frank's theory, the economic connections between core and peripheral countries maintains dependency. Underdevelopment is thus a product of global integration, not internal failings.

Scholars like Zajontz (2022) argue that this dependency restricts economic autonomy, forcing countries to prioritize debt repayment over domestic development needs. Which results in exploitative financial systems that maintain neocolonial control. However, while the theory gives insight into power relations and autonomy, it has been criticized for the simplified view of global economics and power dynamics. This limitation does not fully explain the complex relationship between nations, nor the recent economic successes in developing nations. But it does correlate with the current opposition from the AFDB to some extent.

On the other hand, Hansson and Hentz (1999) discuss how the neoliberalism in the developing world during the 1980s and early 1990s, and argue that the adoption of neoliberal reforms by African governments cannot be fully explained by external financial pressure alone (such as from the Bretton Woods institutions). Rather, the authors argue that local political dynamics and the "ownership" of these neoliberal ideas by African elites were equally significant. This perspective circles back to Nkrumah who acknowledged the participation of domestic elites who govern on behalf of foreign interests, and thereby deepened the economic subordination of their own populations.

While Nkrumah focused on the influence of foreign capital, later scholars have shown how similar patterns of control and dependency continued through formal development mechanisms, for example aid. Langan (2018) builds on this perspective and argues that aid continues to function as a tool of external influence. From a critical constructivist standpoint, he highlights how development efforts are often framed in terms of altruism and partnership. However, this language can conceal the underlying power dynamics and potentially justify the involvement of external actors in domestic policymaking. Langan exemplifies budget support as aid instruments that where introduced under the Post-Washington Consensus, which have reinforced market-oriented reforms from the donors' priorities, rather than local needs. These dynamics show that Africa's debt accumulation cannot be separated from aid's broader political role, which has often included conditions that limit policy space, perpetuating the very patterns of dependence Nkrumah described.

2.4. The Green Transition as a New Development Dilemma

While the debt crises of the 1980s were driven by the macroeconomic policy packages, SAPs, the 21st century has introduced new challenges. Debt relief initiatives such as the HIPC attempted to alleviate the debt burden, but the core structural issues of external financial dependency continued. In today's context, international development is often financed through mechanisms that involve borrowing and continues to be shaped by the influence of global financial institutions. However, the IMF and the World Bank have evolved their strategy in the work towards development, focusing more on country-driven tactics preventing poverty while also evaluating risks of debt distresses (Hansson and Hentz 1999; Loewenson, 1993; Skosireva and Holaday, 2010). Yet, as climate imperatives have grown, the global focus on the green energy transition have added a new dimension to development. The 21st century saw climate change initiatives included in the development agenda. Global climate commitments such as the yearly

COP summits since 1995 and the Global Sustainable Development Goals (SDG) since 2015, has also stirred markets to seek profits from green initiatives. The climate crisis thus added a new dimension to development financing, often referred to as climate finance, which typically involve green bonds, concessional loans, equity and aid aimed at supporting green initiatives and projects.

The SDGs includes both expanding electricity access and scaling up renewable energy to secure sustainable growth in SSA. Two scholars recently argued that renewable energy financing can be seen as a continuation of post-colonial power dynamics, which I understood as neocolonialism within the context of environmental and economic dependency. Haag (2023) for example contextualizes the political economy of energy transitions with the intent to show how renewable energy infrastructure and finance intersects in Senegal due to their colonial history. Likewise, Müller et al. (2020) describe how market-oriented renewable energy policies shaped by external actors, prioritizing investor interests over systemic justice concerns, possibly reinforce post-colonial dependencies.

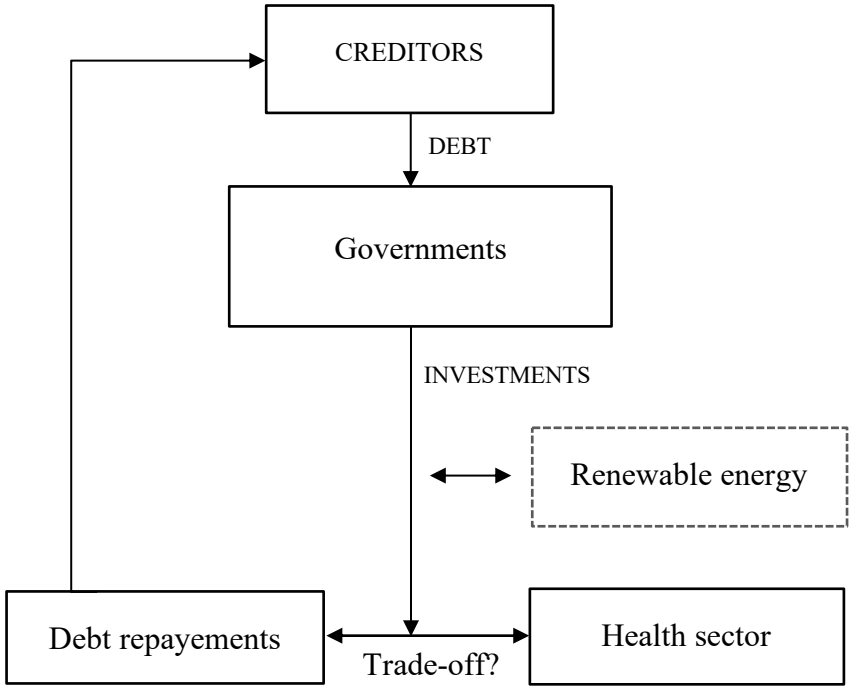
These perspectives challenge the idea that renewable energy is inherently progressive or neutral. Instead, they suggest that the way energy transitions are financed might quietly reinforce power structures. This raises questions about how governments in a debt-constrained context make fiscal decisions and what then gets prioritized. This thesis does not aim solve this question, but to draw attention to how these tensions can take shape and to explore whether they influence how governments prioritize public spending in practice.

2.5. Conceptual framework

Figure 1 below outlines the conceptual framework of the relationship I aim to explore: how high public debt levels might constrain government spending, potentially creating a trade-off between debt servicing and investments in the health sector. From this trade-off, renewable energy is included to reflect another development priority that could shape or complicate this relationship. The idea is not to suggest a fixed causal pathway, but rather to point to how these elements might interact in practice. The bidirectional arrow in the figure reflects a two-way relationship: energy access aims can shape fiscal decisions, while those same decisions, especially when linked to debt-financed investments, influence energy development. Governments, as recipients of public debt, navigate competing fiscal priorities; on one hand, funds going towards debt repayments, on

the other, towards domestic investments like health and energy. Renewable electricity access is not assumed to be a direct cause of changes in spending, or to be a part of the trade-off. Instead, energy is treated here as a relevant development area that may interact with the debt-health trade-off.

Figure 1. Conceptual framework



To put this conceptual framework into practice, Senegal works as an example. Senegal's government, through its state-owned electricity company Senelec, has expanded electricity access in collaboration with international institutions such as the World Bank and the French Development Agency (IEA, 2023, p. 44). These development efforts are often financed through public debt, linking the green transition to fiscal policies and budgets. While private actors such as construction firms and energy companies may also be involved in these projects linked to energy expansion, this thesis focuses on the public side and public debt, or more concretely; whether public investments in energy access, even when framed as sustainable development, contribute to higher debt burdens, and whether that affects the government's ability to invest in public health.

On the theme of energy, liberalization plays an important role in this story. Since liberalizing the electricity market in 1998, Senegal has opened its energy sector to private investment and competition. According to the IEA (2023, p. 85), the World Bank and IMF drove these reforms

by providing conditional loans and grants, contingent on legal restructuring that included privatizing Senelec and unbundling the electricity sector. These changes enabled the development of national grids and mini-grids and has contributed to the increased electricity access. Legal reforms and international partnerships (and public debt) resulted in Senegal reaching a 30% share of renewables in its installed capacity in 2023. Successfully, the green energy market is increasing and the dependency on international institutions help facilitate this green transition. Yet, the green energy market must increase at a slower rate than the non-green energy market as the percentage of use of renewable sources are decreasing, as seen in figure 3 (IEA, 2023, p. 85).

Regarding the debt dynamics, in 2006, Senegal benefited from the Multilateral Debt Relief Initiative (MDRI), which cancelled its debt to the World Bank's International Development Association (IDA). However, this did not cover bilateral loans or private bonds, which have increased significantly since 2015 (World Bank, 2024, IDR). The IEA (2023, p. 72) notes that international partners and multilateral banks have committed 2.5 billion euros to accelerate renewable energy deployment in Senegal. While this may be seen as supportive financing, it also highlights Senegal's reliance on external debt to achieve its energy goals. The IEA further recommends attracting a mix of equity and debt financing for large-scale projects while being cautious of being over-reliant on debt (IEA, 2023, p. 119–123).

In light of these points, these developments raise important questions about whether public debt for energy access and renewable energy crowds out investments in public health, which is what this thesis aims to examine. This can be interpreted as two perspectives: the appreciation of international funding, or Senegal's dependence on it for achieving sustainable growth. Nevertheless, they can both be true at once or studied separately. They however highlight the full concept in which I intend to examine in this study.

3. THEORETICAL FOUNDATION

In this study, I intend to examine if renewable energy impacts public debt, which in turn impacts health expenditure. Public debt includes all debt the government has accumulated – both domestic and external, where external debt can be;

- Bilateral = government to government loans
- Multilateral = multilateral organizational loans such as the IMF, the World Bank and development banks.

- Corporations = both private- and public

To understand the global political economy of public debt in SSA, it is relevant to both comprehend literature examining the macroeconomics of public debt as well as the political economy of the debt-growth nexus. Therefore, this thesis leans on theoretical foundations on debt-overhang to explore this complexity, with a focus on debt overhang from Krugman's (1988) perspective, grounded in neoclassical economics, which focuses on how high debt levels may discourage public investment.

3.1. Debt overhang theory

The debt-overhang as a phenomena will be theorized and discussed in this chapter. Krugman (1988) discuss debt overhangs in his paper Financing VS. Forgiving a Debt Overhang, by theorizing the effects of high levels of debt which can only be fully serviced with new borrowing. Krugman writes specifically "By a debt overhang I mean the presence of an existing, 'inherited' debt sufficiently large that creditors do not expect with confidence to be fully repaid." According to Krugman, high levels of public debt divert government spending from domestic investments to debt repayments, since any additional income generated through reforms or investments primarily benefit the creditors instead of the domestic welfare. The potential benefits from economic growth are then not fully internalized by the debtor, which reduces the incentive to take on new debt. As a result, high public debt becomes self-defeating and harm both debtor and creditor by reducing the country's repayment capacity and delaying development. Krugman created a model that suggests that developing countries' inherited debt has created a tradeoff between new lending and debt forgiveness, where at a certain point the latter is more effective.

Krugman's perspective on debt-overhang arose during the 1980s, specifically as an analysis of the debt crisis that began in the early part of that decade, but it remains relevant in the current context where debt levels in many Sub-Saharan African countries have increased even further, despite debt relief efforts. He approaches the issue from a neoclassical economic framework, with a focus on expected returns and the behavior of rational actors. His model assumes that debtor countries are like debtor firms and make decisions based on whether the benefits of borrowing outweigh the costs. What sets debt overhang apart is that, beyond a certain threshold, this logic breaks down and the costs of borrowing increase, while the expected benefits are increasingly captured by external creditors. In this context, public debt becomes a structural constraint on development, even if it is not always visible immediately.

Following this line of argument, Elbadawi (1997) empirically support Krugman's theorization and shows more sides of debt overhang with a focus on SSA. With a debt-overhang Elbadawi "refers to the existence of a large debt that has adverse consequences for investment and growth because investors expect that current and future taxes will be increased to effect the transfer of resources abroad.". The debt distress is reflected not only in the high debt ratios, but also in the rising arrears. Despite positive net financial inflows and various debt relief initiatives, SSA has on average been able to service only one-third of its debt obligations (between 1991-1997). Elbadawi also argues that large debt burdens, instead of flowing into productive sectors, investment often takes the form of short-term, low-risk ventures or remains in liquid assets. As a result, this creates a coordination problem: potential investors hold back because the risks are too high. Elbadawi argues that without significant outside help, like major debt relief, Sub-Saharan African countries will struggle to enter a positive cycle of reform, stability and lasting growth.

Seemingly, the problem of public debt overhang is knowing the threshold of when debt distress hits, which would then inform us of when for example a debt relief would be appropriate. This is also theorized by Reinhart, Reinhart, and Rogoff (2012) in the discussion of debt-overhangs. They, like the previous scholars, argue that this overhang and slow economic growth often happen at the same time. If a country's economy grows slowly, it will probably pile up more debt. And once the debt overhang is established, slow growth can impede their way out from it. At first, Reinhart, Rogoff, and Savastano (2003) add nuance to this by arguing that developing to emerging economies may struggle with repayments at a much lower debt-to-GDP ratio, compared to advanced economies. This threshold could be as low as 15 to 20 percent of GNP. This vulnerability is rooted in national histories of debt defaults and weak institutions, which leads to volatility and high borrowing costs. To further this argument, Reinhart, Reinhart, and Rogoff (2012) showed that in advanced economies, when debt levels exceed 90 percent of nominal GDP, most of these countries experience notably slower growth. While 90 percent is not a universal threshold, it suggests that periods with high public debt levels can weigh down economies over time. Even though this study does not seek to identify the specific threshold at which a debt overhang occurs, it seeks to assess whether a debt overhang is present. If a negative association is observed between public debt and health expenditure, it would confirm the theoretical arguments proposed by the authors.

Conclusively, these ideas about debt-overhang together reinforce that there is no single "safe"

level of public debt that applies to every country, but it is shaped by a country's history and context. Once public debt gets past a certain threshold, it can actually discourage investment and slow down growth, which goes for any economy - developed or developing. It also informs us that it happens at the same time as slow growth periods. This theoretical lens will guide the analysis of how debt levels may influence government spending priorities, particularly health expenditure. By using debt-overhang as a theory, this study will test (1) if this association also applies for the scope of this thesis, and (2) if renewable energy has an effect on this association.

Based on the theoretical framework of a debt-overhang, the empirical implication is that rising public debt may constrain government investment in health, especially under competing demands like renewable energy. This makes it appropriate to collect panel data on the variables: public debt, health expenditure and energy indicators.

4. LITERATURE REVIEW

In this chapter, I will present the following research, grounded in both public debts effect on development and how scholars comprehend energy in this context. The research found that public debt can support development if it finances welfare-enhancing investments. However, excessive debt may hinder economic growth, reduce fiscal space and also impact social spending negatively. Previous research has supported this claim, while other scholars has showed how energy as electricity led to positive effects in the long run. Prior studies suggest that debt often crowds out social expenditure, but others highlight electricity access as a driver of improved living standards, including health outcomes. If debt is used to finance infrastructure for electricity access, it may reduce the negative impact of debt on health expenditure. At the same time, shifting to renewable energy requires large investment which might accumulate debt. These will now be presented in the following sections.

4.1. Public Debt and Health Expenditure

We can look at public debt from different angles to understand how it impacts the economy. This study is rooted in Global Political Economy (GPE), a field that uses economic analysis to explain broader structures of power, development and global inequality. Recent research has explored public debt's impact on different development outcomes. To start with, Said and Sani (2020), who built upon Fosu's (2008) methodology in analyzing the effects of debt on social spending, found that with higher public debt, health expenditure tends to be lower, but with higher quality

institutions, the impact reverses. This result, based on SSA, suggests that the relationship between public debt and health expenditure is a function of institutional quality. Consistent with this research, Mbewe (2024) recently concluded that rising debt obligations shifts financial resources away from essential public services. The author's analysis focused on education expenditure and public debt service, studying 15 Sub-Saharan and South American countries from 1995 to 2022. Muhammad & Abdullahi (2020) studied the impact from external debt servicing on economic growth. Their result showed that the long-run effect of external debt servicing is a negative effect on economic growth.

This tension is not new. In a widely cited study, Fosu (2010) continued this methodology to show how debt constraints growth in developing countries. Most of the Sub-Saharan African countries were since the early 1980s struggling to generate sufficient resources to meet debt obligations. With a quantitative analysis examining debt servicing, by studying up to 35 African countries over 1975–94, Fosu (2010), showed that debt negatively impacted the ability to allocate funds to healthcare and education. While this study is of major importance and interesting for my research question, the sample period is 1975-1994. Hence, there is need for more research focusing on more recent years.

Lora (2011) on the contrary, also found that higher debt ratios tend to reduce social expenditure, but not necessarily because of the direct burden of debt *servicing.* The author studied total public debt worldwide and in Latin America between 1985-2003. The result showed that governments with high total debt levels, displaces social expenditure, since it reduces the appetite for further indebtedness, rather than being due to it raising the debt-servicing burden. But to protect social expenditures, avoiding over-indebtedness remains as best practice.

4.2. Public Debt and Renewable Energy

Public debt's effect on carbon emission has been studied by Abbas et al (2023), as well as the importance of maintaining a sustainable level of debt. The study discusses debt in the narrative of macroeconomic principles of how it influences investments and welfare; debt works as an investment enabling renewable energy projects, but excessive levels of debt hamper new renewable energy initiatives and investments in welfare. This means that debt can lead to a decrease in public spending, leading the government to make budget cuts.

As Said and Sani (2020) concluded that institutional quality can reduce the negative impacts of

high public debt levels, one study exemplified governance in renewable energy implementation. Brunet et al. (2022) who studied six countries in Africa; Burkina Faso, Madagascar, Morocco, Rwanda, Senegal and South Africa, exploring solar energy's effect on reducing poverty and/or increase energy security. Through qualitative and quantitative methods, the study showed a critical tension in renewable energy projects. The authors concluded that sustainability requires balancing global climate goals with local social acceptance. Successful integration of solar plants thus goes beyond merely technological factors but necessitates addressing local needs and state-driven governance. The study found neutral or negative impact on health due to socio-political factors, with examples including the closure of a health center in Senegal and difficult access to health centers in Madagascar due to poor roads.

Onuoha et al (2023) examine the effect of public debt on renewable energy consumption (REC) in Sub-Saharan Africa. They find that public debt has a direct positive impact on REC, suggesting that debt can be used to finance renewable energy projects and research. However, they also find that the interactive effect of governance quality and public debt impedes REC, suggesting that the effectiveness of debt-financed renewable energy development depends on governance structures. As the previous studies presented, the study also notes that rising debt levels may eventually force governments to reduce investments, where Onuoha et al adds can potentially affect public spending on renewable energy. At the same time, public debt can indirectly support REC through economic expansion, since capital inflows and increased income levels may raise the capacity to adopt modern energy technologies. Onuoha et al. conclude with arguing that SSA economies should increase their investments in renewable energy through targeted public debt financing and other special borrowing arrangements, while being careful with managing fiscal space to maintain economic stability.

4.3. Renewable Energy and Health Expenditure

There are studies linking renewable energy consumption with positive effects on health in the long run, which makes the conceptual framework either more complex or not just yet visible. For example, there is a correlation between Human Development Index (HDI) and power consumption. In a study by Ouedraogo (2013), the result showed that in the long-term, the cointegration relationship between *energy* consumption and the HDI are negative, while there is a positive cointegration relationship between *electricity* consumption and HDI. Access to renewable energy sources (renewable energy) is thus essential for human development since it drives improvements in welfare (including health). This study empirically exemplifies the

necessity for renewable energy in development. Fisher-Vanden & Wing (2018) also studied the relationship between electricity and economic development from a macroeconomic perspective. The study found a strong correlation between electricity use and economic development but emphasized the need for more studies to prove a causal link. It suggests focusing on the impact of electricity reliability and access and improving the theoretical understanding of this relationship.

These studies showcase the interaction between energy and increased living standards. I would say that it could correlate with Said and Sani's study, as they claimed good institutions manages debt more properly. Implementing renewable energy to increase energy access, could thus be an example of well-managed debt. Although, there needs to be actual potential to manage it to these sectors.

4.4. Integrating renewable energy in the trade-off

The next step based on the previous research, is to further understand the positive or negative effects of renewable energy in the debt-health trade-off. Understanding how renewable energy affects debt is important both for the field of economic history and international relations, to understand how this contemporary crisis of indebtedness as well as the green transition, shapes economics and politics. The interaction terms based on previous methods, creates an original approach to the field. By incorporating debt with an interacting variable with electricity access and renewable energy consumption, the study provides a new perspective on how debt driven by energy indicators, influence health expenditure. Previous studies have separately assessed debt's impact on health expenditure and the relationship between energy access and health, while this study aims empirically to test them together.

4.5. Hypotheses

While previous research suggests that public debt often crowds out health expenditure, some studies also indicate that increased electricity access is linked to improved living standards, which includes health. This implies that accumulated debt, if invested in electricity infrastructure or projects, could potentially lessen the negative effects from public debt on health expenditure.

As previous studies emphasized the role that renewable energy plays in development strategies and improving welfare outcomes, transitioning to renewable energy simultaneously requires substantial investments. By interacting public debt with the share of renewable energy

consumption, the aim is to assess how the countries expansion of renewable energy influences the effect of debt on health expenditure. Within the context of SSA's renewable energy transition, this research explores how such a transition may affect debt levels and, in turn, public health expenditure. To better understand the relationship between debt and health expenditure, one interaction term is tested combining public debt with two energy variables, electricity access and renewable energy consumption, together creating a new variable: *renewable energy access*. The other interaction term test renewable energy consumption's sole interacting effect on public debt. The purpose of this new combined variable is to investigate whether the impact of debt on health expenditure varies depending on a country's level of renewable energy access. Based on this gap in the literature, and drawing on the theorization of debt overhang, I have formulated 3 hypotheses to test in the following section:

H1: Higher levels of public debt are negatively associated with public health expenditure.
H0: Higher levels of public debt are positively associated with public health expenditure.

H2: Higher levels of public debt, interacted with renewable energy, is negatively associated with public health expenditure.
H0: Higher levels of public debt, interacted with renewable energy, is positively associated with public health expenditure.

The first hypothesis tests whether the relationship between public debt and health expenditure aligns with previous research findings. The second hypotheses extends the analysis by introducing renewable energy.

5. METHODOLOGY

By analyzing the interacting effects on debt by (1) renewable electricity access and (2) renewable energy consumption, this study explores if debt impacted by energy indicators, affect health expenditure. The study focuses on Sub-Saharan Africa for the period 2004-2021. This study follows an econometric approach similar to Said and Sani (2020), who built upon Fosu's (2008) methodology in analyzing the effects of debt on social expenditure. Both studies examined debt and health expenditure in SSA, with Said and Sani (2020) using an interaction term for institutional quality. With a similar method with an interaction term, this study instead explores the effect on health expenditure by using two variables for energy to create two interaction terms. The aim is to examine the impact of public debt on health expenditure in SSA while also

investigating whether the impact has changed by energy sector indicators.

5.1. Research method

A fixed effect panel regression analysis is used to empirically study the relationships between the variables. The form of energy that is of interest is mainly electricity. The decision to use a fixed effects model, rather than a random effects model, is based on the strong theoretical grounds that these unobserved country-specific factors are likely correlated with the independent variables (Gujarati, 2012, Chapter 17). R was used for the regression coding with technical assistance from the AI-tool ChatGPT.

Historical legacies like colonialism and financial dependency are structural conditions that vary across countries but a theoretical factor that remained stable within each country over the time period. As Gujarati (2012, p. 293) explains, a fixed effects model is appropriate in such cases to control for this unobserved heterogeneity. The theoretical expectations about historical, political and structural factors influencing both debt and health expenditure, align well with the logic of a fixed effects framework.

In the econometric model, this is implemented by allowing each country to have its own intercept, effectively accounting for these time-constant, country-specific characteristics. The theoretical arguments derived from Krugman's debt overhang theory and Frank's dependency theory, both assume structural constraints and historical patterns that influence economic behavior. By focusing on within-country variation over time, this method allows the analysis to concentrate on how variables change within individual countries.

5.2. Model specification

The dependent variable for the study is health expenditure while public debt is the main independent variable. All models control for a set of control variables (explained in the Data chapter below), while the fourth model is a simpler model to test according to the principle of parsimony (Gujarati, 2012, p.44). Meaning a simple model specification might give better results.

Model 1 is without interaction term and identifies whether the variables independently influence health expenditure:

$$XPD = \beta_0 + \beta_1 DEB_t + \beta_2 ELC_t + \beta_3 FEC_t + \beta_4 ODA_t + \beta_5 URB_t + \beta_6 CPI_t + \beta_7 DPND_t + \mu_i + \lambda_t + \varepsilon$$

Model 2 includes the first interaction term (renewable energy access):

$$XPD = \beta_0 + \beta_1 DEB_t + \beta_2 ELC_t + \beta_3 FEC_t + \beta_4 ODA_t + \beta_5 URB_t + \beta_6 CPI_t + \beta_7 DPND_t + \beta_8 DAR_t + \mu_i + \lambda_t + \varepsilon$$

Model 3 includes the second interaction term (renewable energy consumption):

$$XPD = \beta_0 + \beta_1 DEB_t + \beta_2 ELC_t + \beta_3 FEC_t + \beta_4 ODA_t + \beta_5 URB_t + \beta_6 CPI_t + \beta_7 DPND_t + \beta_8 DAR2_t + \mu_i + \lambda_t + \varepsilon$$

Model 4 includes the second interaction term (renewable energy) with a simpler model:

$$XPD = \beta_0 + \beta_1 DEB_t + \beta_3 FEC_t + \beta_4 ODA_t + \beta_7 DPND_t + \beta_8 DAR_t + \mu_i + \lambda_t + \varepsilon$$

where:

XPD = Current health expenditure (% of GDP)

DEB = General government gross debt (% of GDP)

ELC = Access to electricity (% of population)

REC = Renewable energy consumption (% of total energy use)

ODA = Net ODA received (% of GNI)

DAR = Interaction term (DEB x ELC x FEC)

URB = Urban population (% of total population)

CPI = Inflation, consumer prices (annual %)

DPND = Age dependency ratio (% of working-age population)

and:

β_0= the expected intercept parameter

β_n= the coefficient measuring the impact on XPD from a one unit increase of independent variable

μ_i = the country fixed effect

λ_t = the year fixed effect

$\boldsymbol{\varepsilon}$ = the error term

The data covers the period from 2004 to 2021. This time frame is chosen primarily due to data availability, since the main independent variable DEB is not available before 2004, and the dependent variable XPD is not available after 2021. During these years, the data shows notable changes in public debt levels, as well as increased energy access and a global trend toward increased renewable energy adaptation. The balanced panel includes 684 observations from 38 countries, where countries with missing data has been excluded.

5.3. The Data

All the data except DEB is sourced through R from the public database; World Development Indicators (WDI). DEB is extracted through the IMF's public database.

5.3.1. Dependent variable

The dependent variable, XPD, is the level of current health expenditure expressed as a percentage of GDP. It is the weighted average of healthcare goods and services consumed annually, but does not include health expenditures such as buildings, machinery, IT and stocks of vaccines for emergencies or outbreaks. This means the variable is somewhat incomplete as it does not capture long-term investments in for example healthcare facilities, or expenditures such as pandemic emergencies. XPD monitors the annual flow of resources rather than the accumulation of assets or resources over time. This means that the budget of the health sector is not accounted for, but only what was spent during the given time frame (WDI, n.d; WHO, 2025).

In the context of this study, the dependent variable XPD provides a metric to evaluate how fiscal constraints, such as rising debt levels, may affect government spending on health, and it is central to interpreting the interaction between public debt and energy indicators. Although it does not capture the complete picture, it can still reflect shifts in policy and public prioritization in the health sector.

5.3.2. Independent variables

<u>Public debt</u>

The main independent variable is public debt, DEB, represented by the gross government debt-to-GDP ratio from the World Economic Outlook accessed through the IMF database. Gross debt includes all liabilities requiring future payments of principal or interest, excluding equity and

financial derivatives. The variable reflects the stock of public debt and not the flow debt service payments. Although debt service is one factor that shape fiscal space and spending decision, the variable gives an understanding of indebtedness and thus the level of debt-overhang and can work as a proxy for when indebtedness may suppress public spending.

Renewable energy consumption

Renewable energy consumption, REC, is the percentage of renewables in the total final energy consumption, measured as the annual weighted average. While the definition of renewable energy source is not defined in the WDI database, renewables are typically considered to include energy sources such as solar, wind, hydropower and biofuels. It can work as a measurement of green energy transition.

Access to electricity

The variable access to electricity, ELC, is measured as the percentage of the population with access to electricity. This measure thus accounts for a growing population. It can serve as an indicator to both energy poverty and development of energy infrastructure. It does not however account for type of electricity source, such as renewables, or the quality and reliability of the electricity access.

5.3.3. Interaction terms

The interaction term's main purpose is to multiple DEB with energy indicators. The first interaction term is a three-way interaction term. Renewable energy consumption (FEC) and energy access (ELC) multiplied together, results in the share of renewable energy consumption in the share of access to electricity, summarized as *renewable energy access*. The result can show if renewable energy access effect on DEB strengthens or weakens the governments health expenditure. The incorporated interaction term is designed to capture the joint influence of public debt, electricity access and renewable energy consumption on health expenditure. This new variable, DAR, is thus created by multiplying these three independent variables: public debt (as % of GDP), electricity access (as % of population) and renewable energy consumption (as % of total energy use):

$$DEB \times ELC \times FEC = DAR$$

One limitation with the three-way interaction term is that it might be challenging to interpret its real effects. Essentially, the variable is constructed to capture how the relationship between public debt and health expenditure shifts when renewable energy access changes, but the

combination of three variables makes it difficult to determine which of these variables primarily drives the effect.

To examine if the model benefits from a simpler interaction term, the second one is a two-way interaction term. This only multiple public debt with renewable energy consumption. As the theoretical departure point is based on the effects of the green transition in the debt-health trade-off, it could make sense to only test renewable energy consumptions interaction with public debt.

$$DEB \times REC = DAR2$$

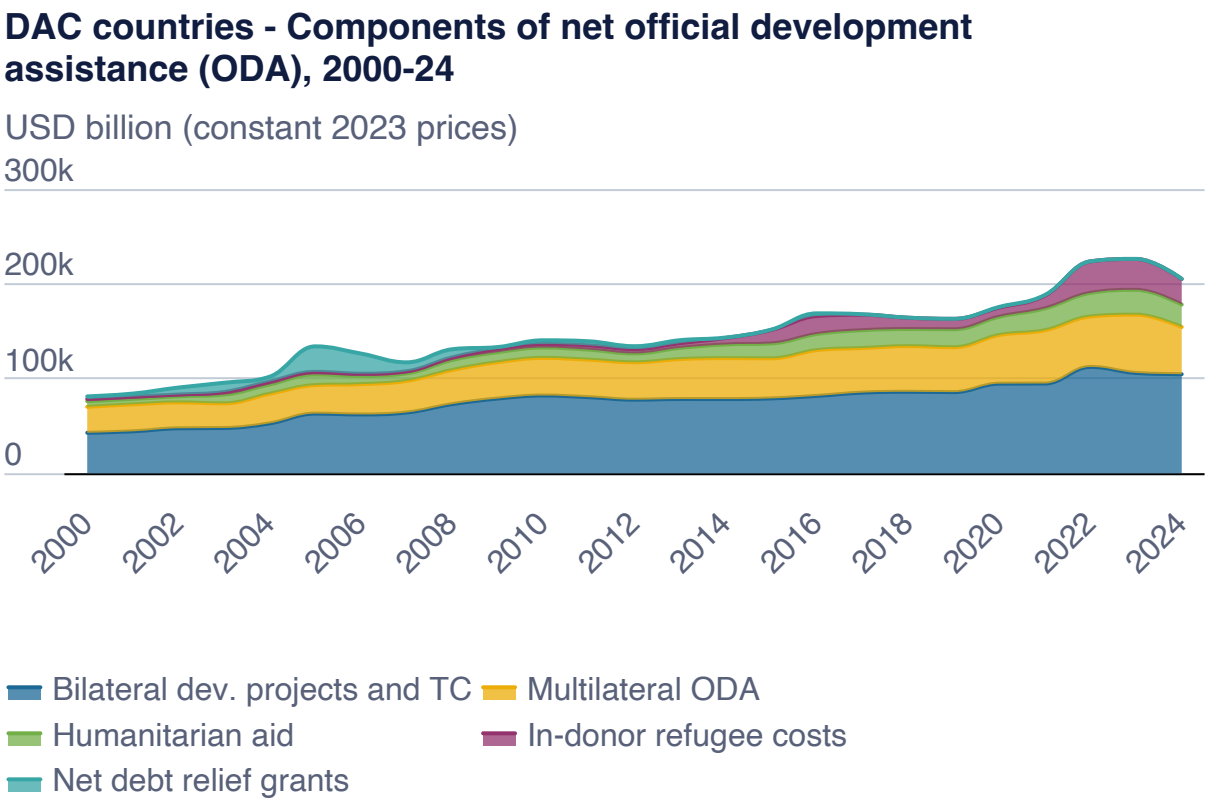
But since the variable REC only captures the share of renewables in the energy used, the total access to renewables goes missing which means it overlooks whether investments in green energy are actually reaching people. It also risks oversimplifying the trade-off by assuming a uniform relationship across countries with very different energy mixes.

5.3.4. Control variables

Official Development Assistance

To understand how development assistance interacts with the broader debt landscape shaped by Bretton Woods institutions, a measurable foreign aid variable is included as a control variable. The OECD's Official Development Assistance, ODA, is government aid targeting economic development and welfare of low- and middle-income countries. ODA comprises bilateral and multilateral concessional loans and grants, multilateral institutions including the IMF, World Bank, Development Banks and the European Union. Figure 3 illustrates the components of net ODA provided by DAC countries from 2000 to 2024. While bilateral development projects consistently account for the largest share, multilateral aid and humanitarian support have also increased. The overall upward trend argues for the relevance of using ODA as a control variable for fiscal buffers.

Figure 2. Foreign aid (ODA)



Source: OECD

Including foreign aid as a control variable can be valuable since aid can potentially finance both health and renewable energy projects, thus influencing the independent variables. The variable is accessed via WDI and is expressed as Net ODA received as a percentage of GNI. However, ODA is not without limitations. It is not distributed randomly, but is based on donor priorities, political relationships and/or country-specific characteristics such as governance or institutional strength. Additionally, the variable captures total aid as a share of GNI without specifying whether the aid targets the energy sector, the health sector or other areas. It also does not reflect the effectiveness of aid or whether the funds are actually absorbed into national budgets.

Urban population (URB)

Urban population (% of total population) refers to people living in urban areas, defined by

national statistical offices but collected by United Nations Population Division. Since electricity access is measured as a share of the population, URB can work as a control for urbanization and accounts for how the population is distributed across areas. This variable can then show if urbanization may influence patterns of energy provision and demand. However, the World Bank acknowledges that because of different country coverage, the aggregation of urban and rural population may not add up to total population. They also point out that there is no consistent and universal standard distinguishing urban from rural areas that is applicable to all countries. For example, the data limitations describe that countries may define urban areas based on the presence of certain infrastructure and services. This means that the variable might reflect where infrastructure is concentrated, rather than where people live (World Bank, n.d).

As a result, using this variable together with electricity access can complicate the interpretation of the regression result, as they both capture overlapping contexts rather than distinct cause and effect. Despite this, even if cross-country comparisons should be made with caution, the variable serves as an appropriate control variable.

Age dependency ratio (DPND)

Another control variable for population is used in the model; Age dependency ratio, as a percentage of working-age population. It is the proportion of dependents, meaning people younger than 15 or older than 64, to the working-age population aged 15-64. The variable shows the weighted average proportion of dependents per 100 working-age population. The World Bank defines the variables relevancy to development as being the impact different age groups have on the environment and on infrastructure needs. A higher dependency ratio might indicate an increased pressure on the health sector since children and elderly people can require more frequent medical needs. With a higher public service demand, including health care, the age structure of a population then becomes an interesting aspect when analyzing resource use (World Bank, n.d).

However, the dependency ratio only shows the age composition of a population, not economic dependency. It does then not show children and elderly who are part of the labor force, or those in working-age that are not. It also assumes they are equally dependent. The World Bank also acknowledges the gender factor of this variable, since single or widowed women many times are are the sole caregiver of a household and thus have a high dependency ratio.

Inflation, consumer prices (CPI)

Finally, to control for mere economic factors, inflation is used a control variable. Inflation is measured by the consumer prices index, reflecting the median annual percentage change in the cost to the average consumer of acquiring a basket of goods and services.

5.3.4.1. GDP considerations

A common control variable used in regression models is some type of growth variable, commonly Gross National Product (GDP). However, when total GDP was added to the original model specification, the model failed to generate in R due to severe multicollinearity. This is most likely due to the methodological challenge stemming from the variable XPD, as it is defined as current health expenditure as a percentage of GDP. To account for economic growth, GDP per capita was considered as an alternative. However, within the fixed effects model, its coefficient consistently approached zero with a high standard error, which indicates minimal within-country variation over the chosen time frame. Diagnostic tests on the panel data confirmed the near-constant nature of GDP per capita for most countries. Therefore, GDP per capita was excluded from final models. While I acknowledge this exclusion as a limitation, the models do implicitly account for time-invariant country-specific factors, which inherently include aspects of economic development. The interpretation of the findings from the regression results should consider that time-varying dimensions of economic development, beyond these fixed effects, are not explicitly controlled for.

5.4. Robustness test

A robustness test will be conducted on all models to ensure the reliability of the models. Inspired by Said and Sani (2020), this study uses out-of-pocket health expenditure as an alternative dependent variable, also obtained from WDI. The variable OOP, out-of-pocket expenditure per capita (PPP, current international $) summarized in Table 1, reflects the average amount individuals pay directly for healthcare services without reimbursement, adjusted for purchasing power.

Unlike the dependent variable (public health expenditure) in the main regression model, this variable reflects the direct financial burden on individuals/households. It is included to examine whether the potential trade-offs identified in the main models are also visible at the individual level. The same fixed effects panel regression models will be applied.

5.5. Ethical considerations

When discussing these variables and historical events in SSA, I recognize the tension between generalizing across the region and therefore acknowledges each country individual political and economical context. As Langan (ch.1, 2018) notes, there is risk of essentialism and erasure of national context when discussing 'Africa', while there are also analytical risks of ignoring patterns and structural dynamics that span over country borders. Drawing on Brown (2012) and Harrison, Langan argues that it is legitimate to speak of Africa as a whole in at least three ways; "as a collective international actor; as a collection of states with (in the 'broadest of sweeps') a shared history; and as a discursive presence, used by both Africans and outsiders, in international politics and policy". In this study, the aim to focus on Sub-Saharan Africa is due to understand the politically interconnected space where many countries face parallel constraints due to shared colonial legacies.

This thesis uses only publicly available, secondary data from the following international organizations; the World Bank, International Monetary Fund and the OECD. That said, this thesis commits to relevant ethical principles of quantitative social science research. This includes transparency in the research design and analysis among other areas. I address issues of bias and misrepresentation in the data since all countries are not represented. Also making sure that my research does not reinforce stereotypes of the economic and developmental realities of the countries in SSA.

This research does not work to undermine debt or development difficulties but aims to offer a sincere analysis of structural patterns with the hope that we can better understand contemporary challenges. For this, it is crucial to avoid oversimplification and maintain a nuanced and respectful perspective throughout the study. Lastly, while I do not directly engage with individuals or communities as part of this research, the thesis uses a respectful tone and aims to capture African actors' agency and voice regarding their role within global development conversations.

6. EMPIRICAL RESULTS

This chapter presents the regression results from Model 1-4, as well as the robustness test and descriptive statistics.

6.1. Descriptive statistics

To provide an overview of the dataset used in the analysis, Table 1 presents all variables used in the regression analysis and robustness test, alongside their definitions, measurement units and descriptive statistics. This overview helps to illustrate how the different variables are distributed and sets the stage for understanding the patterns that emerge later in the results chapter.

Table 1. Variables, definition and descriptive statistics.

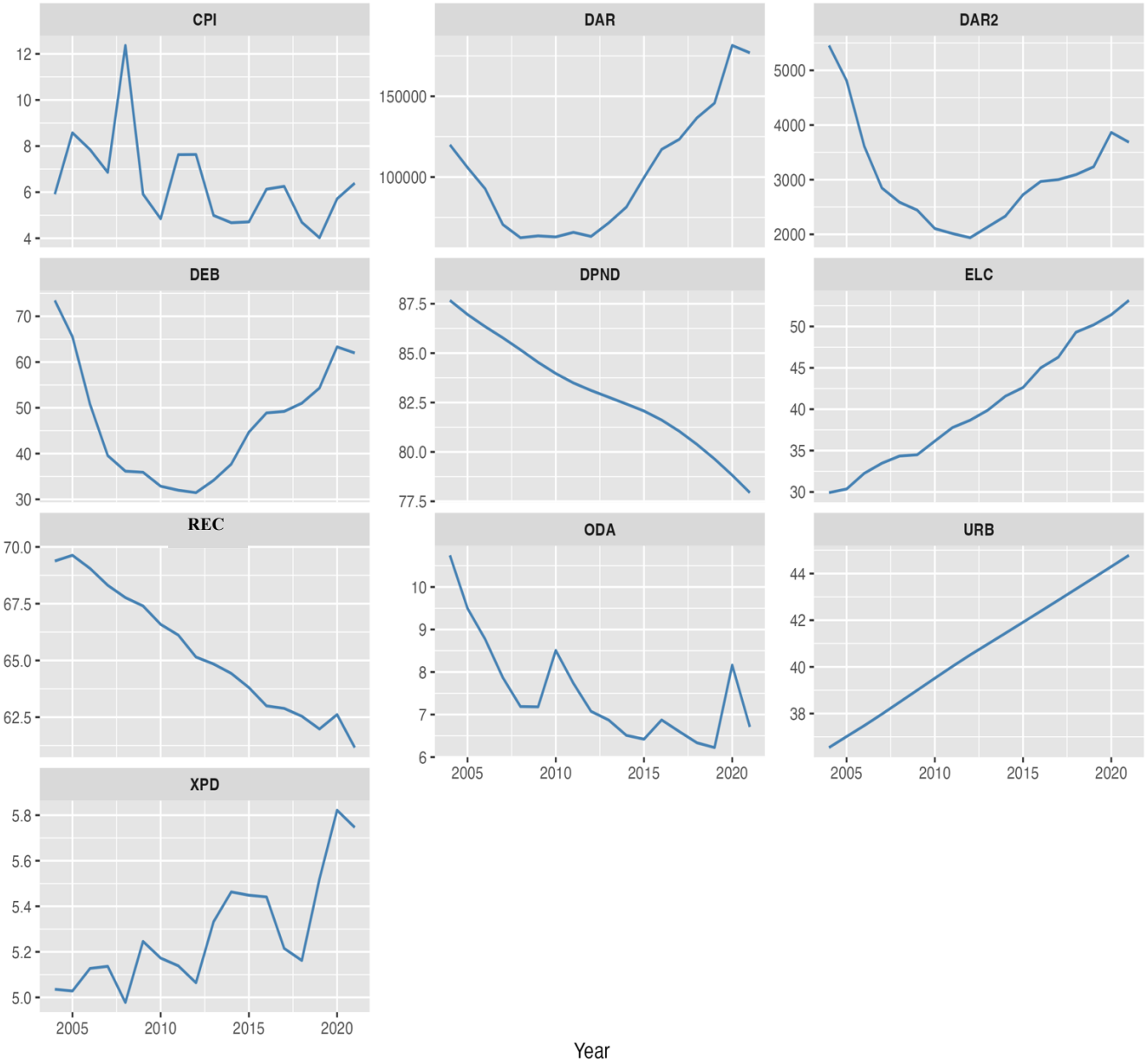
Variable	Definition	Unit of measurement	Min	Median	Mean	Max
XPD	Current health expenditure	% of GDP	1.12	4.69	5.28	21.97
DEB	General government gross debt	% of GDP	0.49	39.95	46.83	354.45
ELC	Access to electricity	% of population	2.70	36.35	40.38	100.00
REC	Renewable energy consumption	% of Total Energy Use	3.70	74.75	65.37	97.90
ODA	Net ODA received	% of GNI	0.00	6.03	7.52	40.41
DAR	Interaction term	-	229.13	69413.13	102280.31	948098.52
DAR2	Interaction term	-	3.51	2509.37	3047.67	18023.15
URB	Urban population	% of total population	9.14	39.78	40.69	90.42
CPI	Inflation, consumer prices	Annual %	-16.86	5.03	6.42	44.36
DPND	Age dependency ratio	% of working-age population	38.39	85.51	82.99	110.09
OOP	Out-of-pocket expenditure per capita, PPP	Current international $	2.99	34.99	36.37	84.12

Note: All statistics are based on the balanced panel dataset, where DAR and DAR2 is an interaction term constructed by the author.

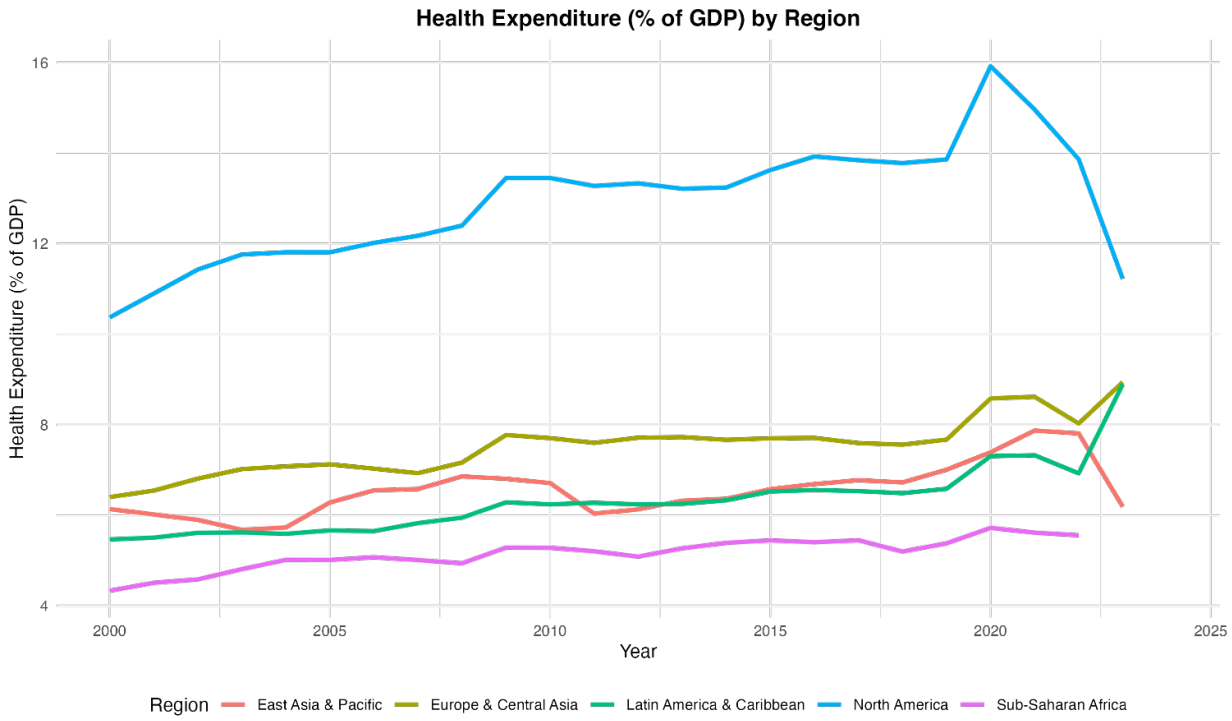
Below, a visual overview of the average development of each variable over time is presented. The dependent variable health expenditure (XPD) shows a low increase during these 17 years, rising from around 5.0% to just under 5.8% of GDP. Just for reference to visualize the dependent variable relative to other regions, a visual overview with comparable global data is also included.

The "dip" we see in public debt (DEB) is most likely due to the set of debt relief in SSA, as discussed in the background section, but the variable however began rising again after around 2012. Electricity access (ELC) has increased steadily, while renewable energy consumption (REC) declined, suggesting that expanding access has been met largely through non-renewable sources.

Table 2. Visual overview of variables.



Source: Researcher's computation based on the WDI database.



Source: Researcher's computation based on the WDI database.

Before running the regression, I included a correlation matrix to get an initial sense of how the variables relate to each other. Table 3 presents the matrix illustrating Pearson's r, ranging from -1 to 1. Although it does not prove cause and effect, it helps spot connections that might matter in the analysis. For example, ELC and REC have a somewhat strong negative correlation at -0.7. This can be interpreted as countries with expanding electricity access still largely rely on unsustainable energy sources such as fossil fuels. Since both ELC and REC are used in the three-way interaction terms, their strong correlation risks shaping the regression outcome in ways that make it harder to distinguish their individual effects. So therefore, it makes sense to also test a simpler two-way interaction that only includes DEB and REC to help reduce the influence of multicollinearity and get a more stable estimation of the interaction term.

Another point that stands out is the high coefficient for DEB with DAR and DAR2, which makes sense since they are constructed by using DEB. While this is not an issue currently, it can be the source of potential multicollinearity.

Table 3. Correlation Matrix

	XPD	DEB	ELC	REC	ODA	DAR	DAR2	URB	CPI	DPND
XPD	1	0.100	-0.150	-0.020	0.310	-0.100	0.050	-0.280	0.040	-0.150
DEB	0.100	1	0.080	-0.020	0.350	0.680	0.820	0.150	0.140	-0.070
ELC	-0.150	0.080	1	-0.700	-0.470	0.400	-0.310	0.660	-0.160	-0.770
REC	-0.020	-0.020	-0.700	1	0.400	0.040	0.450	-0.530	0.140	0.750
ODA	0.310	0.350	-0.470	0.400	1	0.020	0.480	-0.360	0.140	0.420
DAR	-0.100	0.680	0.400	0.040	0.020	1	0.520	0.390	0.080	-0.130
DAR2	0.050	0.820	-0.310	0.450	0.480	0.520	1	-0.120	0.190	0.300
URB	-0.280	0.150	0.660	-0.530	-0.360	0.390	-0.120	1	-0.120	-0.460
CPI	0.040	0.140	-0.160	0.140	0.140	0.080	0.190	-0.120	1	0.130
DPND	-0.150	-0.070	-0.770	0.750	0.420	-0.130	0.300	-0.460	0.130	1

6.2. Pre estimation statistics

The study began with testing for heteroskedasticity by using the Breusch-Pagan test for the four models. The test results strongly suggested that heteroskedasticity was present in both models with $p < 0.0001$ and thus violating the assumption of homoskedasticity. The Huber/White standard error was applied in R to obtain heteroskedasticity robust standard errors together. The coefficient estimates presented in the following result section are thus based on these corrected standard errors. No evidence of statistically significant cross-sectional dependence was found in the models.

Table 4. Test results

	Test	z / BP	P_Value
Model 1	Breusch-Pagan	1569.8597	< 0.0001
	Pesaran CD	1.1057572	0.2688316
Model 2	Breusch-Pagan	1542.0664	< 0.0001
	Pesaran CD	0.10386937	0.917273
Model 3	Breusch-Pagan	1621.1237	< 0.0001
	Pesaran CD	1.2346914	0.2169454
Model 4	Breusch-Pagan	2194.4731	< 0.0001
	Pesaran CD	1.7142075	0.08649063

6.3. Regression results

Table 5 presents the estimates from the fixed effects panel regression models. Model 1 examines the independent effects of public debt, electricity access, renewable energy consumption and the control variables on health expenditure. The extended Model 2 includes the first interaction term which captures the influence of both energy indicators in the relationship between public debt and health expenditure. Model 3 continues with the same model as the second one, but with the two-way interaction term. Model 4 is a simpler model with the two-way interaction term.

Table 5. Fixed Effects Regression Results

	Dependent variable:			
	Health Expenditure (XPD)			
	Model 1	Model 2	Model 3	Model 4
	(1)	(2)	(3)	(4)
Public Debt (DEB)	0.004	-0.007	0.032***	0.033***
	(0.005)	(0.008)	(0.007)	(0.007)
Electricity Access (ELC)	0.008	-0.017	0.011	
	(0.023)	(0.027)	(0.022)	
Renewable Energy (REC)	-0.036	-0.055*	-0.023	-0.033
	(0.032)	(0.032)	(0.032)	(0.034)
Foreign Aid (ODA)	0.062**	0.071**	0.071**	0.067**
	(0.027)	(0.028)	(0.028)	(0.028)
Urbanization (URB)	0.015	0.023	-0.005	
	(0.047)	(0.049)	(0.045)	
Inflation (CPI)	-0.005	-0.006	-0.004	
	(0.013)	(0.013)	(0.012)	
Age Dependency (DPND)	0.028	0.026	0.033	0.024
	(0.034)	(0.034)	(0.033)	(0.022)
Interaction Term (DEB*ELC*REC)		0.00001**		
		(0.00000)		
Interaction Term (DEB*REC)			-0.0004***	-0.0004***
			(0.0001)	(0.0001)
Observations	664	664	664	684
R^2	0.061	0.089	0.105	0.104
Adjusted R^2	-0.006	0.023	0.040	0.045
Note:				*p<0.1; **p<0.05; ***p<0.01

Values in parentheses are robust standard errors.

6.3.1. Model 1 and Model 2

Model 1 shows a positive, but statistically insignificant coefficient for public debt. This outcome does not support H1, which proposed a negative association between debt and health expenditure. Instead, it aligns with the null hypothesis, although I would say the lack of significance prevents any strong conclusions. This result contrasts to the results presented in the literature review (Said & Sani; Fosu; Abbas et al), which all reported a statistically significant negative relationship between public debt and health expenditure in Sub-Saharan Africa. Although this study did not

find evidence of such a direct effect in this baseline model, one possible explanation could be low model performance. The model's adjusted R^2 is negative while the R^2 is really low, which might mean that important variables are missing, or that the model specification could be improved. Another explanation may be that the fiscal effects of debt vary over time and across institutional contexts and make aggregate patterns harder to detect without considering structural variables.

Meanwhile, both electricity access and renewable energy consumption are statistically insignificant. The only statistically significant variable is foreign aid, which supports the idea that external development assistance plays a key role in public health financing.

In Model 2, the regression coefficients for public debt shift from positive to negative, but stays statistically unsignificant. This model more aligns with H1 but is still statistically unexplanatory. However, the coefficient for the interaction term DAR is positive and statistically significant, though the coefficient is extremely small and basically zero. This provides support for the null hypothesis of H2, that higher levels of public debt, interacted with renewable electricity access, is positively associated with public health expenditure. In other words, countries with higher renewable electricity access may actually maintain, or even slightly improve (although the statistic is weak) health expenditure despite rising debt levels. Yet again, the small coefficient size makes interpretation very limited since statistically significance can come without being of practical relevance.

Simultaneously, REC becomes even more negative in Model 2 but with the coefficient being statistically significant. It could be that countries with higher use of renewable sources are spending less on the health sector. ODA has a positive coefficient in Model 2, as it did in Model 1. Both models therefore show an effect of development assistance on health expenditure.

Adjusted R^2 improves in Model 2 compared to the first model, which indicate a very small but yet an improvement in explanatory power once the interaction term (DAR) is added. The increase in both R^2 and adjusted R^2 in Model 2 implies that the interaction between debt and energy variables adds some value to the model's overall fit, even if the interpretation of the result remains very limited. But the adjusted R2 always controls for added variables, which one should keep in mind.

6.3.2. Model 3 and Model 4

In Model 3, the regression coefficient for public debt becomes statistically significant and positive. This marks a clear change from Model 1 and 2, where the effect of debt was insignificant. In this model specification, the result supports the null hypothesis of H1, suggesting that higher debt levels are positively associated with public health expenditure.

The interaction term used in this model, DAR2, is negative in Model 3. This result aligns with H2, since higher levels of public debt, interacted with renewable energy consumption, is negatively associated with public health expenditure. The result suggest that public debt can increase health expenditure, but this effect gets reversed in countries that use more renewable energy. This suggests a possible trade-off mechanism affected by public debt, where investments in renewable infrastructure may crowd out fiscal space for social sectors like health. These findings partially contradict Ouedraogo's (2013) long-term perspective, which links electricity generation from renewable sources to broader welfare improvements such as better health outcomes.

Foreign aid continues to be positively and significantly associated with health expenditure, consistent across all model specifications. Renewable energy consumption remains negative but is no longer statistically significant, while electricity access remains insignificant.

Adjusted R^2 increases from Model 2 to Model 3, which means the explanatory power increases, but by very little. What we can take from this result is that using the simpler two-way interaction (DEB*REC) adds more value to the model than the three-way interaction (DEB*ELC*REC) in Model 2. While the increase in R2 remains very modest overall, it however implies a better model fit..

Model 4 is the simpler version of Model 3 but without electricity access, urbanization and inflation as control variables. Interestingly, the significance and direction of the variables remain unchanged. Adjusted R2 improves slightly in this model which suggests that fewer control variables may have improved with the principle of parsimony. Overall, Model 3 and 4 support the idea that energy variables, particularly renewable energy consumption, matter for understanding the fiscal trade-offs involved in public health financing. The evidence indicates that while debt may in some contexts enable higher health expenditure, this relationship is sensitive to the structure of a country's energy system.

To conclude, while no significant trade-off between public debt (DEB) and health expenditure (XPD) is found in the first two models, Model 2 statistically shows that there might be one if renewable energy access effect on public debt (three-way interaction) is taken into account, which gives some support for H0 in H2. In Models 3 and 4, where the simplified two-way interaction term (DEB × REC) is used, the relationship is negative and significant. This supports H2, that high public debt combined with renewable energy can reduce health expenditure. Overall, the results provide no support for H1, but they partly support H2, depending on how the energy interaction is modeled.

6.3.3. Robustness test

Table 6 presents the estimates from the robustness test of the two fixed effects panel regression models. Model 1 examines the independent effects of public debt, electricity access, renewable energy consumption and official development assistance on out-of-pocket health expenditure (OOP). The extended Model 2 includes the interaction term which captures the influence of energy indicators in the relationship between public debt and out-of-pocket health expenditure.

Table 6. Regression results for robustness test

	Dependent variable:			
	Out-of-pocket Expenditure (OOP)			
	Model 1	Model 2	Model 3	Model 4
	(1)	(2)	(3)	(4)
Public Debt (DEB)	0.045*	0.068	0.115*	0.090
	(0.024)	(0.066)	(0.066)	(0.058)
Electricity Access (ELC)	-0.088	-0.036	-0.080	
	(0.107)	(0.125)	(0.106)	
Renewable Energy (REC)	0.214	0.254	0.248	0.459***
	(0.194)	(0.182)	(0.194)	(0.138)
Foreign aid (ODA)	-0.029	-0.050	-0.005	0.076
	(0.119)	(0.128)	(0.122)	(0.139)
Urbanization (URB)	-0.405	-0.422	-0.454*	
	(0.274)	(0.271)	(0.263)	
Inflation (CPI)	0.163**	0.167***	0.165***	
	(0.064)	(0.064)	(0.064)	
Age Dependency (DPND)	0.043	0.048	0.054	0.268*
	(0.208)	(0.212)	(0.206)	(0.158)
Interaction Term (DEB*ELC*REC)		-0.00001		
		(0.00002)		
Interaction Term (DEB *REC)			-0.001	-0.001
			(0.001)	(0.001)
Observations	664	664	664	684
R^2	0.183	0.187	0.192	0.167
Adjusted R^2	0.125	0.128	0.133	0.113
Note:				*p<0.1; **p<0.05; ***p<0.01
				Values in parentheses are robust standard errors.

Model 1 and Model 3 in positive and statistically significant coefficients for public debt. This means that when public debt increases, so does out-of-pocket health expenditure. Compared to the regression result in Table 5, this show that the debt-burden is more statistically reflecting the financial burden for the countries citizens rather than the public sector.

Electricity access shows a consistently negative coefficient and is not statistically significant. Renewable energy consumption is positive and becomes statistically significant in Model 4, which suggests that countries with higher renewable energy consumption may still experience

high health costs for individuals, this however might reflect affordability rather than energy supply. A control variable of pricing or GDP could be beneficial here.

Foreign aid differs from the results presented in Table 5 where all models displayed a positive and statistically significant association with health expenditure, whereas in the robustness models it appears with a negative and non-significant coefficient. The interaction terms (DAR and DAR2) are statistically insignificant, the opposite of the main models in Table 5.

Urbanization remains negatively associated with the dependent variable but here, it becomes statistically significant in Model 3, which aligns with the idea that urban settings may reduce the need for out-of-pocket health expenditure due to greater access to health services. Inflation is positive and statistically significant in all models, which reaffirm that inflation increases the economic burden on households and individuals. Also, the age dependency ratio becomes statistically significant in Model 4, which imply that there is a demographic effect on out of pocket health expenditure when we account for fewer control variables.

These differences may stem from the fact that out-of-pocket health expenditure captures individual health costs rather than public sector expenditure. It is more sensitive to household-level economic conditions and healthcare access, which means that some variables controlling for these factors would be complementary to the models – if that is what one aims to test. Further, the robustness model would probably allow and benefit for the inclusion of a GDP variable, without generating multicollinearity issues, unlike the main models where the GDP variable led to error in R.

7. DISCUSSION

7.1. Debt Overhang Discussion

The idea behind debt overhang from Krugman's (1988) perspective, is that too large levels of public debt reduces the government's willingness or ability to invest in domestic development, since future returns from these investments are mostly benefitting by creditors. This theoretical lens is particularly useful in a study like this, which examines whether fiscal burdens constrain governments from investing in health when also trying to improve the renewable energy sector. However, from the period between 2004 and 2021, and the 38 countries in SSA included in the study, the empirical results only partially support the presence of a debt overhang. Yet, the region's persistent developmental gap shows the possibility that stagnant health investments in

the long-term creates a burden that builds up as debt increases. What appears to be productive borrowing today may become unsustainable tomorrow, especially if debt servicing increases. But it might depend on what level of debt the threshold is met.

The regression results suggest that public debt's impact on health expenditure should not be assessed in isolation. It must be understood in relation to how public debt is used and who ultimately benefits (both in terms of monetary gains and long-term well-being). Evidence of a health-debt trade-off does appear under certain conditions, when public debt interacts with renewable energy consumption. Krugman's argument that the harmful effects of debt are not immediate or linear, but contingent on whether the benefits of investment are captured domestically or leak out to creditors, supports this result. The study show that public debt may not always suppress social investment, but when coupled with competing energy priorities like renewable energy, fiscal constraints become more evident.

During the observed period of 2004-2021, debt levels may not have reached the critical threshold needed to trigger the negative incentives described in the debt-overhang theory. As Reinhart, Rogoff, and Savastano (2003) discussed, this threshold may be much lower for developing countries due to weaker institutional credibility and higher borrowing costs. As Said and Sani (2020) also showed, institutional quality is of importance in shaping how debt affects social expenditure. Since institutional quality is not tested in this study, and it gave different results compared to these authors, it might imply the importance of including this variable in future research. Since the result showed that energy variables can effect public debts effect on health expenditure, understanding how resources are allocated becomes imperative. The results could also indicate that debt levels remained manageable during these years, or that governments were able to rely on external support, such as concessional loans or aid such as ODA, to prevent major budget cuts or where debt servicing has not yet crowded out social sector expenditure due to temporary buffers such as concessional lending or budget support.

It would be interesting to examine if institutional quality and foreign aid have positive associations, as it might help with fiscal priorities aimed at development. This latter interpretation comes from the variable for foreign aid which is positive and statistically significant across all models. This could mean that aid has a stabilizing role in health expenditure during periods of fiscal pressure. Although aid is not the same as borrowing, aid can ease the fiscal pressure by adding to government budgets. In this sense, aid may act as a temporary buffer by helping countries sustain budgets without directly increasing debt levels. It could reflect a delayed debt-

overhang with aid cushioning budget constraints for now but also signaling a need for debt relief in a near future. In that sense, foreign aid does not contradict the debt-overhang theory but might show a temporary buffer in accordance with Krugman's theorization of a trade-off between debt forgiveness (relief) or new lending, with the latter being less effective. One limitation of using ODA as variable for foreign aid, is that it does not distinguish whether aid was directed toward health, energy or other sectors. This restricts the interpretive power of the regression results, since a positive coefficient may reflect general development assistance rather than ODA's real effect on public health or energy.

Model 2-3 introduces the interaction terms. The coefficient for DAR is positive and statistically significant, yet its magnitude is practically zero, which makes me question if it is even necessary to interpret. While the significance may suggest a conditional relationship where countries with higher energy access can slightly better sustain health expenditure despite rising debt levels, the effect is too weak to draw meaningful conclusions. The joint effect of the variable makes it unclear whether the result stems from debt, the energy indicators or their combination. One possible reading is that renewable energy and electricity access may contribute to broader development, enabling governments to maintain health expenditure, as Fisher-Vanden & Wing (2018) found, but the result from this study is still very speculative. The regression does not prove causality or show that debt actually financed energy directly. The model signals the need for more disaggregated approaches to clarify which components are driving this observed relationship, if it is debt or energy indicators.

On the other hand, the interaction term DAR2 is negative and statistically significant, in clear contrast to the result in Model 2 and supports H2. Excluding energy access in the interaction term seems to have provided better model fit. Model 4 which works as a simpler model than Model 3, confirms excluding more control variables also improves the model. The interaction term remains negative and significant, while public debt continues to have a positive and significant coefficient. A possible explanation is that the fiscal space available for health shrinks when governments prioritize long-term capital investments like renewable energy sources. This finding strengthens the idea that high debt levels may not suppress all forms of public spending equally, but rather force trade-offs shaped by how resources are allocated.

On a final note, the global urgency of the green transition is clearly present in Sub-Saharan Africa, as it is globally as well, but the mechanisms for financing this transition still depend on institutions and capital from the Global North. This creates a risk that even if climate goals are

globally reached with investments in SSA, the economic dependence deepens regionally since the political and financial costs are borne locally, while the long-term profits and strategic control remain with external actors. This however, has not been empirically tested in the study but as noted in the background section, shapes this region.

7.1.1. Practical example: Senegal

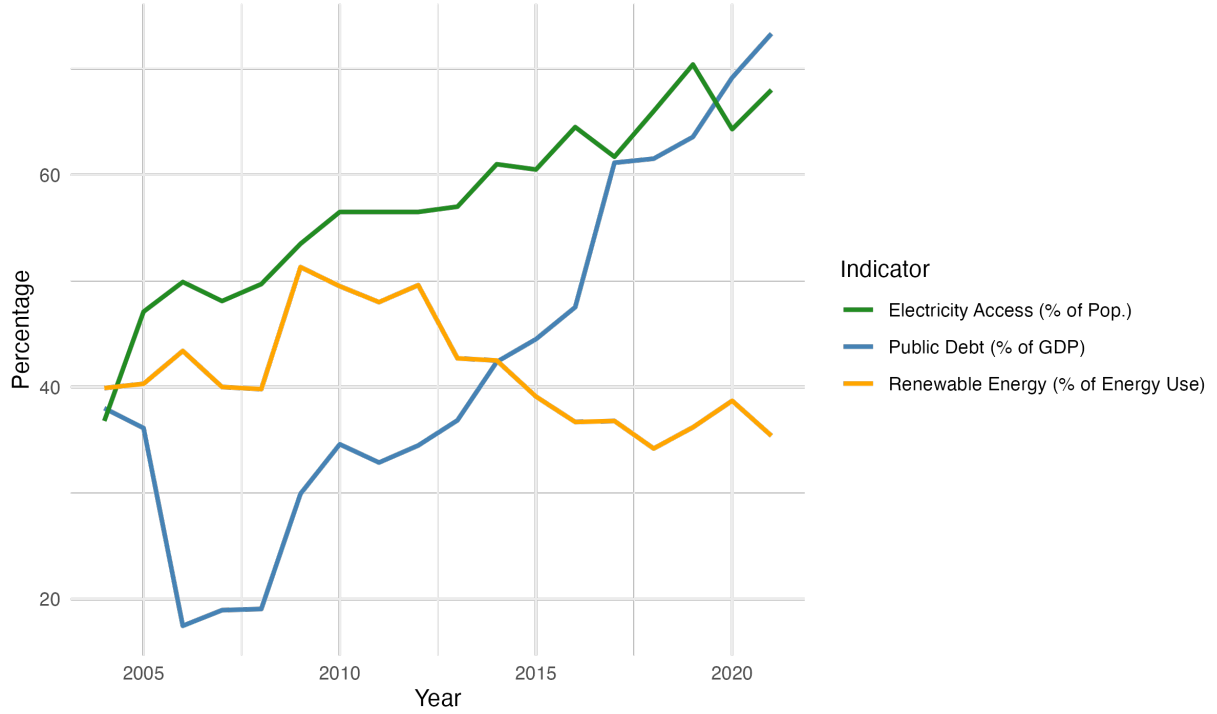
Debt levels in Sub-Saharan Africa have increased during the studied time period, yet health expenditure has remained rather stagnant. If countries are borrowing more but health investment does not increase, who ultimately benefits from this borrowing? Is it the recipient countries and their citizens, or the creditors and contractors linked to the loans? These questions are unanswered from the direct regression results and would need other variables to gain some answers.

While I through this study do not claim that SSA is trapped in a state of full dependency to external creditors and I address that they have autonomy in their decision making, I want to highlight the need to acknowledge who holds control and who gets the gains from debt-financed development when indicators such as health expenditure remain flat. The positive interaction between renewable energy access and public debt (the first interaction term) may indicate that energy infrastructure, even when externally financed, can contribute to fiscal capacity. In this sense, renewable energy investments could be one way towards greater developmental autonomy. But we also saw the opposite.

One country in the midst of this context is Senegal, one of the leading African nations striving to transition to renewable energy sources (Africa Energy Portal, 2024). However, the country faces challenges in independently financing these projects due to a growing external debt burden (World Bank, 2023). As an attempt to translate the statistical findings of this study into real-world dynamics, Senegal will work as a practical example to continue this discussion, and I would argue that this exemplifies how liberalisation and dependency can coexist.

Between 2004 and 2021, electricity access in Senegal increased significantly from under 40 percent to almost 70 percent of the population, as shown in Figure 3. This is in one way a success in development terms. However, during the same period, the share of renewable energy in the total energy use declined (IEA, 2023, p. 85).

Figure 3. Debt, Electricity Access and Renewable Energy in Senegal 2004-2021

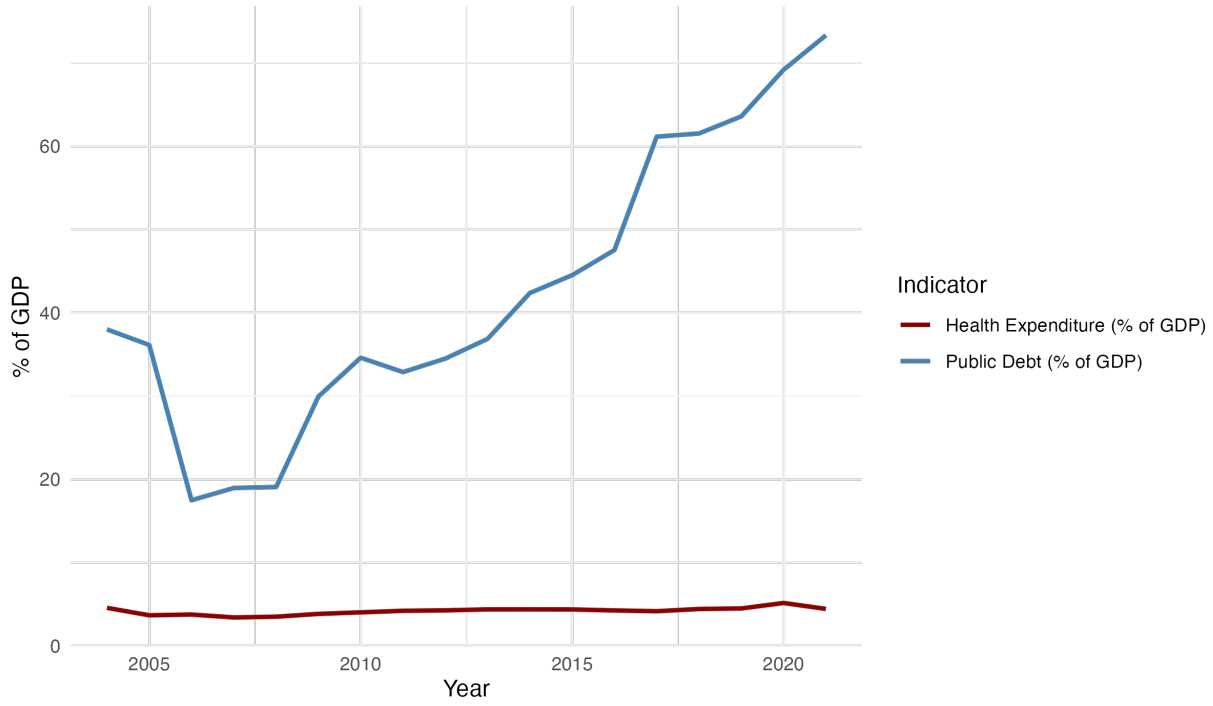


Source: Researcher's computation using the WDI database.

Seemingly, this could be a loss in environmental terms, but in reality, this does not necessarily indicate a lack of investment in environmental energy sources like renewables, but rather that the overall growth in energy demand was met mostly through more accessible source like oil and gas (IEA, 2023). Since renewable energy projects often have long implementation timelines, their impact may not yet be fully reflected in the available data. As discussed in the background and theory chapters, the structure and origin of debt matters. Senegal's energy expansion has largely been financed through bilateral and multilateral loans and grants (Brunet et al., 2022; Haag, 2023), as these continue to expand according to Figure 5. Externally funded renewable energy projects are beneficial in meeting climate goals, but can at times undermine local priorities, and it it creates the question of external actors are the main players creating this debt-health trade-off under a debt overhang (Brunet et al., 2022; Haag, 2023).

Meanwhile, public health expenditure has remained stagnant over the same period, even as public debt increased, as seen in figure 4. This trend suggests that while energy investments may be occurring, they have not translated into significant gains for welfare services. The regression results showed a positive and statistically significant coefficient for the interaction term, but Senegal exemplifies how this potential is not always realized. It clearly shows how these statistical relationships have limited in explanatory power without putting it in a context.

Figure 4. Public Debt and Health Expenditure in Senegal 2004-2021



Source: Researcher's computation based on the WDI database.

Figure 5. External Debt in Senegal.

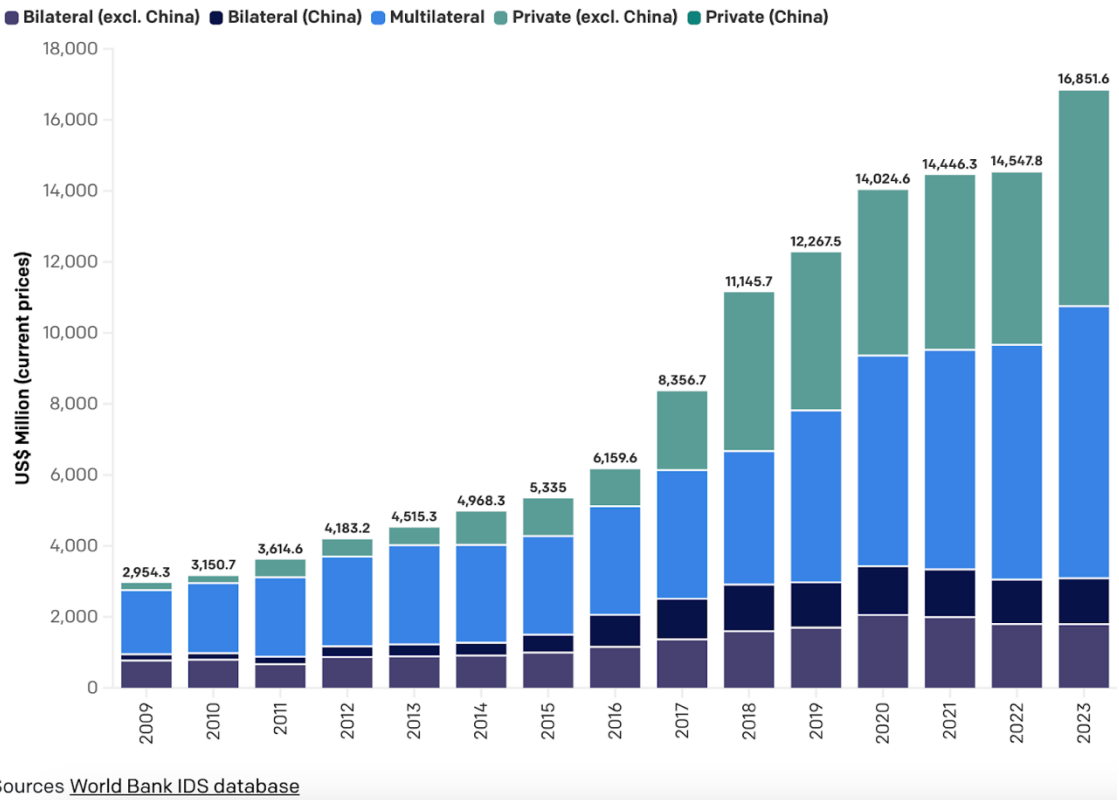


Figure retrieved from ONE Campaign (n.d).

While energy access expands, the distribution of economic and developmental gains seems to remain uneven. The regression results suggest that expanding energy access alone does not guarantee sustainable development outcomes such as abilities to investment more in the health sector. Thus, Senegal does not contradict the theoretical frameworks of debt overhang theory but rather exemplifies the nuances. The practical example of Senegal shows the broader issue raised throughout this thesis: the long-term success of development depends not only on what is being built, but on how it is financed, governed and sustained. It also underscores the importance of placing statistical findings in their historical and political context.

7.2. Limitations

As with any empirical analysis, this study is subject to several limitations. First, the models did not include variables such as debt servicing costs, life expectancy, institutional quality or the ownership structure of infrastructure (public/private for example). These factors are likely to affect how public debt influences both energy and health investments. Second, although fixed effects were used to control for unobserved heterogeneity, potential endogeneity remains a concern for aid allocation since it may depend on unobservable characteristics such as governance, which also influence health expenditure. Third, the data are aggregated and do not distinguish between types of aid or public debt, nor do they specify which sectors received investment. This makes it impossible to determine exactly how energy projects shaping the energy variables was funded or whether aid directly targeted these sectors. Fourth, this study does not separate domestic and external debt, even though they can have different macroeconomic effects. This also limits how deeply the study can discuss issues of sole financial dependence. Lastly, it is crucial to emphasize that this analysis does not prove causality. While statistical associations between variables have been identified, these results do not mean one variable directly causes changes in another. Furter research would be necessary to fully understand the variables underlying mechanisms.

7.3. Future research

Following the presented limitations, a few interesting possibilities for future research emerge. First, future research could build upon this methodological framework by employing more disaggregated data and potentially integrating qualitative methods. The political economy of energy financing could benefit from in-depth case studies exploring aspects like infrastructure ownership, financing terms and governance. Second, there is also possibility to yet again test

Krugman's (1988) model for the trade-off between new debt or debt relief. This could determine if countries in SSA, in light of recent shifts in debt distress, are moving closer to the critical thresholds Krugman theorized, or the threshold Reinhart, Rogoff, and Savastano (2003) theorized. Third, a random effects model could be an alternative way to test the hypotheses. Distinguishing the effects between domestic and external debt could also be one perspective to add to Krugman's discussion. Fourth, examining this dynamic with consideration for global or regional crises such as the global financial crisis of 2008, or covid-19, could provide a future more solid methodological approach. Finally, expanding the regression model to test the effectiveness of health expenditure in relation to public debt and debt overhang could strengthen the theoretical outcomes.

8. CONCLUSION

In this study, I aimed to investigate the trade-off between public debt and public health expenditure in Sub-Saharan Africa and see if the interaction of renewable energy and energy access affect this trade-off. A fixed effects panel regression model over the period 2004 to 2022 was used, which included balanced data with 38 countries. By testing four models, one baseline model, and three with interaction terms, the purpose was to research if renewable energy influence the trade-off between public debt and health expenditure in Sub-Saharan Africa. While previous research found strong evidence of a trade-off between debt and social spending like health and education, this study tested if energy indicators can add an interesting perspective to these results.

However, the baseline model did not produce a statistically significant relationship between public debt and health expenditure, which contradicts previous research. This suggests that, within the observed time frame and panel data, public debt alone did not consistently reduce health expenditure. But when the interaction terms were added, the result was statistically significant. The first interaction term was positive, which indicate that renewable energy access may influence the fiscal space for health expenditure. Although, the small coefficient means this result should be interpreted thoughtfully, but it supports the idea that energy variables deserve closer attention in future studies. The second interaction term was negative, which partly supports previous research if renewable energy is considered in the methodology. From a theoretical standpoint, the study contributes to an extended understanding of how public debt may or may not constrain development and tries to do so by implementing energy indicators.

This thesis contributes to Global Political Economy by empirically examining how new global pressures, such as the green transition, shape the debt-health trade-off in Sub-Saharan Africa. By integrating energy variables into this well studied dynamic, it highlights sectoral budget constraints and opens new pathways for research on climate-related fiscal stress pressures.

Conclusively, to answer the research question if renewable energy influence the trade-off between public debt and health expenditure in Sub-Saharan Africa, the results show that a trade-off emerges only when renewable energy is considered in interaction with public debt. The models without interaction terms do not support this claim. This suggest that public debt's impact on health expenditure should not be assessed in isolation. It must be understood in relation to how public debt is used, who does it come from and who ultimately benefits (both in terms of monetary gains and long-term well-being).

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DATA SOURCES

Data accessed through the World Bank indicators based on the Indicator ID in Appendix A.

https://databank.worldbank.org/

Debt-to-GDP variable accessed through the IMF.

https://www.imf.org/external/datamapper/CG_DEBT_GDP@GDD/CHN/FRA/DEU/ITA/JPN/GBR/USA

APPENDIX A

Variable	Definition	Source	Indicator ID
XPD	Current health expenditure	WDI	SH.XPD.CHEX.GD.ZS
DEB	General government gross debt	IMF	GGXWDG_NGDP
ELC	Access to electricity	WDI	EG.ELC.ACCS.ZS
REC	Renewable energy consumption	WDI	EG.FEC.RNEW.ZS
ODA	Net ODA received	WDI	DT.ODA.ODAT.GN.ZS
URB	Urban population	WDI	SP.URB.TOTL.IN.ZS
CPI	Inflation, consumer prices	WDI	FP.CPI.TOTL.ZG
DPND	Age dependency ratio	WDI	SP.POP.DPND
OOP	Out-of-pocket expenditure per capita, PPP	WDI	SH.XPD.OOPC.PP.CD

APPENDIX B

Descriptive Statistics for selected countries

Variable	Country	Min	Q1	Median	Mean	Q3	Max
ELC	Angola	28.40	34.00	37.95	38.23	42.67	48.20
	Ethiopia	14.00	22.25	28.10	31.31	43.95	54.20
	Kenya	19.20	26.87	37.15	41.89	55.12	76.50
	Senegal	36.80	50.80	56.75	57.11	63.65	70.40
	South Africa	80.60	82.15	84.15	84.11	85.20	90.00
FEC	Angola	46.80	49.50	52.70	54.08	58.02	68.90
	Ethiopia	89.30	90.73	92.85	92.43	94.10	94.70
	Kenya	67.70	68.78	74.15	73.29	77.25	80.30
	Senegal	34.20	37.27	39.95	41.34	43.22	51.30
	South Africa	7.60	7.93	8.85	8.84	9.62	11.00
ODA	Angola	0.03	0.22	0.33	0.64	0.41	5.43
	Ethiopia	3.68	5.18	7.84	8.72	11.21	18.18
	Kenya	2.74	3.28	3.94	4.02	4.32	6.07
	Senegal	3.94	5.20	5.63	5.89	6.28	10.68
	South Africa	0.23	0.25	0.26	0.29	0.33	0.42
XPD	Angola	2.40	2.62	2.72	2.89	3.06	3.97
	Ethiopia	3.21	3.51	4.09	4.08	4.47	5.47
	Kenya	3.99	4.40	4.84	4.75	5.10	5.39
	Senegal	3.41	3.89	4.26	4.19	4.42	5.15

Descriptive Statistics for selected countries

Variable	Country	Min	Q1	Median	Mean	Q3	Max
	South Africa	6.86	7.27	7.96	7.79	8.08	9.01
DEB	Angola	16.73	28.46	38.45	49.22	65.13	119.15
	Ethiopia	29.96	43.31	51.27	53.57	55.13	103.10
	Kenya	34.19	36.79	40.26	45.14	53.00	68.23
	Senegal	17.49	33.28	37.43	42.31	57.74	73.31
	South Africa	24.04	29.91	38.88	40.94	48.22	68.93