



ASYMMETRIC RELATIONSHIP BETWEEN REMITTANCES AND SUSTAINABLE DEVELOPMENT IN SUB-SAHARAN AFRICA

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Abstract

The paper explored the asymmetric or nonlinear effects between remittances and sustainable development in Sub-Saharan Africa. The study used panel data from 30 selected Sub-Saharan African countries for the period spanning 2000 to 2022, which were obtained from the World Development Indicators (WDI) 2022 Database and the Sustainable Development Report 2023 Database. Panel Nonlinear Autoregressive Distributed Lag (PNARDL) methodology was employed for empirical analysis. The empirical results from panel NARDL approach on the asymmetric effects between remittances and sustainable development showed an asymmetric effect with a negative significant relationship between positive remittance shock and sustainable development (coeff. = -0.09 ; $p < 0.05$), while a positive significant link was established between negative remittance shock and sustainable development in the selected SSA countries (coeff. = 0.21 ; $p < 0.05$). Alternative estimations using adjusted net savings (ANS) as alternative proxy and measure of sustainable development besides the sustainable development goals index (SDGI) and the results were robust. The study demonstrated that there exists an asymmetric relationship between remittances and sustainable development in Sub-Saharan Africa. These findings imply that higher inflows of remittances may not necessarily spur sustainable development in the selected SSA countries, as the relationship is nonlinear. The study recommended that governments and policy makers in the subcontinent need to create mechanisms to fully harness remittance inflows so that substantial buffers can be built in periods of economic downturn to cater for shortfalls that may occur in periods of economic boom based on the countercyclicality nature of remittances.

Keywords: asymmetric, remittances, sustainable development, unequal, nonlinear; symmetric

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1. INTRODUCTION

Remittances represent a significant source of finance for sustainable development and exceed Official Foreign Assistance and export revenues in developing countries as far back as 1997 (Qutb, 2022). This is because the need to achieve sustainable development in Sub-Saharan African countries (hereafter, SSA countries) is a lofty goal that can only be achieved when there are adequate global resource inflows to help in its attainment. In other words, central to the success of sustainable development is global resource mobilisation, of which remittances constitute an important source (Ramachandran & Crush 2021; IFAD 2019; UN 2020). Interestingly, extant studies have shown that remittances, by their magnitude, can be a source of sustainable

development and have a fair chance of fostering it (Barkat *et al.*, 2024; Heilmann, 2006). Remittances into the SSA region are, moreover, nearly double the size of foreign direct investment, and relatively more stable in 2022 (World Bank, 2023). The largest remittances-recipient economies in the SSA in 2022 when quantified in US\$ include - Nigeria, Ghana, Kenya and Zimbabwe (see Table 1) while the largest countries that received remittances expressed as the ratio of these capital inflows to GDP include the Gambia, Lesotho, Comoros, and Cape Verde (see Table 2). The issue of whether the remittances-sustainable development nexus is asymmetric or unequal as far as SSA countries are concerned is undoubtedly a research endeavour that is most needed, given the possible impact of a nonlinear/asymmetric association between these variables of interest in broadening our understanding.

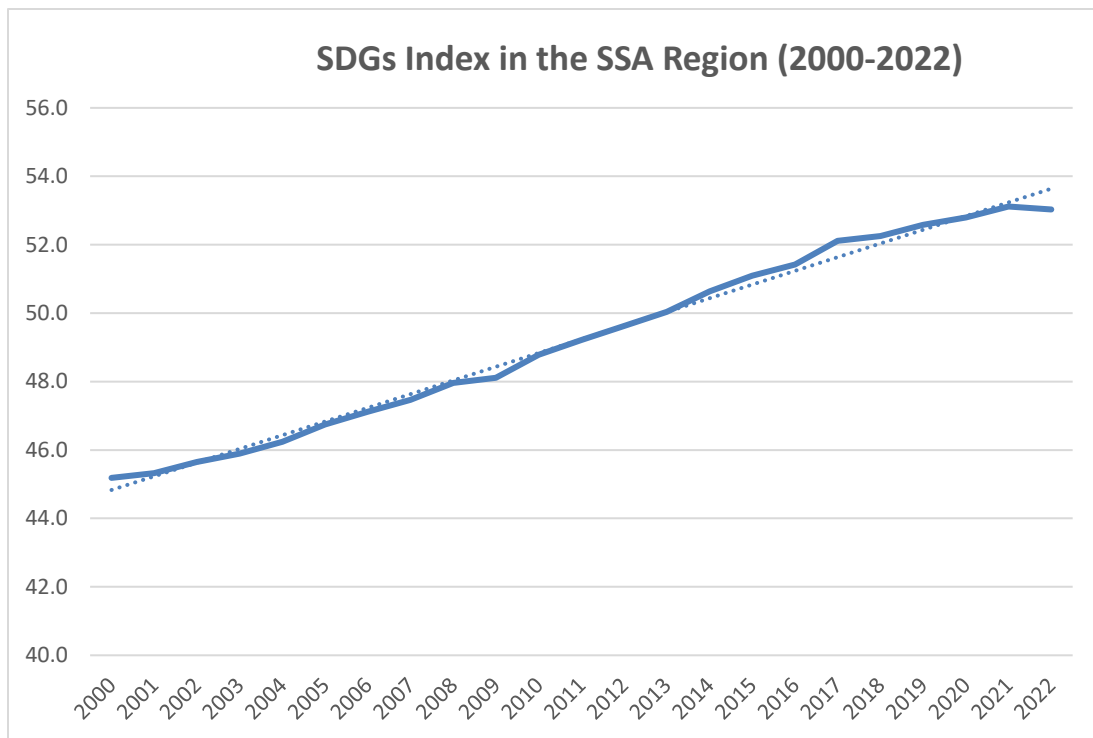


Figure 1: Sustainable Development Goals Index in the SSA Region (2000-2022)

Source: Author’s computation based on SDGI Database

In the light of the foregoing, it is interesting to note that as the sustainable development debate unfolds, the issues of social inclusiveness and sustained economic growth remain critical in the discourse. From Figure 1, it is manifest that the SDGs have experienced improvements in the SSA region for the duration of the time horizon under review as it crossed the 50 SDGs Index score level around 2013, though it remains far below the 80 SDGs Index score level and above that experienced in many advanced industrial economies. Moreover, in Figure 2 it is expressly clear that the challenges of eradicating poverty, ensuring educational attainment, improved health facilities, food security and nutrition, alongside other interrelated social, environmental, and economic goals have also witnessed considerable improvement the SSA region except for the

period between 2005 and 2007 given the negative magnitudes observed in the Adjusted Net Savings (ANS) level –one of the most widely used proxy for sustainable development within this period.

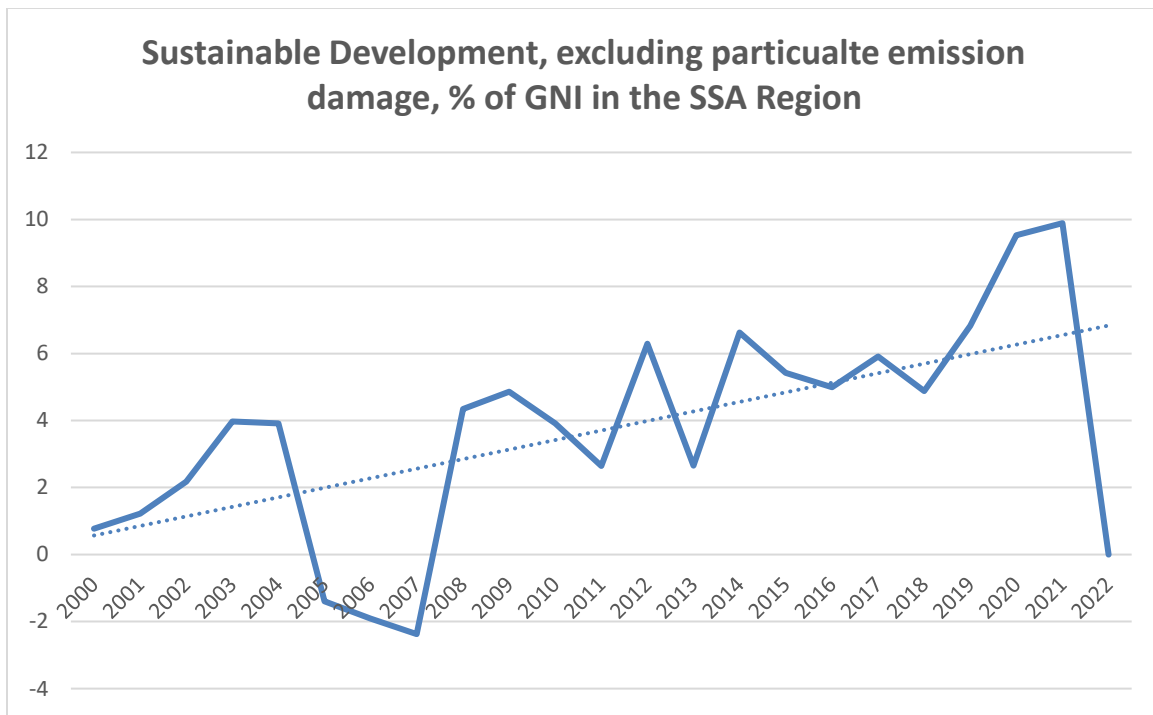


Figure 2: Sustainable Development (Based on the Adjusted Net Savings) in the SSA Region (2000-2022)

Source: Author's computation based on WDI 2022.

Evidence suggests that remittances promote sustainable development by being a pivotal factor in reducing pollution, which undoubtedly plays a part in the enhancement of ecological sustainability in the long run (Daly *et al.*, 2022). Also, according to the United Nations (2015), there exists a mutual unanimity that remittances help in attaining the SDGs as they can lead to the attainment of these goals at numerous levels. Moreover, remittances are stable than other capital inflows and played an important role in economic development, specifically in attaining SDGs (Dash *et al.*, 2024).

It can be established from the foregoing that remittances not only constitute the largest inflows to the SSA region but also remain an inevitable source of finance for sustainable development. Both variables are non-stationary at levels, hence the need to explore the possibility of an asymmetric relationship between them using the latest data available. Since both variables are non-stationary at the level, this strengthens the argument for an empirical investigation of the non-linear relationship rather than the symmetry or linear approach. Based on the foregoing, it is imperative to examine the asymmetric relationship in contrast to the linearity assumption of other studies on the SSA region and elsewhere. This is vital in light of the fact that when the nexus between remittances and sustainable development is nonlinear/asymmetric, then the use of linear

estimates is considered unsuitable and unfitting as it may lead to biased estimates and wrong policy implications.

Table 1: Top 10 SSA Countries with the Highest Remittances (in US\$ billion) in 2022

S/N	Country	Remittances (\$Billion)	Rank
1.	Nigeria	20.1	1 st
2.	Ghana	4.7	2 nd
3.	Kenya	4.1	3 rd
4.	Zimbabwe	3.1	4 th
5.	Senegal	2.5	5 th
6.	Dem. Rep. of Congo	1.7	6 th
7.	Sudan	1.5	7 th
8.	Uganda	1.3	8 th
9.	Mali	1.1	9 th
10.	South Africa	0.7	10 th

Source: World Bank (2023)

There is evidence that remittances and economic growth, for instance, have a nonlinear relationship (Khan, 2023). The non-stationarity of remittances and sustainable development, however, raises the possibility of non-linearity, hence the need to account asymmetrically for the nexus between them in the sub-Saharan African countries. Evidence moreover suggests that remittances have negative effects and inhibit sustainable development, indicating asymmetry and unequal relationship between them (Daly *et al.*, 2022).

Table 2: Top 10 SSA Countries with the Highest Remittances (Percentage of GDP) in 2022

S/N	Country	Remittances (Percentage of GDP)	Rank
1.	Gambia, The	28.9	1 st
2.	Lesotho	23.0	2 nd
3.	Comoros	21.1	3 rd
4.	Cabo Verde	14.1	4 th
5.	Guinea Bissau	10.4	5 th
6.	Zimbabwe	9.3	6 th
7.	Senegal	9.1	7 th
8.	Liberia	8.9	8 th
9.	Togo	8.0	9 th
10.	Ghana	6.4	10 th

Source: World Bank (2023)

From the above, the linear connection between remittances and sustainable development has been seen, and the significance and importance of remittances for the achievements of the SDGs and, by implication, sustainable development have been cited. However, the asymmetric effect between remittance inflows and sustainable development is missing. Therefore, knowledge

of the asymmetric relationship between these variables is vital. This study fills the gap in the literature by examining the asymmetry between remittances and sustainable development in the selected 30 African economies between 2000 and 2022.

Empirical evidence of the asymmetric relationship between remittances and sustainable development would no doubt contribute to the SDGs by revealing how remittance inflows not directly targeted towards SDGs attainment in the SSA countries result in unequal impacts in terms of poverty alleviation, educational attainment, clean environment, etc. The motivation for this study is driven by several important factors which include: first, the possibility of a nonlinear behaviour by remittances and sustainable development given the evidence of asymmetric relationships between remittances and economic growth (Rehman *et al.*, 2023; Odugbesan *et al.*, 2021; Khan, 2023) and between remittances and financial development (Biyase & Naidoo, 2023; Mensah & Abdul-Mumuni, 2023; Mehta *et al.*, 2021; Qamruzzaman & Kler, 2021; Al-Abdulrazag, 2022). This is premised on the ground that if there exists asymmetry in the remittances-growth nexus, asymmetric relationship can possibly be established in the remittances-sustainable development nexus. Second, the impact of remittances as the most resilient capital inflow to developing economies is very likely to have unequal and nonlinear impact on sustainable development especially in areas such as poverty elimination, zero hunger, good health and well-being, quality education, etc. The likelihood of an asymmetric nexus between remittances and sustainable development becomes a major attraction for research by development economists. Third, remittances have more impact on some aspects of sustainable development like No poverty (SDG 1), zero hunger (SDG2), good health and well-being (SDG 3), quality education (SDG 4), responsible consumption and production (SDG 12) than other aspects such as peace, justice and strong institutions (SDG 16) and Partnerships for the Goals (SDG 17) since they are expended mostly for consumption smoothing and human capital development. These unequal and nonlinear impacts intuitively translate into asymmetry in the remittances-sustainable development nexus.

The study, therefore, assesses the asymmetric impact of remittances on sustainable development in the selected SSA countries. In the light of the foregoing, this study has contributed to the existing literature in the following ways: first, to the best of my knowledge, studies have not looked at asymmetry in the remittances-sustainable nexus in Africa. Hence, this study concentrates on asymmetry in the remittances-sustainable development nexus in the SSA region due to the subcontinent's dire need to achieve the SDGs and sustainable development. Second, unlike other studies, the paper also investigate asymmetry in the remittances-sustainable development nexus using the Sustainable Development Goals Index (SDGI), which is the most robust proxy for sustainable development (Al-Thani & Koç, 2024; Barakat *et al.*, 2024).

Finally, the study employed a panel nonlinear autoregressive distributed lag (PNARDL) estimation technique propounded by Shin *et al.* (2014). This methodology is the most appropriate technique for analysing asymmetry for series where unit roots test possesses mixed orders of integration among others.

The paper is organised as follows: after this introduction is Section 2, which explores theoretical issues and an empirical review of the literature. Section 3 presents the theoretical

framework and model specification. Section 4 provides the empirical results and analysis, and Section 5 offers the concluding remarks and policy recommendations.

2. THEORETICAL ISSUES AND EMPIRICAL REVIEW

Few theoretical and empirical studies have explored the remittances-sustainable development nexus. The linear position views remittances as having a positive impact on sustainable development by reason of their direct impact on investment and infrastructure (Ramachandran & Crush, 2021; Vargas-Silva *et al.*, 2009; Kapur, 2004). As remittances increase and grow, capital accumulation and growth are the inevitable outcomes that foster sustainable development. Remittances spur financial development in an economy, and this translates to positive outcomes for growth, a vital component of sustainable development (Olayungbo & Quadri, 2019). The interconnectivity between remittances and sustainable development is summarised in Figure 3 and partly provides the theoretical perspectives on the asymmetric relationship between remittances and sustainable development. From Figure 3, it can be seen that the relationship between remittances can be either positive or negative, signifying that asymmetry exists between them, given the possibility of the non-linearity proposition.

In empirical literature, studies such as Neog & Yadava (2020) support asymmetric correlations between remittances and CO₂ emissions in the case of India. Within the framework of the asymmetric remittances-growth nexus, studies by Rehman *et al.* (2022), for instance, found an asymmetric relationship between remittances and economic growth, while Faheem *et al.* (2019) found evidence of an asymmetric relationship between remittances and financial development.

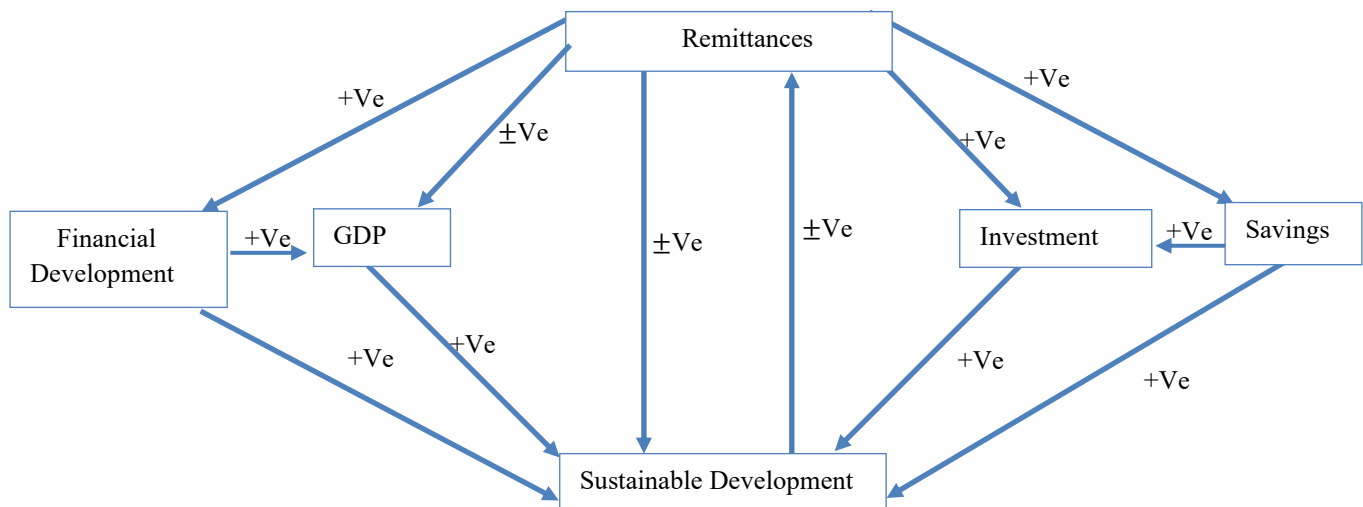


Figure 3: Interconnectivity between Remittances and Sustainable Development and their covariates.

Source: Author’s Conceptualisation from empirical literature.

The extant studies are only tangentially related to the subject matter of this study, and even then, they are mostly inconsistent across countries and regions of the world. However, there are a few methodological limitations, as most of the studies employed either NARDL or PNARDL

methods in the analysis and investigations of asymmetry between remittances-growth, remittances-environmental degradation, remittances-financial development, etc. Nonetheless, there is a paucity of studies on the remittances-sustainable development nexus, while there is a lack of studies that specifically explored asymmetry between remittances and sustainable development globally and in SSA countries.

The reason is not far-fetched. While extant studies focus on asymmetry of remittances in relationship with either environmental degradation, financial development, inequality, human capital development, and economic policy uncertainty, as shown in Table 3, none have examined asymmetric correlation between remittances and sustainable development in SSA using PNARDL. Moreover, existing findings from related studies, for instance from Table 1 on other regions (South Asia, BRIC economies, MINT economies, India, etc.), cannot suffice in the SSA context, as only a research study that addresses this lacuna will be sufficient.

Moreover, from the above, it is obvious that the remittances-sustainable development relationship is hardly explored by researchers, and the remittances-growth nexus and the remittances-financial development relationship, for instance, have been mainly examined within a growth theory framework, as evident in extant studies shown in Table 3. Noting that the asymmetric relationship between remittances and sustainable development is plausible between the two variables, the countercyclicality proposition has been mainly understated in several studies (Singh *et al.*, 2010). Hence, there is a paucity of studies that have examined asymmetry in the remittances-sustainable development nexus based on the countercyclicality theory. Even where there are existing studies, there has not been a consideration given to the asymmetric impact of the remittances-sustainable development nexus based on the countercyclicality theory stemming from the importance of this strand of economic theory in explaining the unequal effects of these cross-country financial transfers on sustainable development.

Table 3: Summary of Related Studies

Authors (Year)	Methodology	Findings	Critique
Biyase & Naidoo (2023)	ARDL, NARDL, FMOLS	Positive and negative asymmetric remittance shocks on financial development in South Africa.	To strengthen the analysis, incorporation of other omitted variables such as sustainable development alongside policy implications on a broader regional basis such as on SADC countries would enhance a more wide-ranging enlightenment of the study's outcomes.
Fang & Qamruzzaman (2021)	OLS, BDS tests, NARDL	Asymmetry established. Long-run asymmetric correlation found between remittances and inequality in some selected South Asian countries.	The policy implications of the study for issues of social inclusiveness and environmental sustainability which are intrinsically linked to sustainable development need to be explored to make it more robust and also give better illumination of the study.
Hussain <i>et al.</i> (2023)	ARDL, NARDL	Short-run asymmetric relationship found between remittances and economic policy uncertainty for	Inclusion of specifics peculiar to the BRIC economies and the incorporation of dynamics of developmental issues will undoubtedly not only be instructive

		Russian and India. Long-run asymmetry established for the BRIC economies as a whole.	but enlightening in the analysis of the study.
Mensah & Abdul-Mumuni (2023)	Kao, Pedroni and Johansen Fisher cointegration tests, PNARDL	Asymmetric relationship found between remittances and financial development in SSA Countries.	To enhance the study, consideration could be given to magnitude of impact and temporal dynamics. The impact of potential factors influencing remittances could be explored.
Odugbesan <i>et al.</i> (2021)	PARDL, PNARDL	Positive and negative asymmetric remittance shocks increase economic growth in the long run in MINT economies.	The exploration of the impact of potential influencing factors in the asymmetry of the remittances-growth nexus would no doubt strengthen the outcome of the study.
Xia <i>et al.</i> (2022)	Pesaran & Yamagata slope homogeneity test; CADF; CIPS, Pedroni cointegration test; Westerlund cointegration test; PARDL; PNARDL	Asymmetric relationship found between remittances and human capital development in the top 10 global remittances-receiving countries.	The incorporation of potential influencing factors would contribute in a more comprehensive understanding of the asymmetric relationship between remittances and human capital development.
Zahran (2023)	VAR, FEVD	Asymmetric correlation found between remittances and oil price shocks in Egypt.	To enhance the study, consideration for statistical significance and policy implications on the wider Maghreb region (Libya, for instance is an oil-exporting country in the region beside Egypt) would provide better understanding of the asymmetric relationship between remittances and oil price shocks.
Mehta <i>et al.</i> (2021)	ARDL, NARDL, BDS Test, nonlinear OLS.	Short and long run asymmetry found between remittances and financial development in Bangladesh.	In summary, incorporation of contextual specifics and consideration of omitted variables would enhance the illumination and understanding of the study's conclusions.
Eggoh <i>et al.</i> (2019)	Panel Smooth Transition Regression (PSTR), SYS-GMM	Nonlinear association found between remittances and growth to primarily depend financial development and investment, and less on remittance level and consumption in 49 developing countries.	To strengthen the study, the exploration of the magnitude of asymmetric correlation as well as omitted variables influencing asymmetry the variables of interest would improve the study. Moreover, contextual specifics would contribute in shedding more light on the remittances-growth correlation across the 49 developing countries considered.
Qamruzzaman & Kler (2021)	DF-GLS, Zivot-Andrews tests, NARDL.	Short and long run asymmetry established between remittances and financial development in Bangladesh, India, Pakistan and Sri Lanka.	To strengthen the study, the consideration of the peculiar dynamics of these countries that shared common historical heritage would undoubtedly shed more understanding on the study's conclusions and policy implications in regard to asymmetry in the remittances-financial development nexus.

Khan (2023)	NARDL	Positive remittance shocks had positive impact on economic growth in the short run and long-run while negative remittance shocks do not affect economic growth in India.	The consideration of the role played by development factors as well as environmental sustainability would strengthen the understanding of the asymmetric connection between remittances and growth in India.
Nathan & Omeje (2022)	Markov time-varying transition probability model.	Remittances had a positive sign in the recession and recovery states in Nigeria.	To strengthen the study, the consideration of the magnitude and significance of asymmetric effects beside other potential factors influencing asymmetry would no doubt enhance the study's outcomes and policy relevance.
Akinlo (2022)	NARDL	Remittances asymmetrically related to ecological footprints in the short and long-run in Nigeria.	To strengthen the study, consideration of other factors influencing environmental sustainability in Nigeria and robustness checks will no doubt enhance understanding of asymmetric relationship between remittances and ecological footprints.
Al-Abdulrazag (2022)	ARDL, NARDL	Asymmetric relationship found between remittances and financial development in Jordan.	To strengthen the study, consideration of temporal dynamics and possible omitted variables will undoubtedly shed more understanding on the study's conclusions on asymmetry in the remittances-financial development nexus in Jordan.

3. Methodology

3.1 Theoretical Framework and Model Specification

The current and extant literature has not offered a viable theoretical framework for asymmetry in the remittances-sustainable development nexus, perhaps because it is a relatively recent topical theme. Moreover, developing a theoretical framework on asymmetry in the remittances-sustainable development nexus for conceptual clarity is a daunting task, as there are no explicit theories on this correlation. Studies have shown that remittances do not fundamentally and consistently support sustainable development and must be intentionally engaged in order to do so (Mills, 2023). Studies such as Mills (2023) and Daly *et al.* (2022) posited the theoretical position that remittances have both positive and negative effects, with sustainable development's implications providing a theory of remittance-sustainable development nexus in the linear sense. The nonlinear or asymmetric theory of this relationship is missing. This study extends the literature by developing a plausible theoretical framework for this subject matter.

Hence, the study proposed a theoretical framework for the asymmetric correlation in the remittances-sustainable development relationship by employing the Counter-cyclicity proposition. Remittances are technically said to behave counter-cyclically (Singh *et al.*, 2010).

This proposition, in which remittances behave countercyclically in relation to business cycles with positive or negative shocks, provides a succinct theoretical framework for explaining the asymmetry in the remittances-sustainable development nexus. The asymmetric effects of either

positive or negative remittance shocks behaving countercyclically with the recipient country's GDP translate to an unequal nexus between the variables. This is true for a theoretical framework for asymmetry in the remittances-growth nexus, as it is also true for asymmetry in the remittances-sustainable development relationship. The reason is not far-fetched. Countercyclical remittances played a huge role in extenuating macroeconomic shocks (positive and negative), specifically in developing countries where remittances have grown to be one of the largest sources of external finance (Kim *et al.*, 2024). Countercyclical remittances, according to Kim *et al.* (2024), helped migrants' families to smooth consumption, finance, education, and ease credit constraints, which altogether foster sustainable development.

The counter-cyclicity proposition on remittances (Kim *et al.*, 2024; Singh *et al.*, 2010) aligns with the empirical strategy of the current study as it non-linearly explains the asymmetric relationship of these cross-country financial inflows with the recipient country's GDP and economic condition.

It is imperative to note that tangentially, there are alternative theories and explanations on the nonlinearity/asymmetry matter regarding remittances. These include the two schools of thought – complementarity and substitutability schools espoused in explaining nonlinearity in the context of the remittances-financial development nexus (Sharaf & Shahen, 2022). Only the countercyclicity theoretical postulate aligns with the asymmetric nexus between remittances and sustainable development (Gröger, 2019).

This study follows Koirala and Pradhan (2019), Hess (2010), Kapur (2004), Heilmann (2006), Solow (1956, 1978), and Haller *et al.* (2018) in capturing the theoretical postulate that remittances are a stable financial source for sustainable development for developing economies. Moreover, this study captures this postulate within a framework of asymmetric relationship, such that the cross-country remittances' unequal impacts on socially inclusive green growth, otherwise known as sustainable development, can be explored empirically. Therefore, the dependent variable, sustainable development, can be assumed to be a function of remittances, financial development, and other covariates, x_{it} . Thus:

$$SD = f(REMS, FD, x_{it}) \quad [1]$$

Where *REM* stands for remittances, *FD* for financial development, and x_{it} for a vector of other control variables. In line with Hess (2013), this study employed sustainable development proxied by the adjusted net saving (% of GDP) (hereafter, referred to also as ANS), given the fact that it remains the only useful and available data on this important concept in this research work. Empirical studies that have used the ANS as a proxy for sustainable development include Ojike *et al.* (2022), Güney (2019), Ullah *et al.* (2021), Güney (2017), Sarpong and Bein (2021), Perveen and Khan (2021), among many others. The study now briefly considers the financing of sustainable development.

The study employed Panel NARDL methodology to explore the unequal effects of remittances and sustainable development in a subset of SSA nations. It is necessary to take into account the symmetric version of the connection between remittances and sustainable development in the chosen SSA nations before looking at the asymmetric consequences. Hence, a Panel ARDL model is specified as:

$$\Delta SD_{it} = \alpha_0 + \alpha_1 SD_{it-1} + \alpha_2 REM_{it-1} + \alpha_3 i^{-} REM^{-} it_{-1} + \alpha_4 FD_{it-1} + \alpha_5 GDP_{it-1} + \alpha_6 INV_{it-1} + \alpha_7 GDPPC_{it-1} + \sum_{j=1}^{N_1} \lambda_{ij} \Delta SD_{it-1} +$$

$$\sum_{j-1}^{N2} \alpha_{ij} \Delta REM_{it-1} + \sum_{j-1}^{N3} \delta_{ij} \Delta FD_{it-1} + \sum_{j-1}^{N4} \varpi_{ij} \Delta GDP_{it-1} + \sum_{j-1}^{N5} \tau_{ij} \Delta INV_{it-1} + \sum_{j-1}^{N6} \phi_{ij} \Delta GDPPC_{it-1} + \varepsilon_i + \mu_{it} \tag{2}$$

Where ε_i stands for the group-specific effect, i denotes the group number; t represents the group period, SD_{it} denotes sustainable development, and $FD_{i,t}$ portrays the financial sector development measure. Remittances are decomposed into positive and negative changes in equations [4] and [5]. As a result, under these assumptions, the behavior of remittances on sustainable development is symmetric. Thus, the specified panel NARDL model is as follows:

$$\Delta SD_{it} = \alpha_0 + \alpha_{1i} SD_{it-1} + \alpha_{2i} \overset{+}{REM}_{it-1} + \alpha_{3i} \overset{-}{REM}_{it-1} + \alpha_{4i} FD_{it-1} + \alpha_{5i} GDP_{it-1} + \alpha_{6i} INV_{it-1} + \alpha_{7i} GDPPC_{it-1} + \sum_{j-1}^{N1} \lambda_{ij} \Delta SD_{it-1} + (\sum_{j-1}^{N2} \gamma_{ij} \Delta \overset{+}{REM}_{it-1} + \gamma_{ij} \Delta \overset{-}{REM}_{it-1}) + \sum_{j-1}^{N3} \phi_{ij} \Delta FD_{it-1} + \sum_{j-1}^{N4} \varpi_{ij} \Delta GDP_{it-1} + \sum_{j-1}^{N5} \tau_{ij} \Delta INV_{it-1} + \sum_{j-1}^{N6} \phi_{ij} \Delta GDPPC_{it-1} + \mu_i + \varepsilon_{it} \tag{3}$$

Where the positive and negative remittance shocks are denoted by REM^+ and REM^- , respectively, μ_i denotes the group-specific effect. The long-run coefficients for REM^+ and REM^- are quantified as $\frac{-\alpha_{2i}}{\alpha_{1i}}$ and $\frac{-\alpha_{3i}}{\alpha_{1i}}$, respectively. These shocks are, correspondingly, computed as positive and negative partial-sum decompositions of variations in remittances and specified as follows:

$$REM^+ = \sum_{k=1}^t \Delta REM^-_{ik} = \sum_{k=1}^t \max(\Delta REM_{ik}, 0) \tag{4}$$

$$REM^- = \sum_{k=1}^t \Delta REM^+_{ik} = \sum_{k=1}^t \min(\Delta REM_{ik}, 0) \tag{5}$$

3.2 Estimation Techniques

This study employed the panel NARDL method to explore the asymmetric effect between remittances and sustainable development. The Panel NARDL Approach employed in this study is premised on a similar approach employed by scholars for empirical investigations of this kind. Methodologically, most of the authors who explored the asymmetric influences of remittances on other macroeconomic variables of interest employed this approach in carrying out their analyses of asymmetric or nonlinear effects among the variables of interest in various studies (Mensah & Abdul-Mumuni, 2023; Odugbesan *et al.*, 2021; Xia *et al.*, 2022; Dash *et al.*, 2024).

3.3 Data: Definition, Measurement, and Sources

The data employed in analyzing the asymmetric relationship between remittances and sustainable development in sub-Saharan African countries (Nigeria, Kenya, Tanzania, Ghana, Gambia, Sudan, Senegal, Burkina Faso, Guinea Bissau, Mali, Liberia, Togo, Sierra Leone, Ethiopia, Rwanda, Uganda, Angola, Gabon, Democratic Republic of Congo and Cameroon, Botswana, Mozambique, Lesotho, Malawi, Namibia, Zimbabwe, South Africa and Eswatini, Comoros and Cape Verde. Each region of sub-Saharan Africa is well represented between 2000 and 2022. The study utilizes data for remittances, financial development, sustainable development, and aggregate investment. The data are obtained from the World Bank database through World Bank Development Indicators Data 2024. However, the study used the SDGs Index (SDGI) as the dependent variable, in which scores are offered on a scale of 0-100 and can be

explained and understood as percentage points towards optimal attainment of the SDGs. The SDGI was obtained from the Sustainable Development Report (Sachs *et al.*, 2023) and herein offers a valuation of the progress accomplished in the attainment of the SDGs by all the selected SSA countries as member nations of the United Nations. All the variables are in log form. For the list of the variables utilised in the study, their description and measurement, the justification for including them, and the data sources, see Table 4: Measurement of Variables and Sources of Data.

Table 4: Measurement Of Variables and Source of Data

S/N	Variables	Description and Measurement	Justification for Its Inclusion	Data Source
1.	Remittances (REM)	Personal remittances as a percentage of GDP.	Goschin (2014);Ratha& Moghaddam (2020); Ito (2019)	WDI 2022
2.	Financial Development (FD)	Banks' domestic lending to the private sector (% of GDP) is the proxy employed to measure financial development.	Aggarwal; <i>et al.</i> (2011); Appiah <i>et al.</i> (2022)	WDI 2022
3.	Aggregate Private Investment (INV)	In 2015 US dollars, the gross fixed capital formation, or GFCF (as a percentage of GDP), is used as a proxy for aggregate private investment.	Kumar & Stauvermann (2014); Goschin (2014)	WDI 2022
4.	Sustainable Development (SDGI)	The Sustainable Development Goal Index (SDGI) serves as the proxy for sustainable development. Also, the adjusted net savings, excluding particulate emission damage (% of GNI), are used for robustness checks. s	Din <i>et al.</i> (2021); Al-Thani and Koc (2024)	WDI 2022; SDGI Website
5	Gross Domestic Product (GDP)	The log of GDP in constant 2015 US\$. This measures the size of the economy.	Djankov <i>et al.</i> , 2007; Kapur (2004)	WDI 2022
6.	GDP Per Capita	GDP per capita (in 2015 dollars constant). This proxied the degree of economic progress. The quality of the nation's legal institutions, which have been demonstrated to positively affect financial development, is also represented by this control variable.	Aggarwal <i>et al.</i> , 2011; La Porta <i>et al.</i> , 1997, 1998; Beck <i>et al.</i> , 2000; Beck <i>et al.</i> , 2003; Djankov <i>et al.</i> , 2007	WDI 2022

Source: Author's compilation

4. Empirical Results and Analysis

4.1 Panel Unit Root Tests

Tables 5 and 6 show that all the variables were stationary at levels using the Hadri LM test except InSDGI (intercept and trend). All the variables (except InSDGI) were stationary at the level (intercept) when the LLC was employed. When the IPS test was employed, only InREM was stationary at the level (using the intercept). At some levels, the outcomes of the IPS test and the Fisher PP panel unit root test were comparable. When these panel unit root tests were used at intercept and/or intercept and trend, all the variables were, however, stationary at first differences, suggesting that they are integrated of order one, or I(1).

All the variables except InSDGI were stationary at levels at the 5% significance level using the LLC panel unit root test, while only InREM was stationary at the 5% significance level when the IPS panel unit root test was employed. The table values were compared with the critical values in testing for the stationarity of the variables. Not all the variables were stationary at levels at the 5% significance level using the Fisher PP panel unit root test, except InREM. However, all the variables were stationary at levels at the 5% significance level using the Hadri LM panel unit root test. All the variables are stationary at first differences at the 5% significance level using all the panel unit root tests.

Table 5: Panel Unit Root Tests (At Levels)

Variable	LLC Panel Unit Root Test		IPS Panel Unit Root Test		Fisher ADF Unit Root Test		Fisher PP Unit Root Test		Hadri LM Unit Root Test	
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend
InSDGI	-0.98	-1.50	5.64	-0.80	5.74	-0.75	6.36	-0.58	17.73***	7.63***
InREM	-5.47***	1.57	-4.75***	-1.14	-3.96	-0.90	-3.14***	-1.68**	-10.25***	6.42
InFD	-2.29**	2.77	-1.39*	-1.14	-1.19	-1.03	-2.01**	-1.83**	12.86***	8.28***
InINV	-1.90**	-0.11	-1.10	0.71	-1.30*	1.15	-1.18	0.73	6.55***	8.74***
InGDP	-7.22***	-1.26	0.29	1.63	0.42	3.00	0.56	3.35	18.11***	11.03***
InGDPPC	-6.66***	0.12	-0.83	2.65	-0.83	3.22	-0.59	3.35	16.09***	11.38***

*, **, and *** denotes 10%, 5%, and 1% level of significance, respectively.

Critical values: -1.95 (intercept) and -2.87 (intercept and trend) at 5% significance level.

Source: Author's computation

Table 6: Panel Unit Root Tests (At First Differences)

Variable	LLC Panel Unit Root Test		IPS Panel Unit Root Test		Fisher ADF Unit Root Test		Fisher PP Unit Root Test		Hadri LM Unit Root Test	
	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend	Intercept	Intercept & Trend
InSDGI	-20.70***	-18.33***	-20.06***	-17.45***	-16.42***	-13.71***	-16.10***	-15.93***	0.02	5.10***
InREM	-16.66***	-14.00***	-19.45***	-16.33***	-15.86***	-13.22***	-18.16***	-16.38***	-0.96	3.58***
InFD	-43.96***	-40.59***	24.43***	-20.34***	-17.46***	-15.46***	-18.27***	-20.50***	2.40***	5.50***
InINV	-17.40***	-15.37***	-15.18***	-10.91***	-13.56***	-11.73***	-17.02***	-17.11***	2.46**	4.00***
InGDP	-14.91***	-11.97***	-13.96***	-12.63***	-12.61***	-11.22***	-13.51***	-14.42***	5.18***	8.19***
InGDPPC	-13.05***	-11.90***	-12.55***	-13.25***	-11.41***	-11.62***	-13.16***	-15.48***	5.43***	8.20***

*, **, and *** denotes 10%, 5%, and 1% level of significance, respectively.

Critical values: -1.95 (intercept) and -2.87 (intercept and trend) at 5% significance level.

Source: Author's computation

4.2 Panel NARDL Results and Analysis

The panel ARDL result (symmetric) as well as the panel NARDL results (asymmetric) are presented in Table 7. A negative and statistically significant nexus was, for instance, found between long-run output growth and sustainable development. This is because a 0.0015% decline in socially inclusive green economic growth (which implies sustainable development) is accounted for by 1% rise in the real GDP. Likewise, a negative and statistically significant nexus was found between long-run aggregate private investment and sustainable development, for the coefficient has a magnitude of -0.10. This signifies that a 0.10% decrease in sustained inclusive green output growth is due to a 1% increase in per capita gross fixed capital formation.

In the short run, a negative significant correlation was found between sustainable development and financial development. It suggests that a 1% increase in domestic credit given by financial institutions in the region to the private sector is the cause of a 0.02% drop in sustained inclusive green output growth. Furthermore, a statistically significant negative correlation was shown between the aggregate private investment and sustainable development. It suggests that a 1% rise in per capita GFCF (% of GDP) can explain a 0.02% drop in socially inclusive green production growth.

The asymmetric effect regression results are presented in the final four columns of Table 7, together with the long and short-run regression outcomes. Long-term results showed that, in the selected SSA countries, there is a statistically significant negative link between positive remittance shock and sustainable development. It suggests that a 1% rise in positive per capita remittance shock is the cause of a 0.09% decline in socially inclusive green economic development.

Table 7: Panel ARDL and NARDL Estimation Results

Dependent Variable: InSDGI								
Variables	Symmetric Effects				Asymmetric Effects			
	Coeff.	SE	t-stat.	Prob.	Coeff.	SE	t-stat.	Prob.
Long Run Estimation								
<i>InREM</i>	0.04***	0.00		12.55				
<i>InREM_{Pos}</i>					-0.09***	0.03	-3.38	0.00
<i>InREM_{Neg}</i>					0.21***	0.06	3.63	0.00
<i>InFD</i>	0.16***	0.01	26.35	0.00	0.62***	0.12	5.35	0.00
<i>InGDP</i>	-0.00***	0.00	-2.31	0.02	0.00*	0.00	1.76	0.08
<i>InINV</i>	-0.10***	0.02	-6.12	0.00	-0.35***	0.05	-7.37	0.00
<i>InGDPPC</i>	-0.00	0.00	-1.05	0.29	-0.04***	0.01	-2.96	0.00
Short Run Estimation								
<i>ECM(-1)</i>	-0.27***	0.01	-37.84	0.00	-0.13***	0.00	-34.76	0.00
$\Delta InREM_{t-1}$	-0.00	0.00	-0.37	0.71				
$\Delta InREM_{t-1Pos}$					0.01***	0.00	9.46	0.00
$\Delta InREM_{t-1Neg}$					-0.02***	0.00	-8.81	0.00
$\Delta InFD_{t-1}$	-0.02***	0.00	-8.96	0.00	-0.07***	0.00	-24.82	0.00
$\Delta InGDP_{t-1}$	0.00	0.00	0.74	0.46	0.00	0.00	1.41	0.16
$\Delta InINV_{t-1}$	-0.02***	0.00	-6.49	0.00	-0.02***	0.00	-5.76	0.00
$\Delta InGDPPC_{t-1}$	-0.01	0.01	-1.37	0.17	-0.05***	0.00	-5.76	0.00

***, **, * indicate statistical significance at 1%, 5% and 10% levels, respectively

Source: Author's computation

Table 8: Wald Test for Asymmetric Effect

Hypothesis	F-statistic	Probability
Long Run Symmetry	12.84***	0.00
Short Run Symmetry	28.64***	0.00

***, **, * indicate statistical significance at 1%, 5% and 10% levels, respectively

Source: Author's computatio

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Dependent Variable: InSD

Table 9: Panel Nonlinear ARDL Results using InSD as the dependent variable

Variable	Coefficient	Std. Error	t-statistic	Prob.
Long Run Estimation				
<i>InREM_{Pos}</i>	0.70***	0.07	10.49	0.00
<i>InREM_{Neg}</i>	3.23***	0.12	25.79	0.00
<i>InFD</i>	1.99***	0.19	10.27	0.00
<i>InGDP</i>	0.01	0.01	0.77	0.441
<i>InINV</i>	0.30	0.28	1.08	0.28
<i>InGDPPC</i>	0.08	0.08	1.03	0.30
Short Run Estimation				
<i>ECM(-1)</i>	-1.31***	0.08	-16.71	0.00
<i>ΔInSD_t 1</i>	0.20***	0.04	4.76	0.00
<i>ΔInREM_t 1Pos</i>	-0.88***	0.13	-6.86	0.00
<i>ΔInREM_t -1Neg</i>	0.35	0.33	1.06	0.29
<i>ΔInFD_t 1</i>	-1.89***	0.30	-6.23	0.00
<i>ΔInGDP_t 1</i>	0.43	0.39	1.12	0.26
<i>ΔInINV_t 1</i>	0.38	0.39	0.98	0.33
<i>ΔInGDPPC_t 1</i>	0.12	0.91	0.13	0.90
<i>Constant</i>	-3.98	0.24	-16.47	0.00

***, **, * indicate statistical significance at 1%, 5% and 10% levels, respectively

Source: Author's computation

Also, in the long run, a positive significant correlation was found between negative remittance shock and sustainable development in the SSA subcontinent. It implies that a 0.2101% increase in socially inclusive green economic growth is due to a 1% fall in negative remittance shock. The result signifies that a negative remittance shock triggers an upsurge in socially inclusive green growth in the SSA region, which, by implication, indicates that the populace in the subcontinent reacts to a reduction in remittances and mitigates its effect on socially inclusive, green growth in the long run.

The long run coefficient of aggregate private investment (-0.3546) is negative and statistically significant, demonstrating that a rise in gross fixed capital formation (% of GDP) is caused by a decline in socially inclusive green growth. A marginal positive and statistically significant relationship at the 10% level was also observed between real GDP and sustainable development, with a coefficient of magnitude 0.0026%. This suggests that a 0.0026% upsurge in socially inclusive green growth is accounted for by 1% increase in the economic size or output growth in the SSA region. Also, a significant negative correlation was observed between the GDP per capita and socially inclusive, green economic growth in the long run, with the coefficient having a magnitude of 0.04. This point toward the view that a decrease of 0.04% in socially inclusive green growth is due to 1% upsurge in economic development and legal institutions' quality in the selected SSA countries, indicating that a rise in economic development and the legal institutions 'quality cause a fall in socially inclusive, green growth in the long run in the region.

The Wald test (Table 8) demonstrates that an asymmetric correlation exists between remittances and sustainable development in the long run. The null hypothesis of long run symmetry with an F-statistic of magnitude 12.84 was rejected at 1% level of significance. Likewise, the null hypothesis of short-run symmetry with an F-statistic of magnitude 28.64 was rejected at 1% level of significance.

When there is a disequilibrium in the asymmetric panel ARDL model, the system will require 13% of its time to converge to its long-run equilibrium. According to the short-run asymmetric effect model regression results, the short-term results showed that, in the SSA region, there is a positive and statistically significant relationship between positive remittance shock and socially inclusive green growth. This relationship has a magnitude of 0.01, meaning that a 1% increase in positive remittance shock is associated with a 0.01% increase in socially inclusive, green growth. Furthermore, a negative and statistically significant correlation was found between remittance shock and sustainable development. It implies that a 0.02% decline in socially inclusive, green economic growth is due to 1% fall in negative remittance shock.

Furthermore, there was a short-term, significant negative correlation between socially inclusive green growth and domestic loans to the private sector. This suggests that a 1% increase in domestic credit to the private sector is the cause of a 0.07% decline in socially inclusive green growth. Also, a negative and statistically significant correlation was found between aggregate private investment and sustainable development. It implies that a 0.02% decrease in socially inclusive, green economic growth is accounted for by 1% increase in gross fixed capital formation as a percentage of GDP.

4.3 Robustness Checks

Robustness analysis was carried out on the asymmetric effects of remittances on sustainable development in the selected SSA countries using the adjusted net savings (ANS) as an alternative proxy for sustainable development. The results are presented in Table 9. The results showed that there is a long-run positive and significant relationship between positive remittance shocks and adjusted net savings (the alternative proxy for sustainable development -used here to conduct robustness check). Likewise, a long-run positive significant nexus was found between negative remittance shock and adjusted net savings. Also, in the long run, a significant positive relationship was observed between domestic credit (financial development) and adjusted net savings. When there is a disequilibrium in the robustness results of the asymmetric panel ARDL model, the system will require 131% of its time to converge to its long-run equilibrium.

In the short run, the robustness results demonstrated a significant negative relationship between positive remittance shocks and adjusted net savings. Likewise, a significant negative correlation was revealed between domestic credit (financial development) and adjusted net savings in the selected SSA countries.

4.4 Discussion

The study found a negative and statistically significant nexus between long-run output growth and sustainable development. This result contrasts with the findings of Azam, Khan, and Zubair (2021), who found that GDP had a positive impact on sustainable development in the case of 47 developing nations.

In the short run, a negative and significant correlation was found between sustainable development and financial development. This outcome aligned with the findings of Dada & Akinlo (2023) regarding Nigeria as well as Yadeta & Hunegnaw (2020) in the case of Ethiopia.

Long-run results showed that, in the selected SSA countries, there is a statistically significant negative link between positive remittance shock and sustainable development. These results align with existing studies' findings, such as Elbatanony *et al.* (2021), Islam *et al.* (2022), and Zafar *et al.* (2022), but contrast with the studies of Dash *et al.* (2022) and Akinlo (2022). This result supports the conclusion by earlier studies such as Sahoo *et al.* (2014) and Rehman *et al.*

(2022) that remittances intensify environmental degradation by an increase in the consumption and usage of energy intensive gadgets as well as the production of items such as refrigerators, washing machines, household appliances et cetera which inevitably caused a decline in environmental quality and by implication, sustainable development since environmental sustainability remain one of the cardinal *troika* of sustainable development (output growth, social inclusiveness and environmental sustainability).

Also, in the long run, a positive significant correlation was found between negative remittance shock and socially inclusive green growth in the SSA subcontinent. The result signifies that a negative remittance shock triggers an upsurge in socially inclusive green growth in the SSA region, which, by implication, indicates that the populace in the sub-continent reacts to a reduction in remittances and mitigates its effect on socially inclusive, green growth in the long run. This outcome conforms to the similar result of Dash *et al.* (2024). This result of the long-run asymmetry between negative remittance shock and sustainable development is in line with the counter-cyclical theoretical proposition, which predicts that remittances upsurge in periods of economic contraction and decrease in periods of economic boom.

The study also revealed asymmetric effects between remittances and sustainable development. It demonstrates that there exists a negative and significant correlation between positive remittance shock and socially inclusive green growth in the selected SSA nations. This outcome is not surprising because it aligns with counter-cyclical theoretical propositions' prediction, as this postulate holds true for the nations in the SSA subcontinent. This result which aligns with the conclusions of existing studies like Elbatany *et al.* (2021), and Zafar *et al.* (2022) but contrast with the verdicts of Dash *et al.* (2022), Akinlo (2022) lend support to the position that remittances increase in periods of economic contraction (which by implication, means low level of sustainable development) and decrease in periods of economic boom which translates to periods of improved levels in socially inclusive green growth.

In the same vein, in the long run, a significant positive correlation was demonstrated between negative remittance shock and sustainable development in the SSA region, which conforms to similar findings of Dash *et al.* (2024). This result of the long run asymmetry between negative remittance shock and sustainable development is in line with the counter-cyclical theoretical proposition, which predicts that remittances increase in episodes of economic contraction and decrease in periods of economic boom.

Furthermore, a negative and statistically significant correlation was found between remittance shock and sustainable development. This result aligns with the findings of Dash *et al.* (2024) and contrasts with the findings of Ahmad *et al.* (2019).

A short-term, significant negative correlation was found between socially inclusive green growth and domestic loans to the private sector. This outcome is consistent with theoretical literature (Dash *et al.*, 2024), which contends that financial development exacerbates environmental degradation by enabling consumers to borrow money to buy durable goods like cars, TVs, washing machines, and other items. These purchases surely worsen the state of socially inclusive, environmentally sustainable output growth.

5. Conclusions and Policy Recommendations.

Existing literature has explored asymmetry in the remittances-growth nexus (Rehman *et al.*, 2023; Odugbesan *et al.*, 2021; Eggoh *et al.*, 2019; Khan, 2023) and in the remittances-financial development nexus (Biyase & Naidoo, 2023; Mensah & Abdul-Mumuni, 2023; Mehta *et al.*, 2021; Qamruzzaman & Kler, 2021). Relying on data obtained from 30 selected SSA countries from 2000 to 2022, the study employed panel nonlinear autoregressive distributed lag (PNARDL) technique

to examine the asymmetric effects of remittances on sustainable development. Empirics from the estimated models suggest that negative remittance shocks have positive impact on sustainable development in the SSA region. Moreover, the results also showed that positive remittance shocks have negative impact on sustainable development. Hence, it is obvious that shocks from remittances result in unequal effects on sustainable development.

These findings provide several insights for development economists and policymakers in the SSA region. First, it is imperative for the SSA region to develop policy mechanisms on remittances at national and regional levels to channel these inflows towards other areas and aspects of SDGs and sustainable development other than for consumption smoothing as the case have been hitherto. In other words, National Policy Mechanisms on Remittances for the major remittances-receiving nations should be put in place in order to provide frameworks under which the efforts toward the attainment of the SDGs and sustainable development could be coordinated for optimal outcomes through the channelling of remittance inflows for this singular purpose. Regional financial entities such as the African Development Bank (AfDB) can be saddled with the responsibility of coordinating these policy frameworks at the continental or regional level for seamless policy implementation. Robust channelling of remittance inflows toward SDGs attainment will undoubtedly hasten the achievement of sustainable development. This is because remittances remain the most resilient source of finance for development purpose exceeding foreign direct investment (FDI), foreign private investment, and Official Development Aid given the fact that they tend to be stable and even increase in periods of economic downturns.

Moreover, governments and policy makers in the subcontinent need to create mechanisms to fully harness remittance inflows so that substantial buffers can be built in periods of economic downturn to cater for shortfalls that may occur in periods of economic boom based on the countercyclicality nature of remittances. Future research on the asymmetric relationship between remittances and sustainable development can include renewable resources and foreign direct investment.

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