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Pollution, Governance, and Women's Work: Examining African Female Labour Force Participation in the Face of Environmental Pollution and Governance Quality Puzzles

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Kingsley I. Okere
Department of Banking and Finance, Kingsley Ozumba Mbadiwe University, Imo State, Nigeria
&
Department of Economics, Banking and Finance, Gregory University, Uturu, Nigeria
E-mail: kingsley.okere@komu.edu.ng

Stephen K. Dimnwobi
(Corresponding Author)
Department of Economics, Nnamdi Azikiwe University, Awka, Nigeria
&
Strategy, Execution and Evaluation (SEE) Office, Awka, Nigeria
E-mail: stephenkcdim@gmail.com

Chukwunonso Ekesiobi
Department of Economics, Chukwuemeka Odumegwu Ojukwu University, Igbariam, Nigeria
E-mail: cs.ekesiobi@coou.edu.ng

Favour C. Onuoha
Department of Economics, Evangel University Akaeze, Nigeria
E-mail: fc.onuoha@evangeluniversity.edu.ng

Research Department

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Kingsley I. Okere, Stephen K. Dimnwobi, Chukwunonso Ekesiobi & Favour C. Onuoha

Abstract

In a rapidly changing world marked by environmental degradation and governance disparities, understanding their impact on African women's participation in the labor force remains a critical puzzle. This research seeks to unveil the intricate connections between pollution, governance quality, and women's economic engagement in Africa, shedding light on vital pathways to empower women, mitigate pollution's impact, and drive sustainable development in the region. Specifically, this study evaluates the impacts of governance quality and environmental pollution on gender economic outcomes in Sub-Saharan Africa (SSA) using data from 28 nations spanning 1996 to 2020. The study employs the dynamic panel threshold model. The key results reveal a negative and significant influence of ecological footprint on female economic participation. Furthermore, the dynamic threshold analysis reveals that environmental degradation undermines female labour engagement irrespective of the threshold level. The study also showed that below the threshold level, the interaction between governance quality variables and the ecological footprint exacerbates the negative impact of the ecological footprint on women's economic participation. Above the threshold level, the interaction between governance quality variables and the ecological footprint mitigates the negative impact. Overall, key recommendations like improved pollution control measures, inclusive governance, and effecting targeted policies and programs to empower women economically, among others, are proffered to contribute to the improvement in governance, environmental sustainability, and gender economic outcomes in SSA.

Keywords: Governance quality, Environmental pollution, Gender economic outcomes, Sub-Saharan Africa

1. Introduction

In Sub-Saharan Africa (SSA), the labour force participation rate was 67% in 2022, which is higher than the global average of 60% for the same period. However, there remains a persistent gender gap in the region's labour markets. The male labour force participation rate in the region was 73%, while their female counterparts were 61% (World Bank, 2022). The foregoing highlights that women are disproportionately underrepresented in the formal economic circle in the region, where most women are engaged in subsistence-oriented informal occupations such as petty commerce and agriculture (Asongu & Odhiambo, 2019; Uduji & Okolo-Obasi, 2020). Additionally, an expanding body of research backs the claim that increasing the number of women in the workforce ultimately boosts economic advancement (Asongu & Odhiambo, 2023). This is corroborated by a World Bank report that posits that barring women from the global formal economy leads to income losses of roughly US$160 trillion (World Bank, 2018). The fact that women in SSA countries are the poorest in the world makes this issue of gender exclusion extremely crucial to these nations (McFerson, 2010).

Given the current spike in unsustainable development plans that prioritize economic expansion beyond what the world can sustain, it is predicted that the miseries of climate change will disproportionately affect women and children (Dimnwobi et al., 2021; Ezenekwe et al., 2023; Okere et al., 2023). It is impossible to separate the environment from the workplace. Environmental deterioration (in)directly affects the levels of economic activity of women through different channels. First, ecological degradation frequently worsens the ecosystem and other facilities that support jobs (Montt, 2018). The majority of women in most developing nations work in climate-sensitive industries like forestry, agriculture, and fisheries to support their families (Terry, 2009). Relatedly, women make up the majority of smallholder farmers on marginal lands, which are vulnerable to floods, droughts, landslides, and other climate hazards (Koehler, 2016). Another channel through which ecological decline affects women's labour supply is through caring for their households or dependents (Aragón et al., 2017). There is evidence that children are especially prone to the damaging health effects of air pollution. For instance, household air pollution caused 237,000 deaths of children in 2020 (WHO, 2022). As a result, if caring for sick children and other dependents such as the elderly relies on working adults, those people are more likely to take time off from work or quit their jobs altogether if the sickness gets worse (Aragón et al., 2017). Children becoming ill due to pollution may affect women's participation in the labour force in the majority of developing nations, especially in SSA, where caring for dependents is mostly the responsibility of women within the family

(Langnel et al., 2021). The study looks at the connection between environmental pollution and female labour force participation to pinpoint the major ways that pollution affects women's job choices. This study provides valuable insights into the specific difficulties faced by women in the African labour market, revealing how environmental degradation has gendered effects. The establishment of tailored interventions and policies to lessen the negative effects of pollution on women's economic empowerment depends on policymakers having a thorough understanding of the consequences of environmental pollution on female labour force participation in SSA. Such a policy grasp will help advance gender equality and promote overall economic development in SSA.

The 2030 Sustainable Development Goals of the United Nations prioritize tackling ecological degradation, emphasizing the critical need for environmental sustainability to achieve global sustainable development (Ezenekwe et al., 2023; Shobande & Asongu, 2023; Shobande & Ogbeifun, 2023). Howbeit, several factors such as resource depletion and climate change represent considerable obstacles to achieving these objectives (Shobande, 2022; Shobande et al, 2023). To adequately evaluate environmental degradation, utilizing carbon dioxide (CO2) emissions as a proxy, as is commonly employed in the literature, may not be sufficient. The ecological footprint (EF) has grown in popularity as a more thorough measure of the ecological impact of human activity (Jahanger et al., 2023). In contrast to CO2, which only accounts for a minor portion of environmental harm, EF evaluates the natural resources used by a population to produce the resources they use (Dimnwobi et al., 2023a). EF is a crucial assessment technique in the context of sustainable development, according to the Global Footprint Network, as it offers a more comprehensive understanding of how human activities affect the environment. Since 1961, the SSA region's ecological reserve status has significantly declined (Awad et al. 2023). Despite having contributed the least to climate change, the SSA region has suffered the most harm (Dimnwobi et al., 2022; Dimnwobi et al., 2023b). Notwithstanding international efforts to safeguard the ecological reserve, it is predicted that Africa will face a serious ecological deficit. Several connected elements may be responsible for this panic (Nchofoung & Asongu. 2022). These causes include globalization dynamics that result in the intense use of nonrenewable energy sources in various economic endeavours. Similarly, the demographic shift has resulted in changes in country population structures, sizes, and distributions. The allocation, distribution, and management of resources have also been impacted by changes in governance infrastructure (Awad et al. 2023)

Furthermore, under the umbrella of environmental protection, the importance of governance cannot be understated. Hence, the pollution-haven theory demonstrated that lenient ecological rules in the host country may stimulate further foreign direct investment from enterprises trying to avoid costly regulatory compliance in their home nations (Awad et al., 2023). As a result, strong governance is a crucial instrument for limiting ecological damage and promoting long-term development (Ofori et al., 2023). However, it is frequently disregarded in the discussion of ecological degradation and female economic engagement. To promote the use of green energy sources, green investments, and ethical international trade, institutional quality is essential (Dimnwobi et al., 2023b). Institutional excellence supports ecological quality when governmental agencies properly implement environmental laws and regulations. Additionally, good governance is essential for promoting private sector development, which will trigger female employment possibilities in the formal economy (Ofori et al., 2022)

Consequently, this work makes at least four insightful contributions. First, the EF is used in this study to reexamine the environmental degradation-female economic participation nexus in the SSA region due to the limitations of CO2 as a complete and reliable indicator of ecological performance. The EF is a gauge of how much the human race is relying on the planet's ecosystems and natural resources. It is determined by using current technology and management techniques and taking into account the amount of land and water needed to produce the resources humans need and to absorb the trash they produce. The six supporting elements that make up the overall EF are fishing grounds, cropland, forests, developed land, grazing land, and land for carbon needs. Second, the number of studies that specifically examine the connection between environmental pollution and female labour force participation in SSA is quite limited. While studies on the effect of pollution on labour force participation, in general, have been conducted, little research has been done explicitly on how this link affects women in the African context. To gain a better understanding of the connection between environmental degradation and female labour force participation in SSA, it will be essential to close this knowledge gap. The creation of evidence-based policies and actions to lessen the negative effects of pollution and advance gender equality in the African labour market would be further supported by this. Third, this study contributes to the literature as the first of its type to examine the moderating impact of governance quality in the nexus between environmental degradation and female economic participation. This is critical for the development and implementation of policies to reduce gender inequality in SSA. Lastly, the significance of gender equality in accomplishing SDGs serves as another driving force for our study. In addition to advancing women's rights, equitable economic opportunities for girls and women have favourable effects on the economy and human welfare, making gender equality essential to achieving the SDGs (Asongu et al., 2021a; Asongu et al., 2021b). Gender equality is also crucial because, in addition to being a human right, no economy can thrive with nearly most of its population being consigned to the economic margins (Asongu et al., 2021a; Asongu et al., 2021b). Nearly half of the nations in SSA failed to meet the MDG target for eradicating severe poverty, which makes this issue even more concerning. Inequality (i.e., gender exclusion) in the sub-region contributed to the failure to achieve this MDG target since it makes extreme poverty less responsive to economic progress (Asongu & Odhiambo, 2019)

This research examines the complex relationship between environmental pollution, the quality of governance, and the participation of women in the labour force in Sub-Saharan Africa. The study covers a period of 25 years, from 1996 to 2020, and includes data from 28 countries. The analysis incorporates the viewpoints of Becker and Mincer's Economic Theory of the Household and Boserup's hypothesis on the feminization-U hypothesis. The research findings demonstrate a substantial and adverse effect of ecological footprint on women's economic participation, using a dynamic panel threshold model. This highlights the negative impact of environmental degradation on female labour participation, regardless of the extent of degradation. Remarkably, the study reveals that when the variables related to governance quality fall below a specific threshold, they intensify the adverse effects of ecological footprint. Conversely, when these variables surpass the threshold, they alleviate the negative influence. These findings emphasize the significance of understanding these complex dynamics and offer suggestions to tackle gender economic inequalities and promote sustainable development in SSA. This analysis highlights the necessity of informed policies to tackle the distinct difficulties that women encounter in the African labour market amid environmental degradation. Moreover, it highlights the crucial importance of governance in the wider effort to attain gender equality and accomplish the Sustainable Development Goals (SDGs) in Sub-Saharan Africa.

The remainder of this article has the following formatting: The following section comprises previous relevant studies, and the study's methodology is provided in the third section. The fourth portion offers the empirical findings, while the final section concludes the study.

2. Literature Review

2.1. Theoretical Perspectives

Gary Becker and Jacob Mincer are credited for advancing the theory regarding married women's participation in the labour force. This theory, also known as the "Economic Theory of the Household" or the "Becker-Mincer Model" sheds light on the variables affecting a married woman's choice to enter the workforce. The theory assumes that individuals, especially married women, make decisions based on logical cost-benefit assessments (Ngoa & Song, 2021). Additionally, by making decisions that optimize their economic well-being, people aim to maximize their total well-being (utility). Likewise, the theory acknowledges that households produce both for the market (such as through paid jobs) and non-market reasons (such as housework and child care). Lastly, the theory proposes that there are compromises between participating in paid employment and engaging in activities outside of the job market. When a married woman devotes time and effort to one of these activities, it diminishes her capacity to engage in the other (Ngoa & Song, 2021). On the other hand, the feminization-U hypothesis, popularized by Boserup (1970) is another prominent theory in the literature utilized in explicating female economic engagement. The theory avers that female labour engagement drops in the early stages of economic development and subsequently rises as economic advancement improves. Put differently, the hypothesis explains the propensity of female labour engagement to drop first and then climb as per capita income increases (Roncolato, 2016; Klasen et al., 2020).

2.2. Prior Studies

On the empirical front, the review focused on works on female labour force engagement. The first part documents studies on ecological damage and female labour force engagement while the other strand explores the governance infrastructure and gender-economic outcome nexus. Regarding past studies for the first strand, Shayegh and Dasgupta (2022) applied South African micro-level data and discovered that whereas the availability of highly skilled labour is unaffected by climate change, the working hours of low-skilled labour are negatively impacted by rising temperatures, especially for women who work in high-exposure industries. Langnel et al. (2021) assessed the influence of environmental pollution on gender economic inclusion in 22 SSA nations between 1990 and 2013 and found that the engagement of women in the labour force is disproportionately influenced by environmental degradation. Moshoeshoe et al. (2021) utilized microdata to appraise the implications of weather shocks on labour supply decisions in Lesotho and revealed that weather shocks do not affect women's labour supply decisions. Using microdata from Cameroon, Bakehe (2021) discovered that respiratory illnesses arising from the utilization of dirty fuels negatively influence women's labour decisions. Gu et al. (2020) utilized microdata to unearth the nexus between air pollution and female labour supply in China and discovered that air pollution hampers female labour force participation. Employing the Computable General Equilibrium (CGE) model in Bolivia, Escalante and Maisonnave (2020) indicated that climate change has a detrimental impact on employment and adds to a load of domestic duties, particularly for women, making them more vulnerable. Montt (2018) explored the influence of air pollution on the labour supply in Chile and revealed that although air pollution is not linked to a decrease in total hours worked, it decreases the labour supply of women especially those with children. Likewise, in Mexico, Stabridis and van Gameren (2018) concluded that exposure to pollution increases the incidence of respiratory illness among women which in turn leads to a decline in their involvement in the labour market.

In the second strand of literature, governance quality is critical in ensuring labour force participation in any economy. Good institutions will guarantee equal access to jobs, finances, and entrepreneurial opportunities while also ensuring that policies and governance procedures are developed in a way that is fair to all. Good institutions foster the growth of the private sector, which contributes significantly to generating employment opportunities for people, particularly women, in the economy's formal sector. On the other side, poor institutions impede private sector development by not providing a conducive environment and infrastructure required for them to thrive and generate employment opportunities (Ofori et al., 2023; Opeloyeru et al., 2023). Studying SSA economies between 1990 and 2014., Efobi et al. (2018) reported that the female labour supply grows considerably as the democracy level increases. Using Italian data, Agovino et al. (2019) discovered that institutional infrastructure significantly affects both men's and women's engagement in the local labour market. Utilizing Indian microdata, Krishnakumar and Viswanathan (2021) documented that increased trust in state institutions (police and judiciary) boosts female labour participation. For 42 SSA economies between 1996 and 2020, Ofori et al. (2022) revealed that female economic engagement is boosted by governance infrastructure. Focusing on 39 African nations, Opeloyeru et al (2023) highlighted that poor-quality institutions in Africa are harmful to labour supply whether overall, female, or male labour supply.

2.3. Empirical Gaps

We discovered the following shortcomings in prior studies after reviewing the relevant literature. First, research on the synergy between governance quality and environmental degradation in female economic engagements is still deficient in the literature. Second, prior studies have majorly employed CO2, and sulfur, among others, to capture ecological damage which do not provide a thorough assessment of how human actions affect the environment. Third, studies in SSA are rare despite the region is most sensitive to ecological issues as well as widening gender gaps in labour engagements. Fourth, the study outcomes on the subject matter review are still conflicting which may be due to the estimation technique deployed as most of these studies employed techniques that do not take care of variable omissions, endogeneity, and reverse causality. With these identified flaws from past studies, it is pertinent to state that this study is desirable. As a result, we tested the following hypotheses: H1: Environmental pollution does not have any significant effects on female labour participation; H2: The interaction between governance quality and environmental degradation does not have any significant effect on female economic participation

3. Methodology

3.1. Model Specification

This study utilizes the theoretical foundation discussed earlier to create a concise model. This model serves to link female labour participation (FLP) with significant environmental impact indicators. These indicators encompass ecological footprint, gross domestic product per capita, population growth, variables related to governance quality, and the U-shaped curve evident in the correlation between FLP and GDPC. The proposed model can be represented as follows:

$$FLP_{it} = \alpha_0 + \beta EF_{it} + \varphi GDPC_{it} + \varphi_{sq} GDPCsq_{it} + \omega POP_{i,t} + \gamma INDEX_{i,t} + \varepsilon_{it} \quad (1)$$

Equation 1 is seen from two dimensions (i) whether Ecological Footprint and Governance Quality indicators independently impact female economic participation. (ii) U-shaped curve, that is, the interactions between Female economic participation and GDPC, implies that as a nation progresses toward its developmental path, its level of female economic participation tends to decrease initially, possibly due to traditional gender roles and limited opportunities for women as seen in the case of many developing economies. $INDEX$=is an index of governance quality[1].

[1] The index under consideration is the governance quality index. It is calculated through the application of the principal component analysis technique, employing the given formula:

$$INDEX = \sum_{t=1}^{n} w_i f v_i$$

In Equation above, fv_i reflects Governance Quality indicators at a certain time period, and wi indicates their weight in explaining variance across all variables. Principal component analysis determines these weights. The Governance Quality index is estimated as a linear combination of the six variables that serve as proxies for Governance Quality, with their weights (wi) being the contributions to PC 1's standardised variance. The justification for selecting principal components in a model is to streamline intricate datasets by decreasing dimensionality, alleviating multicollinearity, and improving interpretability. Principal components enable a more concise and comprehensible depiction of the data, enhancing the effectiveness of models and yielding valuable insights.

To achieve the goals, set out for this empirical adventure, we adopt a methodology similar to previous studies conducted by Alola et al. (2022), Muoneke et al. (2022), and Onuoha et al. (2023a). Accordingly, we extend equation 1, by incorporating the interaction term (Z*EF). There are numerous justifications for including an interaction term in a model that examines the impact of governance quality, ecological footprint, and their combined effect on female economic participation. This approach acknowledges the intricacy of the relationship, examines potential consequences based on conditions, accounts for differences among various subgroups or circumstances, provides valuable information for policy development, and enhances the predictive precision of the model. This approach enables a more thorough and subtle comprehension of the interplay between governance quality and ecological footprint in influencing female economic participation. Such understanding is crucial for making well-informed decisions and designing effective policies.

$$FLP_{it} = \alpha_0 + \beta EF_{it} + \varphi GDPC_{it} + \varphi_{sq} GDPCsq_{it} + \omega POP_{i,t} + \gamma Z_{i,t} + \lambda\left(Z_{i,t} * EF_{i,t}\right) + d_{it} + \varepsilon_{it} \qquad (2)$$

$$\varepsilon_{it} = (v_i + u_{it})$$

Where ε_{it} the composite error term; v_i known as country fixed effect, captures the unobserved or time-invariant characteristics that are unique to each country in a panel dataset; u_{it} is the Time-fixed effects, or time dummies, capture the time-specific effects or common trends that affect all countries or units in the panel dataset during a specific period that is independent and identically distributed (i.i.d); d_{it} indicates time-specific dummies controlling for variation of the dependent variable. Where[2], FLP= Female economic participation, Z = vector of governance quality[3],w_{it} = ε_{it} = general error term; GDPC= Gross domestic product per capita per capita, GDPSQ= Gross domestic product per capita square, POP= Population growth. Consequently, a valid U-shaped curve only exists if φ < 0 and φ_{sq}> 0. The parameter estimations used in this investigation are as follows: $\varphi, \gamma, \lambda. \alpha_0$=intercept of the model, $i = 1 \ldots . N$ is the number of cross-sections, t depicts the period. Equation 1 reveals the role of λ in determining whether the relationship between EP and Z enhances or weakens the influence of EF on FLP. In simple terms, if λ is positive, it signifies that governance quality reinforces the impact of environmental pollution on female economic participation.

[2] All the variables are in their natural logarithm form. The interpretation from the equation is thus: The coefficient for ln(X) represents the percentage change in the dependent variable for a 1% change in X, assuming other variables remain constant.

[3] Governance Quality indicators: Control of corruption (CCR), Political stability and absence of violence (PSA), Government effectiveness (GES), Voice and accountability (VAA), Regulatory quality (RQL), and Rule of law (RLW).

$$\frac{FLP_{it}}{\partial EF_{it}} = \beta + \gamma(Z)_{it} \tag{3}$$

Equation (3) elucidates the significance of governance quality in shaping and mediating the influence of ecological footprint on female economic participation. This relationship is contingent upon the values of β and γ, encompassing their signs, magnitudes, and levels of significance. The interpretation of these parameters can be approached thus: When $\beta < 0$ and $\gamma > 0$, it signifies that ecological footprint hurts the productive capacity of female economic participation, and governance quality complements or substitutes this effect by providing essential mechanisms that amplify the negative or positive influence. Likewise, if the two parameters still maintain thus: ($\beta < 0$ and $\gamma > 0$) in Equation (3), and are statistically significant and possess opposite signs, it indicates the existence of a threshold of governance quality. Beyond this threshold, the ecological footprint is stimulated to exert a robust negative or positive impact on female economic participation. Consequently, a threshold model is employed, enabling the slope coefficients to be contingent on the prevailing regime. This approach is inspired by Henson's (2000) sample split framework.

3.2. Estimation Techniques

Based on the above explanation, the first step in this empirical narration is to test for the presence of threshold Henson's (2000) sample split. The equation for the sample split is shown below as thus:

$$FLP_{it} = \left(\beta_1 EF_{it} + \varphi_1 GDPC_{it} + \varphi_{sq_1} GDPCsq_{it} + \varphi_1 POP_{it} + \varphi_1 K_{it}\right) I(Z \leq \lambda) + \left(\beta_2 EF_{it} + \varphi_2 GDPC_{it} + \varphi_{sq_2} GDPCsq_{it} + \varphi_2 POP_{it} + \varphi_2 K_{it}\right) I(Z \geq \lambda) + d_{it} + \varepsilon_{it} \tag{4}$$

To categorize the sample into different regimes or groups, a threshold variable K, representing the level of governance quality indicators, is employed, with the unknown threshold parameter denoted as λ. The indicator function I(.) yields a value of 1 when the argument is valid and 0 otherwise. This modelling approach allows the impact of ecological footprint to vary based on whether the quality of governance is below or above a threshold value. The primary motivation behind this approach is the recognition that the impact of ecological footprint on female economic participation is not constant, but rather hinges on governance quality. The technique seeks to identify a specific governance quality threshold that delineates shifts in this relationship. Equation (4) incorporates measures of governance quality as threshold variables to partition the study population. The effect of ecological footprint on women's economic involvement is denoted as β_1 for countries in the low regime and β_2 for those in the high regime. Assuming $\beta_1 = \beta_2$ and $\varphi_1 = \varphi_2$ linearizes the model, resulting in Equation (1).

To initiate our estimation procedure, we compared the threshold model defined by Equation (4) with the null hypothesis of linearity, H0: $\beta_1 = \beta_2$. This led to a non-standard inference problem since the threshold parameter could not be determined under the null hypothesis, rendering the conventional chi-square bounds of the Wald or LM test statistics inadequate (Hansen, 2000). To conclude, we calculated a Wald or LM statistic for each value of λ and selected the highest value as our reference point. As the supremum statistic follows a non-standard distribution and depends on several model-specific nuisance parameters, tabular data were unavailable. To overcome this issue, we utilized a bootstrap model, which has been demonstrated by Hansen (1999) to be valid and possess desirable qualities. Estimates of the slope parameters, $\hat{\beta}\hat{\lambda}$ and $\hat{\varphi}\hat{\lambda}$, were easily derived once an estimate of λ was obtained (as the value that minimizes the residual sum of squares computed across all feasible λ values).

3.3. Dynamic panel threshold model

As a result of the work of Seo et al. (2019), the study makes use of the dynamic panel threshold model that Seo and Shin (2016) developed. This approach, which is based on the concepts of the Generalised Method of Moments (GMM), addresses the endogeneity and simultaneity that arise in the context of the connection between dependent and independent variables. The approach also calculates and displays the threshold point between ecological footprint and female economic participation.

$$FLP_{it} = \left(\beta_1 EF_{it} + \varphi_1 GDPC_{it} + \varphi_{sq_1} GDPCsq_{it} + \omega POP_{i,t} + \varphi_1 K_{it}\right) I(Z \leq \lambda) + \left(\beta_2 EF_{it} + \varphi_2 GDPC_{it} + \varphi_{sq_2} GDPCsq_{it} + \omega POP_{i,t} + \varphi_2 K_{it}\right) I(Z \geq \lambda) + d_{it} + \varepsilon_{it} \qquad (5)$$

All the parameters have been discussed in the previous sections.

3.4. Data

Data for this research span the years 1996 to 2020 and are drawn from 28 SSA nations (see Appendix 1). The relevant data are gathered from three main sources notably World Bank World Development Indicators (WDI), World Governance Indicators (WGI), and Global Footprint Network Database. The outcome variable is female labour force participation and the selection is consistent with previous studies (Osinubi & Asongu, 2020; Langnel et al., 2021; Ngoa & Song, 2021; Ofori et al., 2022). Consistent with Dimnwobi et al. (2021); Awad et al. (2023) and

Jahanger et al. (2023), we employed the EF which is regarded as a more accurate technique for determining the environmental stresses caused by human actions on the ecosystem. The EF evaluates the long-lasting and total effects of present human activities on the ecosystem and can be used to track ecological changes, taking into account resource use and environmental degradation in a more holistic, objective, and thorough manner. For several reasons, the EF is preferred to other environmental degradation metrics. First, it offers a thorough and all-encompassing assessment of the effects of human activity on the environment, accounting for elements like resource use and waste production. Second, it takes into account the idea of carrying capacity, which assesses whether our existing way of life is long-term viable (Dimnwobi et al. 2021). Last but not least, the EF enables comparisons across other regions or nations, allowing decision-makers and scholars to pinpoint areas in need of focused actions to alleviate ecological degradation (Awad et al. 2023). Relatedly, the governance infrastructure is represented by six variables notably the rule of law, government effectiveness, corruption control, political stability, voice and accountability, and regulation. There are various reasons for including governance quality in the study on pollution and female labour force participation. First, the effectiveness of governance is vital in determining the environmental laws and policies that have an immediate effect on pollution levels. Better pollution management is anticipated to follow from better governance, which is defined by transparency, accountability, and effective institutions (Dimnwobi et al., 2023b). Second, governance quality can affect how labour rules and regulations are implemented and enforced, particularly those that pertain to workplace health and safety, which can have a direct impact on the involvement of women in the labour force in polluting industries (Asongu & Odhiambo, 2019). Furthermore, the effectiveness of governance can influence the distribution of funds and investments to industries that can offer cleaner and more sustainable employment possibilities for women. Additionally, incorporating governance quality in the study enables a thorough examination of the intricate relationship between pollution, governance, and its impact on female labour force participation (Ofori et al., 2022). This approach provides a more detailed understanding of the underlying mechanisms at play. Besides, analyzing the role of governance quality can assist in identifying specific policy interventions and reforms that can concurrently promote both ecological sustainability and an increase in female labour force participation (Ofori et al., 2022)

Economic growth and population growth were employed as control variables in line with past related studies (Osinubi & Asongu, 2020; Langnel et al., 2021; Ngoa & Song, 2021; Asongu & Odhiambo, 2023; Ofori et al., 2023). The aforementioned variables are included in the study because it is thought that they are crucial in affecting women's participation in economic activities. For instance, increased employment options and the expansion of traditionally male-dominated industries are two ways that economic growth might affect the participation of women in the labour force. More skilled people are needed as the economy expands, which can inspire more women to enter the workforce and pursue higher education or technical training (Ngoa & Song, 2021; Ofori et al., 2022). Additionally, economic progress can result in advancements in social services, healthcare, and infrastructure, which can assist in removing obstacles that have traditionally made it difficult for women to join the workforce (Osinubi & Asongu, 2020). Both positive and negative effects on female labour force participation can be attributed to population expansion. On the one hand, a higher population can result in a larger labour force, which may result in more job opportunities and an increase in the demand for female workers. However, population increase can also put strain on infrastructure and resources, which may make it difficult for women to enter or stay in the workforce, especially if they have restricted access to healthcare and educational opportunities (Langnel et al., 2021). In Appendix 2, the descriptions of the variables are offered.

4. Presentation of Results

4.1. Descriptive Statistics

Table 1 represents the descriptive statistics of the variables of our model. The outcome revealed that female labour participation (FLP) has an average value of 57.9% per year, a median of 56.8%, and a maximum of 87.1% yearly. Female labour participation (FLP), which has an average annual value of 57.9%, indicates that a sizable proportion of women are actively employed in the study's setting. This shows that efforts to advance gender equality and women's economic empowerment have made headway. It also represents the possibility of higher economic growth and productivity due to women's active participation in the workforce. Also, the average ecological footprint (EF) is found to be 1.43% per annum, a median of 1.21%, and a maximum of 3.82% annually. A comparatively little environmental impact per capita is indicated by the discovery that SSA's ecological footprint is 1.43% annually. This indicates that African nations could be displaying responsible consumption habits and sustainable resource management techniques. More so, the mean value of economic growth (GDPC) annually for the SSA is 1976.15 dollars, with a median of $956.66 per year and a maximum of $11949.28 per annum. The discovery that SSA has an average yearly economic increase per capita of 1976.15 USD points to success in the economic development of the area. This suggests that people in SSA will have higher incomes and possibly enjoy higher living conditions. Additionally, population growth (POP) has an average value of 2.46% annually, a median of 2.56% per annum, and a maximum of 16.62% yearly. SSA's yearly population growth rate of 2.46% points to a considerable population rise, which has several repercussions. It shows the need for increased spending on infrastructure, healthcare, and essential services to accommodate the expanding population. The additional consumer market and potential workforce that this growth can bring about can be beneficial economically, but it also presents issues in terms of resource management and ensuring sustainable development to satisfy the requirements of the expanding population. Finally, governance quality (INDEX) has a mean value of 4.15% yearly, a median of 0.4% annually, and a maximum of 5.4% per year. SSA's average annual rating for the index of governance quality of 4.15% indicates that the region's general level of governance effectiveness is low. This result shows that there are issues with accountability, the rule of law, and transparency. It underlines how crucial it is to pursue reforms and better governance practices to increase stability, draw in investors, and promote sustainable development throughout SSA.

The study further shows that GDPC has the highest mean value followed by FLP and then POP while EF has the lowest mean value. The coefficients of the skewness for all the variables are positive which implies that the distributions are skewed to the right. The values of the kurtosis for EF, GDPC, and POP are greater than 3 which entails that they are Leptokurtic and as such the series are peaked relative to normal distribution (that is long tailed). On the other hand, FLP and index of governance quality are platykurtic as their values are less than 3, and as such their distributions have flat curves. Finally, the Jarque-Bera statistics revealed that the variables are not normally distributed as indicated by their probability values which are less than 5% significant level.

TABLE 1: Descriptive Statistics

Variables	FLP	EF	GDPC	POP	INDEX
Mean	57.928	1.434	1976.151	2.465	4.150
Median	56.844	1.210	956.660	2.566	-0.400
Maximum	87.123	3.820	11949.28	16.625	5.407
Minimum	31.694	0.630	202.3721	-0.112	-3.785
Std. Dev.	13.505	0.653	2489.027	1.045	2.199
Skewness	0.180	1.789	2.085	4.803	0.626
Kurtosis	2.585	5.558	6.303	66.153	2.595
Jarque-Bera	8.817	563.806	824.274	118850.7	50.423
Probability	0.012	0.000	0.000	0.000	0.000
Sum	40491.78	1002.585	1381330.	1723.459	2.900
Sum Sq. Dev.	127306.2	297.807	4.320	762.863	3375.939
Observations	700	700	700	700	700

Source: Authors Computation

Table 2 contains the outcome of the correlation matrix of the factors for the study. To be precise, the findings indicate a negative and significant relationship between LEF and LFLP. Also, LGDPC and governance quality index are negatively and significantly correlated with LFLP in SSA during the period of study. However, population growth has a positive and significant association with female economic participation.

TABLE 2: Correlation matrix

Variables	LFLP	LEF	LGDPC	LPOP	INDEX
LFEP	1.000				
P-Value					
LEF	-0.338	1.000			
P-Value	0.000				
LGDPC	-0.410	0.762	1.000		
P-Value	0.000	0.000			
LPOP	0.205	-0.402	-0.326	1.000	
P-Value	0.000	0.000	0.000		
INDEX	-0.252	0.656	0.561	-0.305	1.000
P-Value	0.000	0.000	0.000	0.000	

*Note: ***= p<1%, ** = p<5%,* = p<10%.* Source: Authors Computation

4.2. Cross-sectional Dependency and Slope Homogeneity Tests

As a pre-requisite for carrying out regression on long-term datasets, we conducted the cross-sectional dependency test as well as the slope homogeneity test to avoid incorrect estimation (Shahbaz et al., 2022). Thus, we evaluated cross-sectional dependence by adopting the Lagrangian multiplier (LM) estimation proposed by Pesaran (2015), the CD test developed by Pesaran (2007), the LM methods propounded by Breusch and Pagan (1980), and the slope homogeneity proposed by Pesaran and Yamagata (2008). It is a well-known fact that various nations have distinct policies and economies and assuming homogeneity without properly testing for it might contribute to erroneous outcomes. Nevertheless, the findings presented in Table 3 demonstrated that the Pesaran (2015) LM, Pesaran (2007) CDs, and Breusch-Pagan (1980) LM tests indicated cross-sectional dependence. This suggests that all variables are interconnected with each other throughout the study period. Moreover, the models indicated that both the delta and adjusted delta probabilities hold statistical significance, implying the presence of slope heterogeneity among the factors. Hence, the result obtained here in Table 3 confirmed that the assumption of cross-sectional dependence was right and the assumption of slope heterogeneity was correct.

TABLE 3: Cross-Sectional Dependency and Slope Homogeneity Analysis

Model	Pesaran (2007) CD test	Pesaran (2015) LM test	Breusch-Pagan (1980) LM test	Slope homogeneity test		P-Value
LFLP =f(LEF LGDPC LPOP INDEX)	3844.301	126.0681	3844.301	Delta_tilde	22.769	0.000
P-value	0.035	0.000	0.000	Adj. Delta_tilde	26.124	0.000

*Note: ***= p<1%, ** = p<5%,* = p<10%.* Source: Authors Computation

4.3. Unit root

Based on the existence of cross-sectional dependency, the appropriate panel unit root is second generation unit root and this led us to estimate the stationarity test using CIPS and CADF approaches. These tests were used to determine whether or not a series contain a unit root and they can easily identify heterogeneity inside and among panels and they take care of the issue of a flaw in the pseudo-stationary data collection and making use of a joint cross-sectional time series offered in the inspection results (Shahbaz et al, 2022). Table 4 shows that the outcome of our variables are integrated of order one that is, parameters are non-stationary at levels but become stationary after differencing once.

TABLE 4: Second Generation Unit Root Tests

	CIPS		CADF	
Variables	I(0)	I(1)	I(0)	I(1)
LFLP	-0.850	-2.354	-1.238	-2.405
LEF	-1.988	-5.312	-1.659	-3.633
LGDPC	-1.358	-3.700	-1.887	-2.823
LPOP	-1.993	-2.813	-3.297	-3.592
INDEX	-1.779	-4.787	-1.868	-3.234

*Note: ***= p<1%, ** = p<5%,* = p<10%.* Authors Computation

4.4. Empirical results

The result of the traditional threshold result is presented in Table 5 which consists of seven (7) columns. Column 1 is the outcome with unconditional effect, that is to say that no interaction was made but rather the effect of individual variables was showcased to see how they affect female economic participation which is our dependent variable. Columns 2 to 7 denote the conditional result where interaction was made using individual governance quality indicators to interact with ecological footprint to see if their presence was able to influence further the effect of ecological footprint on FLP. Hence, columns 2 to 7 entail interaction with CCR, GES, VAA, PSA, RQL, and RLW respectively. The result revealed that ecological footprint exerts a negative and significant influence on female economic participation across the seven specifications (that is, the seven columns) in SSA. Also, the coefficients of GDPC and its squared terms exhibit a negative and positive influence on FLP across the specifications respectively. This implies that there exists a U-shaped association between economic expansion and female participation in SSA. By implication, the U-shaped association between economic growth and female participation rate in SSA supports the feminization-U hypothesis propounded by Boserup (1970) which suggests that female labour participation tends to drop in the early stages of economic development but as growth advances, female labour engagement rises. This outcome is in tandem with the findings of Lechman and Kaur (2015) and Kennedy et al. (2017). Furthermore, population growth and governance quality index are positively and significantly connected with female participation across the models in SSA respectively. This means that the rise in population and governance significantly determines the rate at which females participate in economic activities in the region. Hence higher the population growth and increased governance quality, the higher the female labour supply rate (CCR, GES, VAA, PSA, RQL, and RLW). The outcome from the governance quality index corroborates with economic theory and the findings of (Ofori et al., 2023; Opeloyeru et al., 2023, Efobi et al., 2018, and Agovino et al., 2019) who found that good governance encourages female participation while poor institutions deter participation rate.

As part of the major contribution of this study, we considered the role played by governance quality in SSA (that is, interacting governance quality with the ecological footprint on female participation). Particularly, panel [1] consists of average governance (governance quality index) which is our baseline result already interpreted while model Spec [2]–[7] comprises control of corruption, government effectiveness index, voice and accountability index, political stability index regulatory quality index, and rule of law index. Extant literature suggests that the quality of governance matters in the level of labour force participation in every economy. Thus, good governance boosts participation while poor governance impedes participation. In this context, our findings reveal that the marginal effects of the ecological footprint led to a negative combined impact when interacting with CCR. In other words, the negative effect of pollution was diminished due to corruption control, resulting in a favourable marginal impact of pollution on female economic participation in Sub-Saharan Africa. This implies that corruption control and ecological footprint act as substitutes for each other. Furthermore, models 5 and 7 indicate significant negative conditional impacts of -0.190 and -0.018, respectively, resulting from the interaction between PSA and RLW with the ecological footprint, both at the 1% significance level. In contrast, columns 3, 4, and 6 illustrate positive marginal effects of 0.687, 0.118, and 0.357 arising from the interaction between GES, VAA, and RQL with EF, respectively. This suggests that the presence of these mentioned governance quality indicators was able to counter the negative pollution-driven impact of the ecological footprint on female participation in Sub-Saharan Africa. Given the complex interplay between governance, ecological footprint, and their impact on female participation in SSA, it is crucial to adopt a more dynamic approach. Utilizing the dynamic panel threshold model which is based on the system-GMM framework as proposed by Seo and Shin (2016) and further refined by Seo et al. (2019) can offer a more comprehensive and resilient perspective on the connection between these factors.

TABLE 5: Coefficient estimate for the U-shaped and Traditional threshold estimate for ecological footprint and female economic participation

VARIABLES	GL-1	GL-2	GL-3	GL-4	GL-5	GL-6	GL-7
EF	-0.104***	-0.118***	-0.136***	-0.106***	-0.124***	-0.118***	-0.113***
	(0.035)	(0.035)	(0.036)	(0.039)	(0.035)	(0.035)	(0.035)
	[-2.971]	[-3.371]	[-3.778]	[-2.718]	[-3.543]	[-3.371]	[-3.229]
GDPC	-0.530***	-0.517***	-0.571***	-0.546***	-0.500***	-0.518***	-0.520***
	(0.113)	(0.114)	(0.109)	(0.111)	(0.112)	(0.112)	(0.113)
	[-4.685]	[-4.526]	[-5.240]	[-4.910]	[-4.467]	[-4.629]	[-4.587]
GDPSQ	0.064***	0.063***	0.068***	0.067***	0.061***	0.062***	0.063***
	(0.018)	(0.018)	(0.017)	(0.018)	(0.018)	(0.018)	(0.018)
	[3.617]	[3.484]	[4.029]	[3.836]	[3.465]	[3.501]	[3.536]
POP	0.046***	0.043***	0.061***	0.047***	0.047***	0.046***	0.045***
	(0.013)	(0.013)	(0.013)	(0.012)	(0.013)	(0.012)	(0.013)
	[3.696]	[3.462]	[4.587]	[3.782]	[3.723]	[3.689]	[3.597]
INDEX	0.102***						
	(0.013)						
	[7.846]						
EF*CCR		0.107***					
		(0.221)					
		[-2.061]					
EF*GES			0.687***				
			(0.155)				
			[4.432]				
EF*VAA				0.118***			
				(0.113)			
				[3.037]			
EF*PSA					-0.190***		
					(0.060)		
					[-3.167]		
EF*RQL						0.357***	
						(0.129)	
						[2.761]	
EF*RLW							-0.018***
							(0.108)
							[-3.165]
Threshold value (δ)	4.141	4.103	4.199	4.075	4.098	4.177	4.127

Constant	2.745***	2.713***	2.857***	2.769***	2.673***	2.748***	2.723***
	(0.176)	(0.176)	(0.172)	(0.173)	(0.173)	(0.174)	(0.176)
	[15.625]	[15.381]	[16.581]	[16.048]	[15.473]	[15.749]	[15.496]
Observations	700	700	700	700	700	700	700
R-squared	0.444	0.544	0.675	0.745	0.65	0.653	0.743

Note: ***= p<1%, ** = p<5%,* = p<10%,[] t-statistic, ( ) standard error

4.5. Hansen (2000) threshold regression

TABLE 6: Test for threshold effect using the Hansen (2000) sample split

Sample Split	GL-1	GL-2	GL-3	GL-4	GL-5	GL-6	GL-7
Number of Bootstrap Replications	5000	5000	5000	5000	5000	5000	5000
Trimming Percentage	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Threshold Estimate	-2.104	-0.045	-0.042	-0.035	-0.017	-0.038	-0.055
LM-test for no threshold	143.848	173.805	138.583	125.087	90.246	128.362	131.762
Bootstrap P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Note: Confidence interval is 95%. *Note: ***= p<1%, ** = p<5%, * = p<10%*

Table 6 displays the results obtained from estimating Equation (4) using governance quality variables. The statistical significance of the estimated threshold is evaluated by calculating p-values through the bootstrap method with 5000 replications and a 15% trimming percentage. Across all models, the bootstrap p-values indicate the rejection of the null hypothesis of no threshold effect, suggesting that the sample can be divided into two distinct regimes. Examining Models 1 to 7 consistently supports a threshold model. The estimated threshold values for governance quality range from 0.017 to 2.104, accompanied by their corresponding 95% confidence intervals for each model[4]. This suggests that nations are categorized as having low governance quality if their threshold values are less than 0.017 while those with values exceeding the threshold are categorized into the high-governance quality group. Furthermore, we explored the possibility of further splitting the high-governance group into sub-regimes. However, the bootstrap p-values did not yield significant results for the second sample split, indicating that a single threshold in Equation (5) is sufficient for all models.

4.6. Estimation of dynamic threshold

After establishing a threshold for governance quality, the primary focus shifts to comprehending the influence of governance on the connection between ecological footprint and female economic

[4] In the Appendix 3, all the line graph/curves are above the 95% confidence interval indicating strong significance level.

participation. Table 7 displays the outcomes of the non-linear threshold Models 1 to 7, offering interpretations specific to the variables considered. In these estimations, the coefficient of EF exhibits a negative and statistically significant value at the 5% level. It ranges from -0.123 and -0.003 below the threshold and from -0.002 to -0.157 above the threshold across the seven specified models. Holding other factors constant, this suggests that a percentage increase in EF leads to a decrease in female economic participation in SSA. These results indicate that the negative impact of the ecological footprint tends to hinder female economic participation by exacerbating environmental degradation, limiting resource access, and increasing health risks. Given this, we reject the null hypothesis that environmental degradation does not have any significant effects on female labour participation. Consequently, it hampers women's ability to engage in economic activities and achieve sustainable livelihoods. These findings align with the theory of the *Environmental Kuznets Curve*, emphasizing the intersectionality of various forms of oppression, health challenges, and environmental degradation in shaping women's experiences and opportunities in economic participation (Langnel et al., 2021). These findings concur with prior studies conducted in different contexts. For instance, Langnel et al. (2021) examined 22 SSA nations, Bakehe (2021) focused on Cameroon, Gu et al. (2020) investigated China, and Escalante and Maisonnave (2020) explored the case of Bolivia.

The GDPC per capita exhibits negative coefficients below the threshold value across the seven specifications, which are statistically significant at the 1% level, ranging from -0.070 to -0.130. In the case of model 1, a unit change in GDPC per capita leads to a reduction of female economic participation by 0.070%. However, there are notable inconsistencies in the estimates above the threshold level. These findings reinforce the theory of *structural discrimination*, which highlights the common challenges faced by women in accessing economic opportunities and engaging in productive activities within the SSA region. These challenges include gender inequalities, limited access to resources and education, and cultural norms and stereotypes (Newman et al., 2023). Therefore, despite overall economic growth, women's ability to participate in the workforce and contribute to the economy remains constrained in the face of these common social challenges (Newman et al., 2023).

The estimates below the threshold level reveal that population (POP) has a significant negative impact on female economic participation in SSA, with coefficients ranging from -0.001% to -0.025% across the seven model specifications, all statistically significant at the 5% level. This implies that a percentage change in population (POP) leads to a corresponding decline in female economic participation within the range mentioned. A rise in the number of people vying for jobs sometimes goes hand in hand with population expansion, which may result in lower salaries. In particular, if the financial benefits do not outweigh the accompanying expenditures like childcare, commuting, and related expenses, a large fall in salaries may deter some women from obtaining or maintaining employment. Additionally, the amount of dependent people who need care and support, such as children or elderly family members, often rises with population growth. Since women have historically provided the majority of the care in many communities, this typically falls disproportionately on them. Women may experience greater pressure to put their family and caring responsibilities ahead of entering the workforce as the demand for caregivers rises (Liddle, 2017). Conversely, the estimates above the threshold level indicate that population (POP) positively encourages female economic participation in SSA, with coefficients ranging from -0.001% to -0.067% across the seven model specifications, all statistically significant at the 5% level. Population expansion in many African nations is frequently accompanied by accelerated urbanization and expanded economic prospects. Employment options in industries including manufacturing, services, and informal work expand along with metropolitan regions. This may operate as a motivator for women, particularly those from low-income homes, to look for jobs to raise their family's quality of life.

The estimates for the moderating effect provide insights into the relationship between governance quality variables and the ecological footprint-women economic participation nexus in SSA. Below the threshold level, the interaction coefficient between governance quality variables and the ecological footprint exacerbates the negative impact of the ecological footprint on women's economic participation, with a range of -0.006 to -0.331. This implies that when governance quality is low and the ecological footprint is high, there is a compounded adverse effect on female economic participation. The turning point of the governance quality impact on the ecological footprint and women's economic participation ranges from -0.22 to -1.612. This highlights the critical role of good governance in preventing environmental deterioration and promoting sustainable development, which directly affects women's economic opportunities.

Above the threshold level, the interaction coefficient between governance quality variables and the ecological footprint mitigates the negative impact, ranging from 0.055 to 0.196. Given this, we reject the second hypothesis that the interaction between governance quality and environmental degradation does not have any significant effect on female economic participation. This underscores the importance of effective governance in fostering environmental sustainability and creating an environment conducive to women's economic engagement. Better governance practices and reduced ecological footprint contribute to improved access to resources, reduced health risks, and enhanced economic opportunities for women. Lastly, the findings support a U-shaped relationship hypothesis, where the lower region shows a negative sign and the upper region shows a positive sign, confirming earlier reports in the study.

TABLE 7: Threshold effect estimate using Seo and Shin (2016) and Seo et al. (2019) under the system-GMM framework

VARIABLES	GL-1	GL-2	GL-3	GL-4	GL-5	GL-6	GL-7
	$(Z \leq \lambda)$	$(Z \leq \lambda)$	$(Z \leq \lambda)$	$(Z \leq \lambda)$	$(Z \leq \lambda)$	$(Z \leq \lambda)$	$(Z \leq \lambda)$
EF $(Z \leq \lambda)$	-0.003**	-0.018**	-0.012**	-0.072***	-0.013**	-0.017**	-0.123**
	(0.015)	(0.014)	(0.015)	(0.025)	(0.040)	(0.019)	(0.099)
GDPC$(Z \leq \lambda)$	-0.070***	-0.093***	-0.090***	-0.082***	-0.077***	-0.106***	-0.130***
	(0.017)	(0.027)	(0.022)	(0.024)	(0.021)	(0.037)	(0.032)
POP $(Z \leq \lambda)$	-0.011**	-0.009**	-0.025**	-0.007**	-0.001**	-0.019*	-0.004**
	(0.008)	(0.011)	(0.012)	(0.017)	(0.010)	(0.010)	(0.018)
cons_d	-0.047	0.017	0.124***	-0.084	0.039	-0.076**	-0.065
	(0.045)	(0.023)	(0.016)	(0.142)	(0.038)	(0.036)	(0.108)
	$Z \geq \lambda$	$Z \geq \lambda$	$Z \geq \lambda$	$Z \geq \lambda$	$Z \geq \lambda$	$Z \geq \lambda$	$Z \geq \lambda$
EF $(Z \geq \lambda)$	-0.043***	-0.008**	-0.103**	-0.048*	-0.036**	-0.002	-0.157*
	(0.014)	(0.016)	(0.010)	(0.050)	(0.043)	(0.010)	(0.095)
GDPC $(Z \geq \lambda)$	0.023**	-0.012	-0.021***	0.03	-0.009	0.024**	0.023
	(0.015)	(0.010)	(0.006)	(0.046)	(0.014)	(0.012)	(0.035)
POP $(Z \geq \lambda)$	0.039**	0.012**	0.145**	0.065**	0.067**	0.002**	0.01**
	(0.008)	(0.022)	(0.020)	(0.038)	(0.016)	(0.019)	(0.031)
threshold valueλ	-1.612***	-0.642**	-0.521***	-0.041*	-0.22*	-0.806*	-0.873*
	(0.446)	(0.038)	(0.128)	(0.076)	(0.057)	(0.486)	(0.505)
INDEX1$(Z \leq \lambda)$		-0.112**					
		(0.019)					
INDEX1 $Z \geq \lambda)$		0.130**					
		(0.012)					
INDEX2$(Z \leq \lambda)$			-0.124**				
			(0.052)				
INDEX2 $Z \geq \lambda)$			0.055**				
			(0.056)				
INDEX3$(Z \leq \lambda)$				-0.256***			
				(0.070)			
INDEX3 $Z \geq \lambda)$				0.191**			
				(0.091)			
INDEX4$(Z \leq \lambda)$					-0.051**		
					(0.067)		
INDEX4 $(Z \geq \lambda)$					0.057**		
					(0.042)		
INDEX5$(Z \leq \lambda)$						-0.006*	
						(0.075)	
INDEX5 $Z \geq \lambda)$						0.080**	
						(0.039)	
INDEX6$(Z \leq \lambda)$							-0.331***
							(0.116)
INDEX6 $Z \geq \lambda)$							0.196*
							(0.0 59)

Observations	28	28	28	28	28	28	28

*Note: ***= p<1%, ** = p<5%,* = p<10%,*

5. Conclusion and Policy Suggestions

This paper explores the impacts of governance quality and environmental pollution on gender economic outcomes in Sub-Saharan Africa (SSA). Using data from 28 SSA nations spanning from 1996 to 2020, the study focuses on female labour force participation as the outcome variable. The ecological footprint is employed to measure environmental stresses caused by human actions on the ecosystem, while governance infrastructure is represented by six variables: rule of law, government effectiveness, corruption control, political stability, voice and accountability, and regulatory quality. Control variables such as GDP and population growth are also considered. The study utilizes the dynamic panel threshold model to address endogeneity and simultaneity issues. Cross-sectional dependency tests and slope homogeneity tests are conducted to ensure accurate estimation. The results reveal a negative and significant influence of ecological footprint on female economic participation across the specifications, indicating that environmental degradation and limited resource access hinder women's engagement in economic activities. The findings support the theory of the Environmental Kuznets Curve, highlighting the intersectionality of various forms of oppression, health challenges, and environmental degradation in shaping women's experiences and opportunities in economic participation. Furthermore, the study's threshold findings reveal that environmental degradation undermines female labour engagement irrespective of the threshold level. The study showed that below the threshold level, the interaction coefficient between governance quality variables and the ecological footprint exacerbates the negative impact of the ecological footprint on women's economic participation. Above the threshold level, the interaction coefficient between governance quality variables and the ecological footprint mitigates the negative impact. The GDPC per capita exhibits negative coefficients below the threshold value across the seven specifications, however, there are notable inconsistencies in the estimates above the threshold level. The estimates below the threshold level reveal that population has a significant negative impact on female economic participation in SSA while the estimates above the threshold level indicate that expansion in population positively encourages female labour participation in SSA

Based on the research findings, it is necessary to proffer policy recommendations for addressing the observed influences of governance quality and environmental pollution on gender economic outcomes in Sub-Saharan Africa (SSA): The need to strengthen environmental governance is paramount by enhancing environmental governance frameworks and institutions in SSA countries to effectively address environmental pollution and degradation. This can be achieved through the development and enforcement of robust environmental regulations, the promotion of sustainable resource management practices, and the strengthening of monitoring and enforcement mechanisms (Onuoha et al, 2023a; Onuoha et al, 2023b). The promotion of good governance is essential to improve overall governance quality in SSA countries by enhancing the rule of law, government effectiveness, corruption control, political stability, voice and accountability, and regulatory frameworks. Strengthening these governance dimensions will create an enabling environment for economic growth and female labour force participation in the region. For instance, the African Union Convention on Preventing and Combating Corruption (AUCPCC) which establishes a comprehensive framework for preventing and combating corruption at the continental level, promoting good governance, transparency, and accountability should be more active in fulfilling its core objectives. Again, the study findings emphasize the need to strengthen the implementation of policies and initiatives that promote sustainable development practices in SSA (like the African Union Framework for Sustainable Development - Agenda 2063), including sustainable resource use, pollution control measures, and renewable energy adoption. This will help mitigate the negative impact of environmental pollution on women's economic participation and contribute to long-term environmental sustainability.

The empowerment of Sub-Saharan African women is pertinent as the findings also reveal. Hence, effecting targeted policies and programs to empower women economically cannot be overemphasised, including measures to improve access to education, healthcare, financial services, and entrepreneurship opportunities. Addressing gender inequalities through continental programmes like the African Union Protocol on the Rights of Women in Africa (the Maputo Protocol) and providing women with the necessary skills and resources will enable them to actively participate in economic activities and contribute to sustainable development. Also, policymakers need to ensure that gender considerations are increasingly mainstreamed across all relevant policies, programs, and initiatives in the region as prescribed in the African Union Declaration on Gender Equality in Africa. This includes conducting gender impact assessments, integrating gender-responsive budgeting, and promoting women's representation and participation in decision-making processes at all levels in their respective economies. To foster improved development outcomes, recognition should be accorded to the potential of population growth as a driver of economic growth and favourable gender outcomes. Investing in infrastructure, creating job opportunities, and providing essential services such as education, healthcare, and social protection to support women's economic participation in SSA is fundamental. Thus, policymaking should be hinged on fostering inclusive demographic planning and equitable development that takes into account the specific needs and challenges faced by women in the region.

To engender a convergence between low-governance quality and high-governance quality countries in the region, the promotion of regional collaboration is pivotal. Therefore, advancing enhanced regional collaboration among SSA countries to address common environmental and governance challenges portends better welfare for women in SSA. This can be achieved through shared best practices, exchange of knowledge, and collaboration on joint initiatives to enhance environmental sustainability, improve governance practices, and promote gender equality in economic outcomes. Furthermore, collaborative investment in research and capacity-building efforts to further understand the complex interactions between governance quality, environmental pollution, and gender economic outcomes in SSA should be enhanced. In addition, cooperation between academia, policymakers, civil society organizations, and the private sector needs to be stepped up to generate robust evidence and develop innovative solutions for women's economic empowerment. Likewise, there is a need to intensify public awareness campaigns and advocacy initiatives to highlight the importance of addressing the impacts of governance quality and environmental pollution on gender economic outcomes and create a collective commitment towards achieving sustainable and inclusive development in SSA.

In conclusion, this study emphasizes the importance of addressing environmental degradation and improving governance quality to enhance gender economic outcomes in SSA. The findings highlight the need for policy interventions in the region that promote sustainable development, reduce pollution, and enhance governance practices to create more opportunities for women’s economic participation and empowerment. By understanding the complex interactions between governance, environmental factors, and gender economic outcomes, policymakers will develop targeted strategies to promote gender equality and inclusive economic growth in SSA. Despite the modest attempts of the study to contribute to the literature, it is not without some identified shortcomings. For instance, the study focuses on 28 Sub-Saharan African (SSA) nations, which may limit the generalizability of the findings to other regions or countries outside the sample. Also, while the study provides valuable insights into the relationship between governance quality, environmental pollution, and gender economic outcomes, it is important to acknowledge the likely effect of other unobserved factors or omitted variables that might influence the observed relationships in interpreting the results. Based on these, future studies are encouraged to consider expanding the scope to include a broader range of countries or regions within and outside Africa. This would allow for a more comprehensive understanding of the relationship between governance quality, environmental pollution, and gender economic outcomes across the continent and beyond. Also, considering qualitative research methods could provide a deeper understanding of the mechanisms through which governance quality and environmental pollution influence gender economic outcomes. Qualitative research can uncover contextual factors and individual experiences that quantitative data may not capture fully. It is also noteworthy to consider the intersectionality of gender with other social categories, such as race, ethnicity, class, or geographical location, to enrich the understanding of how multiple dimensions of inequality intersect and shape gender economic outcomes in the context of governance quality and environmental pollution. Such analyses can highlight the specific challenges faced by marginalized groups and inform targeted policy interventions.

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Appendix 1. The Study Sample

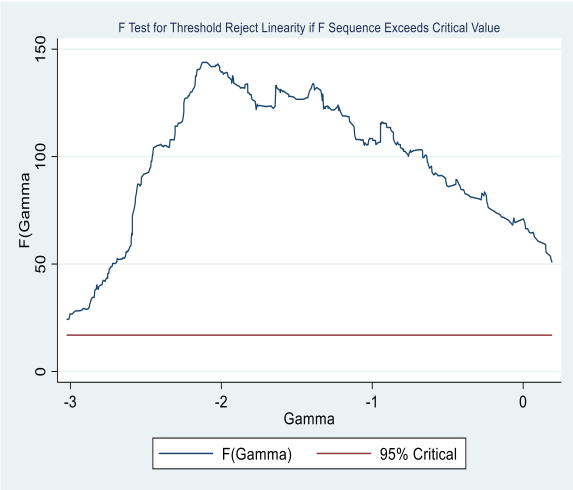
Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central Africa Republic, Chad, Comoros, Congo Republic, Cote d'Ivoire, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Madagascar, Mali, Mauritius, Nigeria, Rwanda, Senegal, Sierra Leone, South Africa, Tanzania, Togo, Zimbabwe.

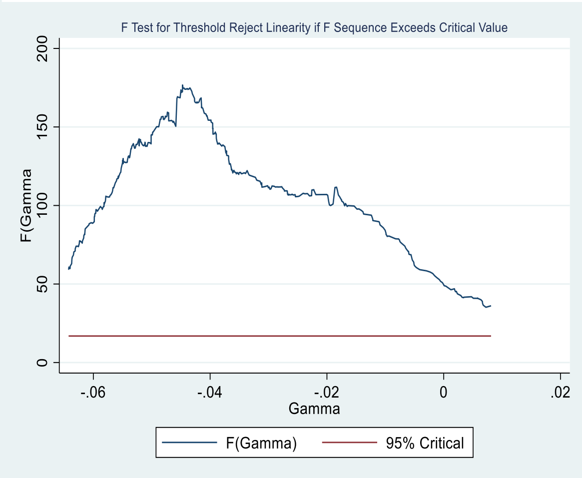
Appendix 2: Variables Data and Sources

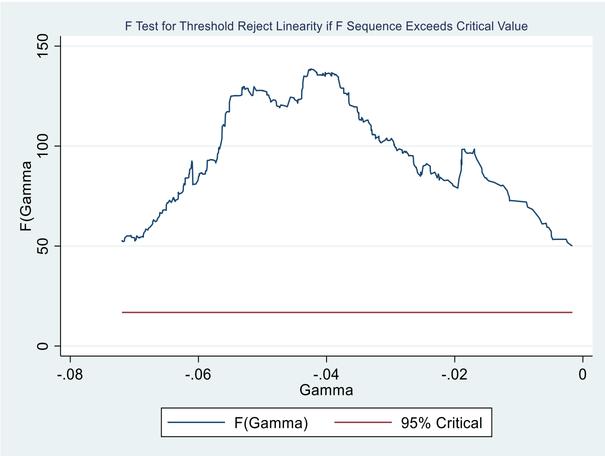
Variables	Descriptions	Sources
Female economic participation (FLP)	Labor force participation rate, female (% of female population ages 15+) (modeled ILO estimate)	WDI Data
Ecological Footprint (EF)	Gha per person	Global Footprint Network Database
Gross Domestic Product Per Capita (GDPC)	Constant 2010 US$	WDI Data
Population growth (POP)	annual %	WDI Data
Control of corruption (CCR)	Reflects perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as “capture” of the state by elites and private interests. Values range from −2.5 (low) to +2.5 (high)	WGI Data
Government effectiveness (GES)	Reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government’s commitment to such policies. Values range from −2.5 (low) to +2.5 (high)	WGI Data
Voice and accountability (VAA)	Reflects perceptions of the extent to which a country’s citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Values range from −2.5 (low) to +2.5 (high)	WGI Data
Political stability and absence of violence (PSA)	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism	WGI Data
Regulatory quality (RQL)	Reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development	WGI Data
Rule of law (RLW)	Reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence	WGI Data

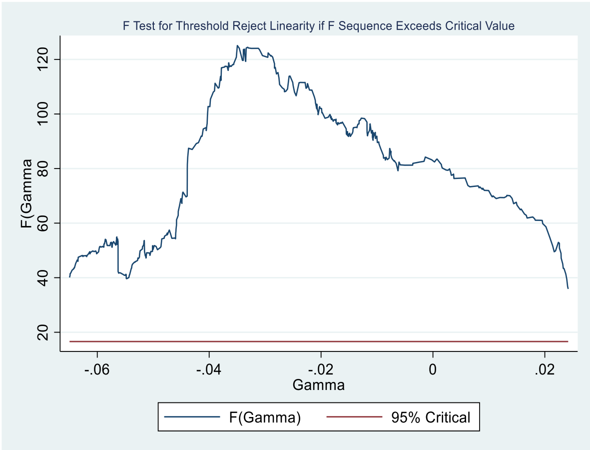
Source: Authors Computation

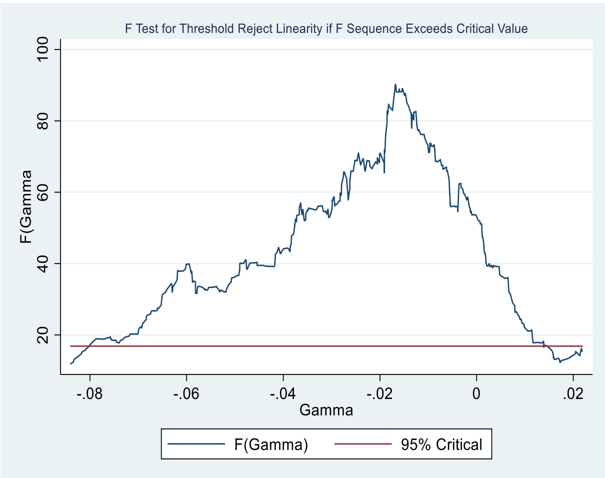
Appendix 3: Graphical representation of sample split using Hansen 2000 procedure

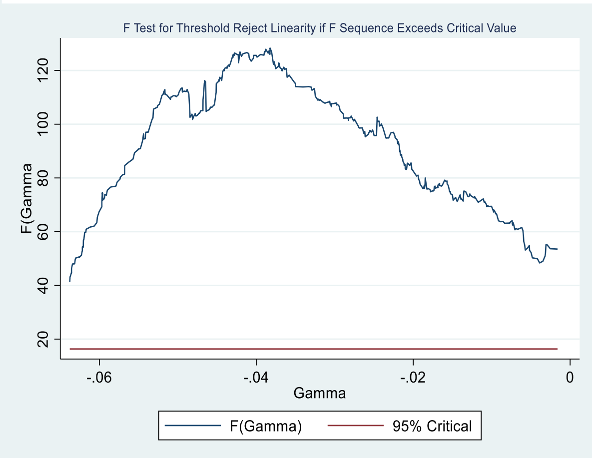


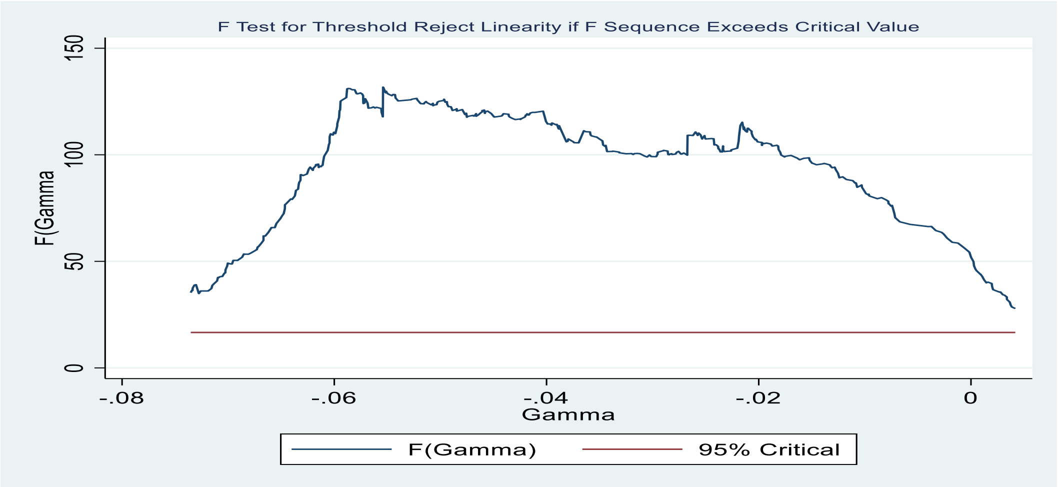











F Test for Threshold Reject Linearity if F Sequence Exceeds Critical Value
F(Gamma
0
50
100
150
-.08
-.06
-.04
-.02
0
Gamma
F(Gamma)
95% Critical