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RESEARCH ARTICLE

Assessing the Gender–Labour–Growth Nexus in West Africa: Econometric Evidence from The Gambia and Senegal

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Abstract

Gender equality is central in the 17 SDG goals, especially in emerging and developing countries, where disparities in gender remain persistent. This study shows the relationship between gender inequality, labour force and economic growth in two countries in Sub-Saharan Africa: The Gambia and Senegal. Data was collected from the World Bank database covering the period from 2000 to 2023. Advanced econometric techniques, including panel data fixed and random effects estimation and System GMM, were used as an endogeneity test. The Hausman specification test reveals that random effects are more appropriate for our data analysis. Random effects estimates reveal that a one-unit increase in the Gender Parity Index reduces GDP per capita by approximately 2.42 units ($p < 0.05$), while a 1% rise in female primary enrolment boosts GDP by 0.085 units. On the other hand, promoting women's school attendance, elementary education and labour force involvement pays off economically. The multi-model results consistently show that gender disparity has both negative and positive effects on GDP per capita, depending on the dimension examined.

Keywords Gender Inequality · Labour Force · Economic Growth · Panel Data · System GMM · Gambia · Senegal

1. Introduction

In The Gambia and Senegal, Sustainable development depends largely on ensuring equal access to quality education, opportunities, and fair work for everyone. These are the core aims at the heart of the United Nations Sustainable Development Goals (SDGs), specifically Goals 4 (quality education), 5 (gender equality), and 8 (decent work and economic growth), which set the framework for improving women's education, dismantling structural barriers, and fostering equitable economic participation (United Nations, 2015). Furthermore, the United Nations Sustainable Development puts gender equality and women's economic empowerment at the core of all development strategies (UNSDF, 2017), with the World Bank endorsing it as critical to sustainable and inclusive growth (Devadas & Kim, 2020). It is, therefore, imperative to understand the dynamics of gender inequality and its implications for female labour participation and economic growth.

Gender disparity can have serious economic consequences as it harms the nation's overall economic growth (Iqbal et al., 2022). Gender inequality and its economic impacts vary widely across regions and income levels, shaped by distinct cultural, economic, and policy contexts (Saeed & Shaiekh, 2024; Hakura et al., 2016; Gdakowicz et al., 2023; Ngulube et al., 2024). Substantial empirical evidence demonstrates that promoting gender equality positively influences economic growth by enhancing female labour force participation, education, and health outcomes, which in turn improve productivity and inclusive development (Mudzakir &

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Rahmadini, 2024; Asuamah & Mogre, 2024; Xu, 2025; Bertay et al., 2020; Agénor et al., 2015; Agénor & Canuto, 2013). Studies across diverse regions, including West Java, India, Latin America, Kenya, and Saudi Arabia, consistently find that reducing gender gaps correlates with sustained economic gains (Fernandez et al., 2021; Kabeer & Natali, 2013; Goyal, 2023).

This study positions gender inequality not only as a social issue but as a structural economic constraint, examining its transmission channels through education and labour participation within a Solow-augmented growth framework.

Conversely, studies also caution that the relationship between gender inequality and growth is context-dependent, with some research identifying negative or non-significant effects in specific settings due to variations in economic structure, social norms, measurement approaches, and policy environments. The empirical literature on gender inequality and economic growth in The Gambia and Senegal is sparse, despite the importance of inequality in the world. To our knowledge, no comparative empirical study has examined the gender–growth nexus in The Gambia and Senegal, two neighbouring West African nations with shared socio-cultural norms but differing economic trajectories. Furthermore, given this complexity, tailored and context-specific policies are essential to effectively address systemic inequalities, enhance women's educational and economic inclusion, and thereby unlock stronger, more inclusive growth in The Gambia and Senegal. We select The Gambia and Senegal for three reasons: (1) they share cultural, religious, and colonial histories but differ in economic size and structure, allowing for comparative insight; (2) both face persistent gender gaps in education and labour participation despite policy efforts; and (3) data availability from 2000–2023 captures post-millennium development goals and pre-SDG periods, enabling analysis of recent trends. Variables such as the Gender Parity Index and educational attainment are chosen to capture multi-dimensional inequality beyond income measures.

The contributions in knowledge of this paper are from different angles, as the empirical evidence from the literature is vague and inconclusive. First, this study purely used these variables to study inequality, such as educational attainment, school enrolment, labour force participation, gender parity index, and literacy rate, to address gender inequality questions in two countries in SSA that have common social norms and cultural as well as religious beliefs. Secondly, there was no comparative study conducted to look at this topic in Gambia and Senegal alone. Furthermore, new variables were introduced, like the gender parity index (GPI) from the World Bank as a proxy for gender inequality. Third, The Generalized Method of Moments (GMM), along with the Hausman test for robustness check were used to tackle endogeneity and multicollinearity issues in the data set.

2. Literature Review

Gender inequality refers to the systematic deprivation of individuals or groups through economic, social, and institutional divisions embedded in societal structures (UNICEF, 2017). While gender disparities persist globally, they are particularly pronounced in developing regions. Countries with lower GDP per capita tend to face greater challenges in school enrolment, healthcare access, and intra-household decision-making power (Jayachandran, 2015; Hakura et al., 2016). Indeed, after the Middle East and North Africa, Sub-Saharan Africa (SSA) remains one of the regions with the highest levels of gender inequality (Hakura et al., 2016). Using system GMM estimation, Hakura et al. (2016) show that both gender inequality and income disparities hinder economic growth, particularly in countries at early stages of development, with substantial welfare losses observed across SSA.

Despite international commitments to gender parity in education, substantial gaps persist. Educational inequality reduces both economic growth and the quality of human capital (Klasen, 1999). Within SSA, The Gambia exhibits one of the highest Gender Inequality Index (GII) scores. In 2021, the country recorded a GII of 0.61 compared with the regional average of 0.57, while female labour force participation stood at 48.9% compared with 66.3% for men (International Monetary Fund [IMF], 2020). Empirical evidence from Ceesay (2013) suggests that educational attainment has a stronger impact on economic growth than employment participation. In The Gambia, secondary education in particular exerts the largest growth effect.

In Senegal, the Gender Development Index stands at approximately 0.88, reflecting persistent disparities in education, health, and economic opportunity (United Nations Development Programme [UNDP], 2015). This score signals ongoing structural inequality linked to gender (Maisonnave et al., 2022). National employment

surveys further show that women tend to occupy less secure and lower-paid positions than men. Globally, disparities remain stark. The United Nations High-Level Panel on Women's Economic Empowerment reported that 700 million fewer women than men of working age were in paid employment in 2016, and women were more likely to work in low-income, precarious occupations (United Nations, 2016).

Gender equality has therefore become a central component of the international development agenda. The 2030 Sustainable Development Agenda explicitly prioritises women's economic empowerment, building on commitments made at the 1995 Beijing Conference on Women. Three decades later, evaluations indicate measurable progress but continued structural barriers, underscoring the need for sustained policy efforts (UN Women, 2025). Gender equality is thus increasingly recognised not only as a human rights issue but also as a macroeconomic imperative (IMF & World Bank, 2007; IMF, 2017). Regional frameworks reinforce this perspective. Africa's Agenda 2063, for example, envisions gender parity in public representation and leadership positions, emphasising women's participation as a prerequisite for inclusive growth.

Early empirical work on gender and growth produced mixed findings. Barro and Lee (1994), using cross-country data from 138 countries, found that male secondary education was positively associated with growth, whereas female education appeared negatively related. This counterintuitive result was later attributed to model specification issues, including omitted variables and endogeneity. Subsequent studies, including Stokey (1994), Dollar and Gatti (1999), and Klasen and Lamanna (2009), revisited the relationship and demonstrated that gender equality in education and employment tends to promote growth once methodological limitations are addressed.

More recent research provides stronger evidence linking gender equality to economic performance. Bertay et al. (2025) show that industries with higher female employment shares experience faster growth. Similarly, Baliamoune-Lutz (2007) finds that literacy disparities significantly reduce economic growth in developing regions. Evidence from African countries suggests that gender inequality varies substantially across contexts, with lower disparities observed in countries with higher literacy and enrolment rates (Appleton & Teal, 1998).

At the macroeconomic level, Alwago (2023), using partial least squares structural equation modelling, demonstrates a significant relationship between gender inequality and growth in SSA, explaining roughly 17% of growth variation. Although direct effects may be modest, indirect channels operating through institutional quality and macroeconomic strategy remain substantial. Altuzarra et al. (2021), analysing 105 developing countries between 1990 and 2017, show that educational equality has a stronger growth impact in SSA than in other regions. They also find a statistically significant relationship between women's political participation and growth, although this relationship appears negative in SSA, suggesting that institutional barriers may limit the economic impact of political representation.

Using a panel of West African countries from 1997 to 2017, Agyina and Osei-Fosu (2020) confirm that gender disparities in labour force participation and school enrolment significantly affect economic growth at the 1% level. While these studies highlight the broader regional dynamics of gender inequality, comparative analyses focusing specifically on The Gambia and Senegal remain scarce. This study addresses that gap by employing a comparative panel approach incorporating variables such as the Gender Parity Index and female educational attainment, which remain under-examined in this regional context (Hakura et al., 2016; UNDP, 2015).

3. Empirical Estimation

To examine the effects of lagged GDP per capita and the influence of gender inequality on the growth rate of current GDP per capita, two complementary econometric models are specified. The first is a Panel model to identify endogenous gender inequality, unobserved factors and quantify its effects. The second is the System GMM model to account for potential endogeneity and dynamic effects. The fixed effect panel removed unobserved factors in each country that do not change over time (Greene, 2002). These are factors affecting the dependent variable and may include the independent variables under study.

3.1. System GMM Estimation

The study further employs the system GMM estimator proposed by Arellano and Bover (1995) and Blundell and Bond (1998) to test and address dynamic panel issues. The GMM model is:

$$\begin{aligned} &\boldsymbol{log\ GDP\ percapita\ curr_{i,t}} \\ &= \boldsymbol{\alpha_0 + \alpha_1 log\ GDP\ percapita\ curr_{i,t-1} + \alpha_3 logHuman\ capita\ index_{i,t}} \\ &\boldsymbol{+ \alpha_4 logLabor\ force\ participation_{i,t} + \alpha_4 Z_{it} + \eta_i + \tau_t + \nu_{it}} \end{aligned} \quad \textbf{(1)}$$

Where:

Table 1. Definition of Key Terms

Term	Description
$\log \text{GDP percapita curr}_{i,t}$	Natural log of GDP per capita for country i at time t
$\log \text{GDP percapita curr}_{i,t-1}$	Lagged dependent variable captures persistence and convergence effects in GDP per capita.
$\text{Human capita index}_{i,t}$	Human capital index, reflecting education and health quality
$\text{Labour force participation}_{i,t}$	The labour force participation rate, indicating labour market engagement
Z_{it}	Vector of additional control variables (e.g., primary enrolment, secondary enrolment, etc.)
η_i	Country-specific fixed effects (unobserved heterogeneity)
τ_t	Time fixed effects (global shocks, trends)
ν_{it}	Idiosyncratic error term

3.2. Panel fixed effect Regression framework

To comprehend panel data model structure and the econometrics behind panel regression models, the article adopted fixed effect (FE), random effects (RE), and dynamic panel to study gender inequality in the Gambia and Senegal and panel OLS and post-estimation tests: Hausman test. In his part, Greene (2002b), panel data are data collected at different points in time and that is why it is also called longitudinal data. Following the work of Ceesay et al. (2021), we estimate panel data models as follows:

$$\boldsymbol{y_{it} = \beta_0 + \beta_1 x_{it1} + \beta_2 x_{it2} + \beta_3 x_{it3} + \beta_4 x_{it4} + ,,,,,,, + \beta_k x_{itk} + u_t + \omega_i + \varepsilon_{it}} \quad \textbf{(2)}$$

$$\boldsymbol{y_{it} = \beta_0 + \beta_1 x_{itn} + u_{it}} \quad \textbf{(3)}$$

Panel data has two dimensions, the time series dimension and the cross-sectional dimension; in other words, this illustrates its strength in data analysis and research. The u_t, unobserved time-dependent error term, ω_i is a city/location/country dependent error term, it affects all observations for the cross-sectional unit for individual city/country/firm/location for all i, and ε_{it}, is the random error term. It can be written as:

$$\begin{aligned} \boldsymbol{Y} &= \boldsymbol{X\beta + D\eta + \varepsilon} \\ \boldsymbol{E(\varepsilon\varepsilon)^T} &= \boldsymbol{\sigma^2 I_n} \end{aligned} \quad \textbf{(4)}$$

The Hausman test is where we adopt the null hypothesis, the favoured model is random effects, where the covariance between the error term is uncorrelated with the error term; i.e. $Co\ (\varepsilon, Xs') = 0$. The other hypothesis is fixed effect, in which all the explanatory variables(Xs) are correlated with the error term, i.e. $Co\ (\varepsilon, X) \neq 0$. If the null hypothesis is not accepted, the fixed effect would be more suitable for the analysis than the random effects (Gujarat 2004).

The overall form of the regression model found in most of the literature is below.

$$\boldsymbol{Y_{it} = \propto + \beta X_{it} + \varepsilon_{it}} \quad \textbf{(5)}$$

Where Y_{it} is the dependent variable for country i in year t, β is the vector of coefficients of the independent variables, and α is the constant term.

X_{it} is the vector of the independent variables for country i, in years t, and ε is the normal error term in the model.

3.3. Empirical model for panel

The equation to be estimated is a basic growth model including the main variables suggested by the Solow (1956) model, plus some other standard controls, and augmented with the measure of inequality by gender:

$$\begin{gathered} \boldsymbol{log\ GDP\ percapita\ curr_{i,t}} \\ \boldsymbol{\alpha_0 + \alpha_1 log\ GDP\ percapita\ curr_{i,t-1} + \alpha_2 logHuman\ capita\ index_{i,t}} \\ \boldsymbol{+ \alpha_4 logLabor\ force\ participation_{i,t} + \alpha_4 Z_{it} + \eta_i + \tau_t + \varepsilon_{i,t}} \end{gathered} \quad \textbf{(6)}$$

4. Results and Analysis

4.1. Estimation Techniques

Preliminary analyses, including descriptive statistics, panel visualisation graphs and correlation assessments, are performed to ensure the appropriateness of the variables included and to avoid multicollinearity issues.

4.2. Data source and variables

The data are collected from secondary sources from 2000 to 2023 for The Gambia and Senegal. The dependent variable in this study is the growth rate of GDP per capita. The explanatory variables are given below.

4.3. Rationale and Support from Literature

The dual methodology is supported by Table 1, which shows diverse approaches: GMM (Pattillo et al., 2002; Clements et al., 2003; Manasseh et al., 2022), dynamic panel models (Chudik et al., 2017). Unlike single-method studies (ARDL in Dey & Tareque, 2020; cross-sectional in Cohen, 1993), this combination captures cross-country impacts by panel fixed, random effects and System GMM.

4.4. Diagnostic and Robustness Tests

The study applied diagnostic tests tailored to GMM and Panel models to validate results and ensure robustness.

4.5. Descriptive Statistics

Table 2. Descriptive Statistics Table (Own Evaluation using Stata 16)

Variable	Obs	Mean	Std. Dev.	Min	Max
LNGDP Perc curr	48	6.769	.408	5.732	7.437
SEPRM	48	80.906	6.049	69.855	93.745
Schoolenrollmentpr~a	48	83.01	8.886	64.706	100.312
Educationalatt~iary1	48	2.018	2.122	-1.326	6.753
Educationalattain~r1	48	.853	1.696	-2.815	6.753
Educationalatt~mary1	48	15.538	13.202	-6.556	48.754
Educationalattain~c1	48	8.214	10.865	-14.933	35.504
Femaleshareofemplo~1	48	28.683	4.394	20.438	34.078
HumancapitalindexH~1	48	.396	.034	.334	.465

Laborforceparticip~l	48	42.036	8.353	22.152	56.194

Table 3. Descriptive Statistics Table (Own Evaluation using Stata 16)

Variable	Obs	Mean	Std. Dev.	Min	Max
Literacyrateadultf~l	48	36.139	7.753	25	64.048
Schoolenrollments~e1	48	51.058	27.499	12.31	121.767
Schoolenrollmentpr~l	48	83.01	8.886	64.706	100.312
Schoolenrollmentte~l	48	4.2	4.657	-1.092	17.633
Schoolenrollments~a1	48	50.576	20.025	18.966	100.438
Gender parity index	48	1.043	.094	.821	1.22

The growth rate of GDP per capita in current terms shows a mean of 6.769 with a standard deviation of 0.408. This suggests moderate variation across countries in the sample. The minimum and maximum values are 5.732 to 7.437, respectively, implying that the underlying GDP per capita ranges from roughly GMD 310 to GMD 1,700, indicating a mix of low and middle-income economies. This variable serves as the central outcome in growth analysis and reflects the economic heterogeneity within the dataset.

Demographic indicators expose persistent development challenges. The female share of employment stands at 28.7%, with a range from 20.4% to 34.1%, indicating limited labour market inclusion for women. Likewise, the labour force participation rate averages 42%, but ranges widely from 22% to 56%, signifying structural differences in employment access.

Education and related variables show both progress and disparities. Primary school enrolment is relatively high, with a mean of 83%, approaching universal access to primary school enrolment. However, tertiary enrolment remains low, averaging just 4.2%, and includes negative values, which may mirror data coding issues. Educational attainment at the primary level averages 15.5%, while bachelor's and tertiary levels remain below 3%, underscoring the limited reach of higher education. These figures highlight the need for expanded admission and holding in the post-primary education system.

Human capital indicators provide further insight into development constraints. The Human Capital Index (female) averages 0.396, suggesting modest but consistent progress in health and education outcomes. The share of firms with female top managers is strikingly low at 11.4%, based on 25 observations, pointing to gender gaps in leadership and decision-making. The variable Gender Parity Index, likely a composite or normalised index, shows minimal variation, which may be useful for comparative benchmarking across countries or sectors.

4.6. Correlation Matrix

Table 4. Pairwise Correlation Matrix (Own Evaluation using Stata 16)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1)LNGDP_Perc_curr	1.000							
(3) SEPRM	0.532	-0.77	1.000					
(4) Educationalatt~y	0.350	-0.78	0.713	1.000				
(5)Humancapitalin~l	0.638	-0.93	0.790	0.889	1.000			
(6)Laborforcepart~l	-0.291	-0.06	0.160	0.551	0.220	1.000		
(7) Literacyratead~l	0.460	-0.85	0.753	0.911	0.896	0.319	1.000	
(8) Gender parity index	0.273	-0.69	0.570	0.765	0.736	0.561	0.705	1.000

Variables such as female secondary education (SEPRM: 0.532), educational attainment (0.350–0.713), literacy rate (0.460), and the Human Capital Index (0.638) all show positive correlations with GDP per capita. These results affirm that gender equality in education and human development contribute positively to economic growth and development. Particularly, the Human Capital Index and literacy rate are also highly

correlated with each other (0.896), reinforcing the idea that integrated investments in female education and health can increase productivity.

Surprisingly, the female labour force participation rate shows a weak negative correlation with the growth rate of GDP per capita (-0.291). This suggests that simply increasing participation without improving job quality, motivation and pay may not boost GDP. The variable Gender Parity Index likely has a modest positive correlation with GDP (0.273), but stronger links to education and literacy (0.570–0.765). This suggests that addressing gendered barriers, such as legal discrimination or unequal access to finance, could enhance the economic returns of female education and labour market participation. Finally, tackling this predicament is essential for translating gender equality into sustained economic growth. The growth rate of GDP per capita in current terms shows a mean of 6.769 with a standard deviation of 0.408. This suggests moderate variation across countries in the sample. The minimum and maximum values are 5.732 to 7.437, respectively, implying that the underlying GDP per capita ranges from roughly GMD 310 to GMD 1,700, indicating a combination of low and middle-income economies. This variable serves as the central outcome in growth analysis and reflects the economic heterogeneity within the dataset.

Demographic indicators expose persistent development challenges. The female share of employment stands at 28.7%, with a range from 20.4% to 34.1%, indicating limited labour market inclusion for women. Likewise, the labour force participation rate averages 42%, but ranges widely from 22% to 56%, signifying structural differences in employment access, possibly influenced by education, tradition, cultural norms, and economic opportunities. Education and related variables show both progress and disparities. Primary school enrolment is relatively high, with a mean of 83%, approaching universal access to primary school enrolment. However, tertiary enrolment remains low, averaging just 4.2%, and includes negative values, which may mirror data coding issues. Educational attainment at the primary level averages 15.5%, while bachelor's and tertiary levels remain below 3%, underscoring the limited reach of higher education. These figures highlight the need for expanded admission and holding in the post-primary education system. Human capital indicators provide further insight into development constraints. The Human Capital Index (female) averages 0.396, suggesting modest but consistent progress in health and education outcomes. The share of firms with female top managers is strikingly low at 11.4%, based on 25 observations, pointing to gender gaps in leadership and decision-making. The variable Gender Parity Index, likely a composite or normalised index, shows minimal variation, which may be useful for comparative benchmarking across countries or sectors.

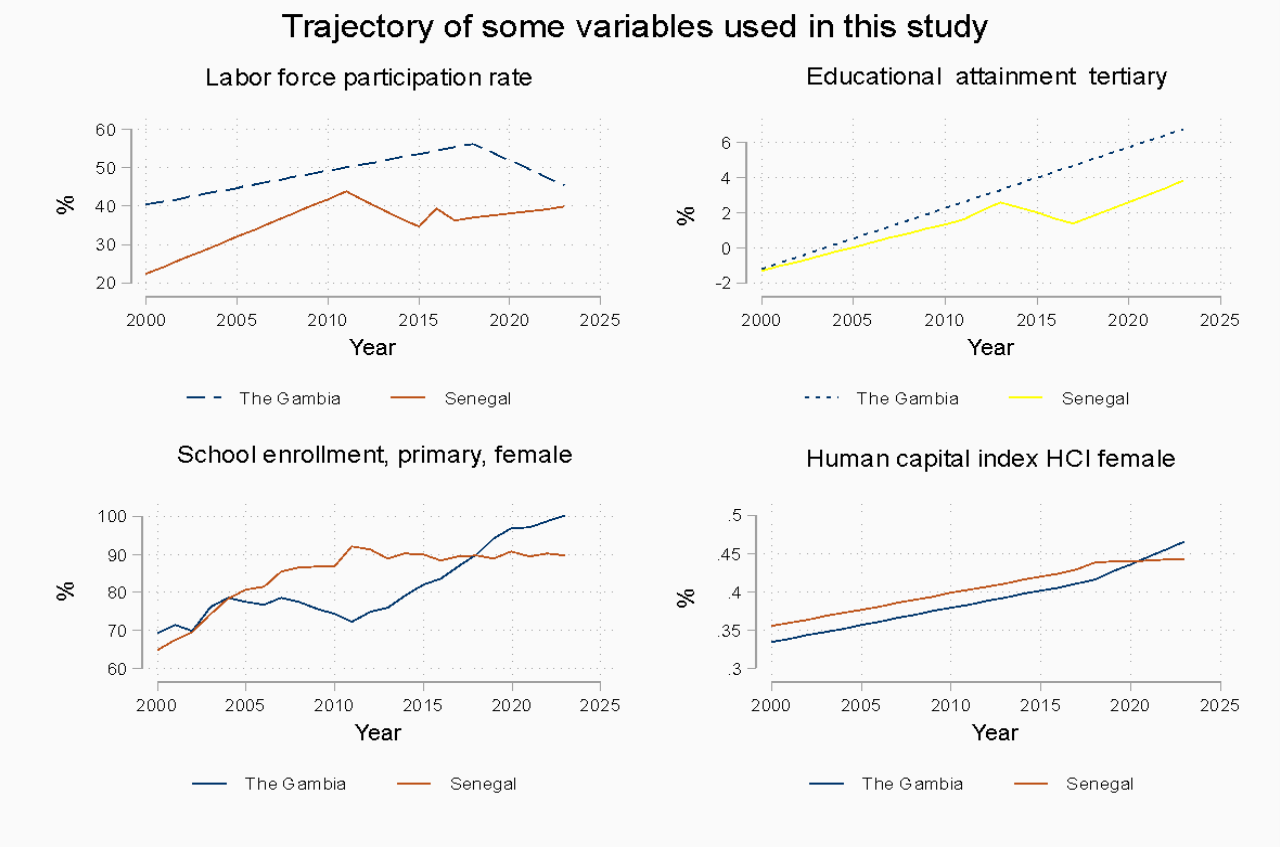

Figure 1. Trend Analysis

The labour force participation rate reveals a compelling divergence between The Gambia and Senegal. In 2000, The Gambia began with a relatively high rate of approximately 40%, rising steadily to a peak of 55% by 2020 before experiencing a slight decline. This trajectory suggests a period of expanding economic engagement, likely driven by demographic shifts, policy reforms, and increased female participation. The post-2020 dip may reflect structural constraints such as job market saturation or pandemic-related disruptions. Senegal, by contrast, started from a much lower base around 25% and increased gradually to 35% by 2025. While the growth is slower, it indicates incremental progress, potentially linked to long-term labour market reforms and educational investments. The contrast highlights The Gambia's relatively stronger mobilisation of its working-age population over the period.

Tertiary education attainment presents a more nuanced pattern. The Gambia began near zero in 2000 and climbed steadily to approximately 5% by 2025, reflecting consistent investment in higher education infrastructure and access. Though modest in absolute terms, this upward trend signals a growing pool of skilled labour and potential for innovation-led growth. Senegal's trajectory is more volatile: a sharp rise around 2015 is followed by a dip and subsequent recovery to about 3% by 2025. This fluctuation may reflect policy inconsistencies, funding challenges, or shifts in enrolment dynamics. Despite the lower final value, Senegal's mid-period spike suggests episodic success in expanding tertiary education. Overall, The Gambia's steadier growth may yield more reliable returns in human capital formation.

Female primary school enrolment is one of the most encouraging indicators. Both countries show strong upward trends, but The Gambia's progress is particularly striking. Starting at 65% in 2000, it reaches 95% by 2025, indicating near-universal enrolment. This reflects successful gender-focused education policies, community engagement, and possibly donor-supported initiatives. Senegal starts slightly higher at 70% and climbs to 90%, also demonstrating commendable progress. The narrowing gap between the two countries suggests regional convergence in primary education access for girls.

The Human Capital Index (HCI) for females, which encapsulates health and education outcomes, offers a composite view of development. Both countries show steady improvement: The Gambia rises from 0.35 to 0.45, while Senegal moves from 0.37 to 0.44. The Gambia's slightly higher final value suggests more consistent gains in female health and education. The parallel upward trends reflect regional efforts to improve

life expectancy, learning outcomes, and overall well-being. While Senegal started ahead, The Gambia's faster growth rate implies more aggressive or effective policy interventions. The convergence by 2025 signals shared regional progress in female human capital. Taken together, these indicators illustrate a dynamic interplay of socio-economic development in The Gambia and Senegal. The Gambia consistently outperforms Senegal in labour force participation and tertiary education attainment, signalling stronger integration of its population into productive and skilled sectors. Senegal, however, shows early advantages in female school enrolment and HCI, though The Gambia eventually catches up or surpasses. These patterns suggest that while both countries are on upward trajectories, The Gambia may be achieving more balanced and sustained improvements across key growth determinants. For policymakers, these insights underscore the importance of coordinated investments in education, gender equity, and labour market access to drive inclusive growth and long-term resilience.

4.7. Hausman Specification Test (Which Method is more Appropriate for our analysis?)

To decide between fixed and random effects, we run a Hausman test where the null hypothesis is that the preferred model is random effects vs. the alternative, the fixed effects (see Green, 2008, chapter 9). It basically tests whether the unique errors (*ui*) are correlated with the explanatory variables; the null hypothesis is that they are not. In that, we run a fixed effects model and save the estimates, then run a random effects model and save the estimates, then perform the Hausman specification test. Thus, our decision rule for which estimate is more appropriate after the Hausman test was random effects, because the probability of chi-square is 0.945, which is greater than 0.05. So, random effects are more suitable for the analysis of the relationship between gender inequality and growth.

4.8. Random effect estimation (Method: Based on GLS (Variance Components estimation/Error Components model))

Table 5. Random Effects Estimation excluded male enrolment. When the dependent variable is the growth rate of the GDP per capita, current

LNGDP_Perc_curr	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
SEPRM	-.087	.028	-3.08	.002	-.142	-.032	***
Schoolenrollmentpr~a	.085	.026	3.28	.001	.034	.136	***
Educationalatt~iary1	-.559	.097	-5.73	0	-.75	-.367	***
Educationalattain~r1	.008	.051	0.16	.871	-.091	.107	
Educationalatt~mary1	.068	.017	3.96	0	.034	.101	***
HumancapitalindexH ~1	9.615	4.66	2.06	.039	.481	18.749	**
Laborforceparticip~1	.022	.01	2.24	.025	.003	.04	**
Literacyrateadultf~1	-.019	.01	-1.86	.063	-.04	.001	*
Gender parity index	-2.421	1.138	-2.13	.033	-4.652	-.19	**
Constant	6.014	3.719	1.62	.106	-1.275	13.302	

Mean dependent var	6.769	**SD dependent var**	0.408
Overall r-squared	0.904	**Number of obs**	48
Chi-square	348.021	**Prob > chi2**	0.000
R-squared within	0.783	**R-squared between**	1.000

*** p<.01, ** p<.05, * p<.1

The random effects model demonstrates exceptional explanatory power, with an overall R-squared of 0.904 and a highly significant chi-square statistic ($\chi^2 = 348.021$, $p < 0.001$). This suggests that the included variables collectively explain over 90% of the variation in GDP per capita across the panel. The random effects approach assumes that individual-specific effects are uncorrelated with the regressors, allowing for both within- and between-country variation to inform the estimates. This is particularly useful for analysing gender inequality's economic impacts across diverse national contexts.

Several indicators reveal the adverse consequences of gender inequality on economic performance. Female secondary education attainment (SEPRM) has a significantly negative coefficient (-0.087, $p = 0.002$), indicating that lower female education levels are associated with reduced GDP per capita. Tertiary education attainment (Educationalatt~iary1) shows an even stronger negative effect (-0.559, $p < 0.001$), suggesting that gender gaps in higher education substantially constrain the productivity of human capital. Additionally, adult female literacy rate has a negative coefficient (-0.019, $p = 0.063$), marginally significant, implying that limited literacy among women may hinder labour market efficiency and innovation.

On the positive side, school enrolment (Schoolenrollemntrp~a) and primary education attainment (Educationalatt~marry1) both have significant positive coefficients (0.085 and 0.068, respectively, $p < 0.01$), highlighting the economic benefits of inclusive access to foundational education. Labour force participation also contributes positively (0.022, $p = 0.025$), reinforcing the idea that integrating women into the workforce enhances productivity and national income. These findings align with global evidence that gender equality in education and employment fosters inclusive growth, reduces poverty, and improves household welfare.

The Human Capital Index (HCI) shows a strong positive effect (9.615, $p = 0.039$), confirming that aggregate investments in health and education, especially when gender-inclusive, boost GDP per capita. However, the variable "Gender parity index" (likely capturing institutional or structural constraints) has a significant negative coefficient (-2.421, $p = 0.033$), suggesting that systemic barriers disproportionately affect women and limit their economic contribution. These constraints may include discriminatory laws, cultural norms, or unequal access to resources, which undermine the returns on female education and labour participation.

This random effects analysis provides compelling evidence that gender inequality, particularly in secondary and tertiary education, has a measurable negative impact on GDP per capita. Conversely, promoting school enrolment, primary education, and labour force participation among women yields clear economic dividends.

4.9. System GMM Results

Table 6. SYSTEM GMM Estimation excluded male enrolment. When the dependent variable is the growth rate of the GDP per capita, current

lngdp_perca	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
L	.441	.104	4.23	0	.237	.645	***
SEPRM	-.1	.024	-4.21	0	-.147	-.053	***
Schoolenrollmentpr~a	.098	.022	4.48	0	.055	.14	***
Educationalatt~iary1	-.239	.094	-2.56	.011	-.423	-.056	**
Educationalattain~r1	.024	.037	0.66	.507	-.048	.097	
Educationalatt~mary1	.029	.014	2.02	.043	.001	.057	**
HumancapitalindexH ~1	-.97	3.797	-0.26	.798	-8.411	6.472	
Laborforceparticip~1	.008	.008	1.10	.273	-.007	.024	
Literacyrateadultf~1	-.008	.008	-1.05	.295	-.024	.007	
Gender parity index	-2.717	.897	-3.03	.002	-4.475	-.958	***
Constant	8.396	2.795	3.00	.003	2.917	13.874	***

Mean dependent var	6.788	**SD dependent var**	0.407
Number of obs.	46	**Chi-square**	206057.286

*** p<.01, ** p<.05, * p<.1

Based on the System GMM Estimation results presented in Table 5, the analysis investigates the impact of various socio-economic and educational variables on the growth rate of GDP per capita, excluding male enrolment. The model uses lagged GDP per capita as a dynamic component, and its coefficient (0.441) is statistically significant at the 1% level, indicating strong persistence in economic growth patterns over time. This suggests that past GDP performance is a reliable predictor of current growth, consistent with dynamic panel modelling expectations.

School enrolment at the primary level (SEPRM) has a positive and highly significant effect (coefficient = 0.098, $p < 0.01$), reinforcing the role of basic education in driving economic development. Interestingly, educational attainment at the tertiary level is negatively associated with GDP growth (coefficient = -0.239, $p = 0.011$), which may reflect mismatches between higher education outputs and labour market demands in the region.

Other educational variables show mixed results. Attainment at the secondary level (Educationalatt-mar y1) is positively and significantly associated with growth, while literacy rate among adult females and labour force participation are statistically insignificant. The gender parity index, however, shows a strong negative effect on GDP growth (coefficient = -2.717, $p = 0.003$), suggesting that imbalances in gender equity may hinder economic performance. This finding underscores the importance of inclusive policies that promote gender-balanced access to education and employment.

The human capital index and other labour-related variables do not show significant effects, indicating that their influence may be mediated through other channels or require more refined measurement. The constant term is positive and significant, suggesting that unobserved factors not captured by the model still contribute meaningfully to GDP growth. Overall, the model is statistically robust, with a high chi-square value (206057.286) and a reasonable number of observations (46), supporting the reliability of the estimates despite the exclusion of male enrolment.

5. Discussions

The econometric analysis across multiple model specifications consistently reveals that gender inequality exerts both negative and positive effects on GDP per capita, depending on the dimension examined.

Conversely, indicators of female education and human capital development, such as secondary and tertiary attainment, literacy rates, and composite indices, show strong positive associations with GDP per capita. These results are robust across fixed effects and random effects models, confirming that gender equality in education enhances labour market outcomes and national productivity (Klasen & Lamanna, 2009).

However, the impact of female labour force participation is more nuanced. While inclusion is generally positive, the correlation and regression results suggest that without improvements in job quality, wage equity, and formal sector access, the economic gains may be limited or even negative. This aligns with Cuberes & Teignier (2016), who argue that occupational segregation and informal employment dilute the macroeconomic benefits of gender inclusion.

The multi-model results consistently demonstrate that gender inequality has both negative and positive effects on GDP per capita, depending on the dimension analysed.

Education-related indicators, such as female secondary and tertiary attainment, literacy rates, and human capital indices, exhibit strong positive correlations and significant regression coefficients. These findings align with Klasen and Lamanna (2009), who show that gender gaps in education and employment reduce national income. Ceesay (2013) reinforces this by emphasising that gender inequality in education and labour access undermines inclusive growth and perpetuates income disparities.

However, labour force participation presents a more complex picture. While inclusion is generally positive, the correlation and regression results suggest that without improvements in job quality, wage equity, and formal sector access, the economic gains may be limited or even negative. Bertay, Dordevic and Sever (2025) show that industries with higher female employment shares experience stronger growth when located in gender equal environments, suggesting that structural context matters.

Recent literature also highlights the macro critical nature of gender equality. The IMF (2020) and OECD (2023) emphasise that removing gender-based barriers like legal discrimination, unequal access to finance, and

limited childcare can unlock substantial economic potential. The World Economic Forum (2023) estimates that closing gender gaps in labour force participation could boost GDP by up to 8% in emerging markets.

Labour force participation presents a more complex picture. Seguino (2000) finds that gender wage gaps can suppress aggregate demand and reduce growth in export-oriented economies.

6. Conclusion

The multi-model analysis confirms that gender inequality is a multidimensional constraint on economic growth, and Labour exclusion exerts downward pressure on GDP per capita, while education and human capital investments offer measurable economic returns. The strength of dynamic panel models like System GMM highlights the importance of sustained and time-sensitive reforms.

Ultimately, the findings reinforce the notion that gender equality is not only a human rights issue but a strategic economic priority**.** Addressing disparities in education, health, and employment is essential for achieving inclusive and sustainable growth.

7. Contribution to Knowledge

This study contributes to the literature in several keyways:

- It applies advanced panel data techniques, including System GMM, fixed/random effects, to assess the economic impact of gender inequality, offering methodological rigour and dynamic insights.
- It integrates correlation analysis to triangulate regression findings, enhancing robustness and interpretability.
- It highlights the non-linear and context-sensitive nature of gender inequality's impact on GDP, showing that not all forms of inclusion yield equal economic returns.
- It proposes the inclusion of financial inclusion and institutional quality variables to capture structural gender barriers, an area underexplored in macroeconomic modelling.

8. Policy Implications

Based on the findings, several policy actions are recommended:

- Expand female education and literacy**:** Education is a consistent driver of GDP growth. Policies should target secondary and tertiary education for girls, with attention to quality and retention (World Bank, 2020).
- Formalise female labour markets: Labour participation must be matched with decent work, wage equity, and social protection. Informal sector reforms are critical (ILO, 2021).
- Address structural constraints: Legal reforms, access to finance, and anti-discrimination laws are essential to unlock women's economic potential (OECD, 2023).
- Track gendered financial inclusion: Incorporating financial inclusion metrics into national statistics can guide targeted interventions (Demirgüç-Kunt et al., 2018).

9. Recommendations for Future Research

- Use longitudinal and dynamic models**:** System GMM and other dynamic estimators should be applied to capture lagged effects of gender reforms.
- Disaggregation by region and sector: Within-country and sectoral analysis can reveal localised gender gaps in education, labour, and finance.
- Integrate qualitative methods: Mixed methods can uncover cultural and institutional barriers that quantitative models may miss.

- Develop composite indices: Gendered financial inclusion, legal empowerment, and informal sector quality should be quantified and modelled.
- Explore climate-gender-growth nexus: Future studies should examine how climate vulnerability interacts with gender inequality to affect economic outcomes.

10. Study Limitations and Future Research

This study is limited to two countries and secondary data; future work could expand to more SSA nations or incorporate primary survey data on gendered financial inclusion. Moreover, dynamic models with institutional variables are also recommended.

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Author Contributions E.K.C. conceived and led the study, developed the research concept and theoretical framework, conducted the literature review, designed the empirical strategy, performed the econometric analyses, interpreted the results, and drafted the manuscript. F.C. collected, organized, and cleaned the dataset and verified the accuracy and completeness of the literature review. L.F.B. contributed to the refinement of the literature review, including cross-checking sources and validating the conceptual background. M.B.O.N. provided academic guidance and critical feedback, contributing to the refinement of the manuscript. All authors have read and approved the final version of the manuscript.

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Declarations

Competing Interests The authors declare no competing interests.

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