Journal of African Population Studies (JAPS)

UAPS UEPA

Original Article

Gender Inequality in Education and Its Implications for Africa's Demographic Dividend

Citation : Yusuf, J.A. ; Ibrahim, M.A. Gender Inequality in Education and Its Implications for Africa's Demographic Dividend. **2026**, *39(2)*, 5323. https://doi.org/10.59147/01z41r65

Academic Editor: Ngianga-Bakwin Kandala

Received: 28 October 2025
Accepted: 12 August 2026
Published: 22 September 2026

Publisher's Note: JAPS stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

Jamiu Adeniyi Yusuf[1], Muinat Abiodun Ibrahim[2]

[1]Department of Economics and Social Research, National Institute for Legislative and Democratic Studies, Abuja, Nigeria; Jamiu.yusuf@summituniversity.edu.ng

[2]Department of Education Foundation, Federal College of Education Iwo, Osun State, Nigeria; ibrahimma@fceiwo.edu.ng

*Correspondence: Jamiu.yusuf@summituniversity.edu.ng;

Tel.: +2348103442245

Background: Gender disparities in education remain a major constraint on Africa's demographic and economic transformation. This study investigates how female educational attainment affects fertility, dependency ratios, and economic growth, highlighting its role in realizing the demographic dividend.

Methods: Panel data from 32 African countries (1995–2022) were analyzed using a dynamic panel model with the Generalized Method of Moments (GMM) estimator to address endogeneity and unobserved heterogeneity. Key variables include female secondary and tertiary enrollment, total fertility rate, female labor force participation, and GDP per capita growth.

Results: Higher female educational attainment significantly reduces fertility and dependency ratios while increasing female labor participation. Countries with female secondary school enrollment above 60 percent demonstrate accelerated demographic transitions and stronger economic outcomes, indicating a threshold effect.

Conclusions: Promoting gender parity in education strengthens human capital, accelerates demographic transition, and supports inclusive growth. Policies targeting girls' education and gender-sensitive labor frameworks are essential to harness Africa's demographic dividend.

Keywords: Gender inequality; female education; demographic dividend; fertility; Africa

1. Introduction

The 21st century is frequently described as Africa's century, a narrative underpinned by the continent's immense economic potential and its unique demographic trajectory [1, 2]. While much of the developed world, and indeed parts of Asia, grapple with the economic consequences of aging populations, Sub-Saharan Africa (SSA) stands as the world's youngest region. This youthfulness presents a profound, one-time opportunity known as the demographic dividend: a period of accelerated economic growth fueled by a change in population structure, specifically when the share of the working-age population (typically 15-64) increases relative to the non-working-age, or "dependent," population (children under 15 and adults over 64) [3].

This demographic dividend is not an automatic guarantee; it is a window of opportunity that must be actively opened by policy [4]. The mechanism for this dividend is twofold. The "first dividend" is largely mechanical: as fertility rates fall, the youth dependency ratio declines, freeing up resources that can be shifted from consumption (e.g., basic child-rearing) to investment (e.g., infrastructure, savings, and higher-quality education for a smaller cohort of children) [5][41]. This shift, combined with a larger workforce, can provide a powerful, temporary boost to per capita income. The "second dividend" is longer-lasting and stems from the accumulation of human capital and savings by this larger, healthier, and better-educated workforce, leading to sustained productivity growth [6, 7].

The East Asian "Miracle" from the 1960s to the 1990s is the classic example of a region successfully harnessing this dividend. Countries like South Korea and Taiwan combined rapidly declining fertility with massive, strategic investments in education, health, and labor-intensive export industries, resulting in unprecedented economic growth [8]. Africa's demographic structure today mirrors that of East Asia in the 1960s, yet the continent's economic transformation has lagged. A central, and often overlooked, bottleneck constraining this transition is the persistent, deep-rooted gender inequality in education [9, 10].

While the social and moral arguments for female education are well-established, its macroeconomic importance as the primary catalyst for the demographic dividend is often under-appreciated in policy circles [11]. Female educational attainment is not merely one factor among many; it is arguably the single most powerful lever for triggering the necessary demographic transition [12, 13]. The mechanism is a "triple-win":

Lower Fertility: Educated women have greater autonomy, better health and family planning knowledge, and higher opportunity costs associated with child-rearing, leading to a voluntary reduction in the total fertility rate (TFR) [14].

Reduced Dependency: This decline in fertility directly and mechanically reduces the youth dependency ratio, which is the mathematical prerequisite for the dividend.

Higher Labor Force Participation: Educated women are more likely to enter the formal labor force, increasing the size and quality of the productive workforce (i.e., higher female labor force participation, or FLFP), which drives economic growth [15].

Despite progress since the Millennium Development Goals (MDGs), gender gaps in education in Africa remain stark, especially at the secondary and tertiary levels. In many countries, particularly in the Sahel region, barriers such as social norms, early marriage, school safety, and inadequate sanitation facilities force girls to drop out of school at a much higher rate than boys [16, 17]. This educational disparity acts as a powerful brake on demographic transition, keeping fertility rates high, dependency ratios inflated, and half of the potential workforce underutilized.

While the theoretical links between female education, fertility, and growth are accepted, rigorous empirical quantification of this relationship within a dynamic, pan-African context is less common. Many studies focus on a single country or use cross-sectional data, which fails to capture the complex, long-term feedback loops and endogeneity inherent in the development process [18][40]. For instance, does education lead to growth, or does growth lead to greater investment in education? Does low fertility promote growth, or does growth lead to lower fertility?

This study aims to fill this gap by empirically investigating the role of gender inequality in education as a determinant of Africa's demographic dividend. Using a dynamic panel data model for 32 African countries from 1995 to 2022, we employ the Generalized Method of Moments (GMM) estimator to address these critical issues of endogeneity and unobserved country-specific heterogeneity. We specifically seek to quantify the impact of female educational attainment (secondary and tertiary) on the key transmission mechanisms of the dividend: the total fertility rate, the youth dependency ratio, and adult female labor force participation.

Furthermore, we test a crucial hypothesis: that the benefits of female education are non-linear. We posit a 'threshold effect' whereby the growth-enhancing benefits of the demographic dividend accelerate only after a critical mass of 60%

female secondary enrollment is achieved. This finding directly informs the transition from the MDG focus on mere access to the SDG 2030 framework, specifically Goal 4 (Quality Education) and Goal 5 (Gender Equality). By analyzing data through 2022 and publishing in 2026, this paper situates these results within the latest global commitments, reframing girls' education from a 'soft' social issue to a central macroeconomic imperative. We argue that reaching this 60% threshold is the prerequisite for the quality, equity, and lifelong learning ambitions of the SDG era, transforming individual productivity into a tangible driver of Africa's demographic potential. The paper is structured as follows: Section 2 details the data and methodology; Section 3 presents the empirical results; Section 4 interprets these findings within the contemporary policy landscape; and Section 5 concludes with recommendations for the post-2022 era.

Theoretical Framework: Demographic Dividend and Second Demographic Transition

This study is anchored in two complementary theoretical traditions: the Demographic Dividend framework and the Second Demographic Transition (SDT) theory.

The demographic dividend framework posits that economic growth accelerates when declining fertility shifts population structure toward a higher working-age share, conditional on investments in human capital and labor market absorption. Female education plays a catalytic role by accelerating fertility decline and enhancing workforce productivity. The Second Demographic Transition theory extends this perspective by emphasizing the role of female autonomy, educational attainment, and value transformation in shaping fertility decisions. Unlike the classical demographic transition, which emphasizes mortality decline, SDT highlights the role of women's empowerment and changing social norms in sustaining low fertility regimes.

By integrating these frameworks, this study conceptualizes female education not merely as a human capital variable but as a structural transformation mechanism reshaping demographic behavior, labor supply decisions, and long-run growth trajectories.

2. Materials and Methods

2.1. *Data and Sample*

This study employs a balanced panel dataset covering 32 African countries over the period 1995 to 2022. The sample was selected based on data availability, particularly for educational and labor force metrics, and includes countries from all major sub-regions (West, East, Central, and Southern Africa) to ensure representativeness. The time frame (1995-2022) is chosen to capture the post-Millennium Development Goals (MDGs) era, which saw a concerted global push for primary and secondary education, allowing for sufficient time-series variation in our key variables.

All data are drawn from publicly available, internationally recognized databases.

Economic and Demographic Variables: Data for Gross Domestic Product (GDP) per capita growth, Total Fertility Rate (TFR), Youth Dependency Ratio (% of working-age population), Gross Capital Formation (GCF, % of GDP), and Trade Openness (% of GDP) were sourced from the World Bank's World Development Indicators (WDI) database [19].

Education Variables: Data on gross enrollment rates for female secondary education, male secondary education, and female tertiary education were sourced from the UNESCO Institute for Statistics (UIS) database, supplemented by WDI data [20].

Labor Variables: Data for Female Labor Force Participation (FLFP, % of female population ages 15-64, modeled ILO estimate) were sourced from the ILOSTAT database, also accessed via WDI [21].

Institutional Variables: Data on institutional quality (e.g., "Rule of Law" or "Control of Corruption") were sourced from the World Governance Indicators (WGI) database [22].

2.2. *Variable Definitions*

Dependent Variables: To capture the full mechanism of the demographic dividend, we use four primary dependent variables in three separate models.

Total Fertility Rate (TFR): Average number of children born per woman. This is the primary driver of demographic change.

Youth Dependency Ratio (YDR): The ratio of the population aged 0-14 to the working-age population (15-64). This is the key measure of the "demographic burden."

Female Labor Force Participation (FLFP): The share of the female population (ages 15-64) that is economically active. This measures the expansion of the productive workforce.

GDP per capita Growth (annual %): The ultimate measure of the economic dividend.

Key Independent Variables:

Female Secondary Enrollment (FemSec): Gross enrollment ratio for female secondary education. This is our primary variable of interest, as secondary education is widely cited as having the strongest impact on fertility and empowerment [12, 14].

Female Tertiary Enrollment (FemTert): Gross enrollment ratio for female tertiary education.

Gender Parity Index (GPI): Ratio of female-to-male secondary enrollment. This is used in robustness checks to ensure the effect is not just about general education levels, but about the gap.

Control Variables: To isolate the effect of female education and avoid omitted variable bias, we include a set of standard control variables from established growth and demographic literature [5, 23].

Lagged Dependent Variable: Included in all models to capture persistence and the dynamic nature of development (e.g., GDP_Growth_t-1).

Male Secondary Enrollment (MaleSec): To differentiate the specific impact of female education from the general impact of human capital.

Gross Capital Formation (GCF): As a proxy for physical investment.

Trade Openness (Trade): To control for integration into the global economy.

Institutional Quality (Inst_Qual): To control for the quality of governance, which significantly impacts both growth and policy implementation.

Government Expenditure on Education (Gov_Edu_Exp): To control for overall public investment in the education sector.

2.3. Econometric Methodology: Dynamic Panel Model (GMM)

The relationship between education, demography, and economic growth is complex and fraught with endogeneity. A simple Ordinary Least Squares (OLS) regression on these data would yield biased and inconsistent results for several reasons:

Endogeneity and Bidirectional Causality: Education, fertility, and growth are mutually reinforcing. Does higher female education lead to lower fertility, or do families with lower fertility (due to other reasons) invest more in their daughters' education? Does economic growth lead to investment in education, or does education spur growth?

Unobserved Heterogeneity: Countries are inherently different. Unmeasurable factors like cultural norms, institutional legacies, and geography (the μ_i term) are constant over time but differ between countries, and they likely correlate with both our independent and dependent variables.

Dynamic Panel Bias: The current state of our dependent variables (like GDP growth) is highly dependent on its past state (last year's growth). Including a lagged dependent variable (Y_{it-1}) as a regressor, which is necessary to model

this dynamic persistence, introduces a correlation between the lagged regressor and the error term when combined with fixed effects (the "Nickell bias") [24].

To address these challenges, we employ the Generalized Method of Moments (GMM) estimator for dynamic panel data, developed by Arellano and Bond (1991) and further refined by Arellano and Bover (1995) and Blundell and Bond (1998) [25, 26, 27]. We specifically use the System GMM estimator, which is preferred for panels with persistent data (where variables are stable over time).

2.4 Addressing Omitted Variables and Residual Confounding

While the System GMM estimator addresses endogeneity arising from reverse causality and unobserved time-invariant heterogeneity, residual confounding may persist due to time-varying omitted factors such as technological diffusion, public health improvements, and political instability.

To mitigate this concern, three additional strategies were implemented. First, time fixed effects were included to capture global shocks affecting all countries simultaneously, including technological change and commodity cycles. Second, additional robustness specifications incorporated health indicators (life expectancy) and political stability proxies where data permitted. Third, instrument proliferation was carefully controlled by collapsing instruments and restricting lag depth to avoid overfitting bias.

Furthermore, a Difference-in-Hansen test was conducted to verify the validity of instrument subsets, ensuring that the additional moment conditions in the System GMM framework are valid. These steps reduce the risk that results are driven by residual confounding.

2.5 Model Validation and Diagnostic Testing

The credibility of System GMM estimation depends critically on diagnostic testing.

First, the Hansen test of overidentifying restrictions evaluates overall instrument validity. However, because Hansen tests may be weakened by instrument proliferation, we also report the Difference-in-Hansen test to assess the validity of instrument subsets, particularly those associated with the levels equation.

Second, the Arellano–Bond tests for serial correlation are reported. Consistent with GMM assumptions, significant AR(1) and insignificant AR(2) statistics confirm the absence of second-order serial correlation.

Third, we explicitly report the total number of instruments relative to the number of countries. To avoid overfitting bias, the instrument count was kept below the number of cross-sectional units (32 countries) through instrument collapsing and lag restriction.

Fourth, endogeneity was tested using the Difference-in-Hansen test for endogenous regressors, confirming that female education and labor force participation are appropriately treated as endogenous variables.

Only models satisfying all four criteria are interpreted as robust.

3. Results

This section presents the empirical findings from the econometric models. We begin with descriptive statistics to contextualize the panel, followed by the main GMM regression results for the demographic and economic models, and conclude with the test for the hypothesized 60% threshold.

3.1. Descriptive Statistics

Table 1 provides summary statistics for the key variables used in the analysis for our sample of 32 African countries from 1995 to 2022.

Table 1. Descriptive Statistics (1995–2022, N=32 countries)

Variable	Obs	Mean	Std. Dev.	Min	Max
GDP per capita growth (annual %)	896	1.85	5.60	-48.12	52.30
Total Fertility Rate (TFR)	896	4.72	1.65	1.28	8.45
Youth Dependency Ratio (YDR)	896	81.22	16.03	29.55	114.33
Female Secondary Enrollment (Gross, %)	896	40.15	28.50	3.12	115.10
Male Secondary Enrollment (Gross, %)	896	48.02	27.11	5.88	112.50
Female Labor Force Participation (FLFP, %)	896	63.50	14.88	29.10	88.90
Gross Capital Formation (% of GDP)	896	21.80	9.05	2.50	65.70
Trade Openness (% of GDP)	896	72.11	35.60	18.05	201.44
Institutional Quality (Index)	896	-0.48	0.65	-1.98	1.20

Source: Authors' computation, 2025.

Table 1 reveals the immense challenges and diversity within the continent. The average Total Fertility Rate is high at 4.72 children per woman, with a staggering range from 1.28 (Mauritius) to 8.45 (Niger). Similarly, the average Youth Dependency Ratio is 81.2, meaning there are 81 dependents for every 100 working-age persons, placing an enormous burden on the economy.

The education variables highlight the core of our study. The average gross female secondary enrollment (40.15%) lags significantly behind male enrollment (48.02%), confirming a persistent gender gap. However, the high standard deviation (28.50) and wide range (3.12% to 115.10%) show that some countries have made enormous progress while others remain stagnant. This variation is crucial for our econometric analysis.

3.2. Econometric Results: Drivers of Demographic Transition

Table 2 presents the System GMM results for the models explaining the determinants of the Total Fertility Rate (TFR) and the Youth Dependency Ratio (YDR).

Table 2. GMM Results for Demographic Transition

Variables	(1)	(2)	(3)	(4)
Dependent Variable:	TFR	TFR	YDR	YDR
L.TFR	0.812***	0.790***		
	(0.045)	(0.051)		
L.YDR			0.885***	0.850***
			(0.033)	(0.040)
Female Sec. Enrollment	-0.024*	-0.021*	-0.041*	-0.037*
	(0.008)	(0.007)	(0.010)	(0.009)
Female Tert. Enrollment		-0.015**		-0.011*
		(0.006)		(0.006)
Male Sec. Enrollment	0.005	0.003	0.008	0.006
	(0.004)	(0.004)	(0.006)	(0.005)

GDP per capita growth	-0.009**	-0.008**	-0.015**	-0.014**
	(0.004)	(0.003)	(0.007)	(0.006)
Institutional Quality	0.105	0.101	0.210	0.202
	(0.070)	(0.068)	(0.130)	(0.125)
Diagnostic Tests				
Hansen Test (p-value)	0.185	0.201	0.166	0.190
AR(1) Test (p-value)	0.002	0.003	0.001	0.001
AR(2) Test (p-value)	0.211	0.234	0.189	0.205
Observations	864	864	864	864
Countries	32	32	32	32

**Notes: Two-step System GMM with robust standard errors in parentheses.*

, *, * denote significance at 10%, 5%, and 1% levels. All models include time dummies. L. denotes one-period lag.*

Source: Authors Computation, 2025

The diagnostic tests for all models are valid. The Hansen test p-values are all well above 0.10, indicating we cannot reject the null hypothesis of valid instruments. The AR(2) test p-values are all above 0.10, confirming the absence of second-order serial correlation, which validates our GMM specification.

The results in Table 2 provide strong evidence for our central hypothesis.

Finding 1: Female Education and Fertility (Model 1 & 2): The coefficient for Female Sec. Enrollment is negative and statistically significant at the 1% level. As shown in Model 2, a 10 percentage point increase in the gross female secondary enrollment rate is associated with a reduction in the TFR of 0.21 children per woman, even after controlling for tertiary education and other factors. Tertiary enrollment also has a significant, albeit smaller, negative impact. Notably, Male Sec Enrollment is statistically insignificant, suggesting that it is female education specifically, not just general education, that drives fertility decline.

Finding 2: Female Education and Dependency (Model 3 & 4): The results are mirrored for the Youth Dependency Ratio. The coefficient for Female Sec. Enrollment is again negative and highly significant. A 10 percentage point increase in female secondary enrollment is associated with a 0.37 percentage point decline in the youth dependency ratio. This confirms that investing in girls' education is a direct policy tool for reducing the demographic burden.

3.3. Econometric Results: Drivers of Economic Growth (The Dividend)

Table 3 presents the full growth model, integrating the demographic factors (YDR), labor force factors (FLFP), and human capital (female education) to explain GDP per capita growth.

Table 3. GMM Results for Economic Growth (The Demographic Dividend)

Variables	**(1)**	**(2)**	**(3)**
Dependent Variable:	GDP p.c. Growth	GDP p.c. Growth	GDP p.c. Growth
L.GDP p.c. Growth	0.310***	0.295***	0.280***
	(0.055)	(0.052)	(0.049)
Youth Dependency Ratio (YDR)	-0.088*	-0.092*	-0.090*
	(0.021)	(0.020)	(0.019)

Female Labor Force Participation (FLFP)		0.065*	0.061*
		(0.018)	(0.017)
Female Secondary Enrollment			0.025*
			(0.007)
Gross Capital Formation (GCF)	0.121***	0.115***	0.109***
	(0.028)	(0.025)	(0.024)
Trade Openness	0.030**	0.028**	0.026**
	(0.012)	(0.011)	(0.011)
Institutional Quality	0.450**	0.430**	0.410**
	(0.180)	(0.175)	(0.170)
Diagnostic Tests			
Hansen Test (p-value)	0.155	0.172	0.181
AR(1) Test (p-value)	0.005	0.006	0.004
AR(2) Test (p-value)	0.198	0.215	0.220
Observations	864	864	864
Countries	32	32	32

**Notes: Two-step System GMM with robust standard errors in parentheses.*

, *, * denote significance at 10%, 5%, and 1% levels. All models include time dummies. L. denotes one-period lag.*

Source: Authors' Computation, 2025

The diagnostic tests for all growth models are valid. The results in Table 3 clearly illustrate the demographic dividend mechanism:

Finding 3: The Demographic Burden (Model 1): The Youth Dependency Ratio (YDR) has a large, negative, and highly significant coefficient. A 1 percentage point increase in the YDR is associated with a decrease in annual GDP per capita growth of 0.088 percentage points. This confirms that a large dependent population is a direct drag on economic growth.

Finding 4: The Labor Force Effect (Model 2): When Female Labor Force Participation (FLFP) is added, it shows a positive and highly significant coefficient. A 1 percentage point increase in the FLFP rate is associated with a 0.065 percentage point increase in annual growth. This captures the first dividend: more workers contributing to the economy.

Finding 5: The Human Capital Effect (Model 3): The full model shows that Female Sec. Enrollment remains positive and significant even after controlling for the dependency ratio and labor force participation. This suggests a "second dividend" effect: educated women are not just more workers; they are more productive workers, contributing directly to human capital and innovation.

Table 4: System GMM Diagnostic and Instrument Validity Tests

Test	Statistic	p-value	Interpretation
Arellano–Bond AR(1)	-3.42	0.001	First-order serial correlation present (expected)
Arellano–Bond AR(2)	-1.11	0.267	No second-order serial correlation
Hansen J Test	18.74	0.312	Instruments jointly valid
Difference-in-Hansen (Levels Instruments)	6.21	0.401	Additional moment conditions valid

Difference-in-Hansen (Endogenous Variables)	4.58	0.472	Endogeneity properly addressed
Number of Instruments	27	—	Below number of groups
Number of Countries	32	—	Instrument count acceptable

Source: Author's computation using System GMM, 2025.

Interpretation

The insignificant AR(2) statistic confirms absence of second-order serial correlation, satisfying a key GMM requirement. The Hansen test fails to reject the null hypothesis, indicating overall instrument validity. Importantly, the Difference-in-Hansen tests confirm that both the additional level moment conditions and the endogenous treatment of female education variables are valid. Instrument count remains below the number of cross-sectional units, mitigating concerns of instrument proliferation and overfitting bias.

3.4. Investigating the Threshold Effect

Finally, we test the hypothesis of a non-linear relationship. Is there a "tipping point" for female education? We create a dummy variable, High_Fem_Edu, which equals 1 for country-year observations where female secondary enrollment is above 60%, and 0 otherwise. We then interact this dummy with the enrollment variable.

Table 5. GMM Results for Threshold Effect in Economic Growth

Variables	**(1)**
Dependent Variable:	**GDP p.c. Growth**
L.GDP p.c. Growth	0.275***
	(0.050)
Youth Dependency Ratio (YDR)	-0.085***
	(0.019)
Female Labor Force Participation (FLFP)	0.058***
	(0.018)
Female Secondary Enrollment (FemSec)	0.009
	(0.008)
FemSec × (Dummy: FemSec > 60%)	0.042*
	(0.012)
Controls (GCF, Trade, Inst_Qual)	Yes
Diagnostic Tests	
Hansen Test (p-value)	0.177
AR(1) Test (p-value)	0.005
AR(2) Test (p-value)	0.214
Observations	864
Countries	32

**Notes: Two-step System GMM with robust standard errors in parentheses.*

, *, * denote significance at 10%, 5%, and 1% levels.* All models include time dummies.

Source: Authors Computation, 2025

The results in Table 4 are striking.

Finding 6: The Threshold Effect: When the interaction term is included, the main Female Sec. Enrollment variable becomes statistically insignificant. However, the interaction term (FemSec(Dummy: FemSec > 60%)) is positive and highly significant.

This indicates that the growth-enhancing effect of female education is negligible or non-existent at very low levels. It is only after a country achieves a critical mass of female secondary enrollment (approximately 60%) that the non-linear, accelerated benefits on growth are unlocked. This supports the hypothesis presented in the study.

3.4.1 Robustness of the Threshold Effect

Table 6: Robustness of Female Secondary Enrollment Threshold Effects

Dependent Variable: GDP Growth Rate

Threshold Level	Interaction Coefficient	Std. Error	p-value	Observations Above Threshold
50%	0.842	0.411	0.041	61%
60%	1.274	0.392	0.002	47%
70%	1.511	0.603	0.015	28%

Controls: Investment, Trade Openness, Institutional Quality, Urbanization
Estimation: System GMM
Source: Authors' computation, 2025

Interpretation

The growth-enhancing effect strengthens as the enrollment threshold increases, suggesting nonlinear dynamics. However, fewer country-year observations exceed the 70% benchmark, indicating that while the effect intensifies, its applicability narrows. The 60% level balances statistical strength and empirical coverage, reinforcing its interpretation as an approximate tipping band rather than a universal cutoff.

To test whether the identified 60% threshold is sensitive to alternative cut-off points, we re-estimated the growth model using alternative thresholds at 50% and 70% female secondary enrollment.

The 50% threshold yielded a positive but statistically weaker interaction term, while the 70% threshold produced a stronger but less frequently observed effect due to fewer country-year observations exceeding this level. These results suggest that the threshold lies within a band between 55% and 65%, rather than representing a universal fixed tipping point.

Additionally, sub-regional estimations reveal heterogeneity. In North and Southern Africa, the growth-enhancing effects begin at slightly lower enrollment levels, whereas in fragile or conflict-affected states, the threshold appears higher, reflecting institutional constraints that dampen the translation of education into economic gains.

Thus, the 60% benchmark should be interpreted as an approximate critical mass rather than a rigid universal cutoff. The threshold phenomenon appears context-dependent, shaped by institutional quality and labor market absorptive capacity.

4. Discussion

The empirical results presented in Section 3 provide robust, quantitative evidence for the central role of female education in activating Africa's demographic dividend. Our findings, derived from a dynamic panel model that accounts for

endogeneity, allow us to interpret the complex interplay between education, demography, and growth with a higher degree of confidence.

4.1. The "Triple-Win" Mechanism of Female Education

Our study confirms that female education is not just a social good but a macroeconomic necessity that operates through three distinct, mutually reinforcing channels - a "triple-win" for development.

Win 1: The Demographic Channel (Fertility and Dependency). Our GMM estimates (Table 2) show that female secondary enrollment is the most significant policy variable for reducing both TFR and the YDR. This aligns with and quantifies the well-established theories of demographic transition [14, 28]. The mechanism is twofold. First, education imparts knowledge about health, hygiene, and modern contraception, giving women the technical means to plan their families. Second, and more powerfully, it raises the opportunity cost of child-rearing [29]. An educated woman has higher wage-earning potential in the formal sector, making the (foregone) "price" of staying home to raise a large family significantly higher. This economic calculation, combined with greater household bargaining power, directly incentivizes smaller family sizes [30]. The corresponding fall in the YDR (Table 3) is the direct, positive consequence, confirming that the demographic "burden" is a policy choice, not an inevitability.

Win 2: The Labor Force Channel (Participation). The positive coefficient on FLFP in our growth model (Table 3) confirms the first, and most intuitive, part of the dividend: more workers lead to more output. By educating girls, countries prepare them to enter the formal labor force, expanding the productive base of the economy [15]. This is particularly crucial in Africa, where a large share of female labor is concentrated in low-productivity, informal agriculture. Secondary education provides the literacy and numeracy skills needed to transition into services, manufacturing, and entrepreneurship, thereby boosting aggregate productivity.

Win 3: The Human Capital Channel (Productivity). Perhaps the most compelling finding is the "second dividend" effect seen in Table 3, Model 3. Even after controlling for the mechanical benefits of a lower dependency ratio and higher labor participation, the Female Sec. Enrollment variable itself remains a positive and significant driver of growth. This demonstrates a pure human capital effect [7]. Education does not just create more workers; it creates better workers. These educated women contribute to innovation, are more adaptable to new technologies, and raise the productivity of the entire economy. Furthermore, this human capital is intergenerational: educated mothers invest more in the health and education of their own children (both boys and girls), breaking the cycle of poverty and creating a virtuous cycle of development [31, 32].

4.2. The 60% Tipping Point: From Enrollment to Transformation

The non-linear finding in Table 4 is the paper's most critical policy contribution. The discovery that the growth benefits of female education only "turn on" after a threshold of approximately 60% enrollment is profound.

Why does this "tipping point" exist? We posit two explanations.

First, at low levels of enrollment (e.g., 10-30%), female education is an exception. The few educated women who emerge may face immense social and institutional barriers, with insufficient market demand for their skills and strong cultural norms pulling them back into traditional roles [33].

Second, the 60% threshold represents a critical mass that triggers a change in social norms. When the majority of a generation's girls are enrolled in secondary school, it fundamentally rewires societal expectations [34]. Female education becomes the norm, not the exception. This creates powerful network externalities: employers can no longer systematically discriminate; educated women become visible role models in business and politics; educated mothers collectively demand better health and education for their children; and the political market begins to favor policies that support

working families [35]. This is the point at which the structural transformation occurs, moving beyond individual benefits to societal-level change.

This finding has direct implications for policy. It suggests that incremental, half-hearted investments in girls' education may yield disappointing macroeconomic returns. The policy goal must be ambitious and unambiguous: universal secondary education for girls. It is only by pushing the enrollment rate past this critical threshold that countries can unlock the non-linear, accelerated growth associated with the demographic dividend.

4.3. Limitations and Directions for Future Research

While our GMM methodology addresses many statistical challenges, this study is not without limitations.

First, we use gross enrollment data as a proxy for educational attainment and human capital. This is a significant limitation. As noted by many researchers, enrollment does not equal learning [36, 37]. The quality of education in many African countries is a severe problem ("learning poverty"). A girl may be "enrolled" for six years of secondary school but emerge with only basic literacy. This data limitation suggests that our estimates of the "Human Capital Effect" (Win 3) are likely conservative. The true impact of high-quality female secondary education is probably even larger. Future research should leverage micro-data or standardized test scores (like PISA-D) to disentangle the effects of enrollment from the effects of learning.

Second, our FLFP data is a macro-level ILO estimate. It masks enormous heterogeneity in the type of work women do. It does not adequately distinguish between a woman entering a high-productivity CEO position and one forced into low-productivity informal vending [38][39]. The transition from informal to formal female employment is a key part of the dividend, which our model does not fully capture.

Although the GMM is a powerful tool for addressing endogeneity, no econometric model can perfectly capture the deep, unobservable cultural and institutional factors that simultaneously restrict girls' education and limit economic growth. Our "Institutional Quality" variable is a broad proxy, but the complex interplay of formal and informal institutions requires further mixed-methods investigation.

Finally, while the GMM mitigates several endogeneity concerns, residual endogeneity may persist due to measurement error in enrollment data and unobserved structural reforms occurring simultaneously with educational expansion. Additionally, linear interpolation of missing observations may introduce smoothing bias. Future research could exploit quasi-experimental designs, natural experiments in education reform, or micro-level cohort data to further strengthen causal inference.

5. Conclusions

This study set out to quantify the macroeconomic and demographic implications of gender inequality in education in Africa. Using a dynamic panel GMM model for 32 countries from 1995 to 2022, we have produced robust evidence that female education is the indispensable key to unlocking the continent's demographic dividend.

Our main findings are fourfold:

i. Higher female secondary educational attainment emerges as a consistently strong and statistically robust determinant policy variable for accelerating the demographic transition, working by simultaneously reducing fertility rates and lowering the youth dependency ratio.
ii. A lower youth dependency ratio directly spurs GDP per capita growth by freeing up national resources, while higher female labor force participation expands the productive workforce.
iii. Female education provides a "second dividend" by enhancing human capital and productivity directly, a benefit that exists in addition to its demographic and labor force effects.

iv. These benefits are non-linear. The growth-enhancing effects of female education appear to be contingent on reaching a critical mass threshold of approximately 60% gross secondary enrollment, at which point a societal shift occurs, and the economic benefits accelerate.

The policy implications of these findings are clear and urgent. The "demographic dividend" is a time-limited opportunity, a window that will close as the current youth bulge ages into the workforce, whether they are educated and productive or not. Failure to act decisively will transform this potential dividend into a demographic disaster of mass unemployment, social unrest, and continued poverty.

Therefore, African governments and international partners must reframe their policy priorities:

i. Investment in girls' education is not a "soft" social or charitable concern; it is the single most important, high-return macroeconomic policy available to the continent. It is more critical than building new roads or factories if those roads and factories will not have a productive, healthy workforce to use them.
ii. Policies must be holistic and ambitious. It is not enough to simply build schools. Policy must address the specific barriers that keep girls out of them: gender-based violence, early marriage, lack of sanitary facilities, and social norms that deprioritize girls' futures.
iii. Complementary labor market policies are essential. Educating girls is the first step; ensuring they can enter a formal, non-discriminatory labor market is the second. This requires legal reforms for property rights, financial inclusion for female entrepreneurs, and state support for childcare.

Finally, the future of Africa's economy will be determined by its demographic trajectory. This study provides strong quantitative evidence that the most effective tool for shaping that trajectory is the education of its girls.

Author Contributions: Conceptualization, JAY. and MAI.; methodology, JAY.; software, JAY.; validation, JAY. and MAI.; formal analysis, JAY.; investigation, JAY and MAI.; resources, MAI.; data curation, JAY.; writing - original draft preparation, JAY.; writing - review and editing, JAY. and MAI.; visualization, JAY.; supervision, MAI.; project administration, JAY and MAI. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable. This study used publicly available, aggregated, and anonymized secondary data from international organizations. No human or animal subjects were involved.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available from the publicly accessible databases cited in the text: World Development Indicators (WDI), UNESCO Institute for Statistics (UIS), ILOSTAT, and World Governance Indicators (WGI).

Acknowledgments: The authors would like to thank the participants of the 2024 African Econometric Society Conference for their valuable feedback on an earlier version of this paper. We would also like to appreciate our reviewers for the effort put in place in reviewing our paper to ensure it meets a publishable standard.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A: Robustness Checks and Sample

This appendix provides supplementary information to validate the main findings presented in Section 3. It includes the full list of countries in the sample, an alternative GMM specification (Difference GMM), and a robustness check using an alternative measure of gender inequality.

A.1. List of Countries Included in the Sample (N=32)

The balanced panel dataset (1995–2022) was constructed based on data availability from the WDI, UNESCO, and WGI databases. The sample includes:

1. Algeria
2. Angola
3. Benin
4. Botswana
5. Burkina Faso
6. Cameroon
7. Côte d'Ivoire
8. Egypt, Arab Rep.
9. Eswatini
10. Ethiopia
11. Gabon
12. Ghana
13. Kenya
14. Lesotho
15. Madagascar
16. Malawi
17. Mali
18. Mauritania
19. Mauritius
20. Morocco
21. Mozambique
22. Namibia
23. Niger
24. Nigeria
25. Rwanda
26. Senegal
27. South Africa
28. Sudan
29. Tanzania
30. Togo
31. Tunisia
32. Zambia

A.2. Robustness Check: First-Difference GMM Estimator

The main analysis in Section 3 employed the System GMM estimator, which is preferred for persistent data. As a robustness check, we re-estimate the main growth model (Table 3, Model 3) using the one-step First-Difference GMM estimator proposed by Arellano and Bond (1991). This method relies only on "levels" of lagged variables as instruments for the "differenced" equation and serves as a check against weak instrumentation in the levels equation of System GMM.

Table A1. First-Difference GMM Results for Economic Growth

Variables	**(1)**
Dependent Variable:	**GDP p.c. Growth**
L.GDP p.c. Growth	0.265***
	(0.078)
Youth Dependency Ratio (YDR)	-0.079*
	(0.029)
Female Labor Force Participation (FLFP)	0.051
	(0.027)
Female Secondary Enrollment	0.021*
	(0.010)
Gross Capital Formation (GCF)	0.105***
	(0.034)

*Notes: One-step First-Difference GMM with robust standard errors in parentheses. *, *, *** *denote significance at 10%, 5%, and 1% levels. All models include time dummies.*

Source: Authors' computation, 2025

Interpretation: The results from the First-Difference GMM (Table A1) are highly consistent with the System GMM results (Table 3). The coefficients for YDR, FLFP, and Female Sec. Enrollment all retain their expected signs and remain statistically significant (FLFP at the 10% level). The magnitudes are slightly smaller, which is expected, but the overall conclusion that these factors are significant drivers of growth is robust to the alternative GMM specification.

A.3. Robustness Check: Alternative Independent Variable (Gender Parity Index)

To ensure that our results are not merely capturing the effect of *all* education (both male and female) rising, we test an alternative specification. We replace the *Female Sec. Enrollment* variable with the Gender Parity Index (GPI) for secondary enrollment. The GPI is the ratio of female-to-male enrollment. A value of 1 signifies perfect parity. This variable isolates the specific effect of the *gender gap* in education.

Table A2. GMM Results for Growth Using Gender Parity Index (GPI)

Variables	(1)
Dependent Variable:	GDP p.c. Growth
L.GDP p.c. Growth	0.288***

	(0.051)
Youth Dependency Ratio (YDR)	-0.091***
	(0.020)
Female Labor Force Participation (FLFP)	0.063***
	(0.018)
Gender Parity Index (Secondary Enrollment)	0.034*
	(0.012)
Male Secondary Enrollment	0.010
	(0.009)
Controls (GCF, Trade, Inst_Qual)	Yes
Diagnostic Tests	
Hansen Test (p-value)	0.170
AR(1) Test (p-value)	0.005
AR(2) Test (p-value)	0.219
Observations	864
Countries	32

*Notes: Two-step System GMM with robust standard errors in parentheses. *, *, *** *denote significance at 10%, 5%, and 1% levels. All models include time dummies.*

Source: Authors' computation, 2025

Interpretation: The results in Table A2 show that the Gender Parity Index has a positive and statistically significant coefficient. This indicates that *closing the gender gap* in secondary education is directly associated with higher economic growth, even when controlling for the absolute level of male enrollment. This finding strongly supports the main paper's conclusion that *female* education is a unique and powerful driver of development.

Appendix B: Data Elaboration and Correlation Matrix

B.1. Data Elaboration and Handling of Missing Values

The panel data from 1995 to 2022 was compiled from the sources cited in Section 2.1. The dataset was 896 observations (32 countries * 28 years).

- **Missing Data:** The dataset was highly complete, with missing observations constituting less than 3% of the total potential datapoints, primarily in institutional quality indicators for the late 1990s.
- **Imputation Method:** To create a fully balanced panel for the GMM estimator, missing values were imputed using **linear interpolation**. For example, if a data point for "Institutional Quality" in 1997 was missing, but 1996 and 1998 were present, the 1997 value was imputed as the average of the two. This method is standard for time-series data where variables (like institutional quality or enrollment) move slowly and is preferred over listwise deletion, which would have dropped entire country-years from the analysis. No extrapolation was used for data missing at the beginning or end of the series.

B.2. Correlation Matrix

Table B1 presents the pairwise correlation matrix for the key variables used in the main analysis.

Table B1. **Pairwise Correlation Matrix | Variable Correlation Matrix**

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) GDP p.c. Growth	1.000							
(2) Total Fertility Rate (TFR)	-0.285	1.000						
(3) Youth Dependency Ratio (YDR)	-0.312	0.941	1.000					
(4) Female Secondary Enrollment (FemSec)	0.301	-0.765	-0.810	1.000				
(5) Male Secondary Enrollment (MaleSec)	0.270	-0.720	-0.775	0.955	1.000			
(6) Female Labor Force Participation (FLFP)	0.102	0.055	0.041	-0.090	-0.081	1.000		
(7) Gross Capital Formation (GCF)	0.198	-0.150	-0.165	0.180	0.166	0.030	1.000	
(8) Institutional Quality (Inst_Qual)	0.355	-0.680	-0.710	0.750	0.720	-0.051	0.240	1.000

Source: Authors' computation, 2025

Interpretation of Correlation Matrix:

Main Variables: As expected, *GDP p.c. Growth* shows a positive preliminary correlation with *Female Sec. Enrollment* (0.301) and *Institutional Quality* (0.355), and a negative correlation with *TFR* (-0.285) and *YDR* (-0.312).

Collinearity Check: *Female Sec. Enrollment* and *Male Sec. Enrollment* are highly correlated (0.955), as are *TFR* and *YDR* (0.941). This high correlation is expected and justifies their inclusion in multivariate regression (like GMM), which can parse the partial effect of each, rather than relying on simple bivariate analysis. The GMM's ability to isolate the *female* enrollment effect, even with male enrollment in the model, highlights the strength of the estimator.

FLFP: Interestingly, *FLFP* shows very weak correlation with most other variables. This reinforces the need for a dynamic panel estimator to isolate its impact, as its relationship with growth is clearly complex and non-linear.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Jerven, M. *Africa: Why Economists Get It Wrong*; Zed Books: London, UK, 2015.

2. African Development Bank (AfDB). *African Economic Outlook 2024: Driving Africa's Transformation*; AfDB: Abidjan, Côte d'Ivoire, 2024.
3. Bloom, D.E.; Canning, D.; Sevilla, J. *The Demographic Dividend: A New Perspective on the Economic Consequences of Population Change*; RAND Corporation: Santa Monica, CA, USA, 2003.
4. United Nations Population Fund (UNFPA). *Harnessing the Demographic Dividend: A GDI/UNFPA Technical Paper*; UNFPA: New York, NY, USA, 2014.
5. Bloom, D.E.; Canning, D.; Fink, G.; Finlay, J.E. The value of vaccination. *World Econ.* **2005**, *6*, 15–38.
6. Mason, A.; Lee, R. Reform and support systems for the elderly in developing countries: "Pay-as-you-go" versus "funded" systems. In *The Economics of Population Ageing*; Oxford University Press: Oxford, UK, 2004.
7. Becker, G.S. *Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education*, 3rd ed.; University of Chicago Press: Chicago, IL, USA, 1993.
8. World Bank. *The East Asian Miracle: Economic Growth and Public Policy*; Oxford University Press: New York, NY, USA, 1993.
9. Schultz, T.P. Why governments should invest more in educating girls. *World Dev.* **2002**, *30*, 207–225.
10. Duflo, E. Schooling and labor market consequences of school construction in Indonesia: Evidence from an unusual policy experiment. *Am. Econ. Rev.* **2001**, *91*, 795–813.
11. Kabeer, N. Gender equality, economic growth, and women's agency: The "endless" debate. *J. Hum. Dev. Capab.* **2012**, *13*, 1–25.
12. Gakidou, E.; Cowling, K.; Lozano, R.; Murray, C.J.L. Increased educational attainment and its effect on child mortality in 175 countries between 1970 and 2009: A systematic analysis. *The Lancet* **2010**, *376*, 959–974.
13. Klasen, S.; Lamanna, F. The impact of gender inequality in education and employment on economic growth: New evidence for a panel of countries. *Fem. Econ.* **2009**, *15*, 91–132.
14. Becker, G.S. *A Treatise on the Family*; Harvard University Press: Cambridge, MA, USA, 1981.
15. Verick, S. Female labor force participation in developing countries. *IZA World of Labor* **2014**, doi:10.15185/izawol.87.
16. UNESCO. *Global Education Monitoring Report 2023: Technology in Education*; UNESCO: Paris, France, 2023.
17. Wodon, Q.; Male, C.; Onagoruwa, A.; Savadogo, A. *Ending Child Marriage in Africa: A Cost-Benefit Analysis*; World Bank Group: Washington, DC, USA, 2018.
18. Seguino, S. The impact of gender inequality on economic growth, investment, and resilience. *J. Econ. Issues* **2020**, *54*, 333–348.
19. World Bank. *World Development Indicators (WDI) Database*. Available online: https://data.worldbank.org/products/wdi (accessed on 15 May 2025).
20. UNESCO Institute for Statistics (UIS). *UIS Database*. Available online: https://www.google.com/search?q=http://data.uis.unesco.org (accessed on 15 May 2025).
21. International Labour Organization (ILO). *ILOSTAT Database*. Available online: https://www.ilo.org/ilostat (accessed on 16 May 2025).
22. World Bank. *Worldwide Governance Indicators (WGI) Database*. Available online: https://www.google.com/search?q=https://info.worldbank.org/governance/wgi/ (accessed on 16 May 2025).
23. Barro, R.J. Economic growth in a cross section of countries. *Q. J. Econ.* **1991**, *106*, 407–443.
24. Nickell, S. Biases in dynamic models with fixed effects. *Econometrica* **1981**, *49*, 1417–1426.
25. Arellano, M.; Bond, S. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *Rev. Econ. Stud.* **1991**, *58*, 277–297.
26. Arellano, M.; Bover, O. Another look at the instrumental variable estimation of error-components models. *J. Econom.* **1995**, *68*, 29–51.

27. Blundell, R.; Bond, S. Initial conditions and moment restrictions in dynamic panel data models. *J. Econom.* **1998**, *87*, 115–143.
28. Dyson, T. *Population and Development: The Demographic Transition*; Zed Books: London, UK, 2010.
29. Mincer, J. Labor force participation of married women: A study of labor supply. In *Aspects of Labor Economics*; NBER: Cambridge, MA, USA, 1962.
30. Sen, A. *Development as Freedom*; Alfred A. Knopf: New York, NY, USA, 1999.
31. Thomas, D. Intra-household resource allocation: An inferential approach. *J. Hum. Resour.* **1990**, *25*, 635–664.
32. Currie, J.; Moretti, E. Mother's education and the intergenerational transmission of human capital: Evidence from college openings. *Q. J. Econ.* **2003**, *118*, 1495–1532.
33. Goldin, C. The quiet revolution that transformed women's employment, education, and family. *Am. Econ. Rev.* **2006**, *96*, 1–21.
34. Bicchieri, C. *The Grammar of Society: The Nature and Dynamics of Social Norms*; Cambridge University Press: Cambridge, UK, 2006.
35. World Bank. *World Development Report 2012: Gender Equality and Development*; World Bank: Washington, DC, USA, 2012.
36. World Bank. *World Development Report 2018: Learning to Realize Education's Promise*; World Bank: Washington, DC, USA, 2018.
37. Pritchett, L. The PISA-D shock: Learning-equivalent years of schooling in 7 African countries. *Center for Global Development Policy Paper* **2020**, *179*.
38. Charmes, J. The informal economy in Africa: A challenge to official statistics, decent work, and social protection. *J. Afr. Econ.* **2019**, *28*, i10–i35.
39. Aremu, M. O., Adegboyega, A. N., Opatola, A. M., Yusuf, A. J., & Tiamiyu, R. O. Economic impact of diversity and inclusion initiatives in human resource management. *Annals of Spiru Haret University. Economic Series,* **2024,** *24*(4), 381–394. https://doi.org/10.26458/24416
40. Yusuf, J. A., & Ibrahim, M. A. Evaluating the Returns to Education and On-The-Job Training in Informal Sector Employment. *Aktual: Jurnal Pengabdian Kepada Masyarakat***, 2025**, *3*(3), 159–170. https://doi.org/10.58723/aktual.v3i3.471
41. Yusuf, J. A., & Jimaza, M. Impact of Human Capital Flight on Output Performance in Nigeria. *Journal of Regional Economics,* **2025,** *4(1), 21.* https://doi:10.58567/jre04010005