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Research Paper

HARNESSING AFRICA'S DEMOGRAPHY DIVIDEND FOR SUSTAINABLE ECONOMIC DEVELOPMENT: PANEL EVIDENCE ON GROWTH AND ADJUSTED NET SAVINGS, 1991-2023

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Abstract

Africa's changing age structure creates a potential demographic dividend, but it does not establish that faster or more sustainable development has occurred. This study examines the relationship between demographic change, medium-term real GDP per capita growth and adjusted net savings using an annual panel of 54 African countries from 1991 to 2023. The main two-way fixed-effects sample contains 1,155 country-year observations from 50 countries. Population-weighted trends show that the working-age share rose from 52.45% to 56.97%, the age-dependency ratio fell from 91.18 to 76.59, and total fertility declined from 5.87 to 4.12 births per woman. Pooled regressions display the familiar demographic-dividend pattern, but the working-age and dependency coefficients become small and statistically insignificant after country and year effects are introduced. Sequential fixed-effects models also show no robust direct age-structure association. Fertility is negatively associated with five-year forward annualised growth in the fully controlled baseline model ($\beta = -1.115$, $p = .032$ with country-clustered inference; $p = .001$ with Driscoll–Kraay inference), but the estimate is sensitive to the control set and loses conventional significance in several stricter checks, including country-specific trends and non-overlapping five-year windows. Interaction terms involving secondary enrolment, employment and female labour-force participation are not robustly significant, and the demographic indicators do not predict adjusted net savings. The findings are associational rather than causal. They support a conditional interpretation in which reproductive choice and age-structure change create opportunities whose economic value depends on learning quality, productive employment, women's economic participation, investment and capable institutions.

Keywords: Africa; Adjusted net savings; Demographic dividend; Fertility transition; Panel data; Sustainable economic development; Working-age population

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1. Introduction

Africa's population structure is changing in ways that will shape development choices for decades. Mortality has fallen, fertility is declining unevenly, and the proportion of people in the working ages is rising in many countries. These shifts create the possibility of a demographic dividend, but recent research shows that the gain appears only when age-structure change is matched by productive employment, human-capital investment, reproductive choice and capable institutions (Cardona et al., 2020; United Nations Department of Economic and Social Affairs, Population Division [UN DESA], 2024a; Woldegiorgis, 2023a). The distinction between possibility and outcome is central. A lower dependency ratio can ease pressure on households and public budgets, but it does not determine whether young adults will find productive work. Recent African evidence therefore treats the dividend as a multisectoral achievement involving health, education, women's empowerment, labour markets, governance and economic institutions rather than as a mechanical consequence of population change (Rusatira et al., 2023; United Nations Population Fund, West and Central Africa Regional Office [UNFPA WCARO], 2024).

Africa also cannot be treated as a single demographic case. Countries differ sharply in fertility, mortality, age structure, employment systems, education quality, institutional capacity and exposure to conflict. Recent continental assessments recommend strategies tailored to each country's position in the demographic transition instead of a uniform prescription for the whole continent (Cilliers, 2025; United Nations Economic Commission for Africa [UNECA], 2025a; Woldegiorgis, 2023a). Empirical work is cautiously optimistic: fixed-effects evidence identifies fertility decline, productive employment, human capital and institutional quality as important conditions, while research on ECOWAS indicates that gains associated with a growing working-age population depend partly on economic institutions. The literature is consequently moving away from deterministic claims and towards a conditional account of the dividend (Gakpa & Kouadio, 2023; Woldegiorgis, 2023a, 2023b).

This study contributes in three ways. First, it uses a continent-wide annual panel rather than a single-country trend model. Second, it separates cross-country associations from within-country changes by comparing pooled estimates with country and year fixed effects. This distinction matters because countries with lower fertility and more favourable age structures may also possess long-standing institutional, geographic and historical advantages. Third, it examines medium-term future growth and adjusted net savings rather than relying on contemporaneous correlation or a simple time trend. The purpose is not to claim a definitive causal estimate, but to determine how much of the apparent dividend remains after stricter controls for unobserved heterogeneity and common shocks.

2. Statement of the Problem

Africa's demographic opportunity is often discussed more quickly than its employment and education systems are changing. Recent ILO evidence identifies the shortage of productive and decent work as the region's central youth labour-market challenge, while the 2025 Spotlight report documents continuing weaknesses in foundational learning. A larger working-age population cannot generate sustained per capita gains when jobs remain low-productivity, skills are weak or firms cannot expand (Global Education Monitoring Report Team et al., 2025; International Labour Organization [ILO], 2024; World Bank, 2025). A second problem is methodological. Demographic

indicators are slow-moving and strongly correlated. Fertility, dependency, working-age share, income, urbanisation and schooling often move together over long periods. Panel methods are therefore needed to separate persistent cross-country differences from changes within countries and to avoid treating mechanically related demographic measures as independent forces (Baltagi, 2021; Hsiao, 2022).

A third problem concerns the meaning of sustainability. Output growth over a few years is not equivalent to sustainable development. The concept also concerns whether countries build human, produced and natural wealth. This study therefore operationalises sustainable economic development narrowly and transparently: five-year forward real GDP per capita growth is the primary outcome, while adjusted net savings is a complementary indicator of wealth accumulation after depreciation, education expenditure, resource depletion and pollution damage are taken into account (UN DESA, 2024b; World Bank, 2024a). The empirical question is whether changes within African countries in fertility and age structure predict these outcomes after stable country characteristics and shared annual shocks are controlled, and whether broad measures of education, employment and women's labour-force participation condition the relationship.

3. Aim and Objectives

The aim of the paper is to assess the relationship between Africa's changing demographic structure and selected indicators of sustainable economic development, and to identify the policy conditions required for a stronger dividend. It specific objectives include, to:

1. describe continental trends in fertility, dependency, working-age population, education, employment, health, urbanization and real income.
2. estimate the association between demographic indicators and medium-term real GDP per capita growth.
3. determine whether the estimated associations persist after country-specific characteristics and common year shocks are controlled.
4. examine whether education, employment and female labour-force participation moderate the association between the working-age share and growth.
5. test whether demographic indicators are associated with adjusted net savings as a complementary sustainability outcome.

4. Research hypotheses

The paper is guided by the following hypotheses:

H_{01}: The age-dependency ratio has no statistically significant association with five-year forward real GDP per capita growth in African countries after controlling for country-specific characteristics and common year effects.

H_{01}b: The working-age population share has no statistically significant association with five-year forward real GDP per capita growth in African countries after controlling for country-specific characteristics and common year effects.

H_{02}: The total fertility rate has no statistically significant association with five-year forward real GDP per capita growth in African countries after controlling for country-specific characteristics and common year effects.

H_{03}: Secondary-school enrolment, employment and female labour-force participation do not significantly moderate the relationship between the working-age population share and five-year forward real GDP per capita growth in African countries.

H_{04}: The age-dependency ratio, working-age population share and total fertility rate have no statistically significant association with adjusted net savings in African countries.

5. Methodology

5.1 Research design, scope and data

The study adopts an observational longitudinal design based on an unbalanced country-year panel. The source panel covers all 54 sovereign African countries from 1991 to 2023, producing 1,782 potential observations. Data were obtained from the World Bank's World Development Indicators (WDI) and archived on 25 July 2026. The demographic series draw mainly on the United Nations Population Division, while the employment and labour-force indicators draw on modelled estimates of the International Labour Organization. Except for the original theoretical formulations, the conceptual, empirical and policy literature was limited primarily to publications from 2020 to 2026. Journal references were checked against DOI or publisher records, while institutional reports were checked against the official repositories of the issuing organisations.

The descriptive analysis uses the full period. The principal outcome is five-year forward annualised real GDP per capita growth, so the last usable base year is 2018. Complete information on the outcome, initial income, investment, trade, urbanisation and employment reduces the principal estimation sample to 1,155 observations from 50 countries. Burundi, Liberia and Nigeria are excluded because the archived WDI workbooks contain no investment and trade observations for the study period; Seychelles is excluded because the archived employment series is unavailable. The education-interaction model contains 669 observations because gross secondary-enrolment data are less complete. Appendix B reports usable observations for every country.

Countries, rather than population, are the unit of inference in the main regressions, and each country-year receives equal weight. Population-weighted estimates are reported as a sensitivity test because continental aggregate trends and country-level relationships answer different questions. Missing values are handled by complete-case estimation within each model; no statistical imputation is used (Baltagi, 2021; Hsiao, 2022).

Table 1. Variables, measurement and sources

Variable	Operational measure	Role	WDI code
Five-year forward GDP per capita growth	Annualized log change in constant-2015-US$ GDP per capita from t to t + 5	Primary outcome	NY.GDP.PCAP. KD
Adjusted net savings	Net national saving plus education expenditure, less depletion and pollution damage, % of GNI	Supplementary sustainability outcome	NY.ADJ.SVNG.GN.ZS
Age-dependency ratio	Population aged 0–14 and 65+ per 100 persons aged 15–64	Demographic exposure	SP.POP.DPND
Working-age	Population aged 15–64 as %	Demographic	SP.POP.1564.TO.ZS

share	of total population	exposure	
Total fertility rate	Expected births per woman under current age-specific fertility rates	Demographic exposure	SP.DYN.TFRT.IN
Secondary enrolment	Gross secondary-school enrolment ratio	Moderator	SE.SEC.ENRR
Employment ratio	Employed persons aged 15+ as % of population aged 15+	Moderator / possible pathway	SL.EMP.TOTL. SP. ZS
Female labour-force participation	Women aged 15+ in the labour force as % of female population aged 15+	Moderator	SL.TLF.CACT.FE. ZS
Initial income	Natural logarithm of real GDP per capita in year t	Control	NY.GDP.PCAP. KD
Investment	Gross capital formation as % of GDP	Control / possible pathway	NE.GDI.TOTL. ZS
Trade openness	Exports plus imports as % of GDP	Control	NE.TRD.GNFS. ZS
Urbanization	Urban population as % of total population	Control	SP.URB.TOTL.IN.ZS

Note. WDI = World Development Indicators. Adjusted net savings is used as a sustainability indicator; it is not treated as a direct measure of household life-cycle saving.

5.2 Model specification and estimation strategy

To reduce the influence of single-year shocks and align demographic conditions with later economic performance, the main dependent variable is defined as:

$$g_{i,t}^{(5)} = \frac{100}{5}\left[ln(y_{i,t+5}) - ln(y_{i,t})\right]$$

where y denotes real GDP per capita. The outcome is winsorised at the first and ninety-ninth percentiles in the main analysis; raw growth and three-year and one-year alternatives are retained for robustness tests.

The baseline two-way fixed-effects model is:

$$g_{i,t}^{(5)} = \alpha + \beta D_{i,t} + \gamma X_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$

where D is one demographic indicator at a time; X is a vector of observed covariates; μ_i captures time-invariant country characteristics; λ captures shocks common to all countries in year t; and ε_i, is the idiosyncratic error. Dependency and working-age share are estimated separately because their correlation in the assembled panel is −.994 and the measures are mechanically related (Baltagi, 2021; Hsiao, 2022).

To distinguish adjustment variables from possible transmission channels, the analysis reports three sequential two-way fixed-effects models on a common sample. Model A contains the demographic indicator and initial income. Model B adds trade openness and urbanisation. Model C adds investment and employment. Because investment and employment may partly mediate a demographic dividend, the Model C coefficient is interpreted as a controlled direct association

rather than the total demographic relationship. The main tables also compare pooled, year-effects, country-effects and two-way fixed-effects estimates.

Conditional models interact the centred working-age share with centred secondary enrolment, employment and female labour-force participation. The principal effects and interaction terms are reported in Appendix D. Country-clustered standard errors with finite-sample corrections provide the main inference. Driscoll–Kraay standard errors are also reported through the cross-sectional group-sum estimator with four lags, reflecting the four years of overlap between adjacent five-year forward-growth observations. The diagnostic section reports a Pesaran-style cross-sectional dependence statistic constructed from pairwise residual correlations, a within-panel residual AR(1) regression, and a Breusch–Pagan heteroskedasticity test. Their null hypotheses are, respectively, cross-sectional independence, no first-order residual persistence, and homoskedasticity. These diagnostics guide the covariance estimators but do not establish causal identification (Hsiao, 2022; MacKinnon et al., 2023).

Robustness checks use raw five-year growth, a three-year forward outcome, annual growth, life expectancy as an additional covariate, exclusion of major oil exporters, lagged demographic indicators, minimum-observation restrictions, population weights, country-specific linear trends, non-overlapping five-year windows and adjusted net savings. Governance is not included as a direct regressor because a consistent annual series was not archived with the study data. Governance-related policy implications are therefore drawn from the cited literature rather than claimed as an empirical result of this model. Reverse causality, measurement error and time-varying omitted variables may remain.

6. Conceptual Review

6.1 Demographic transition

The demographic transition is the movement from high mortality and fertility towards lower mortality and fertility. Mortality commonly falls first, increasing child survival and population growth. Fertility then declines with a lag, changing the population's age composition. The transition is not a single event and does not proceed at the same speed across countries; Africa's current demographic landscape therefore contains countries at markedly different stages (UN DESA, 2024a).

6.2 Demographic dividend

The first demographic dividend is the temporary increase in output per person that may occur when the effective labour force grows faster than the dependent population. A later dividend may emerge if longer lives and smaller families encourage saving, asset accumulation and investment for old age. Recent African scholarship treats both gains as policy-dependent processes rather than automatic results of age-structure change (Cilliers, 2025; Woldegiorgis, 2023a).

6.3 Demographic window and realised dividend

A demographic window describes a potentially favourable population structure. A realised dividend is an economic gain produced when that structure is combined with effective policy and investment. Recent frameworks distinguish the two and show that family planning, maternal and child health, education, women's empowerment, labour markets, governance and economic institutions must reinforce one another (Cardona et al., 2020; Rusatira et al., 2023).

6.4 Sustainable economic development

Sustainable economic development is used here to mean durable improvement in real income per person supported by productive capacity and the maintenance of national wealth. The empirical definition is deliberately limited to medium-term growth and adjusted net savings. The latter incorporates education expenditure while accounting for depreciation, resource depletion and pollution damage, thereby adding an intergenerational wealth perspective without claiming to measure all social and environmental dimensions of sustainability (UN DESA, 2024b; World Bank, 2024a, 2026b).

6.5 Opportunities and challenges

The opportunity lies in a growing labour supply, smaller average families, and greater investment per child, higher female employment and stronger saving. The challenge is to convert these changes into broad-based productivity and welfare. Poor learning outcomes, informality, unemployment, conflict, weak health systems, gender barriers and low investment can interrupt the process at several points. The practical question is not simply how many working-age people Africa will have, but how healthy, skilled, productive and economically included they will be (Cardona et al., 2020; Global Education Monitoring Report Team et al., 2025; ILO, 2024; World Bank, 2024b, 2025).

7. Literature Review

Recent African literature has consolidated the demographic dividend into a conditional development framework. A systematic review of Sub-Saharan African evidence identified governance and economic institutions, family planning, maternal and child health, education, women's empowerment and labour markets as mutually reinforcing sectors. Later work developed measurable indicators of national effort and again found that progress must be coordinated across these policy areas (Cardona et al., 2020; Rusatira et al., 2023). Recent econometric evidence also questions simple age-structure determinism. Woldegiorgis (2023a) used fixed-effects analysis for 34 African countries and identified human capital, employment and institutional conditions as relevant drivers; a companion study connected demographic opportunity to inclusive development (Woldegiorgis, 2023b). In ECOWAS, Gakpa and Kouadio (2023) found that the growth relationship associated with demographic transition depended partly on economic freedom and institutional conditions.

Policy-oriented studies reach a similar conclusion. Current UNFPA and UNECA assessments place voluntary reproductive health, education, women's agency, job creation, migration, industrialisation and effective governance at the centre of the African demographic-dividend agenda. They also stress that the appropriate policy mix varies with a country's stage of transition and productive structure (Cilliers, 2025; UNECA, 2025a; UNFPA WCARO, 2024).

Fertility remains important because it shapes age structure and the allocation of resources within families, but the recent literature does not support coercive numerical targets. The emphasis is on voluntary family planning, child and maternal health, girls' education, women's agency and the capacity of schools and labour markets to absorb large cohorts (Cardona et al., 2020; UN DESA, 2024a; UNFPA WCARO, 2024). An empirical gap nevertheless remains. Many studies use simulations, cross-sectional comparisons, policy reviews or panels that end before the pandemic. These approaches clarify mechanisms and possible futures, but they do not settle whether annual

demographic changes within countries predict later growth after fixed country characteristics and shared shocks are removed. This study addresses that question with a 1991-2023 panel, alternative covariance estimators, sequential controls and an additional sustainability outcome (Baltagi, 2021; Hsiao, 2022).

8. Theoretical Framework

8.1 Demographic Transition Theory

Demographic Transition Theory was outlined systematically by Warren S. Thompson (1929) and developed more explicitly by Frank W. Notestein (1945). It assumes that societies tend to move from high mortality and fertility to lower mortality and fertility as public health, education, urbanisation and economic organisation change. Mortality normally declines first, producing rapid population growth; subsequent fertility decline lowers child dependency and increases the working-age share. The theory's strength is its direct explanation of how fertility and mortality reshape age structure and create a possible demographic window. Its weakness is that the stages can appear too linear and universal, whereas African transitions differ in timing and can be interrupted by conflict, migration, health crises, institutional weakness and persistent social norms. In this study, the theory anchors the fertility, dependency and working-age variables, but the panel models test whether the expected economic association actually appears across heterogeneous African countries (Thompson, 1929; Notestein, 1945; UN DESA, 2024a; Woldegiorgis, 2023a).

8.2 Life-Cycle Hypothesis

The Life-Cycle Hypothesis was proposed by Franco Modigliani and Richard Brumberg (1954). It assumes that individuals seek to smooth consumption over their lives: they save during their principal working years and draw down accumulated assets in old age. At the aggregate level, a larger working-age population may therefore raise saving and investment, creating a possible second demographic dividend. Its strength is that it extends the demographic-dividend argument beyond labour supply to asset accumulation. Its weakness is its reliance on foresight, predictable earnings and access to financial or pension systems conditions that may be weak in economies marked by poverty, informality, unemployment and limited financial inclusion. Adjusted net savings is used here only as a broad sustainability outcome, not as a direct test of household life-cycle behaviour. The absence of a demographic association with adjusted net savings therefore indicates a lack of evidence for national wealth accumulation in these models, rather than a definitive rejection of the Life-Cycle Hypothesis (Modigliani & Brumberg, 1954; Cardona et al., 2020; Cilliers, 2025).

8.3 Human Capital Theory

Human Capital Theory is associated principally with Theodore W. Schultz (1961) and Gary S. Becker (1964), who treated education, training and health as productive investments. The theory assumes that such investments increase workers' skills, productivity and future earnings. In demographic-dividend analysis, lower fertility may allow households and governments to devote more resources to each child and improve the quality of the future labour force. The theory's central strength is that it corrects the tendency to treat every working-age adult as equally productive. Its weakness is that it can place excessive emphasis on individual investment and years of schooling while underestimating learning quality, unequal access, labour demand and institutional barriers. Education cannot generate broad gains where suitable jobs and productive firms are absent. The theory supports the inclusion of secondary enrolment and life expectancy and informs the

interaction test of whether education strengthens the working-age association (Schultz, 1961; Becker, 1964; Cunningham et al., 2025; Global Education Monitoring Report Team et al., 2025).

8.4 Unified Growth Theory

Unified Growth Theory was developed by Oded Galor and David N. Weil (2000). It links technological progress, human-capital investment, fertility behaviour and long-run growth. As technology increases the return to education, families gradually shift from having more children to investing more in fewer children. Fertility decline, improved human capital and changing age structure then contribute to sustained income growth. Its principal advantage is that it integrates demographic transition and human-capital mechanisms within a dynamic explanation and recognises that their effects unfold gradually. Its weakness is that the model is highly stylised and may not fully capture short-run shocks, institutional diversity, conflict, resource dependence and segmented labour markets across Africa. The theory helps explain why fertility may reflect a broader stage of structural transition than the current working-age share and supports the use of forward outcomes and lagged robustness tests (Galor & Weil, 2000; Gakpa & Kouadio, 2023; Woldegiorgis, 2023b).

8.5 Integrated theoretical explanation

Together, the four theories describe connected stages in the conversion of demographic change into sustainable development. Demographic Transition Theory explains how mortality and fertility changes alter dependency and open a demographic window. Human Capital Theory explains how smaller families and public investment can improve the health, education and productivity of emerging cohorts. The Life-Cycle Hypothesis describes how a concentration of adults in the working ages may support saving and asset accumulation, while Unified Growth Theory connects fertility choices, technological change, skills and long-run growth. The theories are complementary rather than competing. A favourable age structure creates an opportunity; productive employment, women's economic inclusion, financial systems and effective institutions determine whether it becomes growth and lasting welfare. In the empirical model, fertility, dependency and working-age share represent the demographic transition; education and health represent human-capital conditions; employment, investment and trade capture productive absorption; and adjusted net savings provides a separate wealth-sustainability check. This integrated framework predicts favourable pooled relationships but also allows them to weaken when country-specific conditions and common stocks are controlled (Cardona et al., 2020; Rusatira et al., 2023; ILO, 2024; UNECA, 2025b).

9. Results

9.1 Descriptive profile and continental trends

Table 2. Population-weighted indicators for Africa, selected years

Year	Working-age %	Dependency ratio	Fertility	Secondary enrolment %	Employment %	Life expectancy	Real GDP pc (US$)
1991	52.45	91.18	5.87	34.33	63.57	52.7	1,503
2000	53.8	86.94	5.32	37.24	63.89	54.62	1,493

2010	54.98	83.54	5	46.75	64.02	59.37	1,902
2020	56.2	79.05	4.3	58.65	59.76	62.74	1,894
2023	56.97	76.59	4.12	61.32	62.68	64.2	1,975

Note. Author's calculations from WDI (World Bank, 2026b). Population weights are recalculated separately for each indicator-year using countries with non-missing observations.

Africa's age structure became more favourable over the study period. The population-weighted working-age share increased by 4.52 percentage points between 1991 and 2023, while the dependency ratio declined by 14.59 dependants per 100 working-age persons and fertility fell by 1.76 births per woman. These changes were accompanied by gains in life expectancy and secondary enrolment, but real GDP per capita remained volatile.

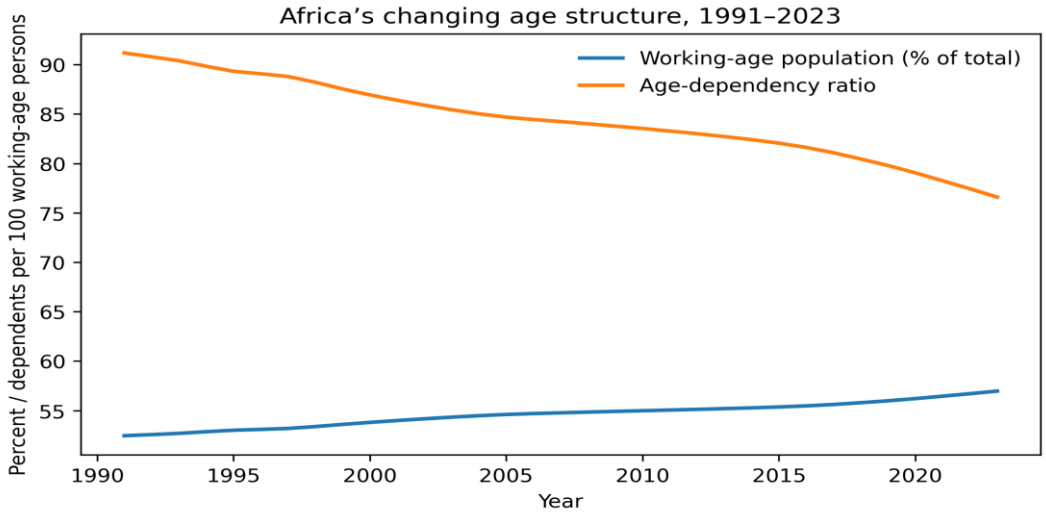

Figure 1. Population-weighted working-age share and age-dependency ratio in Africa, 1991–2023.

Note. Author's calculations from WDI (World Bank, 2026b).

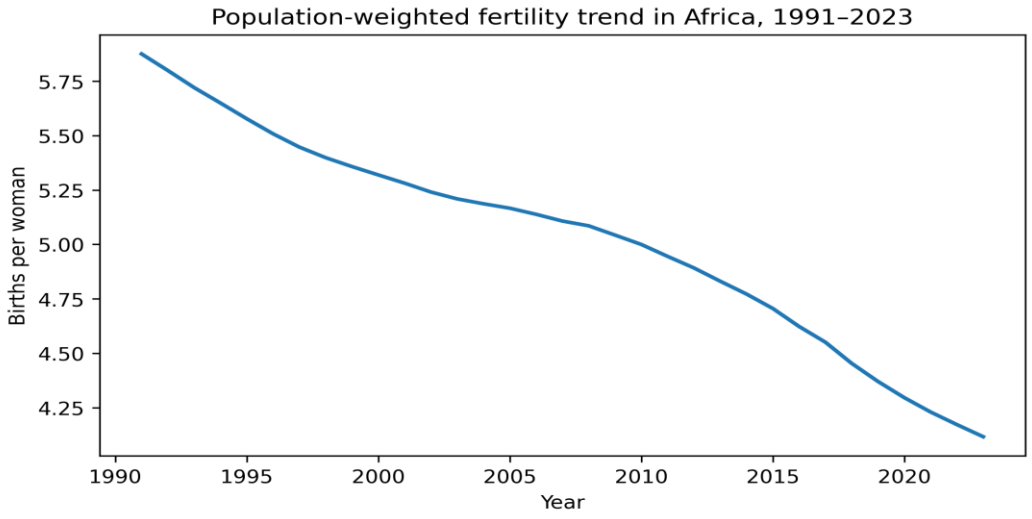

Figure 2. Population-weighted total fertility rate in Africa, 1991–2023.

Note. Author's calculations from WDI (World Bank, 2026b).

Table 3. Descriptive statistics for the country-year panel

Variable	N	Mean	SD	Minimum	Maximum
Five-year forward GDP pc growth (%)	1452	1.4	3.01	-8.78	11.84
Age-dependency ratio	1782	83.2	16.1	38.39	118.45
Working-age share (%)	1782	55.05	5.34	45.78	72.26
Total fertility rate	1782	4.85	1.46	1.33	7.84
Secondary enrolment (%)	961	44.79	26.4	3.35	119.79
Employment-to-population ratio (%)	1748	57.46	16.1	19.84	86.73
Female labour-force participation (%)	1748	54.18	19.6	11.54	89.95
Life expectancy (years)	1782	58.44	8.51	12.16	77.24
Gross capital formation (% GDP)	1459	22	9.97	-15.68	76.78
Trade openness (% GDP)	1470	67.35	37	2.47	347.72
Urban population (%)	1782	40.67	18	5.36	91.64
Real GDP per capita (2015 US$)	1722	2,196	2,764	187	19,482

Note. Author's calculations from WDI (World Bank, 2026b). The five-year growth outcome is winsorised at the 1st and 99th percentiles.

The country-year data show substantial heterogeneity. Fertility ranges from 1.33 to 7.84 births per woman, life expectancy from 12.16 to 77.24 years, and real GDP per capita from $187 to $19,482. Secondary-enrolment coverage is much weaker than coverage for the demographic indicators. Dependency and working-age share correlate at −.994; fertility correlates .911 with dependency and −.897 with working-age share. The demographic indicators are therefore introduced in separate models. Among the covariates in the fertility model, variance-inflation factors range from 1.12 to 3.48.

9.2 Pooled associations, fixed effects and sequential controls

Table 4. Changes in demographic coefficients after fixed effects

Demographic indicator	Pooled OLS	Year effects	Country effects	Country + year effects
Dependency ratio	-0.060*** (0.016)	-0.063*** (0.017)	-0.045 (0.039)	0.003 (0.040)
Working-age share	0.187*** (0.044)	0.195*** (0.047)	0.130 (0.112)	-0.023 (0.106)
Total fertility rate	-0.778*** (0.206)	-0.849*** (0.213)	-1.625*** (0.485)	-1.115** (0.505)

Note. Dependent variable: winsorised five-year forward annualised real GDP per capita growth. All models use the same controls: initial income, investment, trade openness, urbanization and employment. Country-clustered standard errors are in parentheses. N = 1,155; countries = 50. * p < .10, ** p < .05, *** p < .01.

The pooled estimates reproduce the conventional demographic-dividend pattern. A one-point increase in the working-age share is associated with 0.187 percentage points faster annualised growth over the next five years, while higher dependency and fertility are associated with slower growth. Once country effects are introduced, the dependency and working-age coefficients decline sharply and lose statistical significance, indicating that much of the pooled age-structure pattern reflects persistent differences between countries.

Table 5. Sequential two-way fixed-effects models on a common sample

Demographic indicator	Model A	Model B	Model C
Dependency ratio	0.017 (0.036)	0.002 (0.040)	0.003 (0.040)
Working-age share	-0.059 (0.097)	-0.022 (0.107)	-0.023 (0.106)
Total fertility rate	-0.962 (0.580)	-1.158** (0.535)	-1.115** (0.505)

Note. Model A includes initial income. Model B adds trade openness and urbanisation. Model C adds investment and employment. All models include country and year fixed effects and use country-clustered standard errors. N = 1,155; countries = 50. Model C is interpreted as a controlled direct association because investment and employment may be transmission channels. * p < .10, ** p < .05, *** p < .01.

The sequential models confirm the absence of a robust direct association for dependency and working-age share. Fertility is negative in all three specifications, but it does not reach conventional significance in Model A (p = .103). It becomes significant after trade and urbanisation are added and remains significant in Model C. This pattern reinforces the need to treat fertility as a specification-sensitive marker of a broader transition rather than as an isolated causal lever.

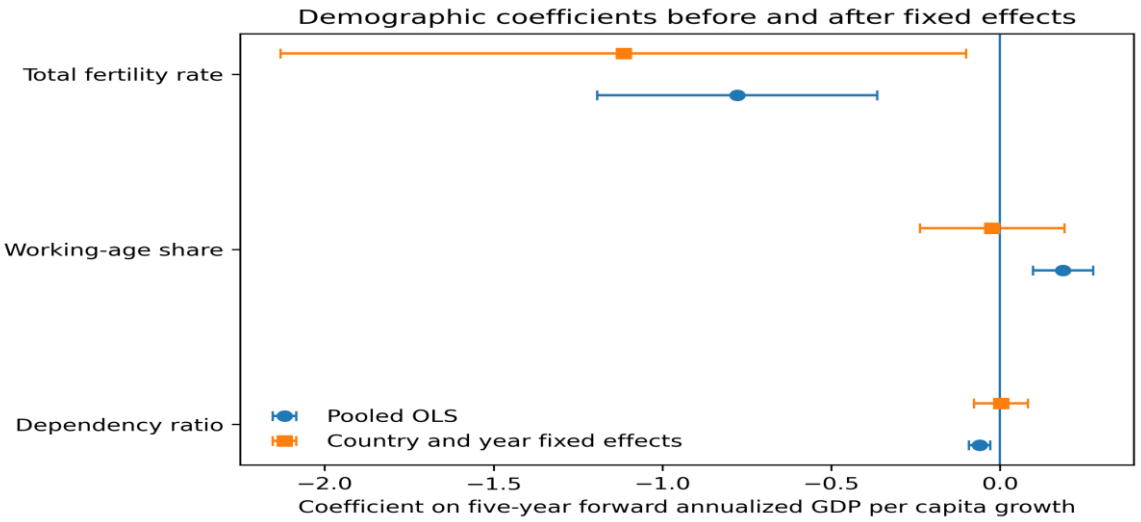

Figure 3. Demographic coefficients in pooled and two-way fixed-effects models.

Note. Error bars show 95% confidence intervals based on country-clustered standard errors. Author's estimates using WDI data (World Bank, 2026b).

Table 6. Two-way fixed-effects estimates with alternative standard errors

Indicator	Coefficient	Cluster SE	Cluster p	D–K SE	D–K p	N	Adj. R^2
Dependency ratio	0.003	0.04	0.937	0.025	0.902	1155	0.453
Working-age share	-0.023	0.106	0.83	0.064	0.72	1155	0.453
Total fertility rate	-1.115	0.505	0.032	0.326	0.001	1155	0.462

Note. Each row is a separate Model C regression with initial income, investment, trade openness, urbanization, employment, country effects and year effects. D–K = Driscoll–Kraay covariance estimated with the cross-sectional group-sum method and four lags. Countries = 50.

The residual diagnostics reject cross-sectional independence (Pesaran-style statistic = −2.20, p = .028), no first-order residual persistence (within-panel AR(1) coefficient = .812, p < .001), and homoskedasticity (Breusch–Pagan LM = 353.10, p < .001). The Driscoll-Kraay results leave the age-structure conclusions unchanged and produce a more precise fertility estimate. These diagnostics justify reporting both country-clustered and cross-sectionally robust inference, but they do not make the estimates causal.

9.3 Conditional effects

Table 7. Interactions between working-age share and enabling conditions

Moderator	Interaction coef.	Cluster SE	Cluster p	D–K SE	D–K p	N
Education	-0.0004	0.0025	0.869	0.0013	0.751	669
Employment	0.0076	0.0062	0.227	0.0045	0.098	1155
Female labour-force participation	0.0035	0.0042	0.418	0.0029	0.24	1155

Note. All variables entering an interaction are mean-centred. Models include the main effects, the interaction, the stated Model C controls, country effects and year effects. The employment model omits employment from the control list because it is entered as a moderator. Full principal and interaction coefficients are reported in Appendix D.

None of the interaction terms is statistically significant at the 5% level under both covariance estimators. The employment interaction is positive and close to the 10% level with Driscoll-Kraay inference, but its country-clustered p-value is .227. The education model is based on only 669 observations and therefore has less precision and a different sample composition. The results do not imply that education, employment or women's participation are unimportant; they show that broad annual macro indicators do not identify stable linear moderation effects after demanding fixed effects are applied.

9.4 Robustness and sustainability tests

Table 8. Robustness of the fertility association

Specification	Fertility coef.	SE	p	N	Adj. R^2
Raw 5-year growth	-1.089	0.52	0.04	1155	0.476
Winsorized 3-year growth	-1.335	0.51	0.01	1255	0.346

Winsorized annual growth	-0.139	0.69	0.84	1401	0.178
Adds life expectancy	-0.805	0.54	0.14	1155	0.476
Excludes oil exporters	-1.315	0.65	0.05	953	0.466
Lagged demographic indicator	-1.054	0.55	0.06	1119	0.47
Minimum 10 usable years	-1.125	0.51	0.03	1114	0.43
Minimum 20 usable years	-1.182	0.5	0.02	1033	0.41
Population-weighted TWFE	-0.247	0.95	0.8	1155	0.488
Country-specific linear trends	-0.863	0.77	0.27	1155	0.698
Non-overlapping 5-year windows	-0.962	0.63	0.14	243	0.315

Note. All models include country and year fixed effects and use country-clustered standard errors. The coefficient is not stable across the stricter trend, weighting, annual-growth and non-overlapping-window specifications.

The negative fertility coefficient persists under raw five-year growth, a three-year horizon, the exclusion of major oil exporters and minimum-coverage restrictions. It becomes statistically insignificant when life expectancy is added, when the demographic indicator is lagged, under population weighting, with country-specific linear trends, and in non-overlapping five-year windows. It is also absent for annual growth. The baseline association is therefore suggestive rather than a stable causal estimate.

Table 9. Demographic indicators and adjusted net savings

Adjusted net-savings outcome	Demographic indicator	Coefficient	Cluster SE	p	N
Forward five-year average ANS	Dependency ratio	0.038	0.263	0.89	757
Forward five-year average ANS	Working-age share	-0.373	0.722	0.61	757
Forward five-year average ANS	Total fertility rate	1.497	4.307	0.73	757
Annualized five-year change in ANS	Dependency ratio	0.001	0.032	0.97	753
Annualized five-year change in ANS	Working-age share	-0.025	0.087	0.77	753
Annualized five-year change in ANS	Total fertility rate	0.004	0.504	0.99	753

Note. Each row is a separate two-way fixed-effects model with the Model C controls and country-clustered standard errors. ANS = adjusted net savings. This is a sustainability test, not a direct test of household life-cycle saving.

No demographic indicator significantly predicts the forward level or subsequent change in adjusted net savings. The null estimates reinforce the central distinction between a favourable age structure and realized wealth accumulation. Investment quality, resource governance, fiscal institutions and environmental management remain separate policy tasks.

Table 10. Summary of hypothesis decisions

Hypothesis	Tested relationship	Decision	Evidence
H_{01}	Dependency and future	Not rejected	Coefficient is small and

	growth		insignificant in two-way fixed-effects models.
H_{02}	Working-age share and future growth	Not rejected	Coefficient is small and insignificant in two-way fixed-effects models.
H_{03}	Fertility and future growth	Rejected in the baseline only	Negative baseline association, but it is sensitive to controls and robustness specifications.
H_{04}	Education moderation	Not rejected	Interaction is insignificant under both covariance estimators.
H_{05}	Employment moderation	Not rejected	Interaction is not significant at 5%; D–K p = .098.
H_{06}	Female participation moderation	Not rejected	Interaction is insignificant under both covariance estimators.
H_{07}	Demography and adjusted net savings	Not rejected	No demographic coefficient is significant for either savings outcome.

Note. “Not rejected” does not establish that the true effect is zero; it indicates that the study did not find statistically sufficient evidence against the stated null hypothesis.

10. Discussion and Policy Implications

The analysis produces a clear but qualified conclusion. Africa is moving towards a more favourable age structure, yet the strongest pooled evidence for a dividend does not survive controls for stable country differences and common annual shocks. The working-age share is positively associated with growth across countries, but changes within a country do not produce a reliable average response in the two-way fixed-effects models. A demographic window should therefore be understood as an enabling condition, not as an economic policy in itself (Cilliers, 2025; Woldegiorgis, 2023a, 2023b).

The fertility result deserves attention but not causal interpretation. In the sequential models it is insignificant with only initial income and fixed effects, becomes significant after trade and urbanization are added, and remains significant in the full baseline. It then loses significance in several stricter checks. Fertility may summarize several connected processes, including child dependency, maternal labour supply, household resource allocation, female education, mortality decline and the wider health transition. The evidence supports a cautious, rights-based account of fertility transition and does not justify coercive population targets (Cardona et al., 2020; UNFPA WCARO, 2024; Woldegiorgis, 2023a).

The null interaction estimates expose the limits of broad annual indicators. Gross secondary enrolment measures participation rather than learning quality, field of study or skill relevance. The employment-to-population ratio treats subsistence work and productive formal employment alike, while female labour-force participation does not distinguish secure paid work from vulnerable activity. Better harmonized measures of learning, job quality, earnings, informality and firm labour demand are required for sharper tests (Global Education Monitoring Report Team et al., 2025; ILO, 2024; World Bank, 2024b).

Policy must therefore be sequenced but coordinated. Health and reproductive choice can accelerate the transition; education shapes cohort productivity; labour-demand policies determine whether skills are used; financial and fiscal institutions influence whether income becomes productive investment; and environmental governance determines whether current gains preserve national wealth. The governance recommendations below are grounded in the cited literature, not in a governance coefficient estimated by this study (Cardona et al., 2020; Rusatira et al., 2023; World Bank, 2024a).

10.1 Policy priorities

1. Complete a voluntary, rights-based fertility transition. Governments should expand child survival, maternal and adolescent health, comprehensive sexuality education and affordable voluntary family-planning services. The objective is to make desired family size achievable, reduce preventable mortality and widen women's life choices. Coercive targets would violate rights and may undermine trust (Cardona et al., 2020; UNFPA WCARO, 2024).

2. Move from school attendance to learning and employable capability. Enrolment gains must be matched by foundational literacy and numeracy, technical and digital skills, teacher quality, reliable assessment and pathways linking schools to firms. Public spending should be judged by learning and labour-market outcomes rather than enrolment alone (Cunningham et al., 2025; Global Education Monitoring Report Team et al., 2025).

3. Create productive work at the scale of population growth. The decisive economic test is whether firms and farms can absorb new workers at rising productivity. Reliable electricity, transport, digital infrastructure, competitive markets, regional trade, access to finance and predictable regulation are central. Policies should support productive agriculture, agro-processing, labour-absorbing manufacturing and modern services rather than rely mainly on temporary schemes (ILO, 2024; UNECA, 2025b; World Bank, 2025, 2026a).

4. Remove barriers to women's economic participation. Lower fertility can create time and opportunity, but women also need safe transport, childcare, property and inheritance rights, access to finance, protection from discrimination and jobs that reward skills. Participation without productivity, pay or security will produce only a limited dividend (UNFPA WCARO, 2024; World Bank, 2024b).

5. Build saving, investment and resource-governance institutions. The adjusted-net-savings results show that demographic change does not automatically preserve wealth. Resource revenues should be converted into infrastructure, human capital and financial assets; public investment appraisal should improve; and pollution and depletion costs should enter fiscal and development planning (UN DESA, 2024b; World Bank, 2024a).

6. Adopt country-stage strategies. High-fertility countries should prioritize child survival, girls' education and reproductive choice while preparing schools and labour markets for large cohorts. Countries further into the transition should emphasize job quality, productivity, saving and social protection. More advanced countries must also prepare for population ageing and a possible later dividend (Cilliers, 2025; UN DESA, 2024a; UNECA, 2025a).

7. Strengthen demographic and labour-market data. African statistical systems need consistent annual series on learning, informal earnings, hours worked, job transitions, migration, saving and

subnational age structure. Better data would permit causal and distributional analysis that continental aggregates cannot provide (ILO, 2024; UN DESA, 2024a; World Bank, 2026b).

11. Limitations

The study is observational and identifies conditional associations rather than causal effects. Country and year fixed effects remove time-invariant country characteristics and common annual shocks, but they do not eliminate reverse causality, time-varying omitted variables or measurement error. Demographic indicators change slowly, and the five-year forward outcome overlaps across adjacent base years. Driscoll-Kraay inference, country trends and non-overlapping windows reduce some concerns but do not fully resolve identification.

The main sample excludes four countries because key control variables are missing, and several included countries contribute relatively few observations. Secondary-enrolment coverage is especially limited. The moderators are broad quantity measures that do not capture learning quality, job quality, earnings, informality or the security of women's work. Adjusted net savings is a useful wealth indicator but does not represent every social and environmental dimension of sustainable development and is not a direct measure of household saving behaviour.

Institutional quality is central to the theoretical and policy argument but is not directly estimated because a consistent annual governance series was not part of the archived dataset. Future research should combine comparable governance, education-quality, employment-quality and reproductive-health measures with designs that exploit credible policy reforms or demographic shocks. Subregional and country-specific studies are also needed because a continental average can conceal markedly different transition paths.

12. Conclusion

Africa's demographic transition is real and economically important. Between 1991 and 2023, fertility and dependency fell while the working-age share rose. These changes expand the field of economic possibility, but they do not guarantee that income, saving or national wealth will rise. The pooled regressions display a demographic-dividend pattern; the fixed-effects and sequential models show how fragile that pattern becomes when persistent cross-country differences and alternative control sets are considered.

The strongest baseline signal is the negative association between fertility and medium-term real GDP per capita growth. Because this result is sensitive to specification, it should be interpreted as part of a wider transition involving health, women's opportunities, child investment and labour markets. Neither working-age share nor dependency has a robust direct within-country association, and none of the demographic indicators predicts adjusted net savings.

The policy implication is not that demography is irrelevant. It is that demography works through institutions and economic choices. Africa can harness population change by enabling people to choose smaller and healthier families, ensuring that children learn, creating firms and sectors able to employ them productively, widening women's economic freedom, and investing current income without eroding future wealth. The dividend is therefore best understood not as a gift delivered by age structure, but as a development achievement that must be built (Cardona et al., 2020; Cilliers, 2025; UNECA, 2025a; UNFPA WCARO, 2024).

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Appendix A.

Country coverage

Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Dem. Rep., Congo, Rep., Cote d'Ivoire, Djibouti, Egypt, Arab Rep., Equatorial Guinea, Eritrea, Eswatini, Ethiopia, Gabon, Gambia, The, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Libya, Madagascar, Malawi, Mali, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, Fed. Rep., South Africa, South Sudan, Sudan, Tanzania, Togo, Tunisia, Uganda, Zambia, Zimbabwe.

Appendix B.

Main estimation-sample coverage

Table B1. Usable country-year observations in the main Model C sample

Country	Usable years	Country	Usable years	Country	Usable years
Algeria	28	Eswatini	6	Namibia	28
Angola	17	Ethiopia	8	Niger	28
Benin	28	Gabon	28	Nigeria	0
Botswana	28	Gambia, The	28	Rwanda	28
Burkina Faso	28	Ghana	28	Sao Tome and Principe	11
Burundi	0	Guinea	28	Senegal	28
Cabo Verde	12	Guinea-Bissau	28	Seychelles	0
Cameroon	28	Kenya	28	Sierra Leone	28
Central African	28	Lesotho	12	Somalia, Fed.	7

Republic				Rep.	
Chad	28	Liberia	0	South Africa	28
Comoros	28	Libya	28	South Sudan	3
Congo, Dem. Rep.	25	Madagascar	28	Sudan	28
Congo, Rep.	28	Malawi	2	Tanzania	28
Cote d'Ivoire	28	Mali	28	Togo	28
Djibouti	6	Mauritania	28	Tunisia	28
Egypt, Arab Rep.	28	Mauritius	28	Uganda	28
Equatorial Guinea	14	Morocco	28	Zambia	9
Eritrea	15	Mozambique	28	Zimbabwe	28

Note. Zero usable observations: Burundi, Liberia and Nigeria because investment and trade are unavailable in the archived WDI workbooks; Seychelles because employment is unavailable. Included-country coverage ranges from 2 to 28 usable base years. The main sample contains 1,155 observations from 50 countries.

Appendix C. Full two-way fixed-effects coefficients

Table C1. Full Model C coefficients

Variable	Dependency model	Working-age model	Fertility model
Dependency ratio	0.003 (0.040)	—	—
Working-age share	—	-0.023 (0.106)	—
Total fertility rate	—	—	-1.115** (0.505)
Initial log income	-6.758*** (1.060)	-6.726*** (1.084)	-7.105*** (1.096)
Trade openness	0.024* (0.013)	0.024* (0.013)	0.023* (0.013)
Urbanisation	-0.034 (0.090)	-0.033 (0.088)	-0.062 (0.083)
Investment	-0.012 (0.022)	-0.013 (0.022)	-0.003 (0.021)
Employment ratio	-0.052 (0.079)	-0.050 (0.078)	-0.041 (0.078)

Note. Dependent variable: winsoried five-year forward annualized real GDP per capita growth. All models include country and year fixed effects. Country-clustered standard errors are in parentheses. N = 1,155; countries = 50. Dummy coefficients are omitted. * p < .10, ** p < .05, *** p < .01.

Appendix D. Full interaction terms

Table D1. Principal and interaction coefficients

Model	Term	Coefficient	Cluster SE	P	N
Education	Centred working-age share	-0.1637	0.2128	0.446	669
Education	Centred secondary enrolment	0.0340	0.0294	0.252	669
Education	Working-age × education	-0.0004	0.0025	0.869	669
Employment	Centred working-age share	0.0612	0.1490	0.683	1155
Employment	Centred employment	-0.0364	0.0805	0.653	1155
Employment	Working-age × employment	0.0076	0.0062	0.227	1155
Female labor participation	Centred working-age share	0.0394	0.1411	0.781	1155
Female labor participation	Centred female participation	-0.0211	0.0769	0.785	1155
Female labor participation	Working-age × female participation	0.0035	0.0042	0.418	1155

Note. All models include country and year fixed effects and the control set described in Table 7. Variables entering interactions are mean-centred. Country-clustered standard errors are reported.