ISSN (Print): 1060-6076
ISSN (Online): Applied

The Journal of African Development
2026; Vol 7: Issue 1
https://www.afea-jad.com/

The Brain Drain in Sub-Saharan Africa: What impact does it have on Human Development? An Analysis Using Beta Regression

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Cite This Paper as: Jacques Hakizimana, Gilles-Fabrice Ndombi Avouba, Conte Facinet, Akouele Arsène Fabrice The Brain Drain in Sub-Saharan Africa: What impact does it have on Human Development? An Analysis Using Beta Regression The Journal Of African Development L, Vol.7, No.1, 281-295

KEYWORDS
brain drain; human development; beta regression; panel data; sub-Saharan Africa..

ABSTRACT

This paper analyses the effects of brain drain in Sub-Saharan African countries of origin. Because
of data availability constraints, particularly for the “brain drain” variable, the study uses data from
29 countries for 2007–2023. We first estimate the model using beta regression, which accounts for the Human Development Index's bound continuous values between 0 and 1. Second, we employ the Tobit model to verify the robustness of the results. In addition, we provide estimates of the various components of human development, calculated using generalised least squares. The results show that the brain drain hinders human development. This finding suggests implementing effective talent retention policies to deter skilled workers from migrating. These include, among other things: (i) improving the social, economic, and professional conditions of skilled workers; (ii) granting graduate scholarships conditional on a commitment to return after completing studies; (iii) promoting policies that incentivise the return of skilled migrants.

1. INTRODUCTION

The migration of skilled workers, commonly referred to as the “brain drain” or “skills exodus,” is a growing concern and a source of anxiety for many countries, particularly developing nations (African Union Commission/Organization for Economic Cooperation and Development (AUC/OECD), 2024; International Organisation for Migration, IOM, 2024; Vega-Muñoz et al.,
2021).

Like other developing nations, Africa also faces brain drain. In this context, this paper aims to analyse the effects of brain drain on human development in Sub-Saharan Africa to answer the following question: What are the effects of brain drain in Sub-Saharan African countries? The literature treats this issue as controversial in both theory and practice.

In theory, skilled migration has consequences for human development, with the debate between “brain drain”, which highlights the negative effects of skill loss (Vega-Muñoz et al., 2021), and “brain gain,” which asserts that the exodus of skilled workers can enhance human development in countries of origin (Oudinet, 2021).

To support their arguments, proponents of the first approach draw on human capital theory (Becker, 1964) and the neoclassical theory of brain drain (Bhagwati & Hamada, 1974). These theories explain brain drain's negative effects on human development through consequences such as declines in human capital and economic growth, reduced innovation, increased inequality, and rising social and public service costs.

Proponents of the second approach, for their part, favour the theory of learning and return migration (Mayr & Peri, 2008), the theory of incentive migration (Piguet, 2013) and the role of remittances to countries of origin (Meyer & Shera, 2017). These theories suggest that brain drain

can promote human development through channels such as remittances, technology transfers, and improved institutional quality.

Empirically, the results remain controversial. Some conclude that brain drain harms human development (Mahmoud, 2020; Marchiori et al., 2013), while others argue that it can improve human development (Collier & Hoeffler, 2018).

Over the past decade, competent African workers have left for other countries. The latest African Union study on labour migration found 14.5 million migrant workers in 2019, up from 9.5 million in 2010. At the end of the study, migrants had a labour force participation rate of 72 per cent and an average annual growth rate of 4.8 per cent. From 2010 to 2019, 38% of international migrant workers were women. According to this, the migrant workforce has a greater gender gap than the general labour force, which averaged 45% women. Of the 14.5 million international migrant workers in 2019, 6.7 million were youthful (15–35).

This exodus of educated and skilled individuals to developed countries in search of better opportunities exacerbates the shortage of professionals in critical sectors such as health, education, and technology. This not only reduces productivity but also worsens existing socio-economic challenges, such as unemployment and income inequality, thereby lowering the population's Human Development Index (HDI).

According to the 2024 United Nations Development Programme (UNDP) report, Africa is one of the world's regions with low human development. The report indicates that, in 2022, countries with low human development were predominantly in Africa, with an average Human Development Index (HDI) of 0.517, while countries with very high human development averaged 0.902.

After two decades of progress, disparities in the Human Development Index have widened between nations at the lower and upper ends of the spectrum. In 2023, the global Human Development Index (HDI) ranking shows that nations in sub-Saharan Africa hold the bottom five spots, with scores below 0.5 (very low HDI) on a scale of 0 to 1. Within the continent, sub-Saharan African countries hold the bottom twelve spots, with scores ranging from 0.388 (South Sudan) to 0.497 (Ethiopia) (UNDP, 2025).

Various studies highlight that human development levels depend on multiple factors, including institutional quality (Vitenu-Sackey, 2023), sociocultural factors (Vlasov et al., 2023), economic factors (Barro, 1990; Lucas, 1988), and economic liberalisation (Kuder & Wróblewska, 2025). Furthermore, recent research highlights the importance of migration, particularly of professionals, as a key factor in analysing human development.

However, research on the effects of brain drain on human development remains understudied in sub-Saharan Africa, a region where brain drain is more significant and human development is low.

Methodologically, this study contributes by using human development in its entirety (as captured by its composite index). Indeed, the studies reviewed have examined these effects only through a single component of human development, such as growth (per capita GDP), education, or health, which does not provide a comprehensive view of human development. Furthermore, unlike the methods used in the reviewed literature, we use beta regression, which is more appropriate for analysing dependent variables bounded between zero (0) and one (1), as is the case for the Human Development Index (Ferrari & Cribari-Neto, 2004). In the reviewed literature, this method is overlooked, at least within our scope of application: sub-Saharan Africa.

Finally, this study contributes to the literature on the effects of skilled migration on human development, as few studies have addressed this topic comprehensively. Our results show that brain drain hinders human development, suggesting that countries south of the Sahara should, on the one hand, strengthen and promote talent-retention measures and, on the other, implement genuine return-incentive policies for emigrants

The remainder of this article is organised as follows. The second section presents the transmission channels through which brain drain affects human development; the third reviews the literature; the fourth outlines the methodology; and the fifth presents the results and discussion. The sixth and final section covers the conclusion and policy implications.

2. CHANNELS THROUGH WHICH THE EFFECTS OF THE BRAIN DRAIN ARE TRANSMITTED TO HUMAN DEVELOPMENT.

An analysis of Figure 1 shows that the brain drain can affect human development in countries of origin in two ways. First, it can harm human development; second, it can also drive improvement.

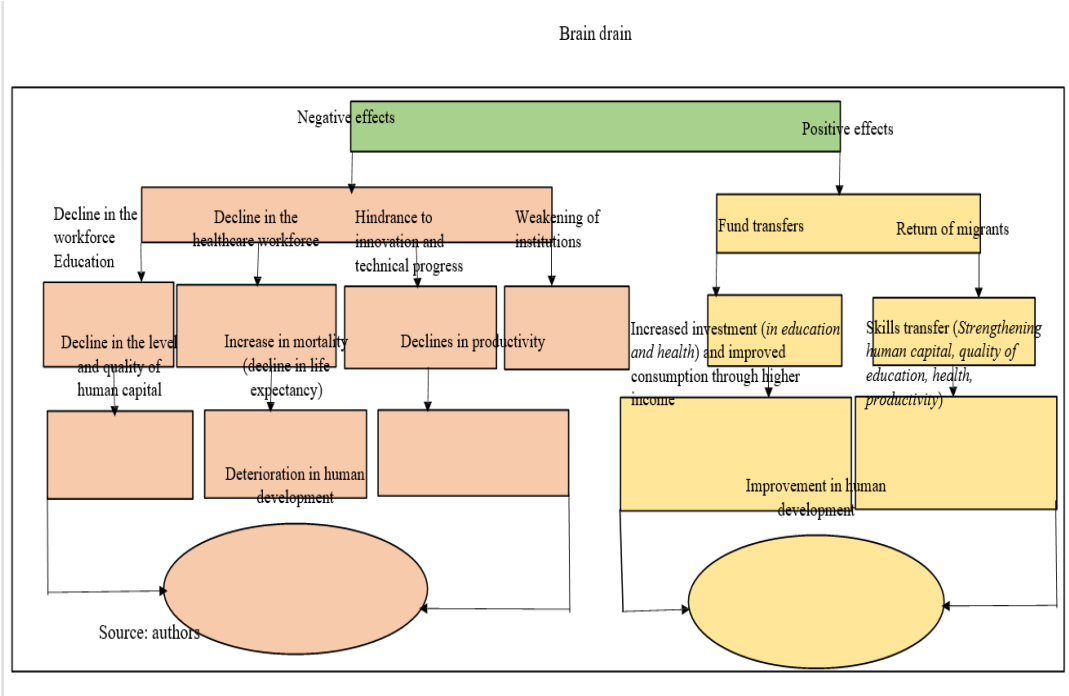
In the first case, brain drain accompanies a loss of human capital in countries of origin. These departures reduce available skills, weakening productivity and innovation and slowing growth (Docquier & Rapoport, 2012). Beine et al. (2008) also argue that brain drain can lower the average education level in countries of origin, directly affecting HDI.

Similarly, brain drain harms health and education systems, which are pillars of human development. The departure of health and education professionals affects the quality and accessibility of basic social services. Carrington and Detragiache (1999) assert that brain drain in the health sector significantly affects public health indicators such as life

expectancy and infant mortality. Kapur and McHale (2005) emphasise that the exodus of teachers undermines education quality, hindering human capital accumulation.

Brain drain lowers institutional quality and governance, impeding human progress. Indeed, public administration and economic policy implementation typically involve the most competent. Their departure can reduce the administrative and institutional capacity needed to implement economic policies that benefit the population. However, Docquier et al. (2016) find that emigration
to democratic countries improves home-country institutions, so the net effect of this channel remains debated. Another channel through which brain drain's negative effects manifest is hindered innovation and technological progress. Indeed, skilled workers are essential to research, development, and the dissemination of technology. Their departure hinders innovation and limits their countries of origin's ability to adapt to global economic changes. According to Aghion et al. (2009), human capital is crucial for innovation, and its decline hinders technical progress. In this regard, Romer (1990) argues that economic growth depends on knowledge accumulation, which talent emigration undermines.
In the second case, brain drain can positively affect human development in countries of origin, primarily through remittances from migrants and their return. Remittances facilitate and improve access to and the quality of health and education services in countries of origin, stimulate investment in local infrastructure, and increase household purchasing power. In this regard,
Clemens & Ogden (2014) argue that these financial flows from migrants accelerate development by supporting local initiatives and improving communities' economic resilience.
Talent return advantages come from transferring skills and knowledge from host countries. Skilled migrants return with knowledge that boosts productivity and innovation in critical economic sectors. Skilled worker mobility increases the dissemination of technology and global human capital, thereby multiplying education and health in home nations, according to Docquier
& Rapoport (2012). Skills circulation boosts local economies and living standards, directly affecting the Human Development Index. The return of highly skilled migrants with new skills strengthens institutions and organisational capacities, driving social and economic transformation. Brain drain affects human development through several mechanisms, as shown in Figure 1.

Figure 1. Implementation of channels.



3. LITERATURE REVIEW

3.1. Theoretical considerations

Traditional (brain drain) and contemporary (brain gain) perspectives are the two main approaches used to explain, in theory, the impact of brain drain on human development. The traditional view holds that brain drain harms human development,

while the contemporary perspective argues the opposite.

When examining brain drain's negative effects on human development, the traditional view holds that migration generally hinders development, particularly human development. Indeed, the departure of educated and skilled individuals creates shortages of professionals in key sectors such as education, health, and technology, lowering productivity, increasing unemployment, and widening income inequality.

From this perspective, Docquier (2007) argues that, in the short term, the migration of the most talented workers reduces the average level of human capital in the labour force and that, all else being equal, such a decline in capital has a negative effect on per capita output and, consequently, on human development. In the long term, declining human capital undermines the country's ability to innovate and adopt new technologies, reducing total productivity and harming human well-being and, thus, development.

For Bhagwati and Hamada (1974) and McCulloch & Yellen (1977), the mobility of skilled workers is a negative externality for those who remain in the country of origin and a positive one for those in the host country. In this view, they treat brain drain as a zero-sum game: it allows rich countries to become richer while poor countries become increasingly poorer. Thus, given the adverse effects of skilled workers leaving their countries of origin, some authors, such as Bhagwati & Dellalfar (1973), advocate limiting this departure by introducing an "international brain tax,"
also known as the "Bhagwati tax," named after its proponent.

In contrast, hypotheses about return migration, incentive migration, and remittance-driven migration raise objections, arguing that brain drain can catalyse human development.

In the first case, Mayr and Peri (2008) argue that skilled migrants returning to their countries of origin bring greater skills acquired abroad, financial capital, and international networks. These factors facilitate investment in education and health and contribute to poverty reduction, thereby significantly improving human development.

In the second situation, Stark et al. (1997) argue that migration increases worker human capital rather than causing a "brain drain." In a slow-growing economy, the authors suggest that the return on human capital is low, reducing incentives to invest in schooling. Because nations that support education reward human capital more, emigration pushes people to attain a socially desirable level of education in their home countries. The authors conclude that while some skilled people emigrate, others remain in their home nation, raising the average educational level. Emigration boosts human development by increasing the number of skilled workers in the home nation, stimulating growth, and boosting development.

Focusing on migrant remittances, the literature shows that these funds can contribute to human development by stabilising household incomes and reducing poverty; financing education and health expenditures, with lasting effects on human capital; and strengthening financial inclusion through access to banking services and digital transfer tools. In this regard, Oudinet (2021) argues that remittances improve human development by boosting investment and consumption and reducing poverty. Similarly, Taylor & López-Feldman (2010) attach great importance to migrant
remittances in improving human development, as they contribute to increasing income and reducing poverty; meeting basic needs; and investing in human capital (health and education); as well as stimulating productive investment (small businesses, housing).

3.2. Empirical Evidence

Some recent research has examined the HDI's components, but few have examined the direct impacts of brain drain. These studies examine brain drain and its effects on economic growth, human capital, health, and institutional quality. This research shows that brain drain has disputed effects. Indeed, they show that these effects can be harmful and beneficial for human development. Empirical evidence shows that skilled migration harms human development. Indeed, a shortage of skilled labour, particularly in health and education, reduces innovation and productivity, weakens public services, reduces investment, and exacerbates inequalities, slowing economic growth and lowering well-being in countries of origin.

From this perspective, Marchiori et al. (2013) analyse brain drain's effects on countries of origin. The study examines ten global regions and uses a general equilibrium model. The results suggest that brain drain's short-term impact on local human capital is paramount, as it affects not only the number of highly skilled workers available for domestic production

but also the home economy's capacity to innovate and adopt modern technologies. This effect is particularly significant in the context of globalisation, where capital investments are concentrated in areas with high production efficiency.

Mahmoud (2020) analysed the effects of brain drain in Egypt. To do so, they used data from
2000 to 2018. Ordinary least squares (OLS) results indicate an inverse relationship between brain drain and gross domestic product. They reveal that in Egypt, a 1% increase in talent migration leads to a 5.7% decline in GDP.

Studies finding positive effects include Beine et al. (2008), who use emigration data from 127 countries of origin, stratified by education level, to examine brain drain's impact on human capital. They find evidence of a positive effect on human capital. Beine et al. (2011) corroborated this result using a panel of 147 countries over 1975–2000.

Giuliano & Ruiz-Arranz (2009) explore the growth-enhancing impact of migrant remittances across 100 developing countries. They find that migrant remittances promote long-term economic growth in less developed countries by providing an alternative means of financing investments and overcoming credit constraints.

Other studies show that brain drain contributes to human development by improving political institutions (Collier & Hoeffler, 2018). In this vein, using international data, Spilimbergo (2009) shows that foreign students play an important role in promoting democracy in their home countries, but only if they have studied in democratic countries.

3.3. Lessons Learned from the Literature Review

The research above shows that the impacts of brain drain on human development are still debated. Brain drain can boost human growth while hurting countries of origin. Differences in analytical frameworks (developed versus developing countries), variables, and methodologies help explain these disparities. Thus, this research contributes to the field by focusing on Sub-Saharan Africa, which has a significant skilled-worker outflow and low human development
Its originality stems, on the one hand, from using human development in its entirety (as measured by its composite index). Indeed, the studies reviewed examined these effects through
only a single component of human development, such as growth (per capita GDP), education, or health, which does not provide a comprehensive view of human development. In contrast, we use beta regression, which is more appropriate for analysing dependent variables bounded between zero (0) and one (1) (Ferrari & Cribari-Neto, 2004), as is the case for the Human Development Index. In the reviewed literature, this method is overlooked, at least within our scope of
application: sub-Saharan Africa.

4. DATA AND METHODOLOGY

4.1. Data

In this study, we analyse the effects of skilled worker emigration on human development in sub- Saharan Africa using secondary data from a panel of 29 sub-Saharan African countries, covering the period from 2007 to 2023. The study period and sample size are limited by data availability, particularly for the "brain drain" variable. The data come from World Bank databases (2025), Fund for Peace (2024), and TheGlobalEconomy.com (2025). The variables are selected based on the literature review and include the dependent variable, the explanatory variable of interest, and control variables.
In this study, the explained variable is human development. We use the Human Development Index. According to the UNDP, human development is understood as a process leading to the expansion of the range of opportunities available to everyone, which opportunities involve the fulfilment of the three essential conditions for well-being: living a long and healthy life, acquiring knowledge, and having access to the resources necessary to enjoy an acceptable standard of living. Improving human development is one of the most critical challenges facing developing countries and is at the centre of debates on development policies (Haq, 1995).
As the variable of interest for explaining human development, we selected the "Human Flight and Brain Drain Indicator". This indicator accounts for the economic impact of population movements (whether for economic or political reasons) and the consequences they may have on a country's development. The higher the index, the greater the population movements. Its value ranges from zero to ten (10). Population movements become more significant as the index rises. The literature shows that the effects of skilled migration on human development remain controversial (Vega-Muñoz et al., 2021; Oudinet, 2021).
Drawing on the economic literature, this paper selects the inflation rate, labour market dysfunctions, institutional quality, investment, economic inequalities, demographic pressures, final consumption, and bank credit extended to the private sector. All of these variables are expected, in theory, to affect human development.
In this study, we approximate the inflation rate as the annual change in the consumer price index. This reflects the change in the average cost to a consumer of purchasing a basket of reference goods and services. Its inclusion as a determinant of

living conditions and, consequently, human development is based on Sirgy (2021). Inflation harms human development by reducing household purchasing power and triggering a bottom-up spillover effect.
Regarding labour market dysfunctions, the approximation is based on the economy's unemployment rate. The International Labour Organisation (ILO) defines this as the share of the labour force that is unemployed but available and seeking employment. Unemployment deprives individuals of the resources needed to meet basic needs, such as food, education, and health care, which are essential to human development.
According to the ILO, an unemployed person is someone who does not have a job, is actively seeking one during a reference period, and is available to work. This definition also includes people who have lost their jobs or left them voluntarily. In addition, some people have not sought work but have arrangements for future employment. In this study, a high unemployment rate is considered to deprive a segment of the population of fundamental rights, such as consumption and freedom of choice in health and education, which are nevertheless necessary for human development.
This study assesses institutional quality using two indicators: the security apparatus and the quality of regulation. The "Security Apparatus" indicator assesses a state's vulnerability to a range of threats, including bombings, deadly clashes, insurrections, mutinies, coups d'état, and terrorism. The "Security Apparatus" indicator also considers the most concerning criminal realities, from organised crime to homicide, and reflects citizens' confidence in their safety within the country. Sometimes, the security apparatus includes state-funded private militias deployed to instil fear among

political opponents, designated "enemies," or civilians sympathetic to the opposition, as well as covert intelligence networks or parallel forces operating in the shadows to serve a political leader's ambitions. It also considers armed challenges to authority, particularly violent uprisings and insurrections, as well as the proliferation of autonomous militias, self-defence groups, or mercenaries that challenge the state's monopoly on legitimate violence. It is measured on a scale from 0 to 10. The higher the score, the more the country is plunged into insecurity.

Regulatory quality, meanwhile, reflects perceptions of the government's ability to formulate and implement sound policies and regulations that foster and encourage private-sector development. It is measured on a scale from –2.5 (inability) to +2.5 (ability) to formulate and implement sound policies and regulations (Kaufmann et al., 2011). Regarding human development, recent studies show that effective government regulation is a source of human development (Ahmad & Saleem, 2014).

Domestic credit extended to the private sector by banks refers to funds provided by banks, not central banks. These resources are primarily provided as loans, purchases of non-stock securities, commercial credit facilities, and other forms of debt that require repayment in the future. Bank credit, as a source of investment financing, is believed to depend on the level of development (Mani et al., 2024).

The Unequal Economic Development Indicator captures economic inequalities within the economy, regardless of overall performance. For example, it examines structural inequalities based on group affiliation (social, ethnic, or religious), educational attainment, and regional economic conditions (the divide between rural and urban areas). In addition to actual inequalities, the indicator accounts for perceptions of economic inequality. This perception can fuel grievances and exacerbate community tensions or nationalist rhetoric, thereby hindering human development.

The demographic pressures indicator assesses pressures likely to affect various aspects of people's daily lives, such as food supply, access to drinking water, and other essential resources. It also considers public health issues, such as disease incidence and epidemic outbreaks. Furthermore, it accounts for situations in which population growth rates vary considerably across competing community groups. These demographic aspects can have significant social, economic, and political repercussions. Beyond population considerations, this indicator also accounts for pressures from extreme weather events such as hurricanes, earthquakes, floods, or droughts, as well as other environmental risks. Empirical studies generally agree that demographic pressures negatively affect human development.

Final consumption, as defined by the Organisation for Economic Co-operation and Development (2008), refers to expenditures by households, government agencies, and nonprofit institutions to acquire goods and services intended to directly satisfy human needs. Mohammed's (2022) results showed that final consumption negatively affects human development.

4.2 Methodology

To analyse the effects of brain drain on human development, the econometric model draws on Mohammed (2022) and Adenutsi (2010), who analyse the relationship between remittances, institutions, and human development (HD). The hypothesis is that human development is negatively correlated with brain drain. Implicitly, the effects of brain drain on human development can be formulated as follows:

□□□□□ □□□□□□□□□□□□ i□□□x = □(□□□i□ □□□i□ □□□ □□□□□□ □x□□□□ , □□□) (1)

This relationship indicates that human development depends on brain drain and a vector of control variables. Assuming that this relationship is linear and that the data are panel data, the relationship can be written in explicit form as follows:

□□□i□□□□□$_{it}$ = □$_0$ + □$_1$□□□□□□$_{it}$ + □□□$_{it}$ + □$_{it}$ + μ_t + □$_{it}$ (2)

In this equation, □U□□□□□X is the human development index; □□□□□□ is brain drain; X is the vector of control variables; □ represents country-specific unobserved factors, μ represents time-specific factors; □ □□ □ are parameters; i and t are the individual (country) and the period (year), respectively

□□□i□□□□□$_{it}$ = □$_0$ + □$_1$□□□□□□$_{it}$ + □$_1$□h□□$_{it}$ + □$_2$□□□□□□□□$_{it}$ + □$_3$□□□□i□□□□$_{it}$ + □$_4$□1□□□□□□□□hi□□□□□□□□□□□$_{it}$ + □$_5i$□□□□□i□□$_{it}$ + □$_6$□□□□□i□□□$_{it}$ + □$_7$□□□□□□□□$_{it}$ + □$_8$□□□□□□□□□□□$_{it}$ + □$_9$□□□□$_{it}$ + □$_{it}$ + μ_t + □$_{it}$

Where,

Hudindex	:	Human Development Index
Hfbrdr	:	Brain drain and talent exodus
Chom	:	Unemployment
Reglqulty	:	Quality of regulation
Fbcf	:	Gross fixed capital formation
Apreilsec	:	Security apparatus
S1demographicpressures	:	Demographic pressures
Inflation	:	Inflation
Consfinali	:	Final consumption
Ecqenqlt	:	Economic inequalities
Creditbnki	:	Loans granted by banks
$\square_{it}$	:	Country-related factors
μ_t	:	Time-related effects
$\square_{it}$	:	Error term
$\square_1$ ..... $\square_9$	:	Parameters

Estimation procedure

Given the nature of our dependent variable (human development index), which is a continuous variable strictly bounded between 0 and 1, our analysis uses the beta regression (Ferrari & Cribari-Neto, 2004). Beta regression is an econometric approach suited to modelling continuous dependent variables strictly bounded between 0 and 1, such as composite development indices, rates, or proportions.

Unlike classical linear regression, beta regression keeps predictions within the permitted interval, eliminating distortions from values outside it. It is based on the beta distribution, whose notable morphological flexibility allows it to model asymmetric or heteroscedastic distributions commonly observed in socioeconomic data.

Furthermore, beta regression explicitly models the relationship between the mean and variance of the dependent variable, providing a structural account of heteroscedasticity and improving estimator efficiency (Cribari-Neto & Zeileis, 2010). The estimated parameters can be interpreted using an appropriate link function (logit, probit, or "complementary log-log"), thereby enabling a coherent economic interpretation of the marginal effects of the explanatory variables (Smithson & Verkuilen, 2006).

This method adds value by departing from studies on the determinants of human development that rely on less suitable methods, such as those by Ogujiuba et al. (2024) and Shah (2016).

5. RESULTS AND DISCUSSION

5.1. Results

The initial results focus on descriptive statistics, which describe the variables using measures of central tendency (mean, maximum, and minimum) and dispersion (standard deviation). A summary of the results is presented in Table 1 below.

Table 1. Descriptive statistics

	Mean	Maximum	Minimum	Std. Dev.	Observations
Human Development Index	0.522	0.804	0.295	0.090	493
Brain drain and talent exodus	6.878	9.000	2.100	1.157	493
Youth unemployment	15.076	64.652	0.414	13.888	493
Quality of regulation	-0.627	1.197	-2.081	0.572	493
Security apparatus	6.814	10.000	1.100	1.747	493
Demographic pressures	8.053	10.000	1.000	1.327	493
Inflation	9.747	557.202	-81.476	34.552	493
Final consumption	84.002	138.830	37.464	16.759	493
Economic inequalities	7.614	9.900	2.600	1.117	493
Loans granted by banks	19.956	103.654	-6.008	17.904	493

Source: the authors, based on results obtained using Stata 17.

Regarding the brain drain, descriptive statistics reveal a key finding: the standard deviation generally remains below the mean for most variables studied. This pattern indicates that the data cluster around the mean, revealing minimal dispersion and remarkable stability. Trend analysis reveals an average value of 0.522 for the explained variable, namely the Human Development Index. Over 2007–2023, values fluctuate between a peak of 0.804 and a low of 0.295. With an average score of 0.522, sub-Saharan African countries unfortunately remain in the low human development category. The reason is simple: this indicator, scaled from 0 to 1, directly reflects the level of human development; the closer its value is to 1, the more advanced the level.

The explanatory variable (brain drain) has an average value of 6.878 and a maximum value of 9.000. An average value above 5 indicates significant skilled-worker outflow from sub-Saharan Africa. This is because the "Human Flight and Brain Drain" index ranges from 0 to 10; the closer the value is to 10, the more skilled individuals leave their country of origin.

The second set of results examines pre-estimation tests. These include tests examining the nature of the data from the countries in our panel (Hausman test, 1978) to distinguish between fixed and random effects; the heterogeneous or homogeneous nature of the data (Pesaran test, 2004); and the constancy or non-constancy of variances modified Wald test (Greene, 2000). The results obtained are summarised in Table 2 below:

Table 2. Results of pre-estimation tests

Types of tests	**Null hypotheses**	**Results**
Dependence	No cross-sectional dependence in the error term	Pesaran's test 34.437 Pr = 0.000
Heteroscedasticity	Constant variance	Chi2(29)= 4020.22 Pr: 0.0000
Autocorrelation	No autocorrelation	F (1, 32) = 1.924 Pr: 0.175
Hausman	Random effects	Chi2 (6) = 62.300 Pr: 0.000

Source: the authors, based on results obtained using Stata 17.

Table 2 shows substantial cross-sectional dependence in the panel structure, suggesting that the study's panel data are homogeneous. At the 1% significance level, the Hausman test results reject the null hypothesis. Thus, the fixed-effects model is preferred over the random-effects model. According to the Wooldridge (2002) and Drukker (2003) tests for autocorrelation in panel data, the null of no first-order autocorrelation is accepted because the p-value exceeds 10%. The modified Wald test (Greene, 2000) for heteroscedasticity of error variances within groups in the fixed-effects regression model exhibits bias. Given these results, especially heteroscedasticity, a robust standard errors estimation approach is needed.

In addition to the previous tests, Gujarati (2004) and Wooldridge (2010) emphasise that multicollinearity is common in macroeconomic time series, as several variables often follow similar trends over long periods. Thus, accounting for multicollinearity among explanatory variables is an essential methodological prerequisite for ensuring the validity of econometric results in time-series analysis. Accordingly, we conducted a multicollinearity test using the variance inflation factor (VIF) (Marquardt, 1970). The relevant results are presented in Table 3 below.

Table 3. Variance Inflation Factor

	VIF	1/VIF
Quality of regulation	3.571	.28
Loans granted by banks	3.497	.286
Security apparatus	2.451	.408
Demographic pressures	2.151	.465
Economic inequalities	1.996	.501
Brain drain and talent exodus	1.858	.538
Youth unemployment	1.725	.58
Final consumption	1.528	.654
Gross fixed capital formation	1.344	.744
Inflation	1.101	.908
Mean VIF	**2.122**	.

Source: the authors, based on results obtained using Stata 17.

The multicollinearity test results in Table 3 show very low multicollinearity, which is acceptable from an econometric standpoint. This conclusion is supported by the average VIF (2.122) and the VIFs for the individual variables. These values are all below 5, indicating that the level of multicollinearity does not introduce a problem in the model, which implies that the regression remains stable; the coefficient tests can be interpreted normally; the signs and magnitudes of the coefficients are less likely to be distorted; in other words, the estimates remain reliable.

In summary, the tests show that the data are subject to heteroscedasticity bias. Under these conditions, the appropriate estimation method is Generalised Least Squares (GLS). This method refines ordinary least squares by accounting for heteroscedasticity. It first estimates the error structure from the OLS residuals to create a weighting matrix, then applies these weights to the regression, yielding results that are more efficient, accurate, and robust than OLS.

Unfortunately, the approach is inadequate for finite samples and can bias the student's t-test by narrowing confidence intervals (Beck & Katz, 1995). The Human Development Index, spans from

0 to 1. Traditional methods for estimating such a variable can produce biased forecasts. Many writers have suggested beta regression to overcome these problems (Smithson & Verkuilen, 2006; Ferrari & Cribari-Neto, 2004). As in this case, it works for bounded endogenous variables. We used a two-sided censored Tobit regression to test robustness, since the human development index is strictly greater than 0 and less than 1. Table 4 shows the results:

Table 4. Estimation results for the coefficients and marginal effects of the brain drain on human development

	Coefficients		**Marginal effects (dy/dx)**	
	Beta Regression	Tobit Regression	Beta Regression	Tobit regression
Human Flight and Brain Drain	**-0.0248*** (-3.672)**	**-0.00679*** (-4.547)**	**-0.00600*** (0.00163)**	**-0.00679*** (0.00149)**
Youth unemployment	-0.00838** (0.00102)	-0.00206*** (0.000345)	-0.00203**	-0.00206*** (-1.994) (-5.977)
Quality of regulation	0.0879***	0.0207***	0.0213***	0.0207***
	(3.444)	(3.292)	(0.00618)	(0.00627)
Gross fixed capital formation	0.00219***	0.000560***	0.000530***	0.000560***

	(3.008)	(3.622)	(0.000176)	(0.000155)
Security apparatus	-0.0120**	-0.00280**	-0.00291**	-0.00280**
	(-2.376)	(-2.066)	(0.00122)	(0.00135)
Demographic pressures	-0.0117*	-0.00246	-0.00283*	-0.00246
	(-1.901)	(-1.434)	(0.00149)	(0.00172)
Inflation	-2.61e-05	-3.94e-06	-6.30e-06	-3.94e-06
	(-0.411)	(-0.142)	(1.53e-05)	(2.78e-05)
Final consumption	-0.00170***	-0.000428***	-0.000411***	-0.000428***
	(-2.965)	(-3.051)	(0.000139)	(0.000140)
Economic inequalities	-0.0169***	-0.00287*	-0.00409***	-0.00287*
	(-3.477)	(-1.785)	(0.00118)	(0.00161)
Loans granted by banks	0.00298*	0.000736***	0.000721*	0.000736***
	(1.739)	(3.024)	(0.000415)	(0.000243)
Constant	0.861***	0.699***		
	(4.375)	(23.16)		
Overall quality indicators, observations, and the number of countries				
Chi-square statistic	73.460	1617		
Probabilities associated with chi-square	0.000	0.000		
Observations	493	493		
Number of countries	29	29		

Robust z-statistics in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: the authors, based on results obtained using STATA.17
The model must be validated before discussing findings. The Wald test chi-square statistic evaluates this. Wald test chi-square statistics are significant at the 1% level. Together, the variables explain the Human Development Index. The majority of control variables are significant at the 1% level. This shows a negligible or minimal carryover effect on the variables of interest. The evidence suggests our model is good, so we can discuss the findings.

5.2. Discussion of the Results

In beta regression, the raw coefficients do not directly represent the effect on the HDI because the HDI is bounded between 0 and 1. They only indicate the direction of causality. To facilitate interpretation, we calculate the average marginal effects, which indicate the average impact of a marginal change in brain drain on the HDI. These effects lead to a key conclusion: "the migration of skilled workers acts as a brake on human development in sub-Saharan Africa." This finding is supported by the negative and statistically significant marginal effect of the "Human flight and brain drain" variable at the 1% level. This result highlights the phenomenon's detrimental nature, suggesting that increased outflow of skilled individuals from their countries of origin is accompanied by a decline in human development. The negative marginal effect (-0.006) of "Human flight and brain drain" implies that a one-point increase in the index reduces the HDI by 0.006 points. The present results are consistent with traditional considerations, notably human capital theory (Becker, 1964) and the neoclassical theory of brain drain (Bhagwati & Hamada, 1974), which highlight the negative effects of brain drain on development through a decline in human capital and economic growth; a decline in innovation; an increase in inequality; and a rise in social costs and the cost of public services. In practice, Mahmoud (2020) and Marchiori et al. (2013) show that brain drain diminishes human capital by reducing the number of skilled workers available for domestic production and by limiting innovation and the adoption of modern technologies in economies of origin. In the context of sub-Saharan Africa, these results can be understood through their impact on factors that could improve human development but, in turn, negatively affect it. Table 5 below illustrates this point.

Table 5. Comparison of selected African countries regarding the level of brain drain, human development, and selected components

Country	Human Development Index	Human flight and brain drain	Life expectancy at birth	Gross domestic product per capita
Countries with high brain drain (Human flight and brain drain index > 5)				
Republic of the Congo	0.522	6.2	65	6.172
Chad	0.416	7.7	55	2.641
Gambia	0.524	6.9	65	2.932
Burkina Faso	0.459	7	61	2.482
Lesotho	0.55	7.5	57	2.596
Average	**0.494**	**7.06**	**61**	**3.365**
Countries with low brain drain (Human flight and brain drain index ≤ 5)				
Equatorial Guinea	0.674	3.7	64	15.688
Gabon	0.733	4.4	68	18.703
Botswana	0.733	4.6	69	18.932
Egypt	0.754	5	71	16.601
Libya	0.721	5	69	12.478
Average	**0.721**	**4.575**	**68**	**16.480**

Source: Author, based on data extracted from the GlobalEconomy database

Table 5 shows that countries with high brain drain (index greater than 5) have a low HDI, whereas those with low brain drain (index less than or equal to 5) have a high HDI. On average, countries with low levels of brain drain have an index of 4.575 and an HDI of 0.721. In countries with high levels of brain drain, the situation is reversed. The average Human Flight and Brain Drain index is

7.06, corresponding to an HDI of 0.494**.** The same trends hold across components of human development, including life expectancy at birth and the economic dimension, measured by GDP per capita in purchasing power parity. Countries with low levels of brain drain have an average life expectancy at birth of approximately 68 years and a GDP per capita of US$16.480. For countries with high levels of brain drain, these figures average 61 years and US$3.365, respectively.

Robustness of results across different components of human development

To further test the robustness of our results, we also conducted an estimation that took into account the various components of the HDI (health as measured by life expectancy at birth, education as measured by the gross enrollment rate in secondary school, and standard of living as measured by gross domestic product per capita in purchasing power parity). However, since the values of these components do not lie between 0 and 1, as is the case for the HDI, we were unable to use beta regression to obtain estimates. For this reason, we used generalised least squares (GLS).

When ordinary least squares (OLS) linear regression fails, generalised least squares is preferable. When errors are not homoscedastic (of constant variance) or autocorrelated, ordinary least squares estimators remain unbiased but become less efficient. In such cases, Aitken (1935) and Greene (2012) suggest using generalised least squares (GLS) to incorporate the error covariance structure and improve estimate accuracy. They prove that generalised least squares produce BLUE (Best Linear Unbiased Estimators).

Gujarati (2004) and Wooldridge (2010) claim this method produces more precise confidence ranges and robust statistical tests for empirical research. The extended least squares approach improves econometric model specifications, supporting this. The generalised least squares (GLS) method and its derivatives, such as FGLS, may be used to model panel data or time-series data with unobserved heterogeneity and time dependence. Baltagi (2008) and Hsiao (2003) say this method improves empirical and economic results. Table 6 shows the HDI component results for this method.

Table 6. Robustness of results by HDI components and the GLS method

VARIABLES	(1) espvie	(2) lpibhppp	(3) secondary_educ
Human Flight and Brain Drain	**-0.282*** **	**-0.0273*** **	**-1.174*** **
	(-5.038)	(-7.338)	(-7.054)
unemployment	-0.0435**	0.000184	-0.123***
	(-2.559)	(0.198)	(-2.866)
Quality of regulation	0.615**	0.0968***	0.994
	(2.536)	(5.746)	(1.468)
Gross fixed capital formation	0.00335	0.00487***	-0.00153
	(0.635)	(9.800)	(-0.108)
Security apparatus	0.173***	-0.0137***	-0.0289
	(3.729)	(-4.326)	(-0.201)
Demographic pressures	0.00561	-0.0260***	0.716***
	(0.102)	(-6.618)	(4.394)
Inflation	-0.00150	-0.000539***	0.00280
	(-0.905)	(-3.479)	(0.934)
Final consumption	-0.0236***	-0.00358***	0.00159
	(-4.279)	(-7.387)	(0.116)
Economic inequalities	0.0730	-0.0129***	0.0431
	(1.093)	(-3.044)	(0.230)
Loans granted by banks	0.0168*	0.00357***	0.00211
	(1.696)	(5.012)	(0.0633)
Constant	59.91***	9.881***	37.45***
	(46.57)	(124.7)	(11.23)
Observations	493	493	493
Number of IDs	29	29	29
chi2	23.055	108.192	44.017
chi2p	0.000	0.000	0.000.

z-statistics in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table 6, which assessed robustness across several human development components, shows that the brain drain negatively impacts human development, as previously found. Education, as measured by gross secondary school enrollment, is most affected. At this level, a one-point increase in the brain drain index reduces gross secondary school enrollment by 1.17, holding all other parameters constant. Docquier and Rapoport (2012) agree that the flight of teachers, researchers, and professionals reduces human capital in the education sector, reducing institutions' ability to provide excellent education and devise innovative programs. Docquier and Rapoport (2012) also noted that when talent emigrates, families tend to spend less time and money on their children's education, which lowers the quality and quantity of education, especially in science and technology.

Second, health is measured by life expectancy at birth. The results show that a one-point increase in the brain drain index is associated with a reduction of approximately 0.282 years.

Finally, the brain drain harms the well-being of the population, as measured here by gross domestic product per capita in purchasing power parity. The results show that when the skilled migration index increases by one point, gross domestic product decreases by approximately 2.73%. This result is not surprising, as Miyagiwa (1991) and Mountford (1997) argue that a shortage of a skilled elite weakens governance and the quality of public policies, thereby hindering investment and capital accumulation. Consequently, these combined mechanisms reduce economic growth and GDP per capita in countries of origin.

6. CONCLUSION AND ECONOMIC POLICY IMPLICATIONS

Talent mobility, or the brain drain, continues to reshape economic dynamics across nations, with far-reaching effects. Brain drain hurts the development of countries of origin by removing qualified taxpayers despite investing heavily in their education. Ignoring potential benefits could harm origin economies. This research examines how skilled migration affects Sub-Saharan Africa's home countries in light of this duality. Due to data availability limits, particularly for the "brain drain" variable, the analysis employs 2007–2023 data from 29 nations. Initial estimates use beta regression to account for the Human Development Index's continuous values between 0 and 1. Second, the results are robustly tested using a Tobit model. These findings show that "In sub- Saharan Africa, the brain drain hinders the human development of the population." To prevent skilled personnel from migrating, implement talent retention strategies. This includes enhancing the social, economic, and professional conditions of skilled workers in high-mobility areas. This includes increasing investment, aligning wage levels with purchasing power, and ensuring regular payments to avoid repeated strikes that discourage professionals in sectors with high skilled worker mobility, such as health, education, and research; (ii) granting graduate scholarships conditional on a commitment to return after studies; and (iii) promoting policies to encourage skilled worker return, which can benefit the population. Beyond the results, we must determine if skilled migration is compatible with human development in our scope. Thus, our future research will address this issue

Competing interests: The authors declare no conflict of interest

Funding: The Author declares that no financial support was received for this research

Data availability statement: The data supporting this study are available upon reasonable request addressed to the corresponding author

REFERENCE

1. Adenutsi, D. E. (2010). Do international remittances promote human development in poor countries ?
2. Empirical evidence from Sub-Saharan Africa (Numéro 29347) [MPRA Paper]. University Library of Munich. https://mpra.ub.uni-muenchen.de/29347/
3. African Union Commission & OECD. (2024). Africa's development dynamics 2024: Skills, jobs and productivity. AUC; OECD Publishing. https://doi.org/10.1787/df06c7a4-enAghion, P., Boustan, L., Hoxby, C., & Vandenbussche, J. (2009). The causal impact of education on economic growth : Evidence from U.S. [Working paper]. Harvard University. https://www.brookings.edu/wpcontent/uploads/2016/07/2009_spring_bpea_aghion_etal.p df
4. Ahmad, Z., & Saleem, A. (2014). Impact of governance on human development. Pakistan Journal of
5. Commerce and Social Sciences, 8(3), 612-628.
6. Aitken, A. C. (1935). On least squares and linear combination of observations. Proceedings of the Royal
7. Society of Edinburgh, 55, 42-48. https://doi.org/10.1017/S0370164600014346
8. Baltagi, B. H. (2008). Econometric analysis of panel data (4th ed.). John Wiley & Sons.
9. Barro, R. J. (1990). Government spending in a simple model of endogenous growth. Journal of Political
10. Economy, 98(5, Part 2), S103-S125. https://doi.org/10.1086/261726
11. Beck, N., & Katz, J. N. (1995). What to do (and not to do) with time-series cross-section data. American
12. Political Science Review, 89(3), 634-647. https://doi.org/10.2307/2082979
13. Becker, G. S. (1964). Human capital : A theoretical and empirical analysis, with special reference to
14. education. National Bureau of Economic Research; Columbia University Press.
15. Beine, M., Docquier, F., & Oden-Defoort, C. (2011). A panel data analysis of the brain gain. World
16. Development, 39(4), 523-532. https://doi.org/10.1016/j.worlddev.2010.03.009
17. Beine, M., Docquier, F., & Rapoport, H. (2008). Brain drain and human capital formation in developing countries : Winners and losers. The Economic Journal, 118(528), 631-652. https://doi.org/10.1111/j.1468-0297.2008.02135.x
18. Bhagwati, J., & Dellalfar, W. (1973). The brain drain and income taxation. World Development, 1(1–2),
19. 94-101. https://doi.org/10.1016/0305-750X(73)90226-2
20. Bhagwati, J., & Hamada, K. (1974). The brain drain, international integration of markets for professionals and unemployment : A theoretical analysis. Journal of Development Economics, 1(1), 19-42. https://doi.org/10.1016/0304-3878(74)90020-0
21. Carrington, W. J., & Detragiache, E. (1999). How extensive is the brain drain? Finance & Development,
22. 36(2), 46-49.
23. Clemens, M. A., & Ogden, T. N. (2014). Migration as a strategy for household finance: A
24. research agenda on remittances, payments, and development (CGD Working Paper No.

25. 354). Center for Global Development. https://www.cgdev.org/publication/migration- strategy-household-finance-research-agenda-remittances-payments-and
26. Collier, P., & Hoeffler, A. (2018). Migration, diasporas and culture : An empirical investigation. Kyklos,
27. 71(1), 86-109. https://doi.org/10.1111/kykl.12163
28. Commission, A. U. & O.E.C.D. (2024). Africa's development dynamics 2024 : Skills, jobs and
29. productivity. AUC; OECD Publishing. https://doi.org/10.1787/df06c7a4-en
30. Cribari-Neto, F., & Zeileis, A. (2010). Beta regression in R. Journal of Statistical Software, 34(2), 1-24.
31. https://doi.org/10.18637/jss.v034.i02
32. Docquier, F. (2007). Fuite des cerveaux et inégalités entre pays. Revue d'économie du développement,
33. 15(2), 49-88. https://doi.org/10.3917/edd.212.0049
34. Docquier, F., & Rapoport, H. (2012). Globalization, brain drain, and development. Journal of Economic
35. Literature, 50(3), 681-730. https://doi.org/10.1257/jel.50.3.681
36. Docquier, F., Lodigiani, E., Rapoport, H., & Schiff, M. (2016). Emigration and democracy. Journal of
37. Development Economics, 120, 209-223. https://doi.org/10.1016/j.jdeveco.2015.12.001
38. Drukker, D. M. (2003). Testing for serial correlation in linear panel-data models. The Stata Journal, 3(2),
39. 168-177. https://doi.org/10.1177/1536867X0300300206
40. Ferrari, S., & Cribari-Neto, F. (2004). Beta regression for modelling rates and proportions. Journal of
41. Applied Statistics, 31(7), 799-815. https://doi.org/10.1080/0266476042000214501
42. Fund for Peace. (2024). Fragile States Index [Data set]. https://fragilestatesindex.org/
43. Giuliano, P., & Ruiz-Arranz, M. (2009). Remittances, financial development, and growth. Journal of
44. Development Economics, 90(1), 144-152. https://doi.org/10.1016/j.jdeveco.2008.10.005
45. Greene, W. H. (2000). Econometric analysis (4th ed.). Prentice Hall. Greene, W. H. (2012). Econometric analysis (7th ed.). Pearson.
46. Gujarati, D. N. (2004). Basic econometrics (4th ed.). McGraw-Hill.
47. Haq, M. ul. (1995). Reflections on human development. Oxford University Press.
48. Hausman, J. A. (1978). Specification tests in econometrics. Econometrica, 46(6), 1251-1271.
49. https://doi.org/10.2307/1913827
50. Hsiao, C. (2003). Analysis of panel data (2nd ed.). Cambridge University Press.
51. https://doi.org/10.1017/CBO9780511754203
52. Kapur, D., & McHale, J. (2005). Give us your best and brightest : The global hunt for talent and its
53. impact on the developing world. Center for Global Development.
54. Kaufmann, D., Kraay, A., & Mastruzzi, M. (2011). The Worldwide Governance Indicators : Methodology
55. and analytical issues. Hague Journal on the Rule of Law, 3(2), 220-246.
56. https://doi.org/10.1017/S1876404511200046
57. Kuder, D., & Wróblewska, J. (2025). Globalisation and human development : Long-term evidence from countries at different levels of development. International Entrepreneurship Review, 11(3),
58. 193-210. https://doi.org/10.15678/IER.2025.1103.09
59. Lucas, R. E., Jr. (1988). On the mechanics of economic development. Journal of Monetary Economics,
60. 22(1), 3-42. https://doi.org/10.1016/0304-3932(88)90168-7
61. Mahmoud, S. M. F. (2020). The brain drain in Egypt and its impact on economic growth. Humanities and
62. Social Sciences Letters, 8(4), 380-396. https://doi.org/10.18488/journal.73.2020.84.380.396
63. Mani, P., Nyamute, W., & Ondigo, H. (2024). Financial inclusion and human development : Evidence from African countries. European Journal of Business and Management Research, 9(3), 80-85.
64. https://doi.org/10.24018/ejbmr.2024.9.3.2274
65. Marchiori, L., Shen, I.-L., & Docquier, F. (2013). Brain drain in globalization : A general equilibrium analysis from the sending countries' perspective. Economic Inquiry, 51(2), 1582-1602.
66. https://doi.org/10.1111/j.1465-7295.2012.00489.x
67. Marquardt, D. W. (1970). Generalized inverses, ridge regression, biased linear estimation, and nonlinear estimation. Technometrics, 12(3), 591-612. https://doi.org/10.1080/00401706.1970.10488699
68. Mayr, K., & Peri, G. (2008). Return migration as a channel of brain gain (NBER Working Paper No.
69. 14039). National Bureau of Economic Research. https://doi.org/10.3386/w14039
70. McCulloch, R., & Yellen, J. L. (1977). Factor mobility, regional development, and the distribution of income. Journal of Political Economy, 85(1), 79-96. https://doi.org/10.1086/260546
71. Meyer, D., & Shera, A. (2017). The impact of remittances on economic growth : An econometric model.
72. EconomiA, 18(2), 147-155. https://doi.org/10.1016/j.econ.2016.06.001
73. Migration, I. O. (2024). World migration report 2024 (M. McAuliffe, L. A. Oucho, & E. IOM, Eds.). https://publications.iom.int/books/world-migration-report-2024
74. Miyagiwa, K. (1991). Scale economies in education and the brain drain problem. International Economic
75. Review, 32(3), 743-759. https://doi.org/10.2307/2527117

76. Mohammed, U. (2022). Remittances, institutions and human development in Sub-Saharan Africa. Journal of Economics and Development, 24(2), 142-157. https://doi.org/10.1108/JED-03-2021-0041
77. Mountford, A. (1997). Can a brain drain be good for growth in the source economy? Journal of
78. Development Economics, 53(2), 287-303. https://doi.org/10.1016/S0304-3878(97)00021-7
79. OECD. (2008). Glossary of statistical terms. OECD Publishing. https://doi.org/10.1787/9789264055087- en
80. Ogujiuba, K., Maponya, L., & Stiegler, N. (2024). Determinants of human development index in South
81. Africa : A comparative analysis of different time periods. World, 5(3), 527-550.
82. https://doi.org/10.3390/world5030027
83. Oudinet, J. (2021). L'impact de la migration sur le développement inclusif. Région et Développement, 53,
84. 5-21.
85. Pesaran, M. H. (2004). General diagnostic tests for cross section dependence in panels (CESifo Working
86. Paper No. 1229). CESifo. https://doi.org/10.2139/ssrn.572504
87. Piguet, E. (2013). Les théories des migrations : Synthèse de la prise de décision individuelle. Revue européenne des migrations internationales, 29(3), 141-161. https://doi.org/10.4000/remi.6571
88. Programme, U. N. D. (2024). Human development report 2023/2024 : Breaking the gridlock :
89. Reimagining cooperation in a polarized world. UNDP. https://hdr.undp.org/content/human- development-report-2023-24
90. Programme, U. N. D. (2025). Human development report 2025 : A matter of choice : People and
91. possibilities in the age of AI. UNDP. https://hdr.undp.org/content/human-development-report-
92. 2025
93. Romer, P. M. (1990). Endogenous technological change. Journal of Political Economy, 98(5, Part 2),
94. S71-S102. https://doi.org/10.1086/261725
95. Shah, S. (2016). Determinants of human development index : A cross-country empirical analysis (MPRA Paper No. 73759). University Library of Munich. https://mpra.ub.uni-muenchen.de/73759/
96. Sirgy, M. J. (2021). The psychology of quality of life : Wellbeing and positive mental health (3rd ed.).
97. Springer. https://doi.org/10.1007/978-3-030-71888-6
98. Smithson, M., & Verkuilen, J. (2006). A better lemon squeezer ? Maximum-likelihood regression with beta-distributed dependent variables. Psychological Methods, 11(1), 54-71.
99. https://doi.org/10.1037/1082-989X.11.1.54
100. Spilimbergo, A. (2009). Democracy and foreign education. American Economic Review, 99(1), 528-543.
101. https://doi.org/10.1257/aer.99.1.528
102. Stark, O., Helmenstein, C., & Prskawetz, A. (1997). A brain gain with a brain drain. Economics Letters,
103. 55(2), 227-234. https://doi.org/10.1016/S0165-1765(97)00085-2
104. Taylor, J. E., & López-Feldman, A. (2010). Does migration make rural households more productive ?
105. Evidence from Mexico. The Journal of Development Studies, 46(1), 68-90.
106. https://doi.org/10.1080/00220380903198471
107. TheGlobalEconomy.com. (2025). Global economic data [Data set]. https://www.theglobaleconomy.com/ Vega-Muñoz, A., González-Gómez-del-Miño, P., & Espinosa-Cristia, J. F. (2021). Recognizing new
108. trends in brain drain studies in the framework of global sustainability. Sustainability, 13(6).
109. https://doi.org/10.3390/su13063195
110. Vitenu-Sackey, P. A. (2023). Exploring the heterogeneous influence of social media usage on human development : The role of carbon emissions and institutional quality. The Economics and Finance Letters, 10(2), 122-142. https://doi.org/10.18488/29.v10i2.3341
111. Vlasov, M., Polbitsyn, S. N., Olumekor, M., & Haddad, H. (2023). Exploring the role of socio-cultural factors on the development of human capital in multi-ethnic regions. Sustainability, 15(21),
112. 15438. https://doi.org/10.3390/su152115438
113. Wooldridge, J. M. (2002). Econometric analysis of cross section and panel data. MIT Press. Wooldridge, J. M. (2010). Econometric analysis of cross section and panel data (2nd ed.). MIT Press. World Bank. (2025). World DevelopmentIndicators [Data set}.
114. https:/Idatabank.worldbank.org/source/world-development-indicators