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Catalysts of Economic Welfare in Africa: A Cross-Sectional Autoregressive Distributed Lag Approach

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Abstract. This study provides empirical perspectives on the catalysts of economic welfare in Africa, drawing inference from macroeconomic and non-macroeconomic factors. Leveraging a sample of a balanced panel dataset of 35 countries across Africa, this study provides novel applications of the cross-sectional autoregressive distributed lag methodology to economic welfare analysis in Africa. Issues of cross-sectional dependence and slope homogeneity were accounted for whilst establishing causal relationships between economic welfare proxied by the Human Development Index and macroeconomic and non-macroeconomic drivers of welfare. Based on cross-sectional autoregressive distributed lag estimation results, a 1% increase in economic growth was shown to account for a 0.233 percent and 0.253 percent increase in economic welfare in the long run and short run respectively. In addition, technology accounted for a 1.81 percent increase in economic welfare in the long run. The outcome of the Dumitrescu–Hurlin causality test demonstrated causality between trade openness, government effectiveness, economic growth, and economic welfare.

Keywords: Africa, CS-ARDL, Human Development Index, economic welfare, poverty

JEL Classification: F43, D60, I32, C33

1. Introduction

For many decades, economic welfare has been a topical issue of policy debates in Africa. Irrespective of the progress Africa has made over the years, the level of economic welfare remains relatively low, and overall growth metrics depict significant discrepancies within and between countries of the continent (Organisation for Economic Co-operation and Development, 2015). A litany of studies has characterized welfare deficiencies in Africa as issues of relative deprivation and poverty. In recent times, this has become even more aggravated following the COVID-19 pandemic, which made Africa distinct as the most affected continent in the world in terms of loss of income of poor households, measured by poverty headcount, which increased by 3 percentage points as opposed to pre-COVID-19 estimates (United Nations Conference on Trade and Development, 2021). Africa's development strides have attracted several multilateral initiatives targeted towards poverty. Such initiatives include, but are not limited to, the Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs) of the United Nations. Particularly, "Goal One" of both initiatives – "Eradicate extreme poverty and hunger" and "No Poverty" – essentially stresses the need to tackle poverty in all its forms, especially in sub-Saharan Africa and South Asia, which account for 80 percent of people living in extreme poverty (United Nations Development Programme, 2022).

Whilst these relatively exogenous interventions and initiatives have increased the attention and consolidated the fight against poverty and underdevelopment, there exists a range of endogenous factors capable of addressing welfare deficiencies in Africa. As documented by the International Monetary Fund (IMF) in 2001, although macroeconomic factors are necessary for poverty eradication, remedies to poverty cannot be solely dependent on economic policies but require an all-encompassing set of well-coordinated measures. Undoubtedly, the macroeconomic environment of nations are crucial determinants of welfare improvements. However, macroeconomic stability does not ensure by itself high rates of economic growth (IMF, 2001), nor does it guarantee welfare improvement. This makes it imperative to examine both the macroeconomic and non-macroeconomic catalysts of economic welfare, as they have been evidenced to be important in addressing poverty.

Extant literature on the subject matter showed that economic welfare has been extensively explored in developed and OECD nations (Aurland-Bredesen, 2021; Deyshappriya, 2017; Lu, Gozgor, Mahalik, Padhan, and Yan, 2022; Nurvita, Rohima, Bashir, and Mardalena, 2022). However, in the context of Africa, only a few studies have examined economic welfare from the perspective of macroeconomic factors (Okoyeuzu and Kalu, 2022; Ramzi, Asma, and Chebbi, 2017; Sakyi, Bonuedi, and Opoku 2018). It is noteworthy that a few studies have also accounted for

non-macroeconomic determinants of economic welfare such as technological advancement, natural resource endowment, and government effectiveness (Ajide, 2022; Albiman and Sulong, 2017; Aljarallah, 2021; David, 2019; Fink and Ducoing, 2022; Haftu, 2019). Nevertheless, there exists no consensus about the non-macroeconomic determinants of economic welfare in Africa. Whilst taking cognizance of macroeconomic factors, this study pays particular attention to the role of technology, natural resource endowment, and political will proxied by the effectiveness of the government. It is from the foregoing that this study aims to examine the macroeconomic and non-macroeconomic drivers of economic well-being in Africa. This is generally not trivial because global poverty is envisaged to become increasingly African by 2030, rising from 55% in 2015 to 90%, cognizant of Africa's population growth trajectories (World Bank, 2019).

As a deviation from existing literature, this research fills the gap between existing single-country and cross-country analysis by employing the cross-sectional autoregressive distributed lag (CS-ARDL) method on a panel data framework, as recommended by Chudik, Mohaddes, Pesaran, and Raissi (2015). This approach has appealing features in that it dampens parameter estimate bias and takes slope heterogeneity and cross-sectional dependence into account. Also, a meta-analysis of relevant literature suggests that there are no studies that have made an attempt to establish a causal relationship between economic welfare and macroeconomic and non-macroeconomic factors (geographic and technological factors). Hence, this study accounts for causality using the Dumitrescu–Hurlin panel causality test.

Subsequent sections of this study are organized in the following way: Section 2 provides an extensive empirical review, synchronizing relevant literature on economic welfare and drivers of economic welfare. Section 3 presents the methods, materials, and empirical strategy adopted in this paper. Section 4 presents the results of our estimations and the related discussions, while section 5 concludes with some policy recommendations.

2. Review of Relevant Literature

2.1. Macroeconomic Factors and Welfare Nexus

A new metric of international trade to quantify the economic benefits of trade using a cross-country dataset from 1996 to 2016 was explored in the study of Lu et al. (2022) for 36 member nations of the Organization for Economic Co-operation and Development (OECD). The new metric was based on the proportion of a country's imports to its respective GDP. Evidence from the dynamic system GMM indicates that weaker economies benefited more from international trade than rich ones. Aurland-Bredesen (2021) found that tiny gains in growth may have a big

influence on the welfare costs of uncertainty. The study revealed the sources of uncertainty to include both economic instabilities and macroeconomic catastrophes for six distinct economic groupings. As regards growth and uncertainty, adjacent groups differ significantly from one another. However, it has been established that the gains of growth and the costs of uncertainty arising from welfare tend to be of equal magnitude. The findings in the study of Nurvita et al. (2022) showed that economic growth, spending on education, and health expenditure have a favourable impact on HDI. The conclusions of this study were based on the conventional fixed-effect estimation for a panel of eleven countries in Jambi Province. A drawback to the estimation technique used in achieving the results has been given an extensive review. Problems of degree of freedom have been identified in estimations based on fixed-effect models using a short-term panel. In a similar study, Deyshappriya (2017) employed a dynamic panel data analysis to investigate how income inequality (proxied by the Gini index) responds to macroeconomic determinants across 33 Asian countries. The study does not only include macroeconomic determinants, but it also incorporates both political and demographic factors to provide a more robust result. A parabolic connection between gross domestic product and inequality provided evidence for the well-known Kuznets hypothesis. In addition, inflation, political risk, terms of trade, and unemployment all contributed to a rise in inequality across the 33 nations, while a decline in inequality was connected with labour force participation, education, and government development aid.

The work of Okoyeuzu and Kalu (2022) analysed the effect of economic policy uncertainty and the trade confrontation between China and the United States on official development aid (ODA) to West Africa. The error correction model illustrates how well ODA adapts to the shocks and dynamics of China and the United States' rising economic instability and trade war. Aids may be utilized as a method to infiltrate markets for commerce and other economic activity, despite the continuous violence. Ramzi et al. (2017) analysed the effect of macroeconomic policies on economic development in Algeria, Morocco, Saudi Arabia, and Tunisia. Using the multivariate Markov switching approach, it was determined how trade openness, financial development, financial integration, inflation, and investment shock impact growth in four open Arab countries. In the major Arab nations, macroeconomic policy does not result in dynamic benefits owing to inflationary pressure driving economic development by way of domestic investment, according to the study's findings. Financial integration and development point to the need for fundamental reforms in the banking sector and financial markets, as well as the necessity for short-term stabilization measures adapted to macroeconomic volatility. Sakyi et al. (2018) employed a cross-section of forty African nations over a 16-year period to determine if trade facilitation enhances social wellbeing. In their research, social welfare included schooling, child health, population health,

and the indicator of human development. Estimations from the system GMM demonstrate that enhanced trade facilitation has a positive impact on social welfare.

2.2. Technological Factor and Economic Growth-Development Nexus

In the findings of Abdulqadir and Asongu (2022), who analysed the asymmetric effect of Internet access on economic growth in sub-Saharan Africa (SSA), adopting a non-linearity threshold model, revealed the significant effect of Internet access on growth. They found that Internet access had a threshold of 3.55 percent growth for economic growth, whilst government regulations were also found to be a significant factor in the operations of the telecommunication industry in sub-Saharan African countries. In contrast, a similar study conducted by Haftu (2019) for a panel sample of forty sub-Saharan African (SSA) countries from 2006 to 2015 using the robust two-step system GMM showed that the Internet has not contributed significantly to GDP per capita. However, increased access to mobile phones raised the per capita income of the region. GDP per capita changes by 1.2 percent for every 10 percent increase in mobile phone access.

Still, with regard to technological factors, in his 2019 study, David considered a panel data framework of forty-six African countries spanning from 2000 to 2015. The Dumitrescu–Hurlin panel causality test was used to estimate the tri-variate effect of telecommunication infrastructures, development, and economic growth. Employing a test for causality, they established a causal relationship between economic growth and development and telecommunication infrastructures. They further opined that telecommunication infrastructures support economic growth and development in Africa, and the reverse was also true. However, establishing a comparison between OECD and sub-Saharan African economies in terms of the role of digitalization as an antecedent for economic growth, Myovella et al. (2020) adopted the generalized linear methods of moments (GMM) estimators on a panel dataset spanning from 2006 to 2016, on thirty-three OECD and forty-one SSA. They revealed that digitalization had a positive effect on the economic growth of both country groupings and further argued that digitalization is largely dependent on the level of development the countries considered. Comparing SSA to OECD nations, the impact of broadband Internet was minimal, whereas mobile telecommunications had a greater effect in SSA countries.

2.3. Geographical Factor and Economic Growth Development Nexus

In the article of Isham, Woolcock, Pritchett, and Busby (2005), to show how nations dependent on natural resources were predisposed to increased economic and social divisions as well as weakened institutional capacity, 90 developing economies were examined. The study found that countries with natural resource

export have had more robust growth recoveries. The findings that resource rents and the quality of institutions translated to increased welfare were pronounced in Muhanji, Ojah, and Soumaré (2019). Forty-four African countries were investigated using a two-stage analysis. The results of their study were conditioned upon the degree of natural resource endowment as well as the countries' level of income.

Short-run and long-run dynamics of natural resource rents on per capita GDP and Total Factor Productivity in Saudi Arabia were examined in the studies Aljarallah (2021). Employing the ARDL and the error-correcting mechanism, he argued that natural resource is a blessing, as it increases GDP per capita and TFP in the long run. However, in a related study conducted by Ajide (2022), the empirical consistency of the resource curse hypothesis with economic complexity was unequivocally proven. The generalized method of moments (GMM), fixed-effects and random-effects estimations, and pooled OLS techniques were employed for both aggregated and decomposed model specifications. Similarly, Tabash, Mesagan, and Farooq (2022) disclosed the link between natural resources, economic complexity, and economic growth. Their study comprises a sample of twenty-four African economies for a period of twenty-three years leveraging the system GMM model. The inverse effect of natural resource rents on economic growth was documented in their study. Inference from their research established an interaction and individual effect for both natural resource as a blessing and natural resource as a curse.

Hypothesis Development

To arrive at a policy-coherent conclusion, the study aims to address the following hypotheses.

H_{01}: *Macroeconomic variables are significant factors that affect economic welfare.*

This study posits that macroeconomic variables are fundamental determinants of economic welfare. In this hypothesis, we argue that in order for African economies to address welfare deficiencies, there is a need to pay unparalleled attention to certain macroeconomic indices such as trade openness, economic growth, and inflation rates. Although hotly contested, trade liberalization vis-à-vis bilateral and multilateral trade agreements, and domestic economic integration into the global economy have long been posited to be a crucial path to the inclusive economic development of third-world nations. Our views are consistent with the Bhagwati hypothesis, which posits that the degree of a country's integration with the international markets provides a leverage for economies to feel the impact of foreign direct investments on economic growth and development. Similarly, economic growth as a macroeconomic parameter has also been exhaustively

documented to be a prerequisite for nations to address welfare concerns. This hypothesis will revalidate the existing arguments on this subject, as economic growth has been evidenced to be an underlying driver of welfare improvements. Lastly, this hypothesis will consider the impact of inflation on economic welfare. Consistent with a priori expectations, we posit that inflation rates adversely impact economic welfare in Africa.

H_{02}: Technological factors are positive drivers of economic welfare in Africa both in the short run and the long run.

Technological advancements have long been characterized to have fundamental influence on the national levels of per capita welfare. There seems to be broad consensus that a country's capacity to increase or maintain desired economic wellbeing and other quality-of-life indicators depends significantly on its investment in technology (Bugliarello, 1984; Freeman, 1987). More so, neo-technology theories of cross-country trade and economic growth postulate a synonymous understanding of the significance of investments in technology and the competence for national welfare. These theories, as documented in the works of Fagerberg (1987), made efforts to clarify the intricate and dependent nature of the relationship between technology and economic growth. Premised on the aforementioned, this study hypothesises that technological factors are crucial determinants of economic welfare in Africa, as it has the potential to serve as a channel for industrialization, which in turn transcends welfare improvements for African economies both in the short run and the long run.

H_{03}: Government effectiveness and geographical factors are both positive drivers of economic welfare in Africa.

The willingness of national governments to enact and implement policies that promote private sector development and also create ease in business operations, especially for the informal sector, is undoubtedly an important factor to be considered. The credibility of governments and the strength of the public service in addressing welfare concerns in Africa play an important role in curbing poverty across the region. Furthermore, several studies have investigated the impact of natural resource endowment and poverty reduction. The concept of "resource curse" has been a topical concept for nations with natural resource endowment failed to be translated to welfare improvements. This hypothesis also seeks to examine the nexus between resource abundance and its capacity to drive welfare improvements in Africa.

3. Materials and Methods

3.1. Model

This study, which is an archetype of Mara (2021), aims to determine how economic welfare responds to macroeconomic policies in Africa. Mara (2021) analysed how unemployment and social services affect the well-being of people in ten European countries. Our econometric model incorporates the macroeconomic policies identified in literature. The functional relationship is expressed in equation (1) as:

$$EconomicWelfare_{it} = f(MacroeconomicPolicies_{it}) \tag{1}$$

The broad model was formulated by tailoring it to the aims of our research while taking cognizance of factors that have been earlier identified in equation (2):

$$EcoWel_{it} = f(Macroeconomic\ Policies_{it}, Technology_{it}, Geography_{it}), \tag{2}$$

where *i, t* signifies country *i* in period *t*, $EcoWel_{it}$ is economic welfare in country *i* over period *t*, *t* is the time series the study intends to cover (2002 through 2016 – 15 years), and *i* contains the cross-sectional characteristics of the data (35 African[1] countries being studied).

The baseline empirical model to evaluate simultaneous macroeconomic policies that affect economic welfare in Africa is given in equation (3) as:

$$EcoWel_{it} = \varphi + \sum_{i=1\ldots15} \sigma_\theta MACRO_{it} + \sum_{i=\cdots15} \rho_\pi \tau_{n_{it}} + \mu_{it}$$

$$\mu_{it} = \emptyset_i + \delta_i s_i + \varepsilon_{it}, \tag{3}$$

where $EcoWel_{it}$ represents the variable of economic welfare measure (the response variable present in the model). For measuring economic welfare, the Human Development Index (HDI) is used as a proxy. UNDP (2020) defines it as the geometric mean of the three dimensions of human development. Here we follow the methodology of UNDP (2020) and define the Human Development Index (HDI) in equation (4) as:

$$HDI_{it} = [(LEXP_{INDEX})(EDU_{INDEX})(GNI_{INDEX})]^{1/3}, \tag{4}$$

where $LEXP_{INDEX}$ is the life expectancy index, EDU_{INDEX} is the expected years of schooling, and GNI_{INDEX} is the proxy for a decent standard of living measured by

1 Algeria, Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Cote d'Ivoire, Democratic Republic of Congo, Egypt, Eswatini, Gabon, Gambia, Ghana, Kenya, Madagascar, Mali, Mauritania, Mauritius, Morocco, Niger, Republic of Congo, Rwanda, Senegal, Seychelles, South Africa, Sudan, Tanzania, Togo, Tunisia, Uganda, and Zambia.

gross national income per capita. In equation (3), *MACRO* measures macroeconomic policies' determinants of economic welfare in Africa (measured with trade openness, the growth rate of GDP, government effectiveness, and inflation rate). $\tau_{n_{it}}$ is the vector of the control variable that is not of primary interest, which constitutes geographical and technological factors. However, due to the significance of these variables found in earlier research, we are unable to exclude them from consideration. i represents the selected countries, t is the year of observations, and μ_{it} includes time-invariant heterogeneity across the panel of countries; $(\emptyset_i)$ stands for unobservable common factors that are not restricted $(\delta_i s_i)$, and the idiosyncratic error terms ε_{it}, σ_θ, and ρ_π are the slope of the economic welfare model.

3.2. Data Sources and Measurements

In analysing how economic welfare responds to macroeconomic policies, this study relied on panel data from 35 African countries. The availability of reliable data and the inclination to restrict attention to how economic welfare responds to macroeconomic policies in the context of Africa served as primary considerations in the selection of countries included in the study. The data used in the study were collected from two databases (i.e. World Development Indicators and World Governance Indicators). Both databases contain information for various years up to 2016. The initial sample comprises 54 countries. Countries that did not meet our information requirements for calculating certain variables were removed. As a result, our final balanced dataset, which spans from 2002 to 2016, includes 35 countries.

Table 1. *Description of variables*

Label	Description	Indicators	Source	Motivating Study
HDI	Human Development Index	Geometric mean of life expectancy at birth, mean years of schooling, and GNI per capita	United Nations Development Programme (UNDP), 2020	(Nurvita et al., 2022)
$\boldsymbol{TRADE_{OPEN}}$	Trade Openness	Export minus import as a ratio of GDP	World Development Indicator (WDI), 2022	(Ramzi et al., 2017)
$\boldsymbol{INF_{RATE}}$	Inflation Rate	Inflation, GDP Deflator (annual %)	World Development Indicator (WDI), 2022	(Deyshappriya, 2017)
$\boldsymbol{GOV_{EFF}}$	Government Effectiveness	Effectiveness of governments in managing and introducing policies aimed at economic growth and development (estimate)	World Governance Indicator (WGI), 2022	(Adekunle, 2021)

Label	Description	Indicators	Source	Motivating Study
$ECON_{GROWTH}$	Economic Growth	The annual growth rate of GDP per capita	World Development Indicator (WDI), 2022	(Lu et al., 2022)
TECH	Technology	Mobile cellular subscriptions (per 100 people)	World Development Indicator (WDI), 2022	(Abdulqadir and Asongu, 2022)
GEO	Natural Resources	Total natural resource rents (% of GDP)	World Development Indicator (WDI), 2022	(Isham et al., 2005)

Source: authors' own compilation (2022)

This study measures economic welfare proxied by Human Development Index as used by Bonasia et al. (2022). Macroeconomic policies were proxied by trade openness as used in Ramzi et al. (2017), inflation rate as used in Deyshappriya (2017), government effectiveness as used in Adekunle (2021), and growth rate of GDP as used in Lu et al. (2022). The inclusion of pertinent control variables was necessary to preclude issues involving biases caused by omitted variables as well as the appositeness in explaining economic welfare in Africa. The choice of control variable is the technological factor (measured by Internet users as adopted in Abdulqadir and Asongu (2022)) and the geographical factor (measured by natural resource endowment as used in Isham et al. (2005)). The variables employed in this study are presented in *Table 1*.

3.3. Empirical Strategy

This study employed a multi-step econometric procedure in arriving at the estimation technique that was employed. Before proceeding with empirical estimations, pre-estimation tests were conducted. The starting point of the analysis was investigating the normalities of the cross-country dataset acquired in consonance with Biørn (2016). The independence of the error term and of the independent variable is one of the presumptions of the linear classical regression model, i.e. $(Cov\,\mu/X = 0)$. Correlation based on the relationship between relevant variables was established to produce results that are reliable. The variance inflation factor was considered to reach orthogonal relations among the regressors in consonance with leading literature on the endogeneity of regressors. A multicollinearity problem is indicated by a variance inflation factor (VIF) of 5 or 10 or above.

The influence of cross-sectional dependence on estimation output is contingent on a wide range of other aspects such as the strength of the correlations that exist between different cross-sections and the very nature of cross-sectional dependence itself. According to de Hoyos and Sarafidis (2006), ignoring the issue of cross-sectional dependence in data can cause a reduction in the efficiency of estimation. Subsequent to accounting for common factors' restriction, Pesaran's cross-sectional

dependence test by Pesaran (2004) and test statistic as proposed by Frees (1995) were conducted. To confirm that the variables used in this study are covariance stationary, the study moves on to panel unit root testing. The issue of testing for unit roots in models associated with panel data has received considerable attention in the past decade (Pesaran, 2007). However, earlier literature (e.g. Choi, 2001; Hadri, 2000; Maddala and Wu, 1999; Shin and Snell, 2002) approached unit root testing with the assumption that the panels exhibit cross-sectional independence. For the panel unit root properties, we will proceed to the following tests developed by Pesaran (2007), whose approach is distinctive in accounting for cross-sectional dependence in the individual series.

Empirical studies have documented the biasness of estimates arising from conventional panel techniques such as random effect, fixed effect as well as the first difference GMM when slope heterogeneity and cross-sectional dependence are ignored. The final step was to estimate the CS-ARDL model as informed by the outcome of the unit root test. Chudik et al. (2015) proposed the CS-ARDL estimation technique with short- and long-run outputs due to its potential in solving heterogeneous panel data with inherent problems of cross-sectional dependence in the short and the long run. The CS-ARDL is specified as:

$$EcoWel_{it} = \varphi_i + \sum_{l=1}^{p_{EcoWel}} \sigma_l EcoWel_{it-l} + \sum_{l=0}^{p_z} \rho_l Z_{n\,it-l} + \mu_{it} \tag{5}$$

To account for cross-sectional dependence, equation (5) is extended with the following cross-sectional averages:

$$EcoWel_{it} = \varphi_i + \sum_{l=1}^{p_{EcoWel}} \sigma_l EcoWel_{it-l} + \sum_{l=0}^{p_z} \rho_l Z_{n\,it-l} + \sum_{l=0}^{p} \rho_l \acute{V}_{t-l} + \mu_{it} \tag{6}$$

In equation (6), $EcoWel_{it}$ represents the dependent variable (*HDI*), followed by $Z_{n_{it}}$, which is the vector of all the independent variables ($TRADE_{OPEN}$, INF_{RATE}, GOV_{EFF}, $ECON_{GROWTH}$, *TECH,* and *GEO*), while $\acute{V}_{t-l} = (\acute{EcoWel}_{it}, Z'_{n_{it}})$ represents the cross-sectional averages.

4. Results and Discussion

4.1. Initial Tests

The summary statistics of the datasets obtained are presented in *Table 2*. These include the mean (averages), the minimum (*MIN*), the maximum (*MAX*), and standard deviation. A high tendency towards normal distribution can be inferred from the fact that the mean and median values of the variables in the panel dataset are

located within the range of values comprising the maximum and minimum. The average value of *HDI* is 0.52, while $TRADE_{OPEN}$, INF_{RATE}, GOV_{EFF}, $ECON_{GROWTH}$, *TECH,* and *GEO* have 6.172, 7.740, -0.594, 4.381, 52.681, and 12.109 as their respective average values.

Table 2. *Summary statistics*

Variable	Obs.	Mean	Std. D.	Minimum	Maximum
HDI	525	0.520	0.119	0.273	0.794
$\boldsymbol{TRADE_{OPEN}}$	525	-6.172	12.487	-100.971	36.068
$\boldsymbol{INF_{RATE}}$	525	7.740	13.717	-21.165	196.984
$\boldsymbol{GOV_{EFF}}$	525	-0.594	0.608	-1.849	1.057
$\boldsymbol{ECON_{GROWTH}}$	525	4.381	4.288	-36.392	33.629
TECH	525	52.681	42.412	0.331	163.875
GEO	525	12.109	11.667	0.001	58.688

Source: authors' own compilation (2022)

There is a high possibility that the slope parameter will defy theoretical predictions as a consequence of the unintended effect of multicollinearity, which occurs when several independent variables are highly correlated with one another. According to the existing body of research, conducting a test to determine whether the variables in question are affected by multicollinearity among themselves can be facilitated by testing for correlations between the variables in question. Multicollinearity is thought to be more likely in studies in which correlations between variables are greater than 0.8, leading to erroneous results by some researchers (Dao and Nguyen, 2020; Nguyen and Dang, 2020; Quoc Trung, 2021). *Table 3* reports the pairwise correlation coefficient, which helps to check the collinearity of independent variables using all the information available. The pairwise correlation coefficient reported across the variables in the study is less than 0.8. In this case, collinearity is unlikely to exist.

In addition, *Table 4* demonstrates how the VIF was applied to analyse the collinearity characteristics of the variables that were investigated. This study optimized the threshold with tolerance (reciprocal of VIF) values > 0.2 and variance inflation factors < 5 and found that the variables do not invalidate the classical linear regression model's collinearity assumption. Thus, output elasticities in the economic welfare model with marginal hindrances of slope endogeneity can be estimated using plausible evidence backed by the VIF.

Table 3. *Correlation matrix*

Variable	***HDI***	***$TRADE_{OPEN}$***	***INF_{RATE}***	***GOV_{EFF}***	***$ECON_{GROWTH}$***	***TECH***	***GEO***
HDI	1.000						
$TRADE_{OPEN}$	0.202*	1.000					
INF_{RATE}	-0.054	0.138*	1.000				
GOV_{EFF}	0.674*	-0.091	-0.089	1.000			
$ECON_{GROWTH}$	-0.098	0.020	0.098	0.035	1.000		
TECH	0.690*	0.077	-0.142*	0.400*	-0.134*	1.000	
GEO	-0.124*	0.376*	0.166*	-0.453*	0.127*	-0.148*	1.000

*Note: * P < 0.01.* *Source: authors' own compilation (2022)*

Table 4. *Variance inflation factor*

Variables	**Collinearity Statistics**	
	Tolerance	**VIF**
$TRADE_{OPEN}$	0.827	1.210
INF_{RATE}	0.944	1.060
GOV_{EFF}	0.662	1.510
$ECON_{GROWTH}$	0.941	1.060
TECH	0.792	1.260
GEO	0.658	1.520

Source: authors' own compilation (2022)

4.2. Cross-sectional Dependence Test

Due to our reliance on panel data, there is the likelihood for cross-sectional dependence among the series of various countries. Cross-sectional dependence may arise due to common factors that are unobserved and ultimately become part of the residual (de Hoyos and Sarafidis, 2006). The conventional panel regression estimations are likely to be biased in cross-sectional dependency series.[2] As a result, this study considers the existence of dependence in the panel data, which considers different dynamics for each country in Africa that may result from a number of factors,[3] and we allowed the individual responses to these factors to vary from country to country. To address the concerns expressed earlier, we employ two statistical procedures designed to test for cross-sectional dependence.[4] The tests considered are in correlation with short periods and large numbers of cross-sections, i.e. N(35) > T(15).

2 The standard fixed-effects (FE) and random-effects (RE) estimators are consistent although not efficient, and the estimated standard errors are biased (de Hoyos and Sarafidis, 2006).

3 Which could be geographic, economic, policy-relevant, or technological factors.

4 Pesaran's (2004) cross-sectional dependence (CD) test and the test statistics proposed by Frees (1995).

Table 5. *Cross-sectional dependence test*

Test		
	Statistic	**p-value**
Pesaran's CD	9.583*	0.000
Frees CD	9.296*	0.335
Total Panel (Balanced) Observations	525	

Notes: * Statistical significance at the 1% level. Null hypothesis: cross-sectional independence (correlation) in weighted residuals.

The results presented in *Table 5* point towards rejecting the null hypothesis of cross-sectional independence. Based on these results, economic welfare and its determinants in one country can be shown to be influenced by factors from other countries.

4.3. Slope Homogeneity Test

This study considered the Pesaran and Yamagata (2008) slope homogeneity tests to determine the structure of homogeneity across slopes. For panel data models with a large cross-section size (N) compared to the time series dimension (T), Pesaran and Yamagata (2008) suggested a standardized version of Swamy's test of slope homogeneity. The suggested test, expressed by $\tilde{\Delta}$, and $\tilde{\Delta}_{adj}$, capitalizes on individual slopes' cross-sectional dispersion, which is weighted by their relative precision.

$$\tilde{\Delta} = \frac{1}{\sqrt{N}}\left(\frac{\sum_{i=1}^{N}\tilde{\delta} - k}{\sqrt{2k}}\right)$$

$$\tilde{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\sum_{i=1}^{N}\widetilde{\delta_i} - k}{\sqrt{v(T,k)}}\right),$$

where N represents the number of cross-section units, $\widetilde{\delta_i}$ is the weighted difference between the cross-sectional unit-specific estimate and the pooled estimate number of the cross-section unit, and k represents the exogenous parameters in the model. However, the $\tilde{\Delta}$ test assumes that residuals are independently distributed but allows for a heterogeneous variance (Bersvendsen and Ditzen, 2021). Cases of heteroscedastic and serially correlated errors cannot be dealt with by using the standardized version of Swamy's test (Blomquist and Westerlund, 2013). The alternative test suitable for the situation is the Heteroscedasticity and Autocorrelation Consistent (HAC) robust test.

$$\Delta_{HAC} = \sqrt{N}\left(\frac{N^{-1}S_{HAC} - k}{\sqrt{2k}}\right)$$

The proposed test produces only minor distortions while simultaneously preserving a satisfactory level of power. The null hypothesis is accepted at a 5-percent significance level, and the cointegrating coefficients are thought to be homogenous if the test's p value is greater than 5 percent.

Table 6. *Slope heterogeneity test*

Test	Statistic	p-value
Pesaran and Yamagata (2008)		
$\tilde{\Delta}$	8.934*	0.000
$\tilde{\Delta}_{adj}$	13.078*	0.000
(Blomquist and Westerlund, 2013)		
Δ_{HAC}	11.890*	0.000
$\Delta_{HAC_{adj}}$	17.406*	0.000

Notes: * Statistical significance at the 1% level. HAC Kernel: Bartlett.

The results presented in *Table 6* show that the null hypothesis of slope homogeneity cannot be accepted, as the p-value of the test statistics in both tests are less than 0.01. Drawing inference from this, heterogeneity exists.

4.4. Panel Unit Root Test

In testing for unit root, the battery of first-generation tests assumed that each individual time series in the panel is cross-sectionally independent. This assumption was considered restrictive in the context of regional regressions. De-meaning the series was thought of as a solution to this restriction (Im et al., 1995). Pesaran (2007) noted that this process was rather deficient and could not work in the case of heterogeneous covariances of the error term. Considering this, a battery of second-generation tests for unit root were proposed. This study uses the test proposed by Pesaran (2007). This direction was explored to avoid getting misleading results when factors such as cross-sectional dependence and slope homogeneity were not considered. *Table 7* reveals the outcome of the test carried out using the cross-sectionally augmented DF (CADF) and the cross-sectionally augmented IPS (CIPS).

The tests in *Table 7* were estimated at level and first difference with the inclusion of a constant term. Following the establishment of cross-sectional dependence and the unit root test, the long-run and short-run relationship between economic welfare and its determinant using the CS-ARDL approach was estimated. Inference from the test carried out exhibits symmetrical consensus. Both CADF and CIPS tests reveal that the variables are a mixture of I(0) and I(1).

Table 7. *Second-generation panel unit root test*

Variable	@Levels		@First Difference		Order of Integration
	CADF	CIPS	CADF	CIPS	
	Intercept {Intercept & Trend}				
HDI	-1.950 {-2.115}	-1.890 {-2.115}	-3.190* {-3.491*}	-3.190* {-3.657*}	I(1)
$TRADE_{OPEN}$	-2.437* {-2.827*}	-2.417* {-3.003*}	-4.081* {-4.294*}	-4.096* {-4.483*}	I(0)
INF_{RATE}	-3.247* {-3.334*}	-3.247* {-3.334*}	-4.472* {-4.336*}	-4.472* {-4.336*}	I(0)
GOV_{EFF}	-1.952 {-2.782*}	-2.112 {-2.906*}	-4.033* {-4.188*}	-4.073* {-4.360*}	I(1)
$ECON_{GROWTH}$	-3.377* {-3.406*}	-3.296* {-3.400*}	-4.751* {-4.755*}	-4.724* {-4.807*}	I(0)
TECH	-1.797 {-2.169}	-2.443* {-2.919*}	-2.902* {-2.806*}	-3.174* {-2.951*}	I(1)
GEO	-1.991 {-2.560}	-2.229 {-2.664}	-3.721* {-3.768*}	-3.660* {-3.904*}	I(1)

Note: * Statistical significance at the 1% level. *Source: authors (2022)*

4.5. Cross-Sectional Autoregressive Distributed Lag (CS-ARDL)

Following the establishment of cross-sectional dependence and the unit root test, the short-run and long-run relationship of economic welfare and its determinant using the CS-ARDL method was estimated. Since the variables are a mixture of I(0) and I(1) and no variable is integrated of an order greater than one, *Table 8* reports the outcomes of the CS-ARDL estimation.

Table 8. *CS-ARDL results*

	Coefficients	Std. Error	z-stat	p-value
Long run				
$TRADE_{OPEN}$	0.028	0.0771	0.36	0.719
INF_{RATE}	-0.042	0.049	-0.87	0.384
GOV_{EFF}	3.384	2.8845	1.17	0.241
$ECON_{GROWTH}$	0.233**	0.099	2.33	0.020
TECH	0.181*	0.040	4.51	0.000
GEO	-7.443	7.755	-0.96	0.337
Short run				
$\Delta TRADE_{OPEN}$	0.034	0.095	0.36	0.722
ΔINF_{RATE}	-0.054	0.071	-0.75	0.453
ΔGOV_{EFF}	4.751	4.0946	1.16	0.246
$\Delta ECON_{GROWTH}$	0.253**	0.127	1.99	0.046

	Coefficients	Std. Error	z-stat	p-value
ΔTECH	0.278*	0.069	4.02	0.000
ΔGEO	-13.121	13.4602	-0.97	0.330
***ECT*(–1)**	-1.317*	0.047	-28.26	0.000
No. of Obs.	490			
No. of Groups	35			

Source: authors (2022)

Notes: *, **, and *** show statistical significance at 1, 5, and 10% respectively.

Results reveal that trade openness, government effectiveness, economic growth, and technology have a positive relationship with human development index. The positive values in the short and long run (CS-ARDL) of the coefficient of trade openness, government effectiveness, economic growth, and technology show that as these variables increase, an improvement in economic welfare in the sample countries occurs, i.e. $\frac{\partial TRADE_{OPEN_{it}}}{\partial HDI_{it}} > 0$, $\frac{\partial GOV_{EFF_{it}}}{\partial HDI_{it}} > 0$, $\frac{\partial ECON_{GROWTH_{it}}}{\partial HDI_{it}} > 0$, and $\frac{\partial TECH_{it}}{\partial HDI_{it}} > 0$.

Conversely, inflation rate and natural resources have negative values in the short and long run, which indicates that if these variables rise, the economic welfare of the sample countries will fall., i.e. $\frac{\partial INF_{it}}{\partial HDI_{it}} < 0$ and $\frac{\partial GEO_{it}}{\partial HDI_{it}} < 0$. More analytically, a 1 percent increase in trade openness increases economic welfare to around 0.28 and 0.34 percentage in the long run and short run respectively. For instance, bilateral trade agreement (e.g. the Africa Free Trade and Continental Agreement) can improve trade ties and shed light on the continent's welfare. This outcome is in tandem with that of Lu et al. (2022). In relation to the effect of inflation rate (*INF*), the coefficient magnitude revealed that a 0.42 percentage decline in economic welfare is a result of inflation rate in the long run. Similarly, 0.54 percentage decline in economic welfare is also caused by the inflation rate in the short run. It is important to note that rising food and other commodity prices reduce the market value of African households' disposable income. A consistent increase in the market's average price of goods suggests significant structural deficiencies.

Government effectiveness (GOV_{EFF}) increases welfare both in the long run and in the short run. 33.84 percentage and 47.51 percentage increases in welfare are associated with 1 percent increase in government effectiveness. In line with the description of the measure of government effectiveness, the ability of governments in handling and developing policies geared towards economic growth and development is evidently a core determinant of welfare improvement. Additionally, our current analysis for African countries demonstrates the progressive impact of economic growth on economic welfare. It implies that a 1 percent change in economic growth

($ECON_{GROWTH}$) is what causes a 0.233 percentage increase in economic welfare in the long run. According to the short-run results, a 1 percent change in $ECON_{GROWTH}$ increases economic welfare by 0.253 percent. Former studies (e.g. Aurland-Bredesen, 2021; Nurvita et al., 2022) also support the positive relationship between economic growth and welfare that we have found in our study.

In addition, technology (*TECH*) has a positive impact on economic welfare, which implies that a 1.81 percentage increase in economic welfare is a result of 1 percent change in technology in the long run. Also, the short-run outcomes validate that there is a positive relationship between *HDI* and *TECH*. This finding is in tandem with the work of Haftu (2019), who also demonstrated a significant relationship between technological advancement and GDP per capita as a proxy for welfare. Concerning the coefficient of natural resources (*GEO*), it decreases welfare by 74.43 and 131.20 percent when it increases by 1 percent in the long run as well as in the short run. This is consistent with the "Dutch disease" and resource curse paradox. Results show that Africa's resource endowment has failed to translate to economic welfare. However, only economic growth ($ECON_{GROWTH}$) and technology (*TECH*) were found to exert a significant impact on economic welfare at the 5 percent and 1 percent significance levels respectively.

Results show that the coefficient of *ECT* that signifies the speed of adjustment is negative (-1.317) and statistically significant at the 1 percent critical level. This demonstrates that in the current year, disequilibrium in economic welfare of about 132 percent from the previous years is corrected. The significance of the *ECT* indicates and confirms the presence of a long-run equilibrium relationship between economic welfare and the macroeconomic and non-macroeconomic factors used in this study.

4.6. Panel Granger Causality

The specification of the heterogeneity between cross-sections has been mentioned as one of the main problems that is unique to panel data models. To consider the heterogeneity across cross-sections, Hurlin and Dumitrescu (2011) assumed that all coefficients differ across panels. The results of the study's attempt to establish any causal relationship among the selected variables are presented in *Table 9*. The critical values and p-values associated with the Z-bar tilde were estimated using a bootstrap procedure to account for cross-sectional dependence.

The outcome of the D-H non-causality test reveals that there is homogeneous unidirectional causality from trade openness ($TRADE_{OPEN_{it}}$) to economic welfare (HDI_{it}). This implies that improved trade interactions accelerate the welfare of African economies. In addition, the result also established that there is a homogeneous unidirectional causality between economic welfare and government effectiveness. The implication of this outcome is that economic welfare (HDI_{it}) generates government

effectiveness ($GOV_{EFT_{it}}$). The need to improve welfare is a stimulant to the willingness of government to set policies that promote welfare in Africa. Likewise, homogeneous unidirectional causality is found between economic welfare (HDI_{it}) and economic growth ($ECON_{GROWTH_{it}}$), which indicates that the latter remains a prerequisite to the attainment of optimal economic welfare. Lastly, no direction of causality was found between welfare and the rest of the variables.

Table 9. *Dumitrescu–Hurlin non-causality test results*

Causality	$\overline{W}$	$\widetilde{\overline{Z}}$	P-value	Direction
$HDI_{it} \rightarrow TRADE_{OPEN_{it}}$	3.090	5.348	0.112	Homogeneous uni-causal relationship between economic welfare and trade openness
$TRADE_{OPEN_{it}} \rightarrow HDI_{it}$	8.550	2.100	0.042	
$HDI_{it} \rightarrow INF_{RATE_{it}}$	9.068	2.407	0.070	No causal relationship between economic welfare and inflation rate
$INF_{RATE_{it}} \rightarrow HDI_{it}$	1.408	0.533	0.609	
$HDI_{it} \rightarrow GOV_{EFT_{it}}$	4.546	9.517	0.019	Homogeneous uni-causal relationship between economic welfare and government effectiveness
$GOV_{EFT_{it}} \rightarrow HDI_{it}$	2.000	2.228	0.061	
$HDI_{it} \rightarrow ECON_{GROWTH_{it}}$	5.807	4.927	0.044	Homogeneous uni-causal relationship between economic welfare and economic growth
$ECON_{GROWTH_{it}} \rightarrow HDI_{it}$	1.271	0.139	0.876	
$HDI_{it} \rightarrow TECH_{it}$	10.341	3.160	0.116	No causal relationship between economic welfare and technology
$TECH_{it} \rightarrow HDI_{it}$	2.918	4.855	0.125	
$HDI_{it} \rightarrow GEO_{it}$	3.378	6.173	0.130	No causal relationship between economic welfare and natural resources
$GEO_{it} \rightarrow HDI_{it}$	7.436	1.441	0.085	

Note: p-values computed using 1,000 bootstrap replications. *Source: authors, 2022*

5. Conclusions and Policy Recommendations

The primary objective of this study is to examine the macroeconomic and non-macroeconomic determinants of economic welfare in African countries. To achieve this objective, thirty-five African countries were selected for the period from 2002 to 2016 by adopting the panel framework of the CS-ARDL, as suggested by Chudik et al. (2015). Cross-sectional dependence as well as slope heterogeneity were well accounted for. More so, the outputs of the cross-sectional dependence test led to the adoption of the second-generation panel unit-root test (CIPS and CADF) of Pesaran (2007). The findings from the CS-ARDL analysis suggest that trade openness, government effectiveness, economic growth, and technology cause an improvement in the economic welfare in the sample countries. While economic welfare in the chosen African nations is negatively impacted by the inflation rate and natural resource availability both in the long and the short run, the extent to which each of these factors affect the economic welfare were carefully addressed. However, of all

the variables considered in this study, economic growth and technology were the only factors found to be statistically significant catalysts of economic welfare in Africa.

Based on the results of the findings, the study suggests the following:

(i) It is important to address the key barriers to digitalization that are prevalent in Africa such as poor infrastructure, connectivity, and illiteracy. In countries such as Tanzania, Sudan, Chad, and Burundi, which are arguably underexposed to technological advancements, the corresponding national governments must adopt policies to guarantee that there is an acceptable level of trust in technology. Digital economy is Egypt's second fastest expanding industry, while the ICT sectors in Nigeria, Kenya, and South Africa also contribute significantly to Africa's growth, but by easing Internet censorship restrictions and disruption, more opportunities could be generated.

(ii) According to the United Nations Educational, Scientific and Cultural Organization (2016), investing an average of 3.5% of a country's GDP in innovation, human capital, basic science, and education is the key to effectively promote sustainable development. The knowledge gap between the developed and underdeveloped nations will be narrowed in a few years if this criterion is embraced by the most underdeveloped nations, especially in Africa.

(iii) Growth and welfare are strongly correlated. Putting aside the continent's natural resources, it is equally important to create a welfare state that is open to all citizens. This can be done by looking at the ingrained ideas and values that form its various social structures. African leaders should develop similar social protection systems that consider the means of subsistence, properties, status, and savings of all classes of citizens.

The scope of this study is limited by the availability of data in the African countries, and only a few numbers of variables were considered. Future studies can extend the formulated model by considering more macroeconomic and non-macroeconomic/institutional variables. Specifically, African nations are marred by the vice of corruption and non-transparent governments. This is undoubtedly a crucial factor that can slow the growth and progress of any nation. As a result, institutional factors like "Control for Corruption" and "Regulatory Quality" are important variables to be considered.

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