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Article

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

International trade and economic growth in Africa: The role of the digital economy

Simon Abendin^{1*} and Pingfang Duan¹

Abstract: This paper examines the role the digital economy plays in international trade impacts on Africa's economic growth based on 53 countries' sample from 2000–2018. We further divided the sample into five sub-regions, and the results are estimated by POLS, random and fixed effects, and the GMM models. The findings showed that (1) trade only has positive effects on economic growth when interacted with the digital economy in the POLS estimations, (2) Trade has a significantly positive impact on economic prosperity without and with the interactive term in the RE, FE, and the sys-GMM estimations, (3) the output elasticities of capital and labor have positive and negative impacts on economic growth, respectively, (4) the regressions for the sub-sample yielded statistically significant differences in the output elasticities for the indicators. The study recommends that concentrated efforts be directed towards developing the digital economy to ensure international trade's full economic effect in Africa.

Subjects: Development Policy; Economics; International Economics

Keywords: International trade; Africa; POLS; random effects; fixed effects; economic growth and digital economy

1. Introduction

The economic growth effect of trade has been the subject of much debate among academic researchers and practitioners, particularly in developing countries. Trade openness is generally believed to create a favorable atmosphere that results in quality products contributing to economic development (Aradhyula et al., 2007). Therefore, international trade is considered a significant source of economic growth worldwide. While international trade flows have often been volatile and prone to

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PUBLIC INTEREST STATEMENT

This paper examines the role the digital economy plays in international trade impacts on Africa's economic growth based on 53 countries' sample from 2000–2018. We further divided the sample into five sub-regions, and the results are estimated by POLS, random and fixed effects, and the GMM models.

The study used secondary data from the World Bank Development Indicators (WDI). This study has shown that the digital economy facilitates economic growth. However, international trade facilitates economic growth after interacting with the digital economy. It was recommended that African governments direct efforts towards developing the digital economy to ensure international trade's full economic growth effect.

recurring trade barriers, many countries still seek international trade because of the large, favorable externalities associated with the trade. Trade's position as a driver of economic growth is fast becoming crucial, particularly in African countries, since the region is endowed with natural resources with low industries to process these resources into consumable goods and other intermediate products. Therefore, external trade in these resources is necessary to complement the local processing industries to promote economic growth (Asiedu, 2013). Governments in developing countries, especially in Africa, have adopted trade policies, including import substitution strategies, exchange rates, tariffs, and quantitative controls, to promote international trade in the region. These trade policies are motivated by international trade's economic spillover effects, such as productivity gains, intellectual capital, advanced economic management, efficient allocation and better utilization of resources, reduction in trade fluctuations, and technology diffusion (Manwa & Wijeweera, 2016).

Conventional trade theory has assumed that trade encourages economic prosperity as trade leads to the reallocation of capital, and countries engaging in trade tend to have a comparative edge as they specialize in manufacturing and exporting to their trading partners, which increases economic growth. Despite various initiatives taken by developing countries to liberalize trade with the rest of the world, economic growth remains a major challenge for developing economies worldwide, of which Africa is a part (Asiedu, 2013; Doan, 2019; Haddad et al., 2013). This has given rise to an intense debate among development economists and other academics about whether international trade boosts economic growth. As a result, several empirical studies have been undertaken by researchers to determine the effect of international trade on economic progress in Africa and the rest of the continents. On the one hand, some of the empirical studies have shown positive effects of international trade on economic growth (Ades & Glaeser, 1999; Badinger & Breuss, 2008; Brini et al., 2017; Doan, 2019; Frankel & Romer, 1999; Gokmenoglu et al., 2015; Grossman & Helpman, 1990; Kumar, 2012; Le, 2020; Manwa & Wijeweera, 2016; Nkikabahizi et al., 2018; Van Den Berg, 1997; Zahonogo, 2017). On the other hand, some scholars reported negative or inconclusive impact of international trade on economic growth in Africa and the rest of the world (Cerdeira Bento & Moutinho, 2016; Manwa et al., 2019; Menyah et al., 2014; Mullings & Mahabir, 2018; Polat et al., 2015; Rahman & Mamun, 2016; Zheng & Walsh, 2019). These contradictory (inconclusive) findings continue to exist and call for more study to fill the knowledge gap.

In recent years, the digital economy has usually been credited with contributing to sustainable economic growth. Undoubtedly, the digitalization of the economy is projected to fuel economic growth. Digitalization promotes economic development through the proper use of human capital and natural resources; and the accumulation of productive capacity in the extractive industries. The digital economy-growth nexus has been theoretically well established in the literature, followed by country-level empirical evidence in studies such as (Cronin et al., 1991; Erumban & Das, 2016; Ghosh, 2016; Saidi et al., 2017) indicating the crucial role of the digital economy in productivity, growth, and development. Empirical studies like (Bahrini & Qaffas, 2019; Ghosh, 2016; Hofman et al., 2016; Njoh, 2018; Petersen, 2019) reported that the economy's digitalization is improving economic growth.

Theoretically, it is argued that the digital economy encourages trade as trade leads to the reallocation of capital, and countries engaging in trade tend to have a comparative edge as they specialize in development and exports to their trading partners, which boosts economic growth (Lwoga & Sangeda, 2019; Sassi & Goaid, 2013). For example, some scholars (Abeliansky et al., 2020; Freund & Weinhold, 2004; Lin, 2015; Ozcan, 2018; Rodríguez-Crespo & Martínez-Zarzoso, 2019; Vemuri & Siddiqi, 2009) document that the digitization of the economy has had a substantial positive effect on foreign trade. It is necessary to note that international trade's growth effects will depend on the digital economy's role. Therefore, it is argued that a well-functioning digital economy guarantees low transaction costs, effective delivery of capital, quick access to foreign

markets, the quicker transmission of business information and data, and thus boosts economic growth (Freund & Weinhold, 2002, 2004; Petersen, 2019).

Despite the massive role that the digital economy plays in trade, this appears to be disregarded by the existing literature on the impact international trade has on economic growth. Empirical surveys have centered on the economic development effect of the digital economy, suggesting a clear correlation. These studies indicate that digital infrastructure improves economic growth (Czernich et al., 2011; David, 2013). In brief, theoretical literature suggests that foreign trade has a favorable impact on economic growth, although empiric literature reports mixed findings. Simultaneously, the digital economy's position has been developed to positively contribute to international trade's economic growth impact. Thus, countries with a well-functioning digital economy are projected to correlate favorably with foreign trade and global growth rates (Abeliansky & Hilbert, 2017).

Our motive is to investigate the extent to which foreign trade facilitates economic growth in Africa, taking into account the digital economy's advancement. Specifically, we examine whether African economies' digitization is necessary for foreign trade to positively affect economic growth. This paper is focused on the fact that, to the best of our knowledge, no longitudinal studies were performed at the time of this study on the crucial role of digitalization in influencing the growth effects of foreign trade. The non-existence of studies on the economic growth effects of the interaction between international trade and the digital economy made this study stand uniquely from the related literature; hence its novelty sources. The study contributes to the existing literature in that earlier studies (Doan, 2019; Manwa & Wijeweera, 2016; Manwa et al., 2019; Zahonogo, 2017) trying to figure out the effect of international trade on economic growth seems to have ignored the role the digital economy in influencing the effect of trade on the economic growth, particularly in Africa. Therefore, the study contributes to the literature by incorporating the digital economy's effects on Africa's trade-led growth. Another gap in the literature that this study fills in is the weak measurement of digitalization. For instance, studies such as (Kouton, 2019; Myovella et al., 2019) measured the digital economy using a single variable or two variables, including mobile subscriptions, internet subscribers, and broadband subscriptions. The inadequate digital economy proxies are insufficient to assess the digital economy's interactive effect and international trade on economic growth. Poor and inadequate digital economy measures may yield results that are misleading and meaningless to policy-makers. Our research aims to fill this void by utilizing three dimensions of the digital economy, the access, use, and skills aspect, to create a digital economy index. We employed the principal component analysis to create the digitalization index called the DIGICONOMY.

Moreover, we show whether the contribution of international trade and the combined effects of the digital economy and trade on economic growth differs from Africa's five regions: Central, East, North, South, and West. The rest of the article is structured as follows: first, we provide theoretical and empirical international trade issues in Africa. Second, we describe the data and overview the digital development and international trade in the countries under study. Next, we include the empirical methods and a discussion of the results. Summary and concluding remarks are made in the final section.

2. Literature review

This section is dedicated to the review of literature relevant to international trade and economic growth. We first reviewed the theoretical literature on international trade and economic growth, followed by empirical literature on international trade and economic growth.

2.1. Theories on trade and economic growth

The relation between international trade and economic growth has drawn a great deal of interest in international economics, theoretically and empirically. Based on this perspective, we have reviewed three theories below related to international trade and economic prosperity.

The mercantilist theory of trade argued that the only means a country or nation can become wealthy and powerful is by maintaining less import of goods and services but instead encourages more export of goods and services to other countries. The mercantilist claimed that growing exports and keeping imports at a minimum level would allow countries to achieve a favorable balance of trade, which, in turn, would contribute to national prosperity and, thus, economic development. Based on this notion, one can conclude that the mercantilist believes in a one-way transaction leading to self-seeking trade.

On the other hand, classical theorists such as Adam Smith (credit with the Absolute Cost Advantage theory) and David Ricardo (also credited with the Comparative Cost Advantage theory) positioned that both countries engage in international trade stand a chance to benefit from the trade even though some countries will gain more than others. Both Adam Smith and David Ricardo concluded that countries prosper from foreign trade if they specialize and export commodities (goods) with notably lower cost advantages and import goods with a significantly higher cost disadvantage. In this view, the classical theory's primary implication is that a country benefits from international trade through specialization and effective distribution of resources. The classical theorists further suggest that trading with other nations will bring in new technology and skills to contribute to higher efficiency and economic development. They also positioned that engaging in foreign trade leads to economic growth since each country would share trade benefits.

The Heckscher-Ohlin theory (H-O model) of trade suggests that the differences in countries' resources are the driving force of international trade. The theory states that the comparative advantage comes from the difference in the abundance of factor production and the factor intensity of the products (Morrow, 2010). It is also referred to as the 2x2x2 model, two countries, two goods, and two production factors. The theory emphasizes that a country should export products that require production factors that it has in abundance. It also emphasizes the importation of goods which cannot be produced as easily by a region. It is of the view that countries should ideally export surplus materials and energy while importing goods that they need proportionately. Heckscher (1919) and Ohlin (1933) concludes that a country with sufficient factor endowment would increase growth if it produces products on a larger scale and exchanges with other countries.

2.2. International trade, digital economy, economic growth, and hypotheses development

Aside from the theoretical view of the economic growth effect of international trade, a large number of empirical studies have been conducted at the macro-level on the link between international trade and economic growth with contrary views, which has been attributed to the varying econometric methodologies used and the scope of the studies. Some of the earlier studies conducted analyze international trade concerning economic growth, financial development, inclusive growth, CO₂ emissions, energy consumption, environmental degradation, to mention a few. For instance, Cerdeira Bento and Moutinho (2016) used data from Italy and the autoregressive distributed lag bound test approach of cointegration and confirm no evidence supporting the trade-led economic growth hypothesis. However, they revealed positive CO₂ emission effects of international trade in Italy.

Polat et al. (2015) reveal that the well-developed financial sector boosts economic growth while providing evidence that foreign trade is counterproductive to the South African economy's development. Sun and Heshmati (2010) conducted a six-year study on the economic growth effects of international trade in China. The results suggest that international trade stimulates national economic growth. Similarly, Zheng and Walsh (2019) analyzed the effect of energy consumption on China's economic development. By expanding existing literature to include international trade and urbanization in the production model in the 2001–2012 provincial panel of evidence, the findings show that urbanization is a key determinant of economic growth, although not having exact results to support the hypothesis that international trade encourages economic growth in China.

In the same vein, Mitsek (2015) modeled the relationship between trade inflation and economic growth using Russia's data for the next 2–3 years starting in 2015. The findings of the model revealed an adverse economic growth effect of foreign trade on the Russian economy. The equations suggest that a percentage rise in import and export rates leads to a 1.5% decline in the Russian economy's economic growth rate. Gokmenoglu et al. (2015) confirmed that trade and well-functioning capital markets drive Pakistan's economic progress. Also, the findings further revealed a long-term relationship between trade, financial sector development, and growth. Similarly, Shahbaz et al. (2013) applied the ARDL model to examine the link between financial sector development, energy use, economic growth, and trade in China. The authors also identified positive economic growth impacts of energy use, financial development, and trade.

Moreover, the results also revealed a bi-directional causality between international and economic growth. Using panel data from the pooled average group estimator (PMG) of six Gulf Cooperation Councils from 1980–2010, Jouini (2015) confirms that international trade positively impacts economic growth in both the short-and long-term. Yenokyan et al. (2014) conclude that trade affects economic activities in two ways: the overall impact of size and technologies' transition. It also clarified that the scale effect is accomplished by trade liberalization, which increases companies' size and results in lower average costs and higher productivity per firm. The transfer of the technology medium is the product of the spread of information developed as countries establish infrastructure, such as communications, to encourage more substantial foreign exchange. Another study by Rahman and Mamun (2016) looked at Australia's energy-led development and trade-led growth over 1960–2012. Using the ARDL estimation process (Rahman & Mamun, 2016) provided data supporting the trade-led growth hypothesis while they do not find evidence to support the Australian economy's energy-led growth. From the theories and the existing literature propositions, the authors deduced the following: trade brings in new technology and skills to contribute to higher efficiency and economic development. Exporting more and import less promotes economic prosperity, and that many empirical studies find support for the theoretical views. Therefore, empirically examining the impact of international trade on economic growth in a region touted with low economic growth is essential. We, therefore, hypothesize that:

H₁: International trade enhances economic growth in Africa

Many empirical studies have argued for a positive relationship between digital development and economic growth in developed and developing countries. For instance, Adeleye and Eboagu (2019) report that internet usage, mobile penetration, and fixed telephone increase economic growth by 0.22%, 0.86%, and 0.68%, respectively, in Africa. Similarly, (Chavula, 2013) hypothesized that telecommunication development enhances Africa's living standards. The general conclusions in the existing literature are that information and communication technology promotes economic growth. Accordingly, we hypothesize that:

H₂: The digital economy enhances economic growth in Africa

Previous studies on the relationship between the digital economy and international trade (Abeliansky et al., 2020; Freund & Weinhold, 2004; Lin, 2015; Ozcan, 2018; Rodríguez-Crespo & Martínez-Zarzoso, 2019; Wang & Choi, 2019) but not limited to documented positive results. Freund and Weinhold (2004) conclude that internet use positively influences international trade. Lin (2015) reported a shred of evidence that indicates international trade positive effects of internet use. Ozcan (2018) documented positive international trade effects of ICT. Rodríguez-

Crespo and Martínez-Zarzoso (2019) examined the link between ICT and international trade and provided evidence that ICT enhances international trade.

Similarly, Wang and Choi (2019) investigated the effects of ICT on trade for BRICS countries, covering 2000 to 2016 panel data. The results of their study suggest that ICT usage promotes international trade. They point out that the digital economy promotes international trade as lower cost of information search and technological advancement improve production efficiency. It revealed that the digital economy positively impacts trade. Bankole et al. (2015) argued that Africa's sustainable socio-economic development could be attained through digitalization-led trade flows. Given the existing literature's positions, we hypothesized that:

H₃: the digital economy enhances Africa's ability to absorb international trade's positive economic growth effects.

Studies linked to trade-led growth in Africa Chang and Mendy (2012) reported evidence supporting the international trade-led growth hypothesis for 36 African countries observed from 1980 to 2009. Hossain and Mitra (2013) used the dynamic panel study methodology to examine economic growth determinants for 33 African countries and presented evidence to support trade's positive economic growth impact. This means that international trade stimulates economic prosperity in Africa. Caleb et al. (2014) look at the relationship between international trade and Zimbabwe's economic growth from 1975 to 2005. The analysts used a cointegration analysis and reported that trade enhances economic growth in Zimbabwe. Similarly, Ajmi et al. (2015) established a significant bi-directional causality link between exports and growth in the South African economy.

Likewise, Ehigiamusoe and Lean (2018) found evidence to support the trade-led economic growth in Ghana, Nigeria, and South Africa. The authors also revealed a tripartite causality amongst financial development, trade, and economic growth. Thus, trade and financial sector development could be deployed to enhance economic growth, while financial development and economic growth can also accelerate international trade. Moreover, international trade spurs financial development. In the same vein, Kumar et al. (2015) applied the autoregressive distributed lag model to study the relationship between energy consumption, financial development, trade, and economic growth in South Africa. The study results suggest that trade has both short and long-run positive impacts on economic growth, while financial development hurts the South African economy. The results' coefficients indicate that a shock in international trade and energy consumption corresponds to a 0.07% and 0.24% rise in economic growth, respectively. On the other hand, a shock in financial development growth rates reduces the economic growth rates by 0.04%.

Oyebowale and Algarhi (2020) investigated using the pooled mean group estimation on panel data from 21 African countries, the macroeconomic determinants of economic growth. The pooled estimations indicate that a shock in exports, gross fixed capital formation, and government expenditures produce positive economic growth in Africa, while a shock in broad money produces an insignificant growth impact. Nkikabahizi et al. (2018) examined similar relations employing data from five East African Community (EAC) countries and found a positive economic growth rate measured as real gross domestic product impact of exports. Asiedu (2013) have applied the ARDL analysis to investigate the relationship between trade liberalization and economic growth in Ghana. Asiedu (2013) produced evidence of positive economic growth of trade liberalization in Ghana. Their analysis further suggests a positive impact of capital and population on economic growth, and foreign direct investment hurts growth while insignificant positive growth affects the inflation rate.

3. Methodology

3.1. Theoretical framework and estimation methods

This study's primary purpose is to examine how the digital economy affects international trade to impact economic growth. The most commonly used model for examining the effects of international trade on growth is the neoclassical growth model (Solow, 1956), where technology is considered an important parameter. Following the neoclassical growth model as the theoretical model; we adopted a Cobb-Douglas production function as follows in equation (1):

$$Y = AL^{\alpha}K^{\beta} \quad (1)$$

Where Y is the output growth (in our case, economic growth), A is the technological growth, L and K represent labor and capital stocks, respectively, while α and β take care of the elasticities of stocks labor and capital, respectively.

Considering this study's primary objective and Cobb-Douglas production function as an analytical framework, we assumed the economy where prosperity depends on human capital, international trade, physical capital, and technological progress. Therefore, equation (1) becomes:

$$Y = AL^{\alpha_1}K^{\alpha_2}T^{\alpha_3} \quad (2)$$

Where Y is the output stocks, A is the technological progress, K is the capital stocks, L represents labor stocks, and T is the international trade. From equation (2), by imposing constant returns to scale, our empirical methodology in a natural logarithm transformation takes the form as given in equation (3):

$$\ln Y_{it} = \alpha_0 + \alpha_1 \ln L_{it} + \alpha_2 \ln K_{it} + \alpha_3 \ln T_{it} + \alpha_4 D'_{it} + \alpha_5 W'_{it} + \gamma_i + \varphi_i + \mu_{it} \quad (3)$$

where $\ln Y_{it}$ is the natural logarithm of Gross domestic product (as economic growth); $\ln L_{it}$, represents the natural logarithm of human capital; $\ln K_{it}$ denotes the natural logarithm of capital stocks; $\ln T_{it}$, denotes the natural logarithm of international trade; D'_{it} designates the vector of the natural logarithm of the digital economy variables (see Table 1); W'_{it} , denotes the vector of controls variables in natural logarithms (see Table 1). Also, α_0 , γ_i , φ_i , μ_{it} represent constant term, regional dummies, year dummies, and the stochastic error term, respectively, while α 's (1,2,3,4,5) denote the variables' respective coefficients to be estimated.

Equation (3) is then extended to incorporate the interaction between international trade and the digital economy ($\ln T * D'$). our second estimable equation becomes:

$$\ln Y_{it} = \alpha_0 + \alpha_1 \ln L_{it} + \alpha_2 \ln K_{it} + \alpha_3 \ln T_{it} + \alpha_4 D'_{it} + \alpha_5 W'_{it} + \gamma_{it} + \varphi(\ln T * D')_{it} + \varphi_i + \mu_{it} \quad (4)$$

The variables already explained in equation (3) remain the same in equation (4) whereas, φ is the interaction term's coefficient to be estimated.

3.2. Empirical estimation strategy

The study uses static and dynamic models to consistently draw on the digital economy's significant effect in influencing international trade impact on Africa's economic growth. Scholars including (Adeleye & Eboagu, 2019; Niebel, 2018) used similar estimation methods and considering that the study uses a large panel of 54 countries over a short period of 19 years. Hence $N > T$. The static estimation models adopted in this study include the pooled ordinary least squares (POLS), and the

Fixed effects model, while the system generalized method of moments (sys-GMM) represent dynamic models. The POLS estimation model ignores heterogeneities issues across the sampled panels, whereas, fixed effects estimation model accounts for the heterogeneities across the panel. Also, the sys-GMM estimator is developed for short panel studies. The sys-GMM hypotheses about the information-generating mechanism consist of the idea that the mechanism may be dynamic, with the current realization of the dependent variable affected by previous ones, in addition to the fact that the regressors are not purely exogenous and can be associated with past and probably current realization of the stochastic term.

Furthermore, to avoid collinearity problems among the digital economy indicator, given the level of replaceability between some indicators such as fixed telephone subscription and mobile phone subscription, and fixed broadband subscriptions and mobile broadband subscriptions, we applied the principal component analysis technique to create a digital economy index. On the grounds of the principal component analysis (PCA) estimation process, the *j*th component index can be specified as:

$$DICONOMY_j = Y_{j1}K_1 + Y_{j2}K_2 + Y_{j3}K_3 \dots \dots \dots + Y_{jp}K_p; \tag{5}$$

Where $DICONOMY_j$ is the digital economy index, Y_j is the weight of the component score parameters, X is the original figure of the respective components, and P represents the equation's number of variables. To construct the digital economy index, we used three dimensions of the digital economy. The access side factors include; fixed telephone subscriptions per 100 inhabitants (FTSPHI), mobile cellular phone subscriptions per 100 inhabitants (MCSPHI), and Secure internet servers per one million people (SISPOP). The usage side factors include; The percentage of people using the internet (POPUI), fixed broadband subscriptions per 100 inhabitants (FBBSPHI), and mobile broadband subscriptions per 100 inhabitants (MBSPHI), and the skills side factors also include; Compulsory Education Duration (Years) (COMEDU). Hence, we specified the DIGIDEX equation as follows:

$$DICONOMY = f(FTSPHI, MCSPHI, SISPOP, POPUI, FBBSPHI, MBSPHI, COMEDU) \tag{6}$$

Moreover, the studied sample is further grouped into five sub-regions: West Africa, East Africa, South Africa, North Africa, and Central Africa. This allows a comparative analysis of the results of the study to ascertain whether regional factors have an impact on our findings. The baseline model, which is the pooled OLS, estimates the full sample and the subsample. Although, the FE and sys-GMM methods are used only on the complete sample because they are not practicable for sub-sample estimation given the small number of observations.

3.3. The indicators

In line with similar empirical studies, the key variables used in this study are as follows: gross domestic product per capita (GDPPC), which is used to measure economic growth; International trade (TRADE) measured as the total merchandise trade as a share of GDP; gross fixed capital formation which present physical capital; Labor (LABOR) which represent labor force; the digital economy (DICONOMY) which represent technological progress; Financial Development (DCPS) is proxied by the financial sector's domestic credit; Consumer Price Index (CPI) measured as the average consumer's cost of acquiring a basket of goods and services; Exchange Rate (XECH) measured as the official exchange rate determined by national authorities. Each of the variables is explained briefly below.

Table 1. Pooled OLS results

Dep. Variable lnGDPPC	Trade-Growth		Trade-Growth: role of the digital economy	
	Main regression	Robustness checks	Main regression	Robustness checks
Variables	Model 1	Model 2	Model 3	Model 4
Constant	5.3218*** (6.7489)	5.3218*** (6.5242)	5.0805*** (6.5421)	5.0805*** (6.6375)
lnTRADE	-0.3044** (-2.8539)	-0.3044 (-1.9200)	-0.4082*** (-3.8355)	-0.4082** (-2.6394)
lnDCPS	0.1944** (3.1043)	0.1944** (2.8041)	0.2153*** (3.4907)	0.2153** (3.1932)
lnGFCF	0.7132*** (5.9154)	0.7132*** (4.6905)	0.6554*** (5.5081)	0.6554*** (4.3934)
lnLABOR	-0.1619*** (-4.0867)	-0.1619*** (-4.4596)	-0.2030*** (-5.1246)	-0.2030*** (-5.3047)
lnCPI	0.7456*** (10.7108)	0.7456*** (7.0203)	0.7862*** (11.4236)	0.7862*** (7.7709)
lnFDI	0.0761* (2.4603)	0.0761* (2.5121)	0.1327*** (4.1511)	0.1327*** (3.8872)
lnEXCH	0.7834*** (30.1609)	0.7834*** (20.6462)	0.7815*** (30.5947)	0.7815*** (21.0823)
DICONOMY	0.4393*** (6.6000)	0.4393*** (7.3176)	-1.9319*** (-4.6149)	-1.9319*** (-3.7536)
Central Africa	0.3623* (2.4595)	0.3623** (2.7905)	0.4430** (3.0440)	0.4430*** (3.4911)
North Africa	-0.2793 (-1.5995)	-0.2793 (-1.8523)	-0.1857 (-1.0765)	-0.1857 (-1.2363)
South Africa	-0.4967*** (-3.3284)	-0.4967** (-2.7070)	-0.3997** (-2.7054)	-0.3997* (-2.1866)
West Africa	-0.2442* (-2.0210)	-0.2442 (-1.9603)	-0.1851 (-1.5523)	-0.1851 (-1.5443)
lnTRADE*DICONOMY			0.5220*** (5.7348)	0.5220*** (4.7010)
Year Dummies	Yes	Yes	Yes	Yes
No. of obs.	966	966	966	966
R-Squared	0.6357	0.6357	0.6480	0.6480
F Statistic	54.3753	132.7673	55.4768	122.6260

Economic growth is measured as GDP per capita. GDP is the amount of the gross value added of all resident producers in the region. The total population is a mid-year population based on a de facto population concept.

International trade is measured as trade in commodities as a share of GDP, the number of exports of goods and imports divided by the amount of GDP, all in current US dollars. International

Table 2. Trade-growth (sub-region pooled ols results) -dep. variable lnGDPPC

Variables	Central Africa	East Africa	North Africa	South Africa	West Africa
Constant	5.9242*** (8.0699)	5.5544*** (4.7330)	10.2857*** (10.6077)	16.8253*** (6.8255)	17.0814*** (10.7047)
lnTRADE	1.2328*** (6.5499)	0.7931*** (5.6650)	-0.3118** (-2.6861)	-2.0302*** (-5.4957)	-1.9552*** (-9.4607)
lnDCPS	-0.1707 (-1.2505)	0.0692 (0.7190)	-0.1757*** (-3.4974)	0.3910*** (3.4029)	0.8856*** (7.9939)
lnGFCF	0.0044 (0.0238)	-0.8591*** (-3.8034)	-0.1255 (-1.2365)	0.8946*** (4.0813)	0.2486 (1.1637)
lnLABOR	-0.4909*** (-10.9588)	0.2836*** (4.2641)	0.0118 (0.2575)	-0.4625*** (-4.8060)	-0.0558 (-0.6826)
lnCPI	-0.0155 (-0.1551)	0.9326*** (12.2963)	-0.4068*** (-4.7840)	1.0877*** (4.1492)	-1.1031*** (-5.5175)
lnFDI	0.1492*** (4.7663)	-0.3471*** (-6.9663)	0.1109*** (3.7548)	0.0139 (0.1845)	0.0351 (0.5839)
lnEXCH	1.1212*** (21.1313)	0.7369*** (21.9803)	0.6741*** (27.2080)	-0.0616 (-0.8121)	0.9372*** (23.0223)
DICOMY	0.2954*** (3.5636)	0.1817 (1.8979)	0.0472 (1.5635)	-0.3176** (-2.8463)	0.2662* (2.4253)
No. of obs.	140	281	109	166	270
R-Squared	0.8903	0.7284	0.9656	0.4097	0.7554
F Statistic	132.8629	91.1762	350.4254	13.6190	100.7794

Table 3. Trade-growth (sub-region pooled ols results)-role of the digital economy (dep. variable lnGDPPC)

Variables	Central Africa	East Africa	North Africa	South Africa	West Africa
Constant	5.8166*** (8.0278)	4.8292*** (4.4012)	10.4017*** (10.7449)	16.5861*** (6.6030)	16.0977*** (9.4684)
lnTRADE	1.2471*** (6.7241)	0.5890*** (4.4001)	-0.4234** (-3.0367)	-1.9835*** (-5.2106)	-1.8419*** (-8.4760)
lnDCPS	-0.1890 (-1.4036)	0.2340* (2.5177)	-0.1824*** (-3.6348)	0.3997*** (3.4356)	0.8642*** (7.7723)
lnGFCF	0.0642 (0.3522)	-0.9612*** (-4.5623)	-0.1408 (-1.3861)	0.8799*** (3.9732)	0.1713 (0.7851)
lnLABOR	-0.5073*** (-11.3460)	0.1952** (3.0824)	-0.0066 (-0.1387)	-0.4586*** (-4.7408)	-0.0218 (-0.2590)
lnCPI	0.0801 (0.7471)	1.0574*** (14.4739)	-0.3437*** (-3.6016)	1.0612*** (3.9678)	-1.0719*** (-5.3542)
lnFDI	0.1577*** (5.0767)	-0.2430*** (-4.9617)	0.1314*** (4.0180)	0.0190 (0.2494)	0.0430 (0.7154)
lnEXCH	1.0463*** (16.8983)	0.7583*** (24.1841)	0.6784*** (27.3202)	-0.0575 (-0.7525)	0.9351*** (23.0346)
DICONOMY	-1.9083 (-1.9431)	-3.4984*** (-6.1795)	-0.4317 (-1.2824)	-1.0108 (-0.7674)	-1.0991 (-1.3075)
lnTRADE*DICONOMY		0.5157* (2.2517)	0.7612*** (1.4282)	0.1088 (0.5281)	0.1613 (1.6382)
No. of obs.	140	281	109	166	270
R-Squared	0.8944	0.7658	0.9663	0.4107	0.7579
F Statistic	122.3330	98.4726	314.9550	12.0812	90.4578

trade is projected to have a positive effect on economic growth. Trading with countries around the world contributes to the effective utilization of capital and technology transfer.

Gross Fixed Capital Formation is expected to enhance economic growth. It captures the absorptive capacity to produce. It includes land improvements, plant, machinery, and equipment purchase.

Labor Force comprises people aged 15 and over who provide labor to manufacture products and services over a given period. It comprises people who are already working and unemployed people but is searching for jobs and first-time job-seekers. Labor is expected to contribute positively to economic growth. It is a key factor of production to developing due to the high cost of obtaining capital.

Digital Economy includes Secure internet servers per one million people (SISPOP), fixed broadband subscription per hundred inhabitants (FBBSPHI), fixed telephone subscription per hundred inhabitants (FTSPHI), mobile broadband subscription per hundred inhabitants (MBBSPHI), mobile cellular subscription per hundred inhabitants (MCSPHI), the percentage of people using the internet (POPUI), and compulsory education duration (Years) (COMEDU). The digitalization of the economy is expected to promote economic growth.

Table 4. Random and fixed effects results

Dep. Variable lnGDPPC	Trade-Growth		Trade-Growth: role of the digital economy	
	Main regression		Main regression	
	RE	FE	RE	FE
Variables	(Model 1)	Model 2	Model 3	Model 4
Constant	10.2325*** (8.8125)	9.8890*** (7.1457)	10.4528*** (9.1544)	10.2669*** (7.4648)
lnTRADE	0.1198*** (4.6424)	0.1247*** (5.1347)	0.1172*** (4.5431)	0.1225*** (5.0859)
lnDCPS	-0.0471** (-3.0129)	-0.0447** (-3.0373)	-0.0452** (-2.8946)	-0.0426** (-2.9205)
lnGFCF	-0.0043 (-0.2219)	-0.0055 (-0.3026)	-0.0070 (-0.3624)	-0.0083 (-0.4598)
lnLABOR	0.0116 (0.1514)	0.0331 (0.3556)	-0.0075 (-0.0996)	0.0033 (0.0357)
lnCPI	0.0888*** (4.2234)	0.0980*** (4.9363)	0.1011*** (4.7513)	0.1106*** (5.5492)
lnFDI	0.0194*** (3.8367)	0.0210*** (4.4100)	0.0196*** (3.8825)	0.0213*** (4.5155)
lnEXCH	-0.0468*** (-4.0933)	-0.0618*** (-5.6709)	-0.0443*** (-3.8764)	-0.0607*** (-5.6219)
DICONOMY	0.0601*** (5.4816)	0.0621*** (5.9914)	-0.1610** (-2.7881)	-0.1512** (-2.8054)
lnTRADE*DICONOMY			0.0490*** (3.8971)	0.0473*** (4.0303)
Year Dummies	Yes	Yes	Yes	Yes
No. of obs.	966	966	966	966
R-Squared		0.4616		0.4713
F Statistic		29.2468		29.2492

Financial Development is proxied by the financial sector's domestic credit, including all loans to different industries on a gross basis, except for credit to the central government, which is net. This was included as a controlled variable and is expected to have a positive impact on economic growth. This is because the financial sector's growth is expected to facilitate the inflow of more capital for investments and enhance economic growth.

Foreign Direct Investment is measured as the net investment inflow to purchase a long-term managing stake in an enterprise. This is the amount of equity capital, the reinvestment of dividends, both long-term capital and short-term capital.

The Consumer Price Index represents changes in the average consumer cost of purchasing a basket of goods and services. It is included as a control variable and is predicted to harm economic growth because the rising cost of acquiring a basket of goods and services has a non-linear relationship with economic growth.

Table 5. System GMM results

Variables	Trade-Growth		Trade-Growth: role of the digital economy	
	Main regression	Robustness checks	Main regression	Robustness checks
	Model 1	Model 2	Model 3	Model 4
L.lnGDPPC	1.0175*** (447.5353)	1.0175*** (91.9569)	1.0208*** (373.9593)	1.0208*** (68.3789)
lnTRADE	0.0196*** (5.4190)	0.0196 (1.0155)	0.0243*** (7.0377)	0.0243 (1.2689)
lnDCPS	-0.0156*** (-6.9824)	-0.0156 (-1.5790)	-0.0186*** (-6.5596)	-0.0186 (-1.5449)
lnGFCF	0.0072* (2.0590)	0.0072 (0.5095)	0.0100* (2.0456)	0.0100 (0.6260)
lnLABOR	0.0026 (1.0688)	0.0026 (0.4487)	0.0031 (1.3168)	0.0031 (0.5070)
lnCPI	-0.0104*** (-3.7909)	-0.0104 (-0.9114)	-0.0159*** (-3.8610)	-0.0159 (-0.8186)
lnFDI	0.0017 (1.5412)	0.0017 (0.6440)	-0.0004 (-0.3900)	-0.0004 (-0.1015)
lnEXCH	-0.0215*** (-7.1565)	-0.0215 (-1.5612)	-0.0241*** (-6.4073)	-0.0241 (-1.4987)
DICONOMY	-0.0161*** (-6.6156)	-0.0161* (-1.9983)	0.1495*** (3.3118)	0.1495 (0.5029)
lnTRADE*DICONOMY			-0.0376*** (-3.6582)	-0.0376 (-0.5487)
Constant	-6.4415*** (-5.6142)	-6.4415 (-1.4093)	-5.7645*** (-5.3037)	-5.7645 (-1.4782)
Year Dummies	Yes	Yes	Yes	Yes
No. of Obs.	915	915	915	915
Instruments/Groups	44/53	44/53	44/53	44/53
Hansen <i>p-value</i>	0.113	0.113	0.114	0.114
AR (2) <i>p-value</i>	0.336	0.337	0.321	0.332

The exchange rate expressed in local currency units proportional to the US dollar is the official exchange rate determined by the national authorities or the rate set in the lawfully approved exchange market.

4. Empirical results and discussions

4.1. Pooled ordinary least squares (POLS) results

Table 1 reports the full sample results of the POLS regression estimator. Models 1 and 2 recorded the results for trade-growth nexus, while models 3 and 4 reported the digital economy's role in influencing trade's impacts on economic growth. Related to trade-growth nexus, model 1 shows a negative and statistically significant growth effect of trade at a 5% level on average ceteris paribus. Trade output elasticity is (-0.3044). The robustness checks in model 2 produce the same output elasticity

Table 6. Multicollinearity test—VIF (variance inflation factor)

Variable	VIF	1/VIF	Tolerance	R-squared
lnFDI	2.0800	0.48122	0.4812	0.5188
lnLABOR	1.7200	0.5799	0.5799	0.4201
DICONOMY	1.6200	0.61555	0.6156	0.3844
lnDCPS	1.6000	0.62376	0.6238	0.3762
lnTRADE	1.4000	0.71269	0.7127	0.2873
lnEXCH	1.3100	0.76134	0.7613	0.2387
lnGFCF	1.3100	0.76345	0.7635	0.2365
lnCPI	1.3000	0.76804	0.7680	0.2320
Mean VIF	1.5400			

Note: we consider the existence of multicollinearity in our logarithmic specifications when the VIF of a variable is greater than 5.

(−0.3044) but statistically not significant. Our finding is consistent with (Polat et al., 2015). On the other hand, the result is inconsistent with the findings by (Asiedu, 2013; Caleb et al., 2014; Chang & Mendy, 2012; Ehigiamusoe & Lean, 2018; Hossain & Mitra, 2013). Furthermore, the result also does not congruent with the theoretical hypothesis that international trade enhances economic prosperity. This result contradicts the eminent mercantilist, the classical, and Heckscher-Ohlin theories of trade, which all posit that international trade enhances economic prosperity. On average, ceteris paribus, the digital economy coefficients for the main regression, and the robustness check regression in models 1 and 2 show a positive and statistically significant economic growth impact. The key findings deduce from the results are: (1) the output elasticity of trade is negative, indicating that an increase in trade has more significant hurt on the African economy on average, ceteris paribus. (2) The digital economy’s output elasticity shows a positive and significant impact on growth, suggesting that an increase in the digital economy development level stimulates Africa’s growth. The positive growth effect of the digital economy also indicates that the leapfrogging hypothesis holds for the Continent. It means that digitalization is likely to leapfrog the Continent through the phases of economic development. This is consistent with previous studies by (Adeleye & Eboagu, 2019; Aghaei & Rezagholizadeh, 2017; Pradhan et al., 2017; Wamboye & Tochkov, 2018; Yousefi, 2011). The finding supports the classical theory, where technological advancement has a positive impact on labor productivity.

***, **, * are statistically significant at the 1%, 5%, and 10% levels, respectively; t-statistics (in parentheses).

On the other variables of production, as shown in Table 1, the GFCF coefficient is positive and statistically significant for the main regression, and the robustness checks regression at a 1% significance level, which is in line with our prior knowledge. An increase of 10% in GFCF with output elasticity of 0.7132 increases output by 7% on average ceteris paribus. This reinforces the role that gross fixed capital investment plays as an economic development factor. In this way, capital input is a major factor in boosting economic growth in Africa. As such, an increase in capital spending will increase productivity in Africa. Our results are in-line with the previous empirical evidence (Adeleye & Eboagu, 2019; Bahrini & Qaffas, 2019; Yousefi, 2011).

However, on average, ceteris paribus, LABOR, a significant factor of production coefficients in models 1 and 2 specifications indicate a negative and statistically significant at a 1% significance level. The output elasticity of −0.1619 suggests that an increase of 10% in LABOR decreases output by 1.6% on

average *ceteris paribus*, which does not align with our expectations *a priori*. Intuitively, the classical theory expects a positive relationship between labor productivity and growth. Our findings contrast the results by (Adeleye & Eboagu, 2019), who produced positive economic growth of labor. For control variables, models 1 and 2 specifications show positive and statistically significant coefficients for DCPS at a 5% significant level on average *ceteris paribus*. This result also confirmed the significant role the local financial sector plays in the economic growth in Africa. The result is consistent with the study's *a priori* expectation. The positive impact of DCPS on economic growth implies that domestic finances to the private sector are channeled to productive activities and, hence, the positive effects on Africa's economies. This finding conforms with the results produced by (Adjasi et al., 2012). FDI exhibits a positive and statistically significant effect on Africa's growth for models 1 and 2. Also, CPI shows a positive and significant impact on economic growth. Similar studies by (Beugelsdijk et al., 2008; Lee & Chang, 2009; Wang & Wong, 2011) documented the positive effects of foreign direct investments on economic growth. Other past studies, such as (Duodu et al., 2020; Fosu & Magnus, 2006), reported negative impacts of foreign direct investments' economic growth. EXCH impacts economic growth positively at a 1% level on average *ceteris paribus*. The positive impact of the exchange rate on economic growth may cause by the depreciation of the currencies that make goods from Africa cheaper on the international market. The lower prices enhance the demand for goods; hence the increase in export stimulates economic growth. The result supports the mercantilist view that countries that export more and import less prosper. This finding is similar to the results by (Duodu et al., 2020; Khan Kakar & Ahmad Khilji, 2011; Rodrik, 2008), while in contrast with the finding by (Wong, 2013).

For the regional dummies, on average, *ceteris paribus*, the GDP in Central Africa region is higher relative to the East African region (base region) by 43.66%¹ on average, *ceteris paribus* for models 1 and 2. On the contrary, GDP in North Africa, South Africa, and West Africa regions is lower than the East Africa region by 24.37%, 39.91%, and 21.67%, respectively, on average, *ceteris paribus*, but the North Africa result is statistically insignificant. Finally, after controlling for the year dummies, the goodness-of-fit of models 1 and 2 revealed that the explanatory variables explained 63.57% of the dependent variable variation, while the *F*-statistic suggests that the variables jointly significant in explaining the economic growth.

The digital economy's role in trade effects on the full sample's economic growth is also reported in models 3 and 4 in Table 1. The results in models 3 and 4 are not different from models 1 and 2 for international trade effects on economic growth with the interactive term. The coefficients of TRADE indicate a negative and statistically significant effect on economic growth in Africa on average, *ceteris paribus* at a 1% significance level. This finding suggests that an increase in Africa's international trade decreases economic growth, holding other factors that affect growth constant. However, it is observed from models 3 and 4 that TRADE's impact on economic growth becomes positive and significant when interacted with the digital economy. This implied that the digital economy does complement international trade to impact economic growth in Africa.

Moreover, the result suggests that trade is more effective in the presence of economic digitalization. This finding is consistent with the mercantilist theory, the classical theory, and the Heckscher-Ohlin theory of trade. The result conforms with previous studies that found a positive impact of the digital economy on trade and economic growth see: (Adeleye & Eboagu, 2019; Freund & Weinhold, 2004; Ozcan, 2018; Wamboye & Tochkov, 2018; Yushkova, 2014). The digital economy in this as an interactive term in models 3 and 4 shows the different direction of impact on economic growth than the results obtained in models 1 and 2 when it is an interactive term. The digital economy's coefficients in models 3 and 4 negatively impact economic growth on average *ceteris paribus* at a 1% significance level. The result contrasts the findings by (Ozcan, 2018; Wamboye & Tochkov, 2018).

Concerning the estimation with the interactive term, it is observed that the other production factors; results are not statistically different. They all show the same direction of economic growth impacts, as shown earlier in models 1 and 2 in [Table 1](#). Likewise, the control variables FDI, CPI, and EXCH suggest similar economic growth impacts, as indicated in models 1 and 2 in [Table 1](#). Moreover, the regional dummies reported similar results as in models 1 and 2. Finally, after controlling the year dummies, the goodness-of-fit of models 3 and 4 showed that the explanatory variables explained 64.8 percent of the dependent variable heterogeneity. The F-statistic shows that the variables were jointly important in understanding economic development.

***, **, * are statistically significant at the 1%, 5%, and 10% levels, respectively; t-statistics (in parentheses).

[Tables 2 and 3](#) documented the results for the full sub-sample regressions. [Table 2](#) reported the regional results without the interactive term, while [Table 4](#) reported the regional results with the interactive term using the pooled OLS estimator. The findings show in [Table 2](#) for international trade are mixed. The output elasticity of TRADE is positive and statistically significant for Central Africa (1.2328) and East Africa (0.7931) regions while showing negative and significant output elasticities for North Africa (-0.3118), South Africa (-2.0302), and West Africa (-1.9552) regions. These findings suggest that trade in Central Africa and the East Africa regions enhances economic growth. This supports our a priori expectations and the mercantilist, the classical, and the Heckscher-Ohlin theories. Contrary, trade hurts economic growth in North Africa, South Africa, and West Africa regions of the Continent. This contradicts the celebrated mercantilist, classical, and the Heckscher-Ohlin theories of trade but supports evidence produced by (Polat et al., 2015). The digital economy positively impacts Central Africa, East Africa, North Africa, and West Africa regions' economic growth. The digital economy's positive impact is congruent with previous studies by (Freund & Weinhold, 2004; Wamboye & Tochkov, 2018). However, those of East Africa and North Africa are not significant.

The DCPS output elasticity shows significant economic growth impacts only for North Africa, South Africa, and West Africa. However, the DCPS economic growth is negative in the North Africa (-0.1757) region. GFCF show mix result across the five regions in [Table 2](#). The GFCF coefficient suggests a negative and statistically significant impact on economic growth for East Africa, positive growth impacts for the South Africa region, while Central Africa, North Africa, and West Africa coefficients are not significant. Also, LABOR show positive and statistically significant impacts on economic growth for East Africa (0.2836) and negative impacts for Central Africa (-0.4909) and South Africa (-0.4625) only. CPI reported a positive growth impact for East Africa (0.9326) and South Africa (1.0877), whereas a negative significant growth impact in North Africa (-0.4068) and West Africa (-1.1031) only. Moreover, FDI positively impacts economic growth in Central Africa (0.1492) and North Africa (0.1109) at a 1% significant level while hurting economic growth in East Africa at a 1% significant level on average ceteris paribus. Finally, EXCH positively impacts economic growth across all the regions except Southern Africa, which reported a negative and insignificant impact.

Similarly, the results documented in [Table 4](#) are also mixed for TRADE and the other variables used in this study. It is observed from [Table 4](#) that the findings do not vary statistically from the findings in [Table 3](#) for TRADE but vary only in their magnitudes. However, the digital economy negatively impacts economic growth across the five regions, but only East Africa indicates a significant impact at a 1% significance level on average ceteris paribus. By Incorporating the interactive term, the digital economy, in the regression, the estimations indicate that the digital economy has a positive influence on trade impact on economic across the five sub-regions while suggesting that only the coefficients for Central Africa and East Africa are significant. On the other variables, DCPS, GFCF, LABOR, CPI, FDI, and EXCH, the results are not statistically different, as reported in [Table 4](#), without the interactive term but only differs in magnitudes.

***, **, * are statistically significant at the 1%, 5%, and 10% levels, respectively; t-statistics (in parentheses).

4.2. Fixed and random effects results

The augmented model results using the random effects (RE)² and fixed effects (FE) estimators, tested for panel heterogeneities, are shown in Table 4 for Africa. Table 4 reported results for models. Models 1 (RE) and 2 (FE) reported the main regression of trade-growth nexus without interactive term, while model 3 (RE) and 4 (FE) reported results of the main regression with an interactive term. The findings in both models 1 and 2 indicate that TRADE exerts a significant positive impact on Africa's economic growth. Specifically, models 1 and 2 show that a 1% increase in trade increases Africa's economic growth by 0.1198% and 0.1247%, respectively. This result supports related studies (Mitsek, 2015; Nkikabahizi et al., 2018; Oyebowale & Algarhi, 2020; Rahman & Mamun, 2016) and in-line with the mercantilist, classical, and Heckscher-Ohlin theories of trade prepositions. The main regression with the interactive term in models 3 and 4 shows significant positive economic growth effects of trade for random and fixed effects estimators. The coefficients of models 3 and 4 suggest that a 1% increase in trade enhances economic growth by 0.1172% and 0.1225%, respectively. Concerning the effects of the digital economy without the interactive term, models 1 and 2 show that a 1% increase in the digital economy's development enhanced economic growth by 0.0601% and 0.0621%. This finding is contemporaneous with studies' results by (Adeleye & Eboagu, 2019; Bahrini & Qaffas, 2019; Choi & Hoon, 2009).

On the other hand, with the interactive term in models 3 and 4, it turned out that a 1% increase in the development of the digital economy decreases economic growth in Africa by 0.1610% and 0.1512% at a 5% significance level. The negative impacts of the digital economy on economic growth contradict the results suggested by (Pradhan et al., 2017; Wamboye & Tochkov, 2018; Yousefi, 2011). We observed that the coefficients in models 3 and 4 are positive and statistically significant at a 1% significance level regarding the interactive term's estimation. This finding appeared to supports the Heckscher-Ohlin and the classical theories of trade. Thus, the digital economy influence trade positively to impact economic growth in Africa. This implies that interaction between trade and the digital economy enhanced Africa's economic growth by 0.0490% and 0.0473% for the random (model 3) and the fixed (model 4) effects, respectively. The finding is quite similar to those obtained using the pooled OLS estimation method on the full sample. This implies that the interaction between trade and the digital economy is consistent.

Also, we observed in Table 4 that the coefficients of DCPS in models 1 and 2 negatively impact economic growth for both the Random and the Fixed effects model. Our results contrast prior findings by (Adeleye & Eboagu, 2019; Anwar & Nguyen, 2011), who posit a positive relationship between financial development and economic growth. This finding suggests that financial sector development in Africa does not promote its economic growth. This result is further confirmed in models 3 and 4. Specifically, a 1% increase in the financial sector development hurt Africa's economy by 0.0471% and 0.0447% in models 1 and 2, respectively, at a 5% significance level. Likewise, models 3 and 4 indicate that Africa's economy decreases by 0.0452% and 0.0426%, respectively, in every 1% increase in its financial sector development. Concerning the impacts of gross fixed capital formation (GFCF) and LABOR, all the four models in Table 4 suggest adverse effects on economic growth but insignificant. This finding implies that capital and labor are not essential determinants of economic growth in Africa. Table 4 shows that the estimated coefficients for the variables consumer price index, foreign direct investment, and the exchange rate significantly affect Africa's economic growth across the four models at a 1% significant level. However, the exchange rate's impact on economic growth is negative, suggesting that exchange fluctuations hurt economic growth. The exchange rate's negative impact is in line with a study by (Rodrik, 2008). Also, a stable consumer price index and inflows of foreign direct investment enhanced Africa's economic growth. This result gives support to previous studies

(Mahmoud, 2015; Ngwen et al., 2017), who hypothesized a positive relationship between the consumer price index and economic growth.

***, **, * are statistically significant at the 1%, 5%, and 10% levels, respectively; t-statistics (in parentheses).

4.3. System GMM results

Controlling for potential variables of endogeneity, heteroscedasticity, and omitted, in Table 5, the sys-GMM estimator's effects are shown. Model 1 is the main regression, while model 2, the robustness check regression without the interactive term. On the other hand, the model represents the main regression and represents the robustness check regression with the interactive term. TRADE exhibits a positive and statistically significant impact on economic growth in models 1 and 3 at a 1% significance level on average ceteris paribus. As noted by (Caleb et al., 2014; Chang & Mendy, 2012; Ehigiamusoe & Lean, 2018; Hossain & Mitra, 2013), international trade has the potential to boost economic growth. This study's results appeared to be in line with the previous results from the literature and the propositions of the mercantilist, classical, and the Heckscher-Ohlin theories of trade. While the robustness check results in models 2 and 4 exert a positive but statistically insignificant impact on economic growth.

The digital economy shows a negative relationship with economic growth in model 1 while showing a positive and statistically significant impact on model 3. The interaction between trade and the digital economy exerts a negative relationship with economic growth. This suggests that the digital economy influences trade negatively to impact economic growth. This finding is not consistent with our main estimation model, the POLS model that interaction between trade and the digital economy enhanced economic growth. Financial development (DCPS) negatively impacts economic growth in models 1 and 4 at a 1% significance level. Thus, financial development hurts economic growth in Africa. Adjasi et al. (2012) draw opposite conclusions after obtaining a positive effect of financial development on economic growth. GFCF has a positive and statistically significant relationship with economic growth at a 10% significance level. Our results concord with the existing literature from studies (Adeleye & Eboagu, 2019; Boamah et al., 2019). Moreover, LABOR shows a positive and statistically insignificant economic growth impact across all the four models estimated. CPI and EXCH exhibit negative and statistically significant economic effects in models 1 and 3 in Table 5.

Concerning the model's goodness-of-fit, we do not find any evidence of second-order serial correlation indicated by the p-values of the AR (2) statistics, both estimations in Table 5. The Hansen statistic of instrument validity cannot be rejected at a 5% significance level, given the p-values. Therefore, the results obtained from the augmented sys-GMM estimation can be used for inferences.

***, **, * are statistically significant at the 1%, 5%, and 10% levels, respectively; t-statistics (in parentheses).

4.4. Multicollinearity test

Since our models have used several variables and are specified in logarithmic form, it is momentous to run a test to detect whether the models suffer from multicollinearity problems. We employed the Variance Inflation Factor (VIF) to test the possible risk of multicollinearity in the models' logarithmic specifications. The key issue with the usage of multiple variables is that the coefficients' estimation becomes unreliable and the standard errors for the coefficients become highly inflated. The VIF test results for multicollinearity documented in Table 6 suggest that the models' variables are not significantly correlated with each other. Hence, the coefficients estimation and the standard errors of the models are reliable estimates.

5. Summary and concluding remarks

This study has examined the effect of international trade on economic growth in Africa, taken into account the role of the digital economy. The study contributed to the trade-led growth literature using annual panel data from 53 African countries from 2000–2018, the digital economy indicators and the pooled ordinary least squares, random and fixed effects, and the generalized method of moment estimations models. We report some convincing and rigorous results that validate that Africa's trade has a statistically influential economic growth impact. Our study shows varying impacts of international trade on economic growth across the four (4) estimation models and the sub-regions. The results show that international trade has significant adverse effects on Africa's economic growth but only shown a significant positive effect on economic growth when interacting with the digital economy in the POLS model. The random and fixed effects estimations show that international trade has significant positive effects on economic growth and trade, and the digital interaction effect has a significant positive impact on economic growth. These findings confirm the results by (Adeleye & Eboagu, 2019; Czernich et al., 2011; Ehigiamusoe & Lean, 2018; Nkikabahizi et al., 2018). The sys-GMM estimations revealed that international trade positively enhances economic growth; however, the interaction effect of trade and the digital economy has a significant negative impact on economic growth. The results suggest that international trade's impact and its interaction effect with the digital economy on economic growth varied across the five sub-regions. The digital economy also shows a significant mixed impact (both positive and negative) on economic growth across the estimation models and the sub-regions for the main and the robustness check regressions. Other outcomes are that gross fixed capital formation, financial development, consumer price index, foreign direct investments, and exchange rates are essential determinants of economic growth while the labor force, for most estimations, has negative impacts on economic growth. This is attributed to a high percentage of unskilled workers, resulting in the labor force's unproductivity, hence a decrease in economic output.

Based on the results, the study concludes that international trade and the digital economy in Africa play an important role in Africa's economic growth. The study also concluded that the digital economy development impacts international trade's effects on economic growth in Africa. It is further concluded that the estimation model also influences the effects of trade and the digital economy on economic growth in Africa. Finally, the sub-regions also influence trade, and the digital economy impacts economic growth in Africa. Therefore, the study suggests that African governments should put in place trade policies that seek to promote exports and reduce imports to ensure trade surplus is achieved. Also, given that the digital economy influences trade impacts on Africa's economic growth, for trade to effectively enhance economic growth, governments must strengthen and further develop the digital economy to ensure full economic benefits of international trade.

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Notes

1. We used the formula: $[e^{\hat{\beta}} - 1] \times 100$, where e is the exponent (i.e., the base or the anti-log) of the natural logarithm and $\hat{\beta}$ is the coefficient. This is often used where a dependent variable is represented in a natural logarithm and the explanatory variable is a dummy (1/0) measure.
2. The Hausman statistic probability value of (0.7971) support the Random effect estimation model to be used to estimate the main regression without the interactive term and with the interactive term.

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Appendix
Table A1. List of Countries

ID No.	Country Name	Region	ID No.	Country Name	Region
1	Algeria	North Africa	29	Libya	North Africa
2	Angola	Central Africa	30	Madagascar	East Africa
3	Benin	West Africa	31	Malawi	South Africa
4	Botswana	South Africa	32	Mali	West Africa
5	Burkina Faso	West Africa	33	Mauritania	North Africa
6	Burundi	Central Africa	34	Mauritius	East Africa
7	Cabo Verde	West Africa	35	Morocco	North Africa
8	Cameroon	Central Africa	36	Mozambique	South Africa
9	The Central African Republic	Central Africa	37	Namibia	South Africa
10	Chad	Central Africa	38	Niger	West Africa
11	Comoros	East Africa	39	Nigeria	West Africa
12	Congo, Republic	East Africa	40	Rwanda	East Africa
13	Cote d'Ivoire	West Africa	41	Sao Tome and Principe	Central Africa
14	Dem. Rep. of the Congo	East Africa	42	Senegal	West Africa
15	Djibouti	East Africa	43	Seychelles	East Africa
16	Egypt, Arab Rep.	North Africa	44	Sierra Leone	West Africa
17	Equatorial Guinea	Central Africa	45	Somalia	East Africa
18	Eritrea	East Africa	46	South Africa	South Africa
20	Ethiopia	East Africa	47	Sudan	East Africa
21	Gabon	Central Africa	48	Tanzania	East Africa
22	The Gambia	West Africa	49	Togo	West Africa
23	Ghana	West Africa	50	Tunisia	North Africa
24	Guinea	West Africa	51	Uganda	East Africa
25	Guinea-Bissau	West Africa	51	Uganda	East Africa
26	Kenya	East Africa	53	Zimbabwe	South Africa
27	Lesotho	East Africa			
28	Liberia	West Africa			

Source: Authors' Compilation

Table A2. Summary Statistics

Variable	Obs.	Mean	Std. Dev.	Min	Max
GDPPC	1007	495,377.6	1,071,094	233.554	8,300,000
TRADE	1007	74.35663	41.17434	19.1008	347.997
DCPS	1007	21.80191	24.40264	0.402581	160.125
GFCF	1007	22.41563	8.708612	2.00044	59.7231
LABOR	1007	7,240,719	9,786,705	43,679	5.80E+07
CPI	1007	94.93315	55.09234	1.7724	890.229
FDI	1007	7.58E+08	1.54E+09	-7.40E+09	1.20E+10
EXCHR	1007	776.9412	2648.507	0.51219	31,558.9
FBBSPHI	1007	11.0554	9.534466	0.005708	50.221
FTSPHI	1007	3.617319	5.97158	0.005988	34.2728
MBBSPHI	1007	75.19271	51.26279	0.028675	345.325
MCSPHI	1007	46.46015	43.09941	0.018092	184.298
POPUI	1007	10.46693	14.10188	0.005902	64.8039
SISPOP	1007	493.8661	9714.137	0	264,257
COMEDU	1007	8.042701	1.741541	4	12

Source: Authors' Compilation



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