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Impact of Innovation and Trade Participation on Economic Growth Among Selected African Countries

Victor Ushahemba Ijirshar[*], Isa Jibrin Okpe[**], Jerome Terhemba Andohol[***]

Abstract: This study examines the impact of innovation and trade participation on economic growth among selected African countries from 1996 to 2021. This study applied nonstationary heterogeneous panel models utilizing pooled mean group estimators, mean group estimators and dynamic fixed effects estimators. Based on the results of the Hausman test, the PMG estimator was considered for the data analysis. The study revealed the significant role of industrial design, patents, trademarks, research and development, exports, and balanced trade policies in driving long-term economic growth in Africa. The synergies between innovation and trade participation are studied, emphasizing their amplified impact on economic growth. The study suggests practical policy recommendations for the selected African countries, urging governments to establish innovation ecosystems, encourage investments in design, strengthen intellectual property protection, prioritize infrastructure development, and develop balanced trade policies. Focusing on SMEs, offering incentives for research and development, and establishing trade promotion agencies are also recommended to create a conducive environment for innovation, trade, and sustained economic growth.

Keywords: economic growth; innovation; trade participation.

JEL classification: F43; F14; O31; O47; O55.

[*] Department of Economics, Benue State University, Makurdi-Nigeria; e-mail: *ijirsharvictor@gmail.com* (corresponding author).
[**] Department of Economics, Benue State University, Makurdi-Nigeria; e-mail: *ijokpe@yahoo.co.uk*.
[***] Department of Economics, Benue State University, Makurdi-Nigeria; e-mail: *torsaa2002@yahoo.com*.

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1. INTRODUCTION

The objective of any economy is to achieve greater national output and foster economic growth, which is recognized as a pivotal macroeconomic goal. This overarching aim is substantiated by a body of research conducted by scholars such as Espeche *et al.* (2023), Haldar *et al.* (2023), and Chien (2015). These studies collectively indicate that economic growth hinges on several key factors, notably capital, labour, technology, investment, expenditure, and net trade. Capital and labour represent the fundamental building blocks of economic production, with technology serving as a catalyst for productivity enhancement. Investment fuels economic growth by promoting infrastructure development and business growth. Moreover, expenditures stimulate demand and, consequently, production. One of the most influential drivers of economic growth is international trade, as highlighted by Wen *et al.* (2023). International trade or trade participation enables countries to specialize in the production of goods and services in which they have a comparative advantage, thereby enhancing efficiency and overall economic growth. Concurrently, innovation emerges as a powerful catalyst for heightened productivity, enabling businesses to achieve more with fewer resources. The innovation and trade participation nexus, as viewed in the catch-up theory, constitutes a pivotal consideration in the pursuit of economic growth and the augmentation of national output.

Statistics have shown that in 2022, Mauritius secured the top spot for innovation in Africa, while South Africa was the second most innovative nation (Ngila, 2022; Oluwole, 2022). South Africa led sub-Saharan Africa in both exports and imports, trailed by Egypt, Morocco, Nigeria, and Algeria (WIPO, 2023). Out of the total export value of US$24,227,433 million from the total number of 4,615 products with 239 trading partners in 2021, sub-Saharan Africa has a total export value of US$310,083 million (1.3 percent) from the total number of 4,536 products (98.29 percent) with 227 partners (94.98 percent). Turning to imports, Sub-Saharan Africa was involved in the import of goods worth US$305,528 million, equivalent to 1.4% of the total global import value, which amounted to US$21,931,213 million. These imports covered a spectrum of 4,624 product categories, encompassing a substantial 99.63% of the total global product variety (WIPO, 2023). This means that Sub-Saharan Africa has a significant number of trading partners globally and participates in a wide variety of product categories both in terms of exports and imports. However, the value of their trade transactions as a percentage of the global market is relatively small. This could reflect the need for further economic development, infrastructure improvement, and trade diversification within the region to enhance its position in the global trade landscape.

Empirical evidence supports the significance of innovation and trade participation as key determinants of economic growth. This has necessitated policies and strategies that encourage advancements in technology and facilitate global trade by governments and organizations seeking to bolster their economies. Consequently, achieving higher levels of economic growth requires a multifaceted approach that encompasses these critical factors, ultimately contributing to a nation's prosperity and well-being since international trade and innovation in the current wave of globalization are seen as important forces in determining global economic outcomes.

International trade is the integration of nations in the world in terms of free trade, free movement of capital and financial activities (Igudia, 2004). It is a well-known concept dating back to Smith's analysis of market specialization and Ricardo's theory of comparative advantage that international trade promotes the efficient allocation of resources and allows for the dissemination of knowledge and technology and improved levels of competition in domestic

and international markets (Smith, 1776; Ricardo, 1817; Ijirshar, 2019). Innovation is also described as the development and application of ideas and technologies that improve goods and services or make their production more efficient. According to Cohen (2020), the role of innovation has been critical to the economic growth and development of several countries over time. It has been seen as a significant driver of economic growth (Gurbiel, 2003; Rosenberg, 2005; Gurría, 2008; European Central Bank, 2017; Broughel and Thierer, 2019).

Both innovation and trade participation can influence the national income of an economy. Both innovation and trade participation generate earnings and boost growth (Economic Commission for Africa, 2016). Theoretical work has demonstrated the growth-promoting impacts of trade participation when trade-promoted specializations experience increasing economies of scale (Grossman and Helpman, 1991a, 1991b; Young, 1991; Lee, 1993; Eicher, 1999; Chang *et al.*, 2009). Contrary to this claim, international trade can result in the underutilization of capital and human resources, concentration in extractive economic activities, or specialization away from technologically sophisticated, increasing-return industries if there are market or institutional inefficiencies (Grossman and Helpman, 1991b; Matsuyama, 1992). The supporters of free trade highlighted some benefits of international trade due to the specialization of countries in the production and distribution of goods that have comparative advantages. Such countries engage in foreign trade to meet their other needs. However, there are tendencies toward the dumping of goods by developed countries in developing economies that are capable of harming developing nations. Given this argument, the impact of international trade on economic growth is still a hotly debated topic among academics, despite the overwhelming support of the theoretical literature for its advantages.

The African continent stands at a pivotal juncture in its economic development, where the intersection of innovation and trade participation plays a crucial role in shaping the trajectory of economic growth. The dynamism of global markets and the rapid evolution of technology have intensified the imperative for African nations to strategically engage in international trade and foster innovation. This study aims to examine the relationships among innovation, trade participation, and economic growth, focusing on a select group of African countries. This study seeks to unravel the impacts of trade participation and innovation on the economic growth of selected African countries by examining factors such as export-led growth, market diversification, and the role of trade policies in fostering sustainable economic development.

The debates about the growing impacts of trade participation and the importance of innovation to economic growth have prompted further research into the nature of the effect of trade participation and innovation on growth, particularly in developing economies such as African countries. This has raised the empirical question of whether the realization of potential growth benefits can occur without incurring large offsetting costs. The growth effects of innovation and trade participation may differ across countries based on the category of the items traded, the trade pattern, or other peculiarities surrounding the phenomenon. Moreover, the importance of innovation has been reinforced by foreign trade, which has opened up new forms of global competition and markets for innovative products and services. However, a comprehensive approach that examines the dynamics among innovation, trade participation and economic growth while also taking into account the diverse country-specific effects on the responses and behaviours of the tradeable items that comprise exports and imports remains limited in Africa.

Recognizing the nature of innovation and trade participation, this study seeks to elucidate the synergistic impact of these two factors on economic growth in selected African countries. Furthermore, by investigating the interactive effects, this study aims to discern

whether innovation amplifies the growth benefits derived from trade participation. This holistic approach aims to capture the dynamics that shape the economic growth of the selected African countries. In addressing these research questions, this study endeavours to contribute valuable insights to the ongoing discourse on economic development in Africa. By examining the relationships among innovation, trade participation and economic growth, this research aims to inform policymakers, businesses, and scholars about strategies that can foster sustainable and inclusive economic growth in the selected African nations.

This study used panel data from 1996 to 2021 on 25 African countries representing all five regions of the continent and aimed to analyse the interplay between innovation, trade participation, and economic growth. Various trade components, such as agricultural and manufactured goods, are considered alongside measures of innovation, such as patent applications and research expenditure. This study employs statistical models to account for country-specific effects and emphasizes the dynamic and heterogeneous nature of the analysed countries. The study provides valuable perspectives for governments, businesses, investors, and academia. To address the gap in understanding country-specific effects, this paper explores the impact of innovation and trade participation on economic growth in Africa. The findings are expected to inform policymaking for sustainable growth, aid businesses in identifying innovative sectors, guide foreign investors, and benefit regional organizations. This study enhances theoretical frameworks and aligns with UN Sustainable Development Goals, emphasizing the potential of innovation to drive economic progress and improve living standards across Africa.

2. LITERATURE REVIEW

2.1 Theoretical Review

The Comparative Advantage Theory, introduced by Ricardo in 1817, posits that even if a country is at a complete disadvantage in producing both goods, favourable trade can still occur (Ricardo, 1817; Boehm *et al.*, 2022; Lin *et al.*, 2022; Zapata *et al.*, 2023). This theory suggests specialization in goods or services with the least disadvantage, fostering economic globalization. Africa's application of this theory faces criticism for static measurements and challenges such as inadequate infrastructure and education. Applying comparative advantage theory to African countries, which possess diverse resource endowments, could enhance productivity and trade. Specialization in areas of comparative advantage, such as agriculture or technology, might stimulate economic growth through efficient goods exchange, access to advanced technologies, and innovation. However, challenges such as infrastructure deficits, dependence on commodity exports, trade barriers, and intellectual property issues need to be addressed for optimal results (Robinson, 1979).

Solow's growth theory, which is part of the neoclassical model, emphasizes factors such as capital, labour, and technological progress (Mankiw *et al.*, 1992; Michaelides and Papadakis, 2023; Seo, 2023). While it provides insights into the African context, critics argue that it overlooks continuous innovation and diminishing returns to capital and neglects institutional factors essential for long-term growth. Complementing Solow's model with a broader perspective is recommended for addressing multifaceted challenges faced by African nations. Keynes's theory of increasing government expenditure suggests that increased spending stimulates aggregate demand and national revenue (Mariati *et al.*, 2022; Michaelides and

Papadakis, 2023; Pham, 2023). While they can stabilize the economy, critics raise concerns about fiscal sustainability, fund allocation efficiency, and governance issues. Balancing growth stimulation with avoiding excessive deficits is crucial for African countries, ensuring that increased expenditures translate into tangible benefits for innovation and trade participation.

Catch-up theory, which originated post-World War II, proposes that less developed economies can achieve convergence with wealthier ones by adopting technologies (Gerschenkron, 1962; Burkett and Hart-Landsberg, 2003). In the African context, this theory suggests significant growth potential by embracing innovation and active participation in international trade. However, challenges in technology transfer, institutional capacity, and effective policies must be addressed for sustainable economic growth. The technology gap theory, formulated by Posner in 1961, also posits that ongoing inventions and innovations drive trade, even among nations with comparable factor ratios. While relevant to Africa, bridging the technology gap requires investments in technological infrastructure, education, and research. Challenges include technology transfer complexities, institutional capacity issues, and economic barriers, emphasizing the need for appropriate skills and supportive policies for successful implementation.

2.2 Empirical Review

Several empirical studies have examined the relationship between trade participation and economic growth, with limited studies on the impact of innovation on economic growth, particularly in developing countries such as Africa. These studies have employed different methodologies and focused on diverse aspects of trade, ranging from international trade to cross-border trade, trade policy, and trade liberalization.

Pham (2023) examined the elasticities of economic growth to changes in trade in Brazil, India, Russia, China, and South Africa. It emphasized that trade fosters short-term economic growth, but poor administration hinders its beneficial effects. This study used annual data from 1971 to 2020 to expand the scope of Gnoleba (2023), which included Côte d'Ivoire, Ghana, Nigeria, and Morocco. The authors found that cross-border trade within the Economic Community of West African States (ECOWAS) region can be beneficial if constraints are removed. Bunje *et al.* (2022), using balanced panel data from 52 African countries from 2000 to 2018, revealed conflicting effects of trade openness on economic expansion, suggesting that exports stimulate growth, while imports impede it. Zahonogo (2017) focused on sub-Saharan Africa and employed a dynamic growth model for 42 SSA countries between 1980 and 2012. This study identified a trade threshold below which greater trade openness has beneficial effects on economic growth. Furthermore, Iyoha and Okim (2017), utilizing panel data from 1990 to 2013 for ECOWAS member countries, found that exports, exchange rates, and investment were key predictors of per capita real income growth. These empirical studies primarily focus on the impact of trade (both exports and imports) on economic growth. While some studies include African countries (Iyoha and Okim, 2017; Zahonogo, 2017; Bunje *et al.*, 2022; Gnoleba, 2023), they cover either a broad region (e.g., sub-Saharan Africa) or specific groups of countries (e.g., ECOWAS). However, none of the studies specifically integrate the role of innovation in conjunction with trade participation on economic growth. Therefore, investigating how innovation (e.g., technological advancements and R&D expenditures) influences economic growth in conjunction with trade participation and assessing the combined effect of innovation and trade on economic growth in developing countries,

particularly with a more focused analysis of specific African countries that have shown varying levels of innovation and trade participation, is imperative.

In terms of country-specific studies, Luo and Qu (2023) focused on the export trade of China from 2000 to 2019 using linear regression and dynamic panel threshold techniques. A substantial single-threshold effect of export trade on China's economic development was found. Agudze and Olarewaju (2021) also investigated the impact of comparative growth on trade in the USA and China from 1985 to 2020. Their study revealed diverging growth benefits, with China experiencing consistently positive effects. Mohsen and Chua (2020) explored the impact of trade liberalization on the Chinese economy from 1980 to 2018, emphasizing that trade liberalization positively influences China's economic growth. Khadka (2019), examining the impact of trade liberalization on Nepal's economic growth from 1980 to 2013, found that trade openness had a positive influence on the economy. Elijah and Musa (2019), also focusing on Nigeria from 1980 to 2016, found a detrimental impact of trade on both short- and long-term growth, raising questions about the precise nature of the link between trade and economic growth.

Amna Intisar *et al.* (2020) examined the impact of trade and human capital on the economic growth of nineteen Asian countries from 1985 to 2017, revealing that trade openness and human capital strongly spur economic growth. Verico and Pangestu (2020) also evaluated the impact of globalization on Indonesia's economy from 1960 to 2018 and found that trade and investment have positive effects, increasing productivity and restructuring the economy. Ramzan *et al.* (2019), investigating the impact of trade on economic growth and considering total factor productivity (TFP), found a nonlinear relationship, suggesting that trade may hinder growth in nations with low TFP development but promote it in those meeting a minimum threshold.

Other empirical studies have explored the relationship between innovation and economic growth across various regions, with a focus on both cross-country analyses and country-specific examinations. In a cross-country analysis from a global perspective, Razzaq *et al.* (2023) investigated the influence of technological innovation on economic growth across ten countries with the highest national income. Positive effects were observed, highlighting the role of technology in high-income countries. However, the study acknowledged variations in technology levels, especially when comparing high-income countries to developing African nations. Kusumawardhana (2020) assessed the effects of innovation and technology on economic growth in Asian countries from 2000 to 2017. The study revealed significant effects of patent applications on economic growth in both upper- and lower-middle-income countries. Using the European Perspective, Maradana *et al.* (2017) examined 19 European countries from 1989 to 2014. The study utilized cointegration and Granger causality methods, revealing a long-run relationship between innovation and per capita economic growth. However, empirical studies on this relationship in Africa are lacking.

Bujari and Mart'ınez (2016) explored the growth effect of technological innovation in 12 Latin American countries from 1996 to 2008. Using the generalized method of moments (GMM) system, the study revealed a positive impact of technological innovation on economic growth in the region. For Central and Eastern Europe, Pece *et al.* (2015) examined the relationship between innovation and economic growth in Poland, the Czech Republic, and Hungary from 2000 to 2013. The study, using ordinary least squares, found a positive influence of innovation on economic development. Using a global sample on the relationship between industrial and developing countries, Agénor and Neanidis (2015) assessed

interactions between innovation, public capital, and human capital across 38 industrial and developing countries from 1981 to 2008. The study revealed that public capital affects growth through multiple channels, including innovation capacity and human capital accumulation.

For country-specific studies, Law *et al.* (2020) and Le and Homel (2015) conducted country-specific studies in Malaysia. Law *et al.* (2020) emphasized the quality of the innovation measure, using patents granted, and found a significant positive effect on economic growth. Le and Homel (2015), using qualitative techniques, asserted that innovation determines economic growth in Malaysia. Ali *et al.* (2022) focused on Pakistan by employing an autoregressive distributive lag and found that technology innovation had a positive influence on economic growth. However, the study has limitations in terms of generalizability.

For African countries, several studies, including Razzaq *et al*. (2023), have emphasized the lack of empirical evidence regarding the relationship between innovation and economic growth in African countries. Acheampong *et al.* (2022) also used a dynamic system generalized method of moments for determining the effects of technological innovation on economic growth, noting a U-shaped relationship. LeBel (2008) also explored the role of creative innovation in economic growth across 103 countries. This study, using fixed and random effect regression estimators, revealed a positive role of creative innovation in economic growth globally. Many of the empirical studies concentrate on countries such as China, the USA, Indonesia, and European and Asian nations. Thus, there is a clear absence of focused empirical studies on African countries, with a few studies that integrate both innovation and trade as dual contributors to economic growth with recent trends in both innovation and trade. Although some studies address the relationship in some African countries, specific analyses on the selected African countries considering both innovation and trade participation are lacking. The lack of empirical evidence in African countries emphasizes a crucial gap in the literature, calling for more targeted research in this region.

3. METHODOLOGY

3.1 Research Design

This study employs a quasiexperimental technique aligned with its underlying theory, utilizing a quantitative research design to explore the relationships between trade participation, innovation, and economic growth in selected African nations. Employing a positivist research approach, the study mitigates researcher bias by utilizing linear and nonlinear panel autoregressive models within a dynamic panel framework. To ensure clarity and quantifiability, observable variables are assessed using appropriate proxies. By adopting a deductive research approach, this study investigates the hypothesis of a positive relationship between innovation, trade participation, and economic growth. Secondary data from sources such as the World Development Indicators, WTO, WIPO, UNCTAD, and The World Economic Forum are utilized. This study focuses on 25 African countries, collecting cross-sectional time-series data spanning 1996 to 2021, covering various indicators such as industrial design, patents, trademarks, research and development, GDP per capita, labour force, households, and trade-related variables. After interpolating missing observations, the data underwent rigorous consistency checks.

3.2 Empirical model for economic growth

Following the theoretical postulations of Keynes (1936), the theory states the following:

$$Y = C + I + G + (X - M) \tag{1}$$

where Y=national income, C=consumption by households, I=investment, G=government expenditure, and (X – M) = trade balance. According to Solow's theory of growth, output is determined by the rate of savings, population growth, and technological progress as exogenous (Mankiw *et al.*, 1992). The theory considers two inputs, capital and labour, and assumes a Cobb–Douglas production function where the output at time t is stated as:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{2}$$

where Y is the output, K is the capital, L is the labour, and A is the level of technology. Taking the natural logarithm of a complex exponential equation can simplify it into a more manageable linear form, stabilize variance and normalize the distribution of data, which is particularly valuable when dealing with datasets that have a right-skewed or exponential distribution, and helps satisfy the assumptions of linear regression models. Thus, by transforming equation (2) by taking the natural logarithm, it can be restated as:

$$\ln Y_t = \ln A_t + a \ln K_t + (1-\alpha) \ln L_t) \tag{3}$$

Considering the theoretical model of Keynes (1936) as stated in equation (1) in the natural logarithm and Solow's growth theory as specified in equation (3) and using the real gross domestic product per capita for output, innovation for the level of technology, labour force for labour (L), household consumption expenditure for consumption expenditure (C), capital investment for investment (I), capital (K) forms part of the capital investment, government spending for government expenditure (G), and capturing the components of exports and imports separately. However, to avoid paramitarism and based on the usefulness of the variables, household expenditure, gross fixed capital formation, and government expenditure were excluded from the model. The economic growth model can be specified with semi-transformation as follows:

$$\ln GDPP_{it} = f(INN_{it}, \ln EXPT_{it}, \ln IMPT_{it}) \tag{5}$$

where GDPP is GDP per capita, PPP (constant 2017 international $), INN is an innovation indicator (that is, industrial design applications, patent applications, trademark applications, research and development expenditure (% of GDP)), EXPT is exports of goods and services (current US$), IMPT is imports of goods and services (current US$), i is the cross-sections and t is the time dimension. The other variables are not transformed by taking the natural logarithm because they are percentages and indices ranging from 0 to 100 or 1 to 7. It is important to note that savings are assumed to be equal to investment at equilibrium. By further decomposing the indicators of innovation (industrial design applications, patent applications, trademark applications, and R&D expenditures), equation (5) can be restated as follows:

$$\ln GDPP_{it} = f(IND_{it}, PAT_{it}, \ln TRD_{it}, RAD_{it}, \ln EXPT_{it}, \ln IMPT_{it}) \tag{6}$$

where IND is an industrial design application, PAT is a patent application, TRD is a trademark application, and RAD is a research and development expenditure. Converting equation (6) to a stochastic form, we obtain:

$$\ln GDPP_{it} = \beta_0 + \beta_1 IND_{it} + \beta_2 PAT_{it} + \beta_3 \ln TRD_{it-1} + \beta_4 RAD_{it} + \beta_5 \ln EXPT_{it} + \beta_6 \ln IMPT_{it} + u_{it} \quad (7)$$

A panel autoregressive lagged model (panel ARDL) is specified in a dynamic form as:

$$\ln GDPP_{it} = \beta_0 + \delta \ln GDPP_{it-1} + \beta_1 IND_{it} + \beta_2 PAT_{it} + \beta_3 \ln TRD_{it-1} + \beta_4 RAD_{it} + + \beta_5 \ln EXPT_{it} + \beta_6 \ln IMPT_{it} + u_{it} \quad (8)$$

where

$\beta_1 - \beta_6$ = parameters to be estimated, and ε_{it} =mutually independent idiosyncratic error.

This study used equation (8) to determine the effects of innovation and trade participation on economic growth in the selected African countries. The study also interacts the innovation indicators with the trade participation indicators using equation (8) as follows:

$$\ln GDPP_{it} = \beta_0 + \delta \ln GDPP_{it-1} + \beta_1 IND_{it} + \beta_2 PAT_{it} + \beta_3 \ln TRD_{it} + \beta_4 RAD_{it} + \beta_5 \ln EXPT_{it} + \beta_6 \ln IMPT_{it} + \beta_8 IND * \ln EXPT_{it} + \beta_9 PAT * \ln EXPT_{it} + \beta_{10} \ln TRD * \ln EXPT_{it} + \beta_{11} RAD * \ln EXPT_{it} + \beta_{12} IND * \ln IMPT_{it} + \beta_{13} PAT * \ln IMPT_{it} + \beta_{14} \ln TRD * \ln IMPT_{it} + \beta_{15} RAD * \ln IMPT_{it} + u_{it} \quad (9)$$

This study used the economic growth model with the interactive effects of innovation and trade participation to examine the interactive effect of innovation and trade participation on economic growth in the selected African countries. The marginal effect of innovation on economic growth in equation (9) is

$$\frac{\partial \ln GDPP}{\partial IND} = \beta_1, \frac{\partial \ln GDPP}{\partial PAT} = \beta_2, \frac{\partial \ln GDPP}{\partial \ln TRD} = \beta_3, \frac{\partial \ln GDPP}{\partial RAD} = \beta_4,$$

while the marginal effect of innovation on economic growth when there is trade participation in the multiplicative interaction equation (9) is

$$\frac{\partial \ln GDPP}{\partial IND} = \beta_1 + \beta_7 \ln EXPT \text{ and } \frac{\partial \ln GDPP}{\partial IND} = \beta_1 + \beta_8 \ln IMPT$$

(and it is applicable to other innovation indicators and trade participation indicators). The assumption is that innovation significantly increases economic growth if and only if trade participation increases, and vice versa). On the other hand, the marginal effect of trade participation on economic growth in equation (9) is

$$\frac{\partial \ln GDPP}{\partial \ln EXPT} = \beta_5, \frac{\partial \ln GDPP}{\partial \ln IMPT} = \beta_6$$

while the marginal effect of trade participation on economic growth when there is innovation in multiplicative interaction equation (9) is

$$\frac{\partial \ln GDPP}{\partial \ln EXPT} = \beta_5 + \beta_8 IND \text{ and } \frac{\partial \ln GDPP}{\partial \ln IMPT} = \beta_6 + \beta_{12} IND$$

for trade participation and industrial design applications (and it is applicable to other innovation indicators). The assumption is that trade participation will significantly increase economic growth if and only if innovation increases, and vice versa).

4. RESULTS AND DISCUSSION

4.1 Panel Unit Root Test Results

To determine the stationarity of the variables, panel unit root tests were conducted. The results of these tests, presented in Table no. 1, provide insights into whether the variables are stationary or nonstationary. The panel unit root tests were conducted using various methodologies, including the Levin–Lin–Chu (LLC), Im–Pesaran–Shin (IPS), and Fisher-type augmented Dickey-Fuller (ADF-Fisher) tests. The null hypothesis for these tests is that the variable has a unit root and is nonstationary, while the alternative hypothesis suggests that the variable is stationary. However, for the Hadri LM test, the null hypothesis states that all panels are stationary, while the alternative hypothesis is that at least some of the panels contain unit roots. The significance level for the tests is set at the 5% critical level.

Table no. 1 – Panel Unit Root Test Results

Panel Unit Root Tests	**lnimpt**	**d.lnimpt**	**lnexpt**	**d.lnexpt**
Harris-Tsavalis (rho)	0.9249	-0.1486***b	0.9254	-0.0630***b
Brei tung (lambda)	5.6169	-5.8208***b	5.7147	-4.8003***b
Levin-Lin chu	-9.6805***a	-1.1649***	-10.7720***a	-1.7943***
Im–Persaran–Shin	3.8792	-9.6502***b	3.7596	-9.7921***b
Fisher-type	2.9942***a	-0.7062	1.2304***a	-1.0137
Pesaran	1.092	-1.221	-1.110	0.888
Hadri LM	60.6129***	-0.1389 b	60.0899***	0.5905 b
Panel Unit Root Tests	**ind**	**d.ind**	**pat**	**d.pat**
Harris-Tsavalis (rho)	0.6055***a	-0.2383***	0.8176***a	0.0527***
Brei tung (lambda)	9.0394	-5.6515***b	4.4588	-8.0935***b
Levin-Lin chu	0.5231*	-5.1256***b	-0.0230*	-26.0678***b
Im–Persaran–Shin	-	-	-0.5704	-12.8431***b
Fisher-type	0.5563	1.9659***b	-3.2415	18.0431***b
Pesaran	4.955	4.383	3.569	1.012
Hadri LM	25.7843***	-3.5150 b	35.7291***	-1.7836 b
Panel Unit Root Tests	**rad**	**d.rad**	**lntrd**	**d.lntrd**
Harris-Tsavalis (rho)	1.031	0.3341***b	0.8748	-0.1756***b
Brei tung (lambda)	9.1162	-5.9085***b	4.9131	1.0882
Levin-Lin chu	0.5843	-5.7283***b	-42.867***a	1.9894
Im–Pesaran–Shin	6.8806		3.4536	-6.9075***b
Fisher-type	5.2991***a	-9.143***	2.6515	5.8026***b
Pesaran	1.726	2.431	-0.537	-1.201
Hadri LM	56.4971***	13.3743***	41.5165***	1.8039**
Panel Unit Root Tests	**lngdpp**	**d.lngdpp**		
Harris-Tsavalis (rho)	0.9706	0.1207***b		
Brei tung (lambda)	11.6048	-8.3938***b		

Panel Unit Root Tests	lnimpt	d.lnimpt	lnexpt	d.lnexpt
Levin-Lin chu	-3.8136***a	-4.7758***		
Im–Pesaran–Shin	1.2939	-10.8485***b		
Fisher-type	1.4535*	-0.8283		
Pesaran	-1.412	1.413		
Hadri LM	75.0793***	9.4630***		

Note: The asterisks (*** ** and *) denote rejection of the null hypothesis at the 1 percent, 5 percent and 10 percent levels of significance, while a and b indicate stationarity at the level and first difference, respectively.

Source: Extracts from STATA 15 Output

From the results in Table no. 1, the first part of the results indicates that some of the variables under consideration were found to be stationary at the level, while others were not. After applying the first difference to all the variables, they became stationary for most of the tests. The results also indicate that the significance level used for assessing stationarity was set at the 5% critical level.

4.2 Correlation Test for Multicollinearity

To assess multicollinearity, the correlation matrix of the predictor variables was examined, and the results are presented in Table no. 2.

Table no. 2 – Results of the correlation test for multicollinearity

Explanatory Variables	Ind	Pat	lntrd	rad	lnexpt	lnimpt
ind	1					
pat	0.4342	1				
lntrd	0.4954	0.4639	1			
rad	0.337	0.4036	0.2674	1		
lnexpt	0.3886	0.4702	0.5305	0.3583	1	
lnimpt	0.4159	0.5032	0.5582	0.4379	0.9745	1

Source: Extracts from STATA 15 Output

The results of the correlation test reveal that weak associations exist among the explanatory variables within the model. These findings indicate the absence of substantial multicollinearity within these models.

4.3 Results of Cointegration Analysis

The panel cointegration results for the economic growth model are presented in Table no. 3.

Table no. 3 – Panel Cointegration Results

Statistics/Probabilities	Statistic	p value
Kao *et al.* (1999) **Test of Cointegration**		
Modified Dickey-Fuller t	1.7465**	0.0404
Dickey-Fuller t	1.4539*	0.073
Augmented Dickey-Fuller t	1.7689**	0.0385
Unadjusted modified Dickey-Fuller	1.3807*	0.0837
Unadjusted Dickey-Fuller t	1.085	0.139

Statistics/Probabilities	Statistic	p value
Predoni Test of No Cointegration		
Modified Phillips-Perron t	4.6299***	0.000
Phillips-Perron t	-4.824***	0.000
Augmented Dickey-Fuller t	-3.863***	0.0001
Westerlund (2005) **Test of No Cointegration [Alternative hypothesis: cointegration in some panels]**		
Variance ratio	-0.1573	0.4375
Westerlund (2005) **Test of No Cointegration [Alternative hypothesis: All panels are cointegrated]**		
Variance ratio	-0.3306	0.3705

Source: Extracts from STATA 15 Output

According to the results in Table no. 3, there is cointegration among the variables. Panel cointegration implies that there exists a long-run relationship among the variables. The use of multiple tests (Kao, Predoni, and Westerlund) to confirm panel cointegration adds robustness and credibility to the study's findings.

4.4 Long-run Impact of Innovation and Trade Participation on Economic Growth in Selected African Countries

The study estimated pooled mean group estimators based on the results of the Hausman test. The long-term results of the estimated pooled mean group estimator are presented in Table no. 4.

Table no. 4 – Long-run Results on the Impact of Innovation and Trade Participation on Economic Growth in Selected African Countries

Variables	PMG
ind	7.53e-05***
	(0.0000)
pat	0.000214**
	(0.0001)
lntrd	0.0374*
	(0.0207)
rad	0.249***
	(0.0760)
lnexpt	0.403***
	(0.0436)
lnimpt	-0.0128
	(0.0444)
observations	625

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Extracts from STATA 15 Output

From Table no. 4, the estimated coefficient of 7.53e–05 signifies a statistically significant positive impact of industrial design applications on economic growth in the selected African countries in the long run at the 1% significance level. This means that a one-unit increase in industrial design applications corresponds to an estimated increase of 7.53e–05 units in economic growth, while holding other relevant factors constant. This is because industrial design applications often involve innovation and enhancement of product

aesthetics, functionality, and market appeal. This can stimulate demand for products, driving economic activity and growth. Moreover, improved design can lead to higher-value products, which can command premium prices in the market, compete effectively in international markets, drive demand, expand export opportunities and boost economic growth through increased trade. The positive impact of industrial design applications on economic growth suggests that industrial design applications play a role in driving economic growth in the selected African countries. This is consistent with the findings of LeBel (2008) and Snieska and Valodkiene (2015), who found a positive and significant influence of innovation on economic growth.

The coefficient of 0.000214 demonstrates a statistically significant positive effect of patent applications on long-term economic growth in Africa at the 1% significance level. The implication is that a one-unit rise in patent applications is associated with an estimated growth increase of 0.000214 units, while considering other factors. This suggests that patents foster innovation, attract investment, encourage technology transfer, and create higher-value products. This implies that promoting intellectual property through patents can contribute meaningfully to Africa's economic expansion over time. Patents enable innovators to reap rewards, fostering a culture of innovation and contributing to higher-value products. Thus, a proactive approach to patent applications can serve as a catalyst for sustainable economic growth in Africa, aligning with the broader global emphasis on intellectual property rights as drivers of innovation and economic development. This is consistent with the findings of LeBel (2008) and Snieska and Valodkiene (2015), who found a positive and significant influence of innovation on economic growth.

The estimated coefficient of 0.0374 indicates a statistically significant positive impact of trademark applications on economic growth in the selected African countries over the long term at the 10% significance level. For each one-unit increase in trademark applications, there is an estimated growth increase of 0.0374 units when accounting for other factors. Trademarks signify branding and intellectual property protection, which can attract investment, enhance product differentiation, and encourage innovation. This result suggests that focusing on trademark applications can contribute positively to Africa's economic growth trajectory by fostering innovation and business development. This is consistent with the findings of LeBel (2008) and Snieska and Valodkiene (2015), who found a positive and significant influence of innovation on economic growth.

The estimated coefficient of 0.249 denotes a significantly positive influence of R&D expenditure on long-term economic growth in the selected African countries at the 1 percent level of significance. Each unit increase in R&D corresponds to an estimated growth increase of 0.249 units when controlling for other variables. This may be attributed to the fact that R&D activities stimulate innovation, technological advancement, and productivity enhancement, thus fostering economic growth. This suggests that investing in R&D can yield substantial economic benefits for Africa by fostering innovation-led growth, attracting investment, and boosting global competitiveness. It has emerged as a pivotal driver of the continent's sustainable development, aligning with the global emphasis on knowledge-based economies and innovation ecosystems. This finding is consistent with the findings of Law *et al.* (2020), who found a positive and significant influence of innovation on economic growth.

The estimated coefficient of 0.403 signifies a strong and statistically significant positive impact of the export of goods and services on economic growth in selected African countries in the long run at the 1% significance level. This means that each unit increase in exports is

associated with an estimated increase in economic growth of 0.403 units, while other factors are held constant. This shows that exports play a pivotal role in generating foreign exchange earnings, attracting investment, and fostering international competitiveness. Thus, export-driven growth indicates a nation's ability to tap into global markets, fostering revenue generation, job creation, and technology transfer. The study findings suggest that expanding exports can significantly contribute to Africa's economic development, and by enhancing international competitiveness, promoting trade diversification, and attracting foreign investment, exports emerge as a vital engine for driving sustained economic growth across the continent in the long run. This is consistent with the findings of Bunje *et al.* (2022) and Khadka (2019), who found a positive and significant influence of trade on economic growth.

The estimated coefficient of -0.0128 implies a negative, yet statistically insignificant, impact of imports of goods and services on long-term economic growth in the selected African countries. This negative relationship suggests that excessive reliance on imports might hinder local industries. While the estimated result does not reach significance at the 5% critical level, the study emphasizes the need for balanced trade policies that prioritize domestic industries to promote self-reliance and sustainable growth.

4.5 Short-run Impact of Innovation and Trade Participation on Economic Growth in Selected African Countries

The study also examined the short-term impact of innovation and trade participation on economic growth in the selected African countries. The results are presented in Annexes 1 to 3. The results revealed a positive and significant impact of lagged real gross domestic product (GDP) on current economic growth in Algeria, Angola, Botswana, Congo DR, Ghana, Kenya, and Zambia in the short run. This implies that past economic performance, as measured by lagged GDP, has a significant influence on current economic growth in the short run. The justification for this significance could be twofold. First, it reflects the persistence of economic growth patterns; when an economy has grown well in the past, it is more likely to continue that growth trajectory due to positive feedback loops, increased investments, and consumer spending. Second, these findings suggest that these countries might be experiencing economic dynamics that are less prone to abrupt changes or external shocks, allowing for the influence of past economic conditions to prevail over the short term. These findings are particularly relevant for resource-rich economies such as Angola and Zambia, where the positive impact could stem from the dependence on commodity exports and their effects on both lagged and current GDP growth. Similarly, the significance might be influenced by policy continuity, investment cycles, or the gradual effects of economic reforms that unfold over time.

The negative and significant impact of lagged real gross domestic product (GDP) on current economic growth in Mauritius, Morocco, and Tanzania suggests that past economic performance, as indicated by lagged GDP, has a strong negative influence on current economic growth in the short run. Policy changes, external shocks, or unique sectoral dependencies could compound the relationship between past and current economic growth. The positive and significant impact of industrial design applications on economic growth in Botswana, Cabo Verde, Mauritius, Morocco, and Tunisia indicates that increased emphasis on industrial design activities contributes to short-term economic growth in these countries. This is consistent with the findings of Lee *et al.* (2022), who found that industrial design drives growth. This is because industrial design applications often involve innovation and

value addition, making products more appealing and competitive in the market. This can boost consumer demand, increase sales, and stimulate economic activity. Second, an active focus on industrial design reflects a commitment to improving product quality, brand recognition, and market positioning, which can attract foreign investment and foster job creation. Third, a culture of innovation through industrial design can drive entrepreneurship, contributing to a vibrant business ecosystem that fuels economic growth.

The estimated positive and significant impact of patent applications on short-term economic growth in Algeria, Botswana, Morocco, Rwanda, Sao Tome, Principe, and Zambia explains the role of innovation and intellectual property protection in driving economic growth. This is consistent with the findings of Lee *et al.* (2022), who found that patent applications drive growth. Patents encourage the development of novel products, technologies, and processes, enhancing economic productivity and positioning these countries as hubs of innovation. In economies such as Botswana and Zambia, this significance aligns with strategies for diversifying and strengthening economic foundations. The study also revealed a positive and significant impact of trademark applications on short-term economic growth in Angola, Botswana, Sao Tome, Principe, and Uganda. This explains the significance of branding and intellectual property protection in driving economic growth. This finding is consistent with that of Phung *et al.* (2019). In countries such as Angola and Botswana, where economic diversification is crucial, and in Uganda and Sao Tome and Principe, which are striving for economic resilience, the robustness of the results adds credibility to the notion that investing in trademarks can yield tangible economic benefits by enhancing branding, fostering entrepreneurship, and driving short-term growth.

The results also show that the positive and significant impact of R&D expenditure on economic growth in Burkina Faso, Kenya, Mauritius, Namibia, South Africa, Tanzania, Uganda, and Zambia in the short run explains the vital role of research expenditure (as a proxy of innovation) in driving economic advancement. This finding is consistent with that of Yazgan and Yalçinkaya (2018). In countries such as South Africa and Mauritius, which emphasize technology-driven growth, and in less industrialized economies such as Burkina Faso and Uganda, the robustness of the results supports the notion that R&D investments yield substantial economic benefits.

The study also revealed a positive and significant impact of exports of goods and services on economic growth in Algeria, Angola, Cabo Verde, the Congo DR, Egypt, Mauritius, Morocco, Mozambique, and Namibia in the short term. This explains why exports of goods and services are crucial in driving economic growth. This finding is consistent with the findings of Nguyen (2020), who found that exports drive exports. The significance of this relationship is particularly relevant for countries such as Angola and Mozambique, where natural resources dominate exports, and for economies such as Mauritius and Cabo Verde, which rely on tourism and services exports. Additionally, the importance of the results reinforces the idea that promoting exports can yield tangible economic benefits, drive entrepreneurship, enhance competitiveness, and generate short-term growth.

In the short run, the influx of imports of goods and services has had a positive and significant impact on economic growth in Algeria, Burkina Faso, Uganda, and Zambia. These countries benefit from imports by accessing a diverse range of products, including raw materials and capital goods, at competitive prices, thereby boosting domestic production and industrialization. Imports also lead to technological spillovers and knowledge transfer, enhancing productivity and innovation. This is consistent with the findings of Hine *et al.* (2005),

who found a negative impact in developed countries. However, prudent policy measures are required to ensure that imports do not negatively impact local industries. On the other hand, the inflow of imports of goods and services has led to negative and significant impacts on economic growth in the Democratic Republic of Congo (DRC) and Mauritius in the short run. Both nations face challenges due to excessive reliance on imports, which can hamper domestic industries, limit employment opportunities, and hinder technological progress. This finding conforms to the findings of Taghavi *et al.* (2012) and Hine *et al.* (2005), who reported a negative impact in developing countries. In the case of the DRC, heavy import dependence undermines the development of local industries, hindering economic diversification and sustainable growth. In Mauritius, although historically reliant on imports for consumption and tourism, overreliance has led to trade imbalances and potential currency depreciation.

The study also revealed that across Botswana, Cabo Verde, Egypt, Ghana, Mauritius, Morocco, Mozambique, Namibia, Nigeria, South Africa, Sudan, Tunisia, and Uganda, a common trend is the negative and significant speed of adjustment towards long-run equilibrium in economic growth. This implies that these countries experience sluggishness in returning to their sustainable growth paths after economic shocks or deviations. The slow pace of adjustment can be attributed to structural complexities, policy uncertainties, or external vulnerabilities. This phenomenon can lead to prolonged periods of economic instability, hindering the ability to harness the benefits of long-term equilibrium. Therefore, policymakers need to address bottlenecks, enhance policy coordination, and implement reforms that promote swift adjustments. By doing so, these nations can reduce the impact of short-term disturbances on their economies and achieve more consistent and sustainable growth trajectories in the long run.

In the context of economic growth in Angola, Burkina Faso, Cabo Verde, the Democratic Republic of Congo (DRC), Mauritius, and Uganda, the positive and significant estimated constant term denotes a baseline level of growth that is not explained by the other variables in the model. This suggests the presence of underlying, consistent factors that contribute to economic growth. These could encompass demographic trends, geopolitical advantages, natural resources, or initial economic conditions. The significance of the constant term highlights the fundamental resilience of these economies, enabling them to sustain growth even amidst varying external influences or policy changes. On the other hand, the negative and significant estimated constant term in the economic growth models of Egypt, Ghana, Morocco, Mozambique, and Rwanda implies that there are fundamental challenges or limitations intrinsic to these economies that hinder their growth potential. This constant might capture factors such as structural weaknesses, institutional inefficiencies, or historical constraints that persistently affect economic performance. Its significance suggests that these countries experience difficulties in achieving sustainable growth without substantial reforms.

4.6 Long-run Interactive Effect of Innovation and Trade Participation on Economic Growth in the Selected African Countries

This study examines the long-term interactive effect of innovation and trade participation on economic growth in the selected African countries using the results of dynamic fixed effects with and without interactive effects, and the results are presented in Table no. 5.

Table no. 5 – Long-run Results of the Interactive Effect of Innovation and Trade Participation on Economic Growth in the Selected African Countries

Variables	Economic Growth Model without Interactive Effects	Economic Growth Model with Interactive Effects
ind	7.47e-05	0.00255
	(0.000251)	(0.00227)
pat	0.000239	0.0102
	(0.000543)	(0.00785)
lntrd	0.152**	0.724
	(0.0694)	(0.707)
rad	0.844***	1.731
	(0.319)	(5.786)
lnexpt	0.251	0.646
	(0.192)	(0.760)
lnimpt	0.00468	-0.545
	(0.202)	(0.823)
indvlnexpt		0.000572
		(0.000468)
patvlnexpt		0.000457
		(0.00148)
lntrdvlnexpt		0.0907
		(0.0994)
radvlnexpt		0.0349
		(0.630)
indvlnimpt		-0.000674
		(0.000453)
patvlnimpt		5.74e-05
		(0.00140)
lntrdvlnimpt		0.116
		(0.112)
radvlnimpt		0.0774
		(0.638)

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Extracts from STATA 15 Output

From the results in Table no. 5, the findings reveal a positive yet statistically insignificant impact of industrial design applications on economic growth in Africa in the long run at the 5 percent level of significance. The coefficient of 7.47e–05 suggests a small positive effect, indicating that industrial design could play a role in fostering economic growth. This implies that while industrial design holds promise as a contributor to economic growth, its influence might be constrained by various factors. The lack of statistical significance could stem from complex interactions between industrial design and other variables affecting economic growth, such as infrastructure, innovation ecosystems, and macroeconomic stability. Despite the nonsignificant result, acknowledging the positive direction of the impact shows the potential importance of fostering industrial design practices for enhancing economic growth. In the model with the interaction term, the coefficient of 0.00255 signifies stronger industrial design applications for economic growth in Africa. A higher coefficient implies that when innovation and trade are considered together, the positive influence of industrial design on economic growth in the region is enhanced. In contrast, the model without the interaction term

might show a lower marginal effect for industrial design applications on economic growth. This indicates that in the absence of the interactive effect of innovation and trade, the impact of industrial design alone might be less pronounced. Therefore, the integration of innovation and trade as interactive factors could lead to a greater marginal effect of industrial design applications on economic growth in Africa, emphasizing the interconnected nature of these elements in driving economic development in the long run.

The positive but nonsignificant impact of patent applications on economic growth in Africa suggests a theoretical link between innovation and economic development. The coefficient (0.000239) indicates that for each additional patent application, a small positive effect on economic growth is expected. However, the lack of significance at the 5 percent level implies that other factors might play a more dominant role in driving economic growth. This could be due to various challenges that African countries face, such as limited technology transfer, inadequate infrastructure, or lack of supportive policies. While patents promote innovation, their impact on economic growth might be constrained by broader structural issues. The greater marginal effects of patent applications on economic growth in Africa, as indicated by the coefficients of 0.000239 and 0.0102 from the two economic growth models, suggest that fostering innovation through patents could have a more substantial impact on economic growth. In the model with the interaction term of innovation and trade (0.0102), the coefficient implies that for each additional patent application, there is a larger positive effect on economic growth. This suggests that the synergy between innovation and trade amplifies the benefits of patents. While the coefficient without the interaction term (0.000239) is smaller, it still signifies a positive connection between patents and economic growth in Africa.

The estimated positive and significant impact of trademark applications on economic growth in Africa (coefficient of 0.152) at the 5% significance level indicates that protecting intellectual property through trademarks contributes to fostering economic growth in Africa. Trademarks play a crucial role in enhancing brand recognition, promoting innovation, and attracting investments, which collectively drive economic activities. The estimated positive (0.844) and significant impact of R&D expenditures on economic growth in Africa at the 5 percent level of significance signifies the crucial role of innovation in driving economic prosperity. Research and development investments lead to technological advancements, new product development, and process improvements, enhancing productivity and competitiveness. The significance of this impact shows that fostering a culture of innovation and investing in research and development activities can lead to greater economic growth.

From the results, the estimated positive (0.251) but insignificant impact of exports of goods and services on economic growth in Africa at the 5 percent level of significance suggests that while there is a theoretically expected relationship between exports and economic growth, the statistical analysis did not find strong enough evidence to establish a significant causal link. This could be due to various factors, such as limited export diversification, trade imbalances, or domestic structural constraints. While exports can potentially contribute to economic growth by generating foreign exchange, technology transfer, and market expansion, the lack of significance implies that other factors might influence economic growth more significantly in the selected African countries. The greater marginal effect of exports of goods and services on economic growth in Africa, represented by coefficients of 0.251 and 0.646 from the two economic growth models (with and without the interaction term of innovation and trade, respectively), signifies the importance of considering the interaction between innovation, trade, and economic growth. The presence of the interaction term in the second model demonstrates that when innovation and

trade are combined, the positive impact of exports on economic growth becomes even more pronounced. This suggests that innovation-driven exports can have a stronger influence on economic growth than can exports in isolation. An increase in the coefficient from 0.251 to 0.646 indicates that for each additional unit of exports, the growth impact is magnified by the presence of innovation and trade interactions. Similarly, the study explored the interactive impact of various innovation indicators – resident industrial design applications, resident patent applications, resident trade mark applications, and research and development – in conjunction with imports of goods and services on Africa's long-term economic growth. The findings suggested a positive trend in these interactions, which indicates that a combination of innovative activities and imports can potentially contribute to economic growth. The negative interactive effect of resident trade mark applications on economic growth, albeit not statistically significant, is an intriguing finding that explains the role of innovation in reducing the level of imports.

4.7 Short-run Interactive Effect of Innovation and Trade Participation on Economic Growth in the Selected African Countries

This study also examines the short-term interactive effect of innovation and trade participation on economic growth in the selected African countries using the results of dynamic fixed effects with and without interactive effects, and the results are presented in Table no. 6.

Table no. 6 – Short-run Results of the Interactive Effect of Innovation and Trade Participation on Economic Growth in the Selected African Countries

Variables	Economic Growth Model without Interactive Effects	Economic Growth Model with Interactive Effects
ect	-0.0450***	-0.0484***
	(0.00872)	(0.00975)
D.llngdpp	0.0745*	0.0700*
	(0.0386)	(0.0383)
D.ind	1.10e-05	0.000288
	(1.21e-05)	(0.000219)
D.pat	-3.67e-05	0.00165**
	(3.87e-05)	(0.000682)
D.lntrd	0.00344	-0.0302
	(0.00496)	(0.0836)
D.rad	-0.0215	-0.422
	(0.0511)	(0.727)
D.lnexpt	0.0527***	0.203***
	(0.0121)	(0.0538)
D.lnimpt	-0.0143	-0.158**
	(0.0118)	(0.0648)
D.indvlnexpt		7.21e-05**
		(3.01e-05)
D.patvlnexpt		0.000253***
		(9.31e-05)
D.lntrdvlnexpt		-0.0108
		(0.00698)
D.radvlnexpt		0.190***
		(0.0643)

Variables	Economic Growth Model without Interactive Effects	Economic Growth Model with Interactive Effects
D.indvlnimpt		6.06e-05**
		(2.96e-05)
D.patvlnimpt		-0.000324***
		(9.55e-05)
D.lntrdvlnimpt		0.0121
		(0.00847)
D.radvlnimpt		0.205***
		(0.0696)
Constant	0.172***	0.346
	(0.0589)	(0.249)

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1
Source: Extracts from STATA 15 Output

From the results in Table no. 6, the low marginal effects of the negative and significant speed of adjustment towards long-run equilibrium in economic growth for Africa, represented by the coefficients of -0.0450 and -0.0484 from the two economic growth models, indicate the sensitivity of the system to deviations from equilibrium, especially in the presence of the interactive term of innovation and trade. These negative coefficients signify that any deviation from the long-run equilibrium is corrected at a slow pace in the economies studied. The presence of the interactive term of innovation and trade seems to reinforce this adjustment process, suggesting that the incorporation of innovation and trade factors enhances the speed of convergence to equilibrium. This could reflect economies' resilience and ability to self-correct imbalances over time.

The estimated positive and significant impact of lagged economic growth on the current level of economic growth in Africa, as observed in the short run at the 10 percent level of significance, suggests the presence of a persistent growth pattern. This phenomenon could be attributed to the cumulative effects of past economic activities, indicating that higher economic growth in the past contributes to higher current economic growth. This positive relationship signifies the presence of economic momentum or path dependence, where past economic conditions continue to shape and influence the current trajectory. The positive and significant impact of patent applications on economic growth in Africa, observed in the short run at the 5 percent level of significance, suggests that innovative activities that lead to patent applications can play a role in driving economic development. Patents are often indicators of new technologies, processes, or products that can enhance productivity and competitiveness in the economy. This result aligns with the idea that patents provide incentives for firms and individuals to invest in R&D, leading to technological advancements and knowledge spillovers that contribute to economic growth.

The study also revealed a positive and significant impact of exports of goods and services on economic growth in Africa, which was observed in the short-run at the 1 percent level of significance. Exports can serve as catalysts for economic growth by introducing domestic products to global markets, thereby increasing demand and generating revenue. Export-oriented industries often spur technological innovation and productivity enhancements to remain competitive in the international market. The greater marginal effects of exports of goods and services on economic growth in Africa, as indicated by the short-run coefficients of 0.0527 and 0.203 from the two economic growth models (with and without the interaction term of

innovation and trade, respectively), signify the significance of trade activities in driving immediate economic expansion. In the model without the interaction term, the coefficient of 0.0527 suggests that for every unit increase in exports of goods and services, short-term economic growth increases by 0.0527 units. This finding implies that boosting export activities can have a positive and direct impact on short-term economic growth, underscoring the importance of trade diversification and market access. When considering the model with the interaction term, a higher coefficient of 0.203 suggests a stronger influence of exports on economic growth. This indicates that the presence of innovation and trade interaction amplifies the positive impact of exports on short-term economic growth, emphasizing the role of technological advancements and trade synergies in accelerating economic expansion.

The estimated negative and significant impact of imports of goods and services (0.158) on economic growth in Africa in the short run at the 5 percent level of significance shows the potential challenges posed by high import dependency. This outcome might be attributed to the fact that excessive reliance on imports can lead to trade deficits, currency depreciation, and reduced domestic production.

The significant positive interactive effect (7.21e-05) of residential industrial design applications and exports of goods and services on economic growth in Africa in the short run at the 5 percent level of significance indicates the potential synergy between innovation in design and international trade. The estimated coefficient of 7.21e-05 implies that a unit increase in residential industrial design applications, in conjunction with exports of goods and services, leads to a corresponding increase in economic growth of 7.21e-05 units. This outcome suggests that economies with higher resident industrial design applications might experience enhanced trade competitiveness, possibly due to innovative and uniquely designed products that capture global market demand. The interactive effect highlights the importance of combining innovative design efforts with effective export strategies to promote economic growth. The significant positive interactive effect (0.000253) of resident patent applications and exports of goods and services on economic growth in Africa in the short run at the 1 percent level of significance suggests a synergistic relationship between innovative patent activity and international trade. This finding implies that countries actively engaging in patent applications and simultaneously focusing on exporting their goods and services may experience greater economic growth. The interactive effect explains the importance of protecting intellectual property rights and fostering a conducive environment for innovation while also emphasizing the role of international trade in translating innovation into economic gains.

The results further reveal the significant positive interactive effect (0.19) of R&D and exports of goods and services on economic growth in Africa in the short run at the 1 percent level of significance. This highlights the crucial role of innovation-driven exports in fostering economic growth. This finding shows the importance of investing in research and development to enhance a country's competitiveness in the global market. When research and development efforts result in innovative products or services that are successfully exported, they contribute to economic growth through increased market share, job creation, and technological advancement. This symbiotic relationship can drive long-term economic development and help African countries diversify their economies and reduce their dependency on traditional sectors. Thus, to capitalize on this positive linkage, strategies that encourage patenting activities, strengthen intellectual property rights enforcement, and facilitate trade opportunities need to be developed.

The significant positive interactive effect (6.06e-05) of industrial design applications and imports of goods and services on economic growth in Africa in the short run at the 1 percent level of significance indicates the potential for design-led imports to contribute to immediate economic expansion. The estimated coefficient of 6.06e-05 implies that a unit increase in industrial design applications, combined with imports of goods and services, leads to an increase in economic growth of 6.06e-05 units. This finding explains the importance of incorporating innovative design elements into imported products, which can enhance their appeal, quality, and competitiveness in the local market. The significant negative interactive effect (-0.000324) of patent applications and imports of goods and services on economic growth in Africa in the short run at the 1 percent level of significance suggests that an increased emphasis on patenting activities in conjunction with imports may not necessarily lead to immediate economic benefits. This could be attributed to factors such as limited technology absorption capacity or potential negative effects of excessive patenting on competition and innovation.

The study also shows a significant positive interactive effect (0.205) of R&D and imports of goods and services on economic growth in Africa in the short run at the 1% level of significance, which implies that combining R&D efforts with imports can have a synergistic effect on short-term economic growth. This finding explains the importance of fostering an environment that promotes innovation through research and development activities and facilitates the efficient utilization of imported goods and services. This suggests that importing complementary inputs or advanced technologies can enhance the impact of domestic research and development efforts, leading to accelerated economic growth in the short term. The positive and significant impact of the constant term (0.172) on economic growth in Africa in the short run at the 1 percent level of significance signifies the baseline level of growth that is not accounted for by the explanatory variables in the model.

5. CONCLUSION

The study also highlights industrial design, patents, trademarks, research and development, exports, and balanced trade policies as contributors to long-term economic growth in Africa. The study further concludes that the interactive effects of innovation and trade participation, particularly in amplifying the impact of industrial design and patents on economic growth, offer valuable insights for policymakers and stakeholders seeking to leverage both aspects of development. Based on the insightful findings of the study, several practical policy recommendations can be proposed to enhance innovation, trade participation, and economic growth in selected African countries:

The governments of African countries should focus on fostering innovation ecosystems that support research and development activities. This can be achieved through the establishment of research institutes, innovation hubs, and collaboration between universities, research centers, and industries. These initiatives would facilitate knowledge exchange, technological advancements, and the creation of high-value products.

By recognizing the positive yet potentially impactful role of industrial design applications in the region, policymakers should encourage investments in design capabilities. Initiatives such as design education, workshops, and design competitions can help industries create innovative and appealing products that stand out in global markets.

The governments of African countries should strengthen intellectual property protection mechanisms, including those for patents and trademarks. Robust protection incentivizes

innovation and ensures that businesses can reap the benefits of their creativity, fostering an environment conducive to both domestic and international trade.

Given that efficient logistics systems are essential for facilitating trade, policymakers should prioritize infrastructure development, including transportation, communication, and trade routes, to reduce trade barriers, lower transaction costs, and ensure timely delivery of goods. This would enhance efficient logistic systems that could enhance trade participation and economic growth.

The governments of African countries should develop balanced trade policies that promote both export growth and import sustainability. This involves nurturing domestic industries while fostering trade relationships, ensuring that excessive import reliance does not undermine local production capabilities. SMEs often drive innovation and contribute significantly to trade. Policymakers should implement initiatives that provide SMEs with access to financing, training, and technology transfer to enable them to participate more actively in trade activities.

The governments of African countries should offer incentives for R&D activities, such as tax breaks, grants, and subsidies. This would encourage businesses to invest in innovative solutions, leading to the creation of higher-value products and enhancing trade competitiveness. Moreover, establishing or strengthening trade promotion agencies can help businesses navigate international markets, identify trade opportunities, and overcome export and import challenges. These agencies can provide market research, networking, and export-import assistance.

Incorporating these recommendations into policy frameworks can contribute to fostering a conducive environment for innovation, trade participation, and sustained economic growth in selected African countries. By aligning policies with the intricate relationships highlighted by the study's findings, governments can work towards creating resilient and prosperous economies that thrive in the global marketplace.

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ANNEX 1

Short-run Results on the Impact of Innovation and Trade Participation on Economic Growth in Selected African Countries

Variables	Algeria	Angola	Botswana	Burkina Faso	Cabo Verde	Congo DR	Egypt	Ethiopia	Gambia
ect	0.125	-0.0419	-0.473***	0.0394	-0.292***	-0.0676	-0.476***	0.0761	-0.0642
	(0.0852)	(0.0535)	(0.1110)	(0.0361)	(0.0847)	(0.0440)	(0.1230)	(0.0647)	(0.0659)
D.llngdpp	0.220*	0.298**	-0.259**	-0.197	-0.0315	0.530***	-0.103	0.212	0.27
	(0.1330)	(0.1420)	(0.1300)	(0.1880)	(0.1460)	(0.1360)	(0.1800)	(0.2560)	(0.1710)
D.ind	-1.1E-05	-6008	0.0112***	3.73E-05	0.00523*	-10205	2.55E-05	0.000306	0
	(0.0000)	0.0000	(0.0030)	(0.0001)	(0.0029)	0.0000	(0.0000)	(0.0003)	(0.0008)
D.pat	0.000522**	-0.00019	0.0162***	-7.6E-05	-0.0428	-0.00025	-0.00013	-0.00303	73762
	(0.0002)	(0.0004)	(0.0038)	(0.0002)	(0.0791)	(0.0017)	(0.0001)	(0.0025)	0.0000
D.lntrd	-0.034	0.226**	0.196***	-0.0477	0.138	-0.0104	-0.0369	-0.028	-0.0148
	(0.0236)	(0.1050)	(0.0642)	(0.0361)	(0.1660)	(0.0295)	(0.0536)	(0.0300)	(0.0125)
D.rad	-0.0449	3387000	-0.383	0.201*	0	-0.0982	-0.205	-0.335	-0.703
	(0.0827)	0.0000	(0.3770)	(0.1080)	0.0000	(0.3160)	(0.1860)	(0.4110)	(0.4650)
D.lnexpt	0.0754***	0.108***	0.0185	-0.0174	0.127**	0.107**	0.0985*	-0.132	-0.0401
	(0.0227)	(0.0345)	(0.0743)	(0.0377)	(0.0554)	(0.0430)	(0.0578)	(0.2240)	(0.0459)
D.lnimpt	0.119**	-0.0108	0.0812	0.118**	0.0167	-0.0710**	0.0187	0.234	0.0192
	(0.0479)	(0.0359)	(0.0633)	(0.0475)	(0.0722)	(0.0313)	(0.0811)	(0.1470)	(0.0569)
Constant	0.0762	20,454***	0.167	0.0943*	0.161*	258.2***	-0.364**	0.247	-24587
	(0.0561)	(0.0557)	(0.1550)	(0.0529)	(0.0890)	(0.1130)	(0.1830)	(0.1820)	0.0000
Observations	625	625	625	625	625	625	625	625	625

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Extracts from STATA 15 Output

ANNEX 2

Short-run Results on the Impact of Innovation and Trade Participation on Economic Growth in Selected African Countries

Variables	Ghana	Kenya	Madagascar	Mauritius	Morocco	Mozambique	Namibia	Nigeria	Rwanda
ect	-0.342***	-0.0246	0.00808	-0.0457**	-0.257***	-0.301***	-0.248***	-0.0818*	-0.0116
	(0.1220)	(0.0342)	(0.0715)	(0.0194)	(0.0555)	(0.0584)	(0.0808)	(0.0439)	(0.0764)
D.llngdpp	0.479***	0.466**	-0.289	-0.277***	-0.373***	-0.127	0.129	0.234	-0.159
	(0.1450)	(0.1850)	(0.2080)	(0.0991)	(0.0955)	(0.1510)	(0.1710)	(0.1790)	(0.1820)
D.ind	3.22E-05	-0.00025	0.000143	0.000953**	2.84e-05***	-0.00021	-0.00062	-1.4E-05	-0.0104
	(0.0001)	(0.0002)	(0.0001)	(0.0005)	(0.0000)	(0.0004)	(0.0005)	(0.0000)	(0.0064)
D.pat	-0.00767	-0.00022	0.00169	-0.00243	-0.000395***	-0.00077	0.00103	0.000151	0.00567*
	(0.0162)	(0.0002)	(0.0019)	(0.0024)	(0.0001)	(0.0008)	(0.0013)	(0.0002)	(0.0032)
D.lntrd	0.0973	-0.0152	-0.0308	0.0747	0.00333	-0.0364	0.00103	0.0637	0.00332
	(0.0667)	(0.0918)	(0.0748)	(0.0520)	(0.0466)	(0.0254)	(0.0090)	(0.0775)	(0.0139)
D.rad	0.0499	0.183*	0.0452	0.281**	-0.0812	-0.11	1.426**	-0.242	3086000
	(0.2990)	(0.0982)	(0.2420)	(0.1330)	(0.0548)	(0.1010)	(0.5660)	(2.2280)	0.0000
D.lnexpt	-0.0434	0.00935	0.134	0.380***	0.204**	0.111**	0.106*	8.25E-05	-0.0313
	(0.0891)	(0.0949)	(0.0834)	(0.1000)	(0.0827)	(0.0479)	(0.0625)	(0.0187)	(0.0424)
D.lnimpt	0.0322	0.0406	-0.0353	-0.145*	-0.101	-0.0258	0.00989	0.0261	0.0223
	(0.0536)	(0.0689)	(0.1030)	(0.0830)	(0.0715)	(0.0269)	(0.0504)	(0.0199)	(0.0682)
Constant	-0.316**	-0.01	0.0228	0.0735***	-0.200*	-0.553***	0.0296	-0.117	-456.1***
	(0.1550)	(0.0484)	(0.0989)	(0.0194)	(0.1150)	(0.1640)	(0.0769)	(0.0769)	(0.0854)
Observations	625	625	625	625	625	625	625	625	625

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Source: Extracts from STATA 15 Output

ANNEX 3

Short-run Results on the Impact of Innovation and Trade Participation on Economic Growth in Selected African Countries

Variables	Tome and Principe	South Africa	Sudan	Tanzania	Tunisia	Uganda	Zambia
ect	0.0716	-0.103**	-0.0277*	0.113	-0.336**	0.250**	0.003
	(0.0498)	(0.0512)	(0.0156)	(0.117)	(0.147)	(0.123)	(0.0313)
D.llngdpp	-0.0332	-0.314	-0.00489	-0.458**	-0.0657	-0.282	0.185*
	(0.097)	(0.216)	(0.152)	(0.2230)	(0.154)	(0.2190)	(0.108)
D.ind	20317	1.53E-05	6.44E-05	0.00519	0.000265*	0.000164	4.14E-05
	0.0000	(0.0000)	(0.0001)	(0.0098)	(0.0002)	(0.0002)	(0.0002)
D.pat	5,100***	6.24E-06	2.92E-05	-0.0686*	-1.2E-05	0.000392	0.00190***
	(0.0890)	(0.0000)	(0.0001)	(0.0381)	(0.0002)	(0.0015)	(0.0005)
D.lntrd	0.0165***	-0.0901	0.0345	0.00546	-9.711	0.140*	-0.0248
	(0.0059)	(0.0567)	(0.0212)	(0.0109)	(7.3430)	(0.0846)	(0.0163)
D.rad	1366000	0.290*	-0.463	0.870***	0.057	0.329**	0.362**
	0.0000	(0.166)	(0.44)	(0.313)	(0.128)	(0.162)	(0.143)
D.lnexpt	5.34	0.0707	0.0499	0.043	0.22	-0.0485	0.0234
	(4.501)	(0.0902)	(0.0354)	(0.0803)	(0.158)	(0.0541)	(0.0257)
D.lnimpt	-3.441	0.0422	-0.0519	0.0844	-0.14	0.241***	0.0819**
	(3.052)	(0.0816)	(0.0321)	(0.0536)	(0.152)	(0.0925)	(0.0371)
Constant	-4983	-0.0688	-0.00176	0.213	-0.332	0.348**	0.018
	0.0000	(0.0653)	(0.0139)	(0.172)	(0.232)	(0.16)	(0.032)
Observations	625	625	625	625	625	625	625