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HOW TRADE PARTICIPATION FUELS INNOVATION IN AFRICA: UNVEILING INSIGHTS THROUGH EMPIRICAL ANALYSIS

ABSTRACT: *By utilising a nonstationary heterogeneous approach to uncover the dynamics between foreign trade participation and innovation levels in developing economies, this empirical study investigates how trade participation fuels innovation in 25 selected African countries. The African continent is experiencing significant economic growth and globalisation, making it essential to understand the potential linkages between international trade and innovation. Using a dynamic fixed effect estimator within the framework of nonstationary heterogeneous panel models on panel data of 25 African countries from 1996 to 2021, the study revealed that national income significantly influences both exports and imports in the region. The study also identified bidirectional causal links between industrial design applications, patents, and trademarks with exports and imports, highlighting the symbiotic relationship between innovation and trade engagement. Successful exports are found to foster investments in design, patents, and branding. Recommendations on the basis of these findings include fostering innovation ecosystems through research institutes and collaborations, developing balanced trade policies to support domestic industries and SMEs, offering incentives for research and development, and strengthening trade promotion agencies to assist businesses in navigating international markets, identifying trade opportunities, and addressing export-import challenges.*

KEY WORDS: *industrial design applications, patent applications, research and development expenditure, trade participation, trademark applications.*

JEL CLASSIFICATION: F140, O32, O360

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1. INTRODUCTION

The African continent has gained increasing prominence in global economic trends in recent years due to increasing levels of globalisation. With its vast natural resources, youthful population, and expanding consumer markets, the continent presents an attractive investment destination and is seen as a frontier for business opportunities. However, the primary objective of any economy is to achieve greater national output and foster economic growth, which is widely recognised as a pivotal macroeconomic goal. Innovation serves as a potent source of productivity gains, enabling businesses to produce more with fewer resources and ensuring increased output. One of the drivers of innovation is international trade, foreign trade, or trade participation.

International trade refers to the integration of nations in terms of free trade, the free movement of capital, and financial activities (Igudia, 2004). This well-established concept, dating back to Smith's analysis of market specialisation and Ricardo's theory of comparative advantage, highlights that international trade promotes the efficient allocation of resources and allows for the dissemination of knowledge and technology, as well as improved competition in domestic and international markets (Ijirshar, 2019; Ricardo, 2001; Smith, 1776). Scholars have shown how exposure to international markets through trade participation affects incentives for innovation (Akcigit & Melitz, 2021; Gür, 2020; Kiriyama, 2012; Melitz & Redding, 2021). Firms primarily engage in foreign markets through the export of goods and services, which plays a crucial role in their worldwide expansion and is favourable for their innovation activities. Studies have increasingly focused on technological innovation since it directly impacts product characteristics (Geng & Kali, 2021). According to Geng and Kali (2021), trade affects the innovation of firms through three channels: increasing market size (driven by export opportunities), intensifying market competition (through trade-induced competition), and facilitating foreign sourcing. Foreign sourcing can either complement or substitute for domestic innovation. On the one hand, it enhances innovation by reducing production costs for domestic firms, encouraging knowledge spillovers, and improving absorptive capacity. On the other hand, it can dampen domestic innovation by allowing firms to acquire external inputs rather than developing them through in-house research and development.

While considerable research has focused on these global dynamics, significant gaps remain in understanding how trade participation specifically influences innovation in African economies, where distinct regional factors such as nascent industrial bases and unique market structures may alter the typical trade-innovation relationship. To address this gap in the literature, this study seeks to examine how trade participation operates as a catalyst for economic growth, innovation, and development across African nations. It has been argued that by actively participating in international trade, countries may expand their economic horizons, accessing larger markets that incentivise innovation and economic activity. Exposure to global competition compels domestic firms to increase their efficiency and competitiveness, fostering innovation as they adapt to meet diverse consumer demands. Trade participation also facilitates the transfer of technology and knowledge, contributing to technological advancement. Therefore, trade participation has been recognised as a key driver of innovation and development in many parts of the world, with the potential to stimulate productivity, increase competitiveness, and foster innovation. African nations, aware of these benefits, have actively participated in trade activities both within the continent and with international partners. Regional economic communities such as the African Union and the African Continental Free Trade Area (AfCFTA) have emerged to facilitate intra-African trade.

Despite the increasing participation of African nations in global trade, there remains a critical lack of empirical studies that directly assess the extent to which trade fuels innovation in this unique regional context. By addressing this void, the present study offers a rigorous empirical examination of how trade participation influences innovation in Africa. This research not only contributes to the global understanding of trade-driven innovation but also provides region-specific insights that are crucial for African policymakers and business leaders aiming to foster sustainable growth. The selection of African countries is based on the availability of innovation indicators, allowing the study to explore whether the effects of trade participation on innovation are homogenous across the region. Through this empirical analysis, the study aims to bridge existing knowledge gaps and offer actionable insights into how trade participation catalyses innovation across selected African countries. Consequently, this research has significant implications for development agencies, policymakers, and businesses striving to

harness innovation-centric strategies for economic diversification and global competitiveness.

2. LITERATURE REVIEW

The study hinges on the export-led growth hypothesis and the innovation-led growth model. These theories posit that increased trade participation can stimulate innovation, resulting in greater economic growth. The export-led growth hypothesis posits that an increase in exports can drive economic growth (Dreger & Herzer, 2013). In the context of African economies, the theory is closely related to the impact of trade participation on innovation. As African countries actively engage in international trade, they expand their export opportunities, leading to increased revenue. This additional income can be reinvested in innovation-related activities, such as research and development (R&D) and technology adoption. Moreover, trade exposes African firms to global competition, encouraging them to innovate to remain competitive in international markets. The pressure to improve product quality, reduce costs, and introduce new products or services serves as a powerful incentive for innovation. Moreover, trade facilitates knowledge transfer and technology adoption, further fostering innovation within African economies. In a closely related manner, innovation-led growth theory also asserts that innovation is the primary driver of sustained economic growth (Smorodinskaya et al., 2019). In the context of African economies and their trade participation, this theory is pertinent. Trade can serve as a catalyst for innovation in Africa by expanding market opportunities, promoting competition, and facilitating knowledge transfer. As African nations actively engage in global trade, they create conditions conducive to innovation, emphasising the critical role of trade participation in fostering innovation-led growth in the region.

The catch-up theory explores the dynamics of economic development in less advanced countries. It posits that these countries can experience rapid industrial growth by importing technology and innovation from more developed nations (Veblen, 1915). In the context of Africa, this theory suggests that the region which is seen as a developing area with potential for significant industrial growth can achieve convergence with wealthier nations through technological advancements and innovation. However, challenges exist, including technology transfer difficulties, institutional limitations, and policy effectiveness.

Product cycle theory posits that affluent nations typically innovate new products, often enjoying a monopolistic advantage fuelled by domestic market needs (Gerschenkron, 1962). However, they might lack knowledge of foreign market conditions, leading rival firms in other countries to imitate and eventually dominate the global market. The theory delineates stages: initial monopoly, foreign expansion, competitive advantage of lower costs, and eventual global dominance by foreign producers, turning innovating nations into net importers (Gerschenkron, 1962). In the context of African countries, this theory emphasises the role of trade and innovation. Initially, African nations may import innovative products, but as these mature, they can engage in trade and domestic innovation to adapt and enhance these technologies, fostering economic growth. However, the theory's applicability today is challenged by rapid technological advancements and evolving consumer preferences that can significantly alter product life cycles, highlighting the need for a nuanced understanding of innovation and trade dynamics.

The escape-competition effect theory, initially proposed by Arrow (1962) and further developed by Aghion et al. (2005), posits that import competition can stimulate business innovation. Arrow argued that competition prompts companies to invent as a means of outperforming rivals, whereas in the absence of competition, firms may lack the incentive to innovate. The Aghion et al. (2005) model emphasised the conditions under which competition encourages innovation, particularly when rival firms possess similar technological potential, leading to increased returns on innovation. This theory suggests that innovation can be employed by businesses to evade trade rivalry, ultimately driving higher levels of innovation in response to increased competition. In the context of African countries, escape-competition effect theory highlights the importance of innovation as a tool to break free from stagnation caused by diminishing returns to capital and labour. By investing in R&D and cultivating entrepreneurial ecosystems, African nations can create new products and technologies, fostering economic growth and trade participation, especially in innovation-rich sectors. However, challenges such as inadequate infrastructure, limited access to financing, and human capital deficiencies may impede the effective implementation of innovation policies in these countries.

A few studies have explored the impact of trade participation on innovation. For example, Damijan and Kostevc (2015) analysed data from Spanish manufacturing firms from 1990 to 2008, employing ordinary least squares analysis. Their findings indicated that firms glean insights from trade activities, leading to the introduction of novel products or processes influenced by their foreign trade connections. Notably, the study suggested that import links play a significant role in fostering innovation, allowing firms to prepare for entry into export markets. More recently, Cai et al. (2020) investigated Chinese data from 2001 to 2007, revealing a link between participation in export trade and product innovation. Additionally, Geng and Kali (2021) delved into the effects of trade participation, with a focus on technological innovation. Their research highlighted that international trade fosters innovation by intensifying market competition, expanding market size, and facilitating foreign sourcing, ultimately resulting in a positive impact on domestic innovation.

3. METHODOLOGY

Our study relied on secondary data obtained from various sources, including the World Bank (2021). and the World Intellectual Property Organization. (2021). Panel data were collected on 25 selected African countries covering all variables in the models from 1996 to 2021, a period of 26 years. The variables of interest include industrial design applications, patent applications, trademark applications, research and development expenditure, GDP per capita (PPP, constant 2017 international $), exports and imports of goods and services (current US$), and overall logistics performance index. The data on innovation indicators are limited to a few periods, and only countries with data covering at least three periods were selected, with the study interpolating missing observations. Specifically, data for some innovation measures (industrial designs, patents, and trademark applications) were sourced from the World Intellectual Property Organization. (2021). Industrial design applications measure only the appearance or aesthetic features of a product, whereas a patent protects an invention that offers a new technical solution to a problem. The study used the applications (industrial designs, patents, and trademarks) taken out by the country's residents in the respective country. On the other hand, research and development was sourced from the World Bank (2021) as gross domestic expenditures on R&D, expressed as a percentage of GDP. Other variables, such

as the logistics performance index, assess real-world trade logistics performance, providing valuable insights to national leaders, influential policymakers, and private sector traders. It aids in comprehending the obstacles encountered by these stakeholders and their trading counterparts, as they work to diminish logistical hindrances in international trade. The data on exports and imports were sourced from the World Bank (2021). The export of goods and services constitutes the total value of all commodities and additional market-related services supplied to the global market, whereas the import of goods and services signifies the total value of all commodities and additional market-related services acquired from the global market.

3.1. Theoretical model and empirical model specification

To examine the influence of trade participation on innovation, our study uses the approach employed by Geng and Kali (2021) and is anchored in the escape-competition effect theory propounded by Arrow (1962), who claimed that import competition fosters business innovation. In addition, enterprises with the same technological potential often experience increased returns on innovation (Aghion et al., 2005; Meza-González & Sepulveda, 2019; Sedgley, 2022). Our study uses the market size effect and competition effects on innovation. It has been stated that trade exposes countries to competition, which dampens innovation by restricting firm size, whereas less trade competition may have less of an effect on innovation (Aghion & Howitt, 1992; Arrows, 1962; Geng & Kali, 2021; Griffith & Van Reenen, 2023; Tingvall & Poldahl, 2006). According to Gür (2020), a country's trade is very instrumental in increasing innovation capabilities in developing economies. The GDP per capita, PPP (constant 2017 international $) (GDPP) and the overall logistics performance index (LPI) both play crucial roles in driving innovation. A higher GDPP provides the financial resources necessary for research and development, education, and infrastructure, fostering an environment where innovation can thrive. Additionally, a larger domestic market resulting from a strong GDPP encourages firms to invest in innovation to gain a competitive edge. The LPI, on the other hand, impacts innovation by streamlining supply chains, reducing costs, and improving the efficiency of logistics systems. Efficient logistics enable companies to bring new products to market more quickly and engage in international trade, facilitating the exchange of ideas and technologies. Together, a robust national income (GDPP) and a high LPI score create an ecosystem that supports innovation by providing the

necessary resources, incentives, and infrastructure for research, development, and market access. Thus, the model for assessing the influence of trade participation on innovation can be stated as follows:

$$INV_{it} = f(Trade_{it}, \ln GDPP_{it}, ALPI_{it}), \quad (1)$$

where *INV* is innovation and *Trade* is the trade participation component. Importantly, trade participation occurs through either exports or imports. Decomposing trade participation into the exports and imports of goods and services, the model can be specified as follows:

$$INV_{it} = f(EXPT_{it}, IMPT_{it}, \ln GDPP_{it}, ALPI_{it}). \quad (2)$$

The variables represent each country i in year t for each variable. The model was used to estimate the impact of exports and imports on all innovation indicators, including the IND model for industrial design applications, the PAT model for patent applications, the TRD model for trademark applications, and the RAD model for research and development expenditure. The stochastic form of equation (2) can be specified as:

$$INV_{it} = \beta_0 + \beta_1 \ln EXPT_{it} + \beta_2 \ln IMPT_{it} + \beta_3 \ln GDPP_{it} + \beta_4 ALPI_{it} + \varepsilon_t, \quad (3)$$

where $\varepsilon_{it} = \mu_i + \eta_{it}$, β_0 is the intercept, $\beta_1 to \beta_4$ represent the parameters to be estimated, μ_i represents the individual-specific effect, η_{it} represents the idiosyncratic error, and $i = 1,...,n$ (for all countries in each region), $t = 1996,...,2021$. Following equation (3), the dynamic panel models that were estimated are as follows:

$$IND_{it} = \beta_0 + \beta_1 IND_{it-1} + \beta_2 \ln EXPT_{it} + \beta_3 \ln IMPT_{it} + \beta_4 \ln GDPP_{it} + \beta_5 ALPI_{it} + \varepsilon_t \quad (4)$$

$$PAT_{it} = \beta_0 + \beta_1 PAT_{it-1} + \beta_2 \ln EXPT_{it} + \beta_3 \ln IMPT_{it} + \beta_4 \ln GDPP_{it} + \beta_5 ALPI_{it} + \varepsilon_t \quad (5)$$

$$\ln TRD_{it} = \beta_0 + \beta_1 \ln TRD_{it-1} + \beta_2 \ln EXPT_{it} + \beta_3 \ln IMPT_{it} + \beta_4 \ln GDPP_{it} + \beta_5 ALPI_{it} + \varepsilon_t \quad (6)$$

$$RAD_{it} = \beta_0 + \beta_1 RAD_{it-1} + \beta_2 \ln EXPT_{it} + \beta_3 \ln IMPT_{it} + \beta_4 \ln GDPP_{it} + \beta_5 ALPI_{it} + \varepsilon_t \quad (7)$$

The theoretical a priori expectations are that the influence of trade participation on innovation is either positive or negative, depending on whether the countries that are trading have copied the technology or upscaled in their process because participation in the global market or trade competition constrains performance.

3.2. Method of data analysis

Our study focuses on analysing the relationships between trade participation and innovation among African countries. To ensure robust and reliable estimations via panel data, the analysis begins by testing for stationarity and the presence of unit roots, which is critical for avoiding spurious regressions. Panel unit root tests were conducted via both first- and second-generation methods, particularly to account for cross-sectional dependency when present. These tests included the Levin, Lin, and Chu (LLC) (2002), Hadri (2000), Pesaran (2003), and Maddala and Wu (1999) tests, which assume common persistent parameters across cross-sections, with the exception of the Breitung test (Breitung, 2001). Additionally, the Im, Pesaran, and Shin (IPS) (2003) test was employed to allow for parameter variation across cross-sections (Im et al., 2003; Im et al., 2023).

To analyse the long-term relationships between trade participation and innovation, the study employed nonstationary heterogeneous panel estimators, specifically the pooled mean group (PMG), dynamic fixed effect (DFE), and mean group (MG). These estimators were chosen to accommodate the diverse economic dynamics, nonstationarity, and long-run equilibrium relationships among African countries. They also enabled the analysis to account for both country-specific effects and the heterogeneity or homogeneity of the panel. The selection of the appropriate estimator was based on Hausman-type tests, ensuring both efficiency and robustness in the analysis. The study ultimately selected the DFE estimator on the basis of the results of the Hausman (1978) test, which indicated its suitability for the panel structure. The analysis assumed that cross-sectional dependence could affect the validity of panel unit root tests, particularly given the interconnectedness of African economies. Thus, second-generation unit root tests (such as Pesaran's [2003] cross-sectional augmented tests) were employed where appropriate. Additionally, the assumption of long-run homogeneity was tested via the Hausman test to determine whether pooling the data across countries would be valid or whether a country-specific approach would be more appropriate. The Juodis, Karavias and Sarafidis (2021) Granger

noncausality test was used to assess the direction of causality between trade participation and innovation, offering insights into whether trade participation directly stimulates innovation or whether the causality operates in reverse. The limitations encountered during the analysis included potential data constraints, especially regarding the availability of consistent innovation indicators across all African countries. However, this limitation was carefully considered in the interpretation of the results, and appropriate robustness checks were performed to mitigate their impact.

4. RESULTS AND DISCUSSION

4.1. Panel unit root test results

The results of these tests, presented in Table 1, provide insights into whether the variables are stationary or nonstationary. The null hypothesis for these tests is that the variable has a unit root and is nonstationary, whereas the alternative hypothesis suggests that the variable is stationary. The significance level for the tests is set at the 5% critical level.

The results in Table 1 indicate that while some of the variables were initially found to be stationary at their original level, all the variables exhibited stationarity after applying a first difference transformation.

Table 1: Panel unit root test results

Panel Unit Root Tests	**lnimpt**	**d.lnimpt**	**lngdpp**	**d. lngdpp**	**lnexpt**	**d.lnexpt**
Harris-Tzavalis (rho)	0.9249	-0.1486***b	0.9706	0.1207***b	0.9254	-0.0630***b
Breitung (lambda)	5.6169	-5.8208***b	11.6048	-8.3938***b	5.7147	-4.8003***b
Levin-Lin-Chu	-9.6805***a	-1.1649***	-3.8136***a	-4.7758***	-10.7720***a	-1.7943***
Im–Pesaran–Shin	3.8792	-9.6502***b	1.2939	-10.8485***b	3.7596	-9.7921***b
Fisher-Type	2.9942***a	-0.7062	1.4535*	-0.8283	1.2304***a	-1.0137
Pesaran's CADF	1.092	-1.221	-1.412	1.413	-1.110	0.888
Hadri LM	60.6129***	-0.1389 b	75.0793***	9.4630***	60.0899***	0.5905 b
Panel Unit Root Tests	**ind**	**d.ind**	**rad**	**d.rad**	**alpi**	**d.alpi**
Harris-Tzavalis (rho)	0.6055***a	-0.2383***	1.031	0.3341***b	0.9089	0.3516***b
Breitung (lambda)	9.0394	-5.6515***b	9.1162	-5.9085***b	1.8871	-8.8698**b
Levin-Lin-Chu	0.5231*	-5.1256***b	0.5843	-5.7283***b	-0.1428	-8.8493***b
Im–Pesaran–Shin	-	-	6.8806		1.2385	-5.6891***b
Fisher-Type	0.5563	1.9659***b	5.2991***a	-9.143***	0.2492	-1.1639
Pesaran's CADF	4.955	4.383	1.726	2.431	6.016	-3.138***b
Hadri LM	25.7843***	-3.5150 b	56.4971***	13.3743***	44.1506***	6.5872***
Panel Unit Root Tests	**pat**	**d.pat**	**lntrd**	**d.lntrd**		
Harris-Tzavalis (rho)	0.8176***a	0.0527***	0.8748	-0.1756***b		
Breitung (lambda)	4.4588	-8.0935***b	4.9131	1.0882		
Levin-Lin-Chu	-0.0230*	-26.0678***b	-42.867***a	1.9894		
Im–Pesaran–Shin	-0.5704	-12.8431***b	3.4536	-6.9075***b		
Fisher-Type	-3.2415	18.0431***b	2.6515	5.8026***b		
Pesaran's CADF	3.569	1.012	-0.537	-1.201		
Hadri LM	35.7291***	-1.7836 b	41.5165***	1.8039**		

Source: Extracts from STATA 15 Output. **Note:** The asterisks (***, **, and *) denote rejection of the null hypothesis at the 1%, 5%, and 10% levels of significance, whereas a and b indicate stationarity at the level and first difference, respectively. CADF=cross-sectional augmented Dickey–Fuller, LM= Lagrange multiplier

4.2. Correlation test for multicollinearity

Table 2 presents the correlation matrix of the predictor variables. Correlation coefficients ranging from -1 to 1 indicate the strength and direction of linear relationships between pairs of variables. High absolute correlation coefficients may indicate multicollinearity. However, it is important to note that correlation does not imply causation, and further diagnostics are necessary to address multicollinearity concerns.

Table 2: Results of the correlation test for multicollinearity

Innovation Model	lnexpt	lnimpt	lngdpp	alpi
lnexpt	1			
lnimpt	0.7745	1		
lngdpp	0.5412	0.4836	1	
alpi	0.2306	0.26	0.2588	1

Source: Extracts from STATA 15 Output.

The results from Table 2 indicate the absence of substantial multicollinearity. The observed weak relationships among the explanatory variables suggest that they do not redundantly convey the same information. This is favourable for the reliability of the models' coefficients and predictions, as the presence of multicollinearity can lead to unstable and less interpretable results or indeterminate estimates. Therefore, the results from the correlation test provide evidence that the examined model is free from severe multicollinearity issues, reinforcing the credibility of their analytical outcomes, and enhancing the models' utility for informed decision-making.

4.3. Nature of causality between trade participation and innovation for the selected African countries

The results are presented in Table 3, and a discussion is provided below on the results presented in Table 3.

Table 3: Juodis, Karavias and Sarafidis (2021) Granger noncausality test results

Hypothesis	HPJ Wald Test	*P*-value HPJ
lnexpt does not Granger-cause lngdpp.	1.822455	0.1770
lngdpp does not Granger-cause lnexpt.	6.222917**	0.0126
lnimpt does not Granger-cause lngdpp.	571712	0.9397
lngdpp does not Granger-cause lnimpt.	36.98981***	0.0000
ind does not Granger-cause lnexpt.	4.780569**	0.0288
lnexpt does not Granger-cause ind.	4.856023**	0.0275
pat does not Granger-cause lnexpt.	12.4831***	0.0004
lnexpt does not Granger-cause pat.	0.040775	0.8400
lntrd does not Granger-cause lnexpt.	50966551	0.4753
lnexpt does not Granger-cause lntrd.	102.7355***	0.0000
rad does not Granger-cause lnexpt.	0.050205	0.8227
lnexpt does not Granger-cause rad.	5.62997**	0.0177
ind does not Granger-cause lnimpt.	9.306808***	0.0023
lnimpt does not Granger-cause ind.	11.67317***	0.0006
pat does not Granger-cause lnimpt.	11.34989***	0.0008
lnimpt does not Granger-cause pat.	10070539	0.7510
lntrd does not Granger-cause lnimpt.	10.32785***	0.0013
lnimpt does not Granger-cause lntrd.	107.6093***	0.0000
rad does not Granger-cause lnimpt.	1.392559	0.2380
lnimpt does not Granger-cause rad.	2.57651	0.1085
ind does not Granger-cause lngdpp.	3.39781*	0.0653
lngdpp does not Granger-cause ind.	13.56904***	0.0002
pat does not Granger-cause lngdpp.	37407229	0.5408
lngdpp does not Granger-cause pat.	2.496329	0.1141
lntrd does not Granger-cause lngdpp.	0.025771	0.8725
lngdpp does not Granger-cause lntrd.	4.108367**	0.0427
rad does not Granger-cause lngdpp.	4.72E-05	0.9945

Note: Standard errors in parentheses – *** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Source: Extracts from STATA.

The results reveal several causal relationships among economic indicators and innovation-related activities in selected African countries. First, there is a unidirectional causal relationship from the GDPP to exports of goods and services, indicating that GDP growth positively influences exports. The GDPP generates more resources and demand for domestic goods and services, increasing export activities. However, the reverse relationship is not significant, indicating that changes in exports do not substantially affect the GDPP. Similarly, a unidirectional causal relationship runs from the GDPP to imports of goods and services, highlighting that GDPP growth significantly and positively impacts imports. A flourishing economy generates greater purchasing power and demand for foreign goods, driving import activities. Conversely, the causal link from imports to the GDPP is not statistically significant.

The study also identifies a bidirectional causal relationship between industrial design applications and exports, emphasising how design enhances the competitiveness of exported products, whereas export success prompts investment in design innovation. Similarly, there is a unidirectional causal link from patent applications to exports, highlighting the role of patent protection in fostering innovation and export growth. Moreover, a unidirectional causal relationship exists from the export of goods and services to trademark applications, showing that successful exports drive trademark protection efforts. Additionally, there is a unidirectional causal relationship from exports to R&D activities, underlining how export success encourages investment in research and innovation.

Furthermore, a bidirectional causal relationship is observed between the import of goods and services and industrial design applications, illustrating the interplay between design and import activities. A unidirectional causal relationship also runs from the GDPP to trademark applications, highlighting the role of economic growth in fostering an environment conducive to innovation and branding. Finally, there is a unidirectional causal relationship from the GDPP to R&D activities, underscoring the importance of economic prosperity in promoting investment in research and technological advancement.

4.3. Impact of trade participation on innovation in selected African countries

The results concerning the impact of trade participation on innovation in selected African countries are presented in Table 4 and discussed below.

Table 4: Impact of trade participation on innovation in selected African countries

Variables	ind Model (4)	pat Model (5)	lntrd Model (6)	rad Model (7)
ect	-0.414***	-0.252***	-0.140***	-0.0137
	(0.0414)	(0.0273)	(0.0238)	(0.0134)
d.lind	-0.0359			
	(0.0431)			
d.lpat		0.191***		
		(0.0402)		
d.llntrd			-0.120***	
			(0.0436)	
d.lrad				0.340***
				(0.0418)
d.lnexpt	12.05	-8.409	-0.101	-0.00565
	(44.20)	(13.14)	(0.103)	(0.0103)
d.lnimpt	-29.20	5.451	-0.00951	0.00716
	(42.70)	(12.70)	(0.0998)	(0.00992)
d.lngdpp	85.46	-14.82	-0.419	-0.00787
	(149.2)	(44.28)	(0.350)	(0.0346)
d.alpi	78.08	34.18*	-0.0513	0.0110
	(61.92)	(18.58)	(0.144)	(0.0143)
lnexpt	125.2*	-43.30	-0.808	-0.569
	(75.24)	(36.75)	(0.523)	(0.671)
lnimpt	130.8*	48.22	0.534	0.163
	(77.83)	(37.96)	(0.538)	(0.548)
lngdpp	36.03	21.92	1.582***	0.994
	(73.46)	(36.10)	(0.590)	(0.934)
alpi	-99.08	75.52**	0.153	-0.103
	(73.49)	(35.46)	(0.511)	(0.527)
Constant	87.30	-96.96	-0.00494	0.0239
	(210.3)	(62.27)	(0.501)	(0.0490)
Observations	.	.	.	.

Note: Standard errors in parentheses. ect=error correction term

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Source: Extracts from STATA Output

From the results in Table 4, the estimated impact of the export and import of goods and services has a substantial and statistically significant positive effect on industrial design applications in Africa in the long run at the 10% level of significance. This dynamic is driven by several factors. First, international trade facilitates the exchange of knowledge, technology, and innovative ideas, thereby promoting the adoption of advanced design methodologies and practices within African industries. Second, access to global markets through trade encourages local industries to enhance the quality and aesthetic appeal of their products, resulting in improved industrial designs that can better compete internationally. Third, trade-driven economic growth increases domestic demand for creative and aesthetically pleasing goods, encouraging firms to invest in design innovation. Finally, exposure to diverse design trends from different markets fosters a cross-pollination of ideas, leading to a richer and more vibrant African design landscape. Thus, the symbiotic relationship between trade and industrial design applications propels Africa's creative industries forward.

The results also showed an estimated coefficient of 75.52, which signifies a highly significant positive impact of the logistics performance index on patent applications in Africa (p-value < 0.05) in the long run. This means that for every unit increase in the logistics performance index, there is an expected increase of 75.52 units in patent applications. The robust logistics performance index indicates efficient infrastructure and streamlined trade processes, which foster an environment conducive to innovation and research. The substantial coefficient underscores the pivotal role of effective logistics in driving intellectual property creation across the continent. This finding validates the logistics performance index's significance in facilitating a favourable ecosystem for innovation and contributing to increased patent applications in Africa.

The study also reveals a coefficient of 1.582, which signifies a robust and statistically significant positive impact of gross domestic product per capita (GDP per capita) on trademark applications in Africa (p-value < 0.01) in the long run. This finding indicates that each unit increase in GDP per capita leads to an increase of 1.582 units in trademark applications in Africa. A higher GDP per capita reflects increased economic prosperity and resources, enabling businesses to invest in brand development and protection. Wealthier economies can afford to allocate funds to marketing and branding efforts, leading to more trademark

applications to safeguard their intellectual property. The significant coefficient highlights the pivotal role of economic well-being in driving brand consciousness and trademark creation on the continent. This finding shows the significant influence of GDP per capita in fostering an environment conducive to trademark applications in Africa.

The estimated coefficient of 75.52 signifies a strong and statistically significant positive effect of the logistics performance index on patent applications in Africa (p-value < 0.10) in the short run. This implies that for every unit increase in the logistics performance index, there is an anticipated increase of 75.52 units in patent applications in Africa. This means that an enhanced logistics performance index reflects efficient trade infrastructure and streamlined logistics, which foster an environment conducive to innovation and research. Improved logistics enable the seamless exchange of knowledge and resources, contributing to increased patent filings. The significant coefficient highlights the crucial role of well-organised logistics in driving intellectual property creation in the short run across the continent. Although the significance level is at the 10% critical level, the coefficient still suggests the potential influence of the logistics performance index in promoting innovation and, subsequently, patent applications in Africa.

The estimated lagged patent applications exert a strong positive influence on current patent filings in Africa, which is evident at the 1% significance level. This suggests that previous patent applications stimulate contemporary innovation efforts. As inventors build upon prior research, technological advancements accumulate, fostering a culture of innovation. The causal relationship implies that each earlier application fuels subsequent creativity, potentially driven by knowledge spillovers, economic incentives, or collaborative momentum. Consequently, leveraging historical patent applications as a foundation propels a surge in novel inventions, amplifying Africa's patent landscape and accelerating technological progress in the short term.

The study also revealed that at the 1% significance level, a strong positive effect of lagged research and development on current R&D endeavours in Africa emerges. This phenomenon implies that prior R&D investments propel ongoing innovation initiatives. As previous research efforts have yielded insights and knowledge, they have become catalysts for contemporary scientific exploration.

The statistical significance underscores a clear causal linkage, suggesting that each preceding R&D endeavour stimulates subsequent creative pursuits. This could be attributed to knowledge accumulation, learning curves, or collaborative synergies. The outcome highlights the vital role of historical R&D activities in boosting current scientific progress, fostering a cycle of innovation and driving short-term advancements across various fields.

The study additionally revealed significant findings at the 1% significance level showing a notable adverse influence of lagged trademark applications on present trademark filings in Africa. This counterintuitive result suggests that past trademark applications may discourage current filing efforts. Possible justifications include heightened competition due to a surge in previous filings, potential saturation in certain industries, or shifts in market dynamics. This shows the need for strategic considerations when filing trademarks, as excessive past applications might hinder current attempts. Balancing brand protection with market trends becomes crucial for optimising short-term trademark application outcomes and aligning them with evolving business landscapes.

4.4. Discussion

The study also examined the impact of trade participation on innovation in selected African countries. It assessed the pivotal role of trade participation in driving innovation (industrial design applications, patent filings, and trademark creations) among the selected African countries. This is consistent with the findings of Damijan and Kostevc (2015), Cai et al. (2020), and Geng and Kali (2021). The significant and positive impact of the export and import of goods and services on industrial design applications highlights the mutually reinforcing dynamics between trade participation and design innovation. International trade acts as a conduit for the exchange of knowledge, technology, and ideas, fostering the adoption of advanced design practices in African industries. Access to global markets incentivises local businesses to enhance the aesthetic quality of their products, promoting better industrial designs that can compete effectively in the global stage. Furthermore, trade-driven economic growth stimulates domestic demand for aesthetically pleasing goods, encouraging firms to invest in design innovation. The exposure to diverse design trends from various markets cultivates a cross-fertilisation of ideas, contributing to a richer African design

landscape. This symbiotic relationship between trade and industrial design applications has amplified the growth of Africa's creative industries.

The causal relationship between lagged patent applications and current patent filings signifies the accumulation of technological advancements and the cultivation of a culture of innovation. As previous patent applications provide a foundation for further research and development, they stimulate ongoing creativity. This suggests that innovation begets innovation, with earlier applications acting as catalysts for subsequent inventive efforts. This finding underscores the importance of leveraging historical patent applications to drive contemporary innovation and technological progress. The strong positive effect of lagged R&D on current R&D endeavours reinforces the idea that past research efforts serve as stepping stones for ongoing innovation initiatives. Each previous research endeavour contributes to a collective knowledge pool that fuels current scientific exploration. This emphasises the iterative nature of research and the importance of building upon prior findings to drive scientific progress in the short term. The counterintuitive adverse influence of lagged trademark applications on present trademark filings raises important strategic considerations for brand protection. Excessive past trademark applications might create a competitive landscape that hinders current filing efforts. This suggests the need for careful brand management strategies that balance protection with evolving market trends. By understanding the potential saturation in certain industries and adapting to changing market dynamics, businesses can optimise their trademark application outcomes and navigate the complex landscape of intellectual property protection.

Thus, the study's findings highlight the interplay between international trade participation, innovation, and intellectual property protection in Africa. The results underscore the importance of well-functioning logistics, economic prosperity, and strategic decision-making in fostering industrial design, patent applications, and trademark creations. These insights have practical implications for policymakers and businesses seeking to drive innovation and protect intellectual property across the continent.

5. CONCLUSION AND POLICY RECOMMENDATIONS

Our study concludes that national income drives both exports and imports in the region and that there are bidirectional causal links identified between industrial design applications and exports, patents and exports, and trademarks and imports, highlighting the symbiotic relationship between innovation and trade engagement. The study also emphasises that successful exports foster investments in design, patents, and branding.

On the basis of the insightful findings of the study, several practical policy recommendations can be proposed to increase trade participation and innovation in selected African countries:

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 centres, and industries. These initiatives facilitate knowledge exchange, technological advancements, and the creation of high-value products.

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.

Governments of African countries should offer incentives for research and development 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.

Glossary of Terms and Abbreviations

1. **AfCFTA (African Continental Free Trade Area)**: A regional trade agreement among African Union member states that aims to create a single market for goods and services, facilitating intra-African trade.
2. **Breitung test**: A panel unit root test that assumes no trend in the data and is more powerful in small samples than other tests.
3. **CADF (cross-sectional augmented Dickey–Fuller)**: A second-generation panel unit root test used to check for stationarity, accounting for cross-sectional dependencies.
4. **Cross-sectional dependency**: A condition in panel data analysis where cross-sections (e.g., countries) are not independent of each other, often owing to economic linkages or global factors.
5. **DFE (dynamic fixed effects)**: A panel data estimation method that accounts for time-invariant country-specific effects and dynamics within a dataset.
6. **GDP (gross domestic product)**: A measure of the total economic output of a country.
7. **IND (industrial design applications)**: The number of applications for industrial design protection, which measures innovation in product appearance and aesthetics.
8. **IP (intellectual property)**: Legal rights protecting the creations of the mind, such as inventions (patents), designs (industrial designs), and symbols or names (trademarks) used in commerce.
9. **IPS (Im, Pesaran, and Shin)**: A panel unit root test allowing for heterogeneous unit roots across cross-sections, used to determine stationarity in panel data.
10. **LLC (Levin, Lin, and Chu)**: A panel unit root test assuming homogeneity of unit root processes across cross-sections.
11. **LPI (logistics performance index)**: A measure that evaluates a country's logistics performance on the basis of factors such as efficiency, infrastructure, and trade processes.
12. **MG (mean group)**: A panel data estimation technique allowing for both short- and long-run heterogeneity across individual cross-sections.
13. **PAT (patent applications)**: The number of patent applications filed in a country, which serves as a key indicator of technological innovation.

14. **PMG (pooled mean group)**: A dynamic panel data estimation method that assumes long-run homogeneity while allowing for short-run heterogeneity across cross-sections.
15. **PPP (purchasing power parity)**: A method of measuring economic variables in different countries to account for differences in price levels.
16. **R&D (research and development)**: Activities undertaken by firms or governments to innovate and introduce new products or processes.
17. **Trade participation**: Engagement in the exchange of goods and services across borders.
18. **Trademark applications**: Requests for legal protection of brand identifiers such as logos, names, and slogans to prevent unauthorised use by others.
19. **WIPO (World Intellectual Property Organisation)**: A global organisation that promotes IP protection through cooperation among nations and the management of IP rights.

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