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Revolutionising Trade: Exploring how Innovation in Selected African Countries Shapes Economic Relations with Key Regions

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Abstract

This study investigates the impact of innovation on trade participation between selected African countries and key global economic regions. The study used panel data on 25 African countries from 1996 to 2021. Non-stationary heterogeneous panel model of pooled mean group, mean group, and dynamic fixed effect estimators. The results reveal the significance of trademarks, patents, industrial design, and efficient logistics in enhancing trade competitiveness and market presence for African nations. The results suggest that fostering innovation ecosystems, investing in design capabilities, and strengthening intellectual property protection are essential for sustained trade growth. Policy recommendations suggested the need for investment in research and development, promotion of industrial design capabilities, and balanced trade policies to stimulate economic growth. Moreover, incentivizing SME participation in trade activities and prioritizing regional economic integration are crucial steps towards fostering sustainable trade relations. By implementing these recommendations, African countries can harness innovation to propel their economies into the global market, fostering trade relations that are mutually beneficial and sustainable.

Keywords: African countries, economic regions, innovation, trade participation

JEL classification: O31, O32, O33, O34, P45, F10, F12, F14, F15, O55

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1. Introduction

Trade constitutes a critical factor for determining the pace of sustained economic growth and development in any modern economy. However, trade is in turn influenced by the quality and state of innovation in such a nation (Fauzel, 2022; Melitz & Redding, 2021; Akcigit & Melitz, 2021). Africa appears to have witnessed some degree of innovation in recent times. 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 (World Integrated Trade Solution, 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 (World Integrated Trade Solution, 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.

The symbiotic relationship between innovation and trade participation across regions and the interconnectivity of countries among nations in terms of economic activities act as powerful engines for driving positive economic growth globally. Advanced economies, exemplified by countries such as the United States and Germany, continuously pioneer technological innovations in sectors such as information technology, biotechnology, and automation. These innovations not only increase domestic productivity but also become sought-after commodities in international markets, fostering robust trade participation. Simultaneously, emerging economies such as China leverage their manufacturing prowess and innovation initiatives to become global economic powerhouses.

Furthermore, regional collaborations, such as those within the European Union, create environments where innovation seamlessly translates into cross-border trade, exemplified by the success of industries such as automotive manufacturing. In this ideal scenario, the positive feedback loop between innovation and economic relations among countries becomes a driving force for economic growth. Thus, it has been axiomatically accepted that innovation influences trade activities among countries. This is because higher levels of innovation, encompassing both process and product innovation, lead to increased productivity and greater output. Thus, innovation is likely to influence or drive trade activities and the level of trade participation or competition among countries.

This examination of the trade benefits of being innovative and how innovation influences the share of trade among economic regions across the globe requires further empirical investigation. In this context, an empirical investigation was conducted to understand how innovation by selected African countries shapes economic relations with key economic regions in the world. The above line of thought has stimulated the following question: *How does innovation influence the share of trade by the selected African countries with some economic regions?* This study is an attempt to clarify the puzzle surrounding the issue under investigation. The rest of this article is arranged as follows: Section 2 provides a brief theoretical and empirical review. The methodology of the study is outlined in part 3. The analysis of the results and findings is performed in section 4, and the next one presents the conclusion and recommendations.

2. Brief review of the theoretical and empirical literature

This study employs a concatenation of relevant theories to explain the problem under consideration. First, the traditional theory of comparative advantage developed by Ricardo (1817) provides a formidable platform for international trade and globalisation among nations. It maintains that a country should specialise in producing and exporting the good or service with the smallest disadvantage (that is, the good or service in which it has a comparative advantage) while importing the good or service with the greatest disadvantage. On this note, Ricardo made an effort to theoretically demonstrate that the globalisation of the economy or international trade is always advantageous and that trade between the two nations would be mutually beneficial (Zapata *et al.*, 2023; Boehm *et al.*, 2022; Lin *et al.*, 2022; Ricardo, 1817).

Africa is known for its poor levels of innovation and institutional problems. The theory has been criticised for, among other things, measuring only static advantages rather than any dynamic advantages, transportation costs potentially outweighing any comparative advantages, increased specialisation potentially resulting in diseconomies of scale, and governments potentially imposing trade restrictions (Robinson, 1979). The theory of comparative advantage can be applied to research in the sense that African nations exhibit diverse resource endowments, including natural resources and human capital. By specialising in sectors where they have comparative advantages, such as agriculture or technology-related industries, these countries can boost productivity and create a basis for trade among economic regions. Engaging in international trade allows them to exchange goods and services efficiently, access advanced technologies, and encourage innovation. This, in turn, can drive economic growth as countries become more competitive and expand their market presence.

The technology gap theory was formulated by Posner (1961). This approach is also called the imitation gap theory. The theory states that a never-ending stream of inventions and innovations can spur trade even if nations share comparable factor ratios and preferences. The theory explains the advantages gained by countries that introduce new products or goods into a market (Hong *et al.*, 2019). The theory states that technology is a continuous process, unlike the static assumption in the earlier theory of Heckscher-Ohlin. Similar to earlier theories of trade, the Heckscher-Ohlin theory presupposed that the methods of production were set and predetermined. However, only in a static system is such a premise possible since there cannot be a place for such an assumption in actual changing reality or a dynamic world. Thus, technical improvement or technological advancement has a substantial impact on trade and trade relations.

Posner (1961) asserts that trade can develop even when countries have comparable factor ratios and preferences. This is because trade can result from ongoing invention and innovation processes. The proponents of the theory argued that the relative technological sophistication of countries influences their trade participation in the global market. Thus, the theory explains the rate of diffusion in technology. The theory holds that new products grant the manufacturing company or exporting nation a brief monopoly position in the global market. Monopolies are typically protected through the use of patents and copyrights. The exporting nation enjoys a competitive advantage over the rest of the world until foreign firms copy new product variations or discover new manufacturing techniques. The theory assumes that two countries engaging in trade have comparable factor endowments, demand dynamics, and factor price ratios. However, it is assumed that the two countries have different technology techniques.

This study conducts a thematic review of studies to explore the relationship between innovation and trade relations from a thematic perspective. A plethora of studies in the literature have identified innovation as a key driver of trade (Fauzel, 2022; Melitz & Redding, 2021; Akcigit & Melitz, 2021; Ghanbari & Ahmadi, 2017; Colantone & Crinò, 2014; Bhujabal & Sethi, 2019). Their common argument is that since innovation necessarily engenders creativity, invention, knowledge utilisation and transfer, it has the tendency to improve the quality and quantity of a country's products via product differentiation (rebranding, trademarks and patents), and it is capable of promoting trade flows among countries. Colantone and Crinò (2014) previously demonstrated the strong positive effects of imported inputs on product creation. The transmission channels include exports, imports and technological breakthrough. Another strand of literature concludes instead that trade rather influences the pace of innovation (Grossman & Helpman, 1990; Shu & Steinwender, 2019; Bujari & Martínez, 2016; Gür, 2020; Cai *et al.*, 2020).

However, the nature and extent of the impact differs across countries, industrial, firm or product levels. For instance, it has been empirically established that trade liberalization rather fuels productivity and innovation among the emerging market economies, just as in the developed nations where export opportunities and access to imported inputs often foster innovation.

Using a fixed effect estimator, Ghanbari and Ahmadi (2017) found from 2003 to 2012 that innovation has a positive influence on the export performance of all industries. The empirical attempt was able to confirm that innovation is one of the drivers of international trade. Yet, it is still not clear whether innovation drives trade to different economic regions. Moreover, the specific examination of the impact of innovation on trade is yet to be directed to Africa, and particularly how it influences the share of trade by the selected African countries with some economic regions. The existing studies focus on developed, transition or other continents, even as intra-African trade intensifies. This obviously constitutes an empirical gap that needs to be filled, and hence this study.

3. Methodology

The use of a quasi-experimental technique is an appropriate approach for this study because it is consistent with the theory that underlies it. This study is concerned with cause-effect relationships using linear panel autoregressive models within a dynamic panel framework. This makes it simple to measure the dependent and explanatory variables to the point where they may both be assessed to have a statistically significant measurement error, allowing the researcher to make unbiased inferences based on the study's findings. To this end, the study relied on secondary data sources such as the World Development Indicators (WDI), World Trade Organisation (WTO), World Intellectual Property Organisation (WIPO), Intellectual property (IP), Statistics Data Center, WIPO statistics database, and United Nations Conference on Trade and Development (UNCTAD). Specifically, the study used four indicators to measure innovation (that is, industrial design applications, patent applications, trademark applications, research and development expenditure) and two indicators to measure trade participation (that is, exports and imports of goods and services).

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, merchandise exports (current US$) (MACE), merchandise exports to economies in the Arab World (percent of total merchandise exports) (MEAW), merchandise exports to low- and middle-income economies in East Asia and Pacific (percent of total merchandise exports) (WEEA), merchandise exports to low- and middle-income economies in Europe and Central Asia (percent of total merchandise exports) (MEECA), merchandise exports to low- and middle-income economies in Latin America and the Caribbean (percent of total merchandise exports) (MELC), merchandise exports to low- and middle-income economies in Middle East and North Africa (percent of total merchandise exports) (MEMEN), merchandise exports to low- and middle-income economies in South Asia (percent of total merchandise exports) (MESA), merchandise exports to low- and middle-income economies in Sub-Saharan Africa (percent of total merchandise exports) (MESSA), merchandise exports to low- and middle-income economies outside region (percent of total merchandise exports) (MEOR), merchandise exports to low- and middle-income economies within region (percent of total merchandise exports) (MEWR), merchandise imports (current US$) (MACI), merchandise imports from economies in the Arab World (percent of total merchandise imports) (MIAW), merchandise imports from low- and middle-income economies in East Asia and Pacific (percent of total merchandise imports) (MIEA), merchandise imports from low- and middle-income economies in Europe and Central Asia (percent of total merchandise imports) (MIECA), merchandise imports from low- and middle-income economies in Latin America and the Caribbean (percent of total merchandise imports) (MILC), merchandise imports from low- and middle-income economies in Middle East and North Africa (percent of total merchandise imports) (MIMNA), merchandise imports from low- and middle-income economies in South Asia (percent of total merchandise imports) (MISA), merchandise imports from low- and middle-income economies in Sub-Saharan Africa (percent of total merchandise imports) (MISSA), merchandise imports from low- and middle-income economies outside region (percent of total merchandise imports) (MIOR), merchandise imports from low- and middle-income economies within region (percent of total merchandise imports) (MIWR), total population, world real gross domestic product, exchange rate, and overall logistic 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. The consistency and differences in the results of the raw and extrapolated data were preliminarily checked.

3.1. Empirical model

To examine the influence of innovation on trade, this study adopted the model developed by Palangkaraya (2012). Palangkaraya's model posits that innovation plays a central role in enhancing a country's comparative advantage in international trade. This diversification in products enhances a country's export portfolio, making it more attractive to international buyers. Innovation improves a country's export capacity by enabling it to produce higher volumes of goods efficiently. This expanded capacity can lead to an increase in market share in international trade. As a result of innovation, the country experiences increased trade volumes due to enhanced productivity, diversified exports, and improved competitiveness. Innovation allows a country to access new markets and expand its presence in existing ones, ultimately increasing its trade participation. Palangkaraya (2012) illustrates how innovation positively impacts trade by enhancing a country's comparative advantage, reducing costs, improving product quality, and increasing market access. It not only boosts the country's trade volume but also contributes to market expansion and trade policy alignment, fostering greater engagement in international trade with economic regions or trading blocks. This leads to an increase in productivity, which in turn leads to a reduction in production costs. This reduction in production costs makes firms more competitive in the international market, leading to an increase in exports. Adopting this approach, the model for assessing the influence of innovation on trade is specified as follows:

$$Trade_{it} = f(INV_{it}) \quad (1)$$

Where: Trade = the trade indicator and INV = the innovation indicator.

Other determinants of the overall logistic performance index (ALPI) and real-world gross domestic product (RWGDP) for exports and total population (TPOP) for imports are also included.

Moreover, a favourable exchange rate (EXR) can enhance a country's export competitiveness. When the domestic currency depreciates (its value falls relative to that of other currencies), exports become less expensive for foreign buyers. This can boost the demand for domestically produced goods and services in international markets. On the other hand, a depreciating exchange rate can make imports more expensive. This can incentivise domestic consumers and businesses to purchase more domestically produced goods as foreign alternatives become costlier. Depreciation can help improve the trade balance by increasing exports and reducing imports. Thus, the models can be restated as follows:

$$\ln EXPT_{it} = f(INV_{it}, ALPI_{it}, RWGDP_{it}, EXR_{it}) \quad (2)$$

$$\ln IMPT_{it} = f(INV_{it}, ALPI_{it}, TPOP_{it}, EXR_{it}) \quad (3)$$

The trade indicators include the exports of goods and services (EXPT) and imports of goods and services (IMPT). By replacing innovation indicators such as IND for industrial design applications, PAT for patent applications, TRD for trademark applications, and RAD for research and development expenditures, the model can be restated as follows:

$$\ln EXPT_{it} = f(IND_{it}, PAT_{it}, \ln TRD_{it}, RAD_{it}, \ln RWGDP_{it}, EXR_{it}) \quad (4)$$

$$\ln IMPT_{it} = f(IND_{it}, PAT_{it}, \ln TRD_{it}, RAD_{it}, \ln TPOP_{it}, EXR_{it}) \quad (5)$$

The stochastic form of equations (4) and (5) can be specified as:

$$\ln EXPT_{it} = \beta_0 + \beta_1 IND_{it} + \beta_2 PAT_{it} + \beta_3 TRD_{it} + \beta_4 RAD_{it} + \beta_5 ALPI_{it} + \beta_6 \ln RWGDP_{it} + \beta_7 EXR_{it} + \varepsilon_t \quad (6)$$

$$Trade_{it} = \beta_0 + \beta_1 IND_{it} + \beta_2 PAT_{it} + \beta_3 TRD_{it} + \beta_4 RAD_{it} + \beta_5 ALPI_{it} + \beta_6 \ln TPOP_{it} + \beta_7 EXR_{it} + \varepsilon_t \quad (7)$$

Where: $\varepsilon_{it} = \mu_i + \eta_{it}$, β_0 = intercept, β_1-β_6 = parameter to be estimated, μ_i = individual specific effect or fixed effects, and η_{it} = idiosyncratic error, $i = 1 \ldots n$ (for all countries), $t = 1996 \ldots 2021$.

Innovation indicators are also expected to exert a positive influence on export trade performance and a negative influence on import trade performance.

3.2. Method of data analyses

Testing the stationarity and unit roots in the data is critical for improving and increasing the reliability of panel data estimations (Naik & Padhi, 2015). Thus, prior to executing the primary analysis, panel unit root tests were performed utilising the first- and second-generation panel unit root tests. The study computed five types of panel unit roots in the following types of panel unit root tests: Levin *et al.* (2002), Breitung (2001), Im *et al.* (2003), Fisher-type tests using ADF and PP tests (Maddala & Wu, 1999; Choi, 2001), Hadri (2000), Pesaran (2003) simple panel unit root test in the presence of cross-section dependence, and Maddala and Wu (1999) panel unit root test. For purposes of testing the unit root in this study, the study employed Levin *et al.* (2002), Hadri (2000), Pesaran (2003), and Maddala and Wu (1999) panel unit root tests with the assumption that the persistent parameters are common across cross-sections $p_i = p$ for all i excluding the Breitung unit root test. Im *et al.*

(IPS) (2003) assumed that p_i it varies freely across cross-sections. These are prominent in the procedures that gained superseding importance in testing for unit roots in panel data.

The study examined the cross-sectional dependency of the variables. The study also employed the Dumitrescu and Hurlin causality test, the Westerlund and Edgerton LM bootstrap cointegration test and the conventional panel cointegration test to conduct causality and cointegration analyses. The study further used dynamic panel data approaches that have the following techniques or estimators: generalised method of moments (GMM) (either first difference GMM or system GMM, that is, the Arellano-Bond estimator and the Arellano-Bover/Blundell-Bond estimator), mean group (MG), pooled mean group (PMG) and dynamic fixed effects (DFE) (Bun & Sarafidis, 2013; Drukker, 2008). However, since the cross-sections for each region are less than the time dimension, the panel GMM is not applicable to avoid bias (Blundell & Bond, 1998; Moral-Benito *et al.*, 2017; Arellano & Bond, 1991; Arellano & Bover, 1995).

The traditional panel techniques (fixed estimator (FE), instrumental variable (IV), and GMM estimators) can produce inconsistent and potentially deceiving estimates of the average values of the parameters in a dynamic panel data model unless the slope is taken into account. This is because the number of time series for this research is relatively greater than the number of cross sections (T > N) for the selected countries in Africa. Hence, there is a need to analyse the long-run effects and the speed of adjustment to the long run using a dynamic nonstationary heterogeneous panel approach. Blackburne and Frank (2007) introduced a command for nonstationary heterogeneous panel estimators, viz., the fixed-effects estimator, the mean-group estimator of Pesaran *et al.* (1999) (estimating long-run relationships in dynamic heterogeneous panels), and the pooled mean group estimation of dynamic heterogeneous panels.

Nonstationary heterogeneous panel estimators are statistical tools used to analyse data from panel data sets in which individual units (in this context, African countries) exhibit nonstationary behaviour. Nonstationary means that the variables under investigation do not have constant statistical properties over time.

PMG is an intermediate estimator between DFE and MG that allows the intercepts, short-run coefficients and error variances to differ freely across groups but constrains the long-run coefficients to be similar across groups. It has the advantage of determining long-run and short-run dynamic relationships. This is especially helpful when there are grounds to believe that a subset of the countries or, at the very least, all of them share a comparable long-run equilibrium connection between the variables. The MG estimator is a flexible method that does not impose cross-country restrictions on parameter heterogeneity. Instead, it involves estimating separate regressions for each country and computing averages of country-specific coefficients to obtain consistent estimates of long-run coefficients. However, this method assumes that the group-specific parameters are independently distributed from the regressors and that the regressors are strictly exogenous. The dynamic fixed effect (DFE) regulates effects that are distinctive to a country (such as country, state, or enterprise) and often requires homogeneity of all slope coefficients, allowing only the intercepts to vary across countries. In addition, the dynamic fixed effects estimator, which is very similar to the PMG estimator, places limitations on the slope coefficients and error variances, requiring them to be equal in the long run across all nations. The DFE model also limits the speed at which the adjustment coefficient changes to a constant value. The cluster option in DFE can be used to calculate intragroup correlation with standard error (Blackburne & Frank, 2007).

To determine which estimator is appropriate for the study, a Hausman-type test was conducted on the difference between the MG and PMG. If the null hypothesis (H0: PMG estimator is preferred) holds true, then the estimated coefficients between the MG and PMG are not significantly different, and the PMG was considered more efficient and preferred. If the p-value was greater than 5%, then PMG was used, and if it was less than 5%, MG was used. A similar approach was used for the PMG and DFE estimators.

4. Results and discussion

4.1. Panel unit root test results

The results of panel unit root tests are presented in Table 1 to provide insights into whether the variables are stationary or nonstationary.

Table 1. Panel unit root test results

Panel unit root tests	MIECA	D.MIECA	lnEXPT	D.lnEXPT	ALPI	D.ALPI	lnTPOP	D.lnTPOP
Harris-Tzavalis (rho)	0.8314***a	-0.2631***	0.9254	-0.0630***b	0.9089	0.3516***b	0.9978	0.2836***b
Brei tung (lambda)	1.0209	-10.7117***b	5.7147	-4.8003***b	1.8871	-8.8698**b	20.0179	3.3745
Levin-Lin-Chu	3.4805	-13.7354***b	-10.7720***a	-1.7943***	-0.1428	-8.8493***b	-11.4392***a	-0.9224
Im-Pesaran-Shin	1.5240	-14.5841***b	3.7596	-9.7921***b	1.2385	-5.6891***b	3.6209	0.5575
Fisher Type	0.1966	3.2477***b	1.2304***a	-1.0137	0.2492	-1.1639	-1.3825	-0.4788
Pesaran's CADF	3.379	1.113	-1.110	0.888	6.016	-3.138***b	1.491	2.592
Hadri LM	47.9417***	-1.8633 b	60.0899***	0.5905 b	44.1506***	6.5872***	78.3503***	10.4187***
Panel unit root tests	**MEAW**	**D.MEAW**	**lnIMPT**	**D.lnIMPT**	**lnMACE**	**D.lnMACE**	**lnMACI**	**D.lnMACI**
Harris-Tzavalis (rho)	0.7563***a	-0.2459***	0.9249	-0.1486***b	0.9423	-0.1355***b	0.9458	0.0055***b
Brei tung (lambda)	-1.7023**a	-15.3194***	5.6169	-5.8208***b	5.2202	-12.8839***b	5.1526	-12.2112***b
Levin-Lin-Chu	-1.1767	-10.8230***b	-9.6805***a	-1.1649***	-1.1414	-9.3577***b	-3.1815***a	-8.5837***
Im-Pesaran-Shin	-1.2193	-13.2425***b	3.8792	-9.6502***b	3.5170	-12.3571***b	2.3241	-11.7947***b
Fisher Type	-1.8315	3.0159***b	2.9942***a	-0.7062	1.4609*	1.1698	2.7094***a	0.8440
Pesaran's CADF	3.615	0.501	1.092	-1.221	-1.234	-0.552	-0.143	-0.431
Hadri LM	26.5402***	-2.9235 b	60.6129***	-0.1389 b	66.1860***	-0.3836 b	69.9253***	0.8249 b
Panel unit root tests	**MELC**	**D.MELC**	**PAT**	**D.PAT**	**MILC**	**D.MILC**	**MIMNA**	**D.MIMNA**
Harris-Tzavalis (rho)	0.2613***a	-0.0894***	0.8176***a	0.0527***	0.5585***a	-0.3098***	0.3904***a	-0.2748***
Brei tung (lambda)	-4.1755***a	-7.6808***	4.4588	-8.0935***b	-4.5750***a	-8.9633***	-3.9308***a	-12.5907***
Levin-Lin-Chu	9.5555	-0.8412	-0.0230*	-26.0678***b	-2.4331***a	-12.9069***	-5.3692***a	-17.9281***
Im-Pesaran-Shin	-8.8101***a	-16.4238***	-0.5704	-12.8431***b	-7.6753***a	-15.6309***	-3.6844***a	-13.6313***
Fisher Type	0.1520	2.3777***b	-3.2415	18.0431***b	0.0780	5.8802***b	-1.6121	3.4889***b
Pesaran's CADF	0.829	1.859	3.569	1.012	0.827	1.981	4.062	1.914
Hadri LM	5.8704***	0.2828 b	35.7291***	-1.7836 b	24.7180***	-3.4621 b	12.9565***	-2.6209 b
Panel unit root tests	**MIOR**	**D.MIOR**	**MISA**	**D.MISA**	**WEEA**	**D.WEEA**	**IND**	**D.IND**
Harris-Tzavalis (rho)	0.8847	-0.2841***b	0.7910***a	-0.1822***	0.6462***a	0.0045***	0.6055***a	-0.2383***
Brei tung (lambda)	2.8902	-14.5631***b	-1.3118*	-13.2137***b	-2.5842***a	-14.8712***	9.0394	-5.6515***b
Levin-Lin-Chu	-0.1546	-12.6602***b	-1.1637	-9.4627***b	-1.3730*	-11.7596***b	0.5231*	-5.1256***b
Im-Pesaran-Shin	2.3000	-14.3805***b	-1.2669	-14.0055***b	-2.7127***a	-14.2041***	-	-
Fisher Type	-2.4333	1.9157**b	-2.9374	4.0114***b	0.1048	4.7730***b	0.5563	1.9659***b
Pesaran's CADF	3.748	2.779	0.586	-1.539*	1.316	2.509	4.955	4.383
Hadri LM	61.9835***	-2.4557 b	39.3848***	-1.3735 b	18.7658***	-3.5973 b	25.7843***	-3.5150 b
Panel unit root tests	**MEMEN**	**D.MEMEN**	**MEOR**	**D.MEOR**	**MESA**	**D.MESA**	**MESSA**	**D.MESSA**
Harris-Tzavalis (rho)	0.4978***a	-0.4886***	0.7364***a	-0.1255***	0.8325***a	-0.0667***	0.6796***a	-0.1761***
Brei tung (lambda)	-4.7429***a	-13.5853***	-0.1296	-10.3494***b	-0.5144	-14.2813***b	-1.7559**a	-16.0885***
Levin-Lin-Chu	-4.6428***a	-11.6674***	0.6638	-10.4144***b	-2.1861**a	-11.4749***	-1.5507**a	-12.5484***
Im-Pesaran-Shin	-7.4723***a	-14.4344***	-1.5870*	-14.2391***b	-1.8867**a	-13.8842***	-2.6996***a	-14.3349***
Fisher Type	8.0132***a	2.5289***	-2.1490	2.6716***b	-0.0953	3.6651***b	3.0435***a	6.7745***
Pesaran's CADF	0.329	3.198	1.757	3.203	3.407	1.174	0.129	-1.582***b
Hadri LM	20.7043***	-4.0302 b	36.3330***	-1.1002 b	40.3333***	-1.8093 b	28.9271***	-2.5856 b
Panel unit root tests	**MEWR**	**D.MEWR**	**MIAW**	**D.MIAW**	**MIEA**	**D.MIEA**	**RAD**	**D.RAD**
Harris-Tzavalis (rho)	0.6771***a	-0.1749***	0.4803***a	-0.3503***	0.8614**a	-0.2758***	1.0310	0.3341***b
Brei tung (lambda)	0.8477	-15.6201***b	-3.5592***a	-11.8559***	3.9464	-14.8431***b	9.1162	-5.9085***b
Levin-Lin-Chu	-0.4121	-13.0668***b	-3.4848***	-11.3025***a	-0.1613	-12.8071***b	0.5843	-5.7283***b
Im-Pesaran-Shin	-3.7210***a	-13.8897	-3.0638***a	-13.6264***	2.4813	-14.5891***b	6.8806	-
Fisher Type	3.3463***a	5.7038***	-0.9971	1.9959**b	-3.2305	1.3553*	5.2991***a	-9.1430***
Pesaran's CADF	1.020	0.178	2.412	2.283	4.719	5.202	1.726	2.431
Hadri LM	28.4602***	-2.5899 b	17.1414***	-3.6369 b	60.3851***	-3.1621 b	56.4971***	13.3743***
Panel unit root tests	**MISSA**	**D.MISSA**	**MIWR**	**D.MIWR**	**lnTRD**	**D.lnTRD**	**RWGDP**	**D.RWGDP**
Harris-Tzavalis (rho)	0.6576***a	-0.1546***	0.6497***a	-0.1594***	0.8748	-0.1756***b	0.9788	0.1773***b
Brei tung (lambda)	-2.6614***a	-9.1826***	1.2159	-9.3979***b	4.9131	1.0882	6.0773	-11.6913***
Levin-Lin-Chu	-9.6131***a	-38.4361***	0.4339	-37.5260***b	-42.8670***a	1.9894	1.4287	-3.4923***b
Im-Pesaran-Shin	-4.2280***a	-14.4495***	-3.2489***a	-14.4502	3.4536	-6.9075***b	3.2296	-
Fisher Type	-1.2736	2.8014***b	-2.6128	1.8879**b	2.6515	5.8026***b	-1.1241	15.0064***b
Pesaran's CADF	4.562	2.796	5.177	4.077	-0.537	-1.201	5.973	8.945
Hadri LM	25.7128***	-0.1764 b	25.4330***	-0.2560 b	41.5165***	1.8039**	62.9658***	8.4560***
Panel unit root tests	**EXR**	**D.EXR**	**MEECA**	**D.MEECA**				
Harris-Tzavalis (rho)	1.0043	0.1153***b	1.0791	0.0950***b				
Brei tung (lambda)	9.9829	-9.2826***b	-2.2383**a	-10.4566***				
Levin-Lin-Chu	3.1564	-5.7262***b	-0.9408	-10.6345***b				
Im-Pesaran-Shin	11.4644	-7.5044***b	-2.7169***a	-13.7201***				
Fisher Type	-0.9935	-0.6656	0.1891	7.1482***b				
Pesaran's CADF	-0.984	-2.106**b	0.181	0.566				
Hadri LM	71.4137***	-0.1232 b	16.0514***	7.1400***				

Note: The asterisks (***, **, and *) denote rejection of the null hypothesis at 1%, 5%, and 10% levels of significance, while a and b indicate stationarity at the level and first difference, respectively. CADF = Cross-sectional Augmented Dickey Fuller and LM = Lagrange multiplier.

Source: Extracts from STATA Output.

From the results in Table 1, the first part of the result indicates that some of the variables under consideration were found to be stationary at the level. After applying the first difference to all the variables, they became stationary. In summary, the results indicate that while some of the variables were initially found to be stationary at their original level, all variables exhibited stationarity after applying a first difference transformation. This suggests that the variables had some underlying patterns or trends that were removed through differencing, making them suitable for analysis techniques that assume stationarity of at most I(1).

4.2. Correlation test for multicollinearity

To assess multicollinearity, the correlation matrix of the predictor variables is examined. The presence of high correlations among predictor variables suggests potential multicollinearity issues. Table 2 presents the correlation matrix of the predictor variables.

Table 2. Results of the correlation test for multicollinearity

Export model	IND	PAT	lnTRD	RAD	ALPI	lnRWGDP	EXR
IND	1						
PAT	0.4342	1					
lnTRD	0.4954	0.4639	1				
RAD	0.3370	0.4036	0.2674	1			
ALPI	0.0236	0.4190	0.1857	0.2727	1		
lnRWGDP	0.0103	0.1096	0.0764	0.1541	0.3293	1	
EXR	-0.1690	-0.1763	-0.0353	-0.1624	0.0777	0.1824	1
Import model	**IND**	**PAT**	**lnTRD**	**RAD**	**ALPI**	**lnTPOP**	**EXR**
IND	1						
PAT	0.4342	1					
lnTRD	0.4954	0.4639	1				
RAD	0.3370	0.4036	0.2674	1			
ALPI	0.0236	0.4190	0.1857	0.2727	1		
lnTPOP	0.3014	0.3286	0.6472	0.2562	-0.0160	1	
EXR	-0.1690	-0.1763	-0.0353	-0.1624	0.0777	0.2096	1

Source: Extracts from STATA Output.

The results of the correlation test reveal that there are weak associations among the explanatory variables within the two models: the export model and the import model. These findings indicate the absence of strong multicollinearity within these models.

4.3. Results of cointegration analysis

The panel cointegration results for the export and import models are presented in Table 3.

Table 3. Panel cointegration results

Statistics/Probabilities	Statistic	p-value	Statistic	p-value
Models	**Export model**		**Import model**	
Kao (1999) Test of cointegration				
Modified Dickey-Fuller test	1.5868*	0.0563	1.9908**	0.0233
Dickey-Fuller test	1.5561*	0.0598	2.0841**	0.0186
Augmented Dickey-Fuller test	0.8495	0.1978	2.4789***	0.0066
Unadjusted modified Dickey-Fuller test	0.3876	0.3491	-0.0911	0.4637
Unadjusted Dickey-Fuller test	0.4541	0.3249	0.1322	0.4474

Statistics/Probabilities	Statistic	p-value	Statistic	p-value
Models	**Export model**		**Import model**	
Predoni (1999, 2004) Test of no-cointegration				
Modified Phillips-Perron test	5.7106***	0.0000	5.3994***	0.0000
Phillips-Perron test	-2.0426**	0.0205	-2.0097**	0.0222
Augmented Phillips-Perron test	-1.5760*	0.0575	-2.0846**	0.0186
Westerlund (2005) Test of no-cointegration (Alternative hypothesis: cointegration in some panels)				
Variance ratio	-0.6792	0.2485	-1.0855	0.1388
Westerlund (2005) Test of no-cointegration (Alternative hypothesis: all panels are cointegrated)				
Variance ratio	-0.3177	0.3754	-0.6608	0.2544

Source: Extracts from STATA 15 Output.

Table 3 shows that there is cointegration among the variables for all the models (the export and import models). Panel cointegration implies that there exists a long-run relationship among the variables within each of these models. The use of multiple tests (Kao, Predoni, and Westerlund) to confirm panel cointegration adds robustness and credibility to the study's findings.

4.4. Impact of innovation on trade of exports and imports

This study examines the impact of innovation on export and import trade by the selected African countries with other economic regions in the world. The study examined the merchandise exports to the economies in the Arab World and the merchandise imports from the economies in the Arab World, the merchandise exports to the low- and middle-income economies in East Asia and Pacific and the merchandise imports from the low- and middle-income economies in East Asia and Pacific, the merchandise exports to the low- and middle-income economies in Europe and Central Asia and the merchandise imports from the low- and middle-income economies in Europe and Central Asia, the merchandise exports to the low- and middle-income economies in Latin America and the Caribbean and the merchandise imports from the low- and middle-income economies in Latin America and the Caribbean, the merchandise exports to the low- and middle-income economies in Middle East and North Africa and the merchandise imports from the low- and middle-income economies in Middle East and North Africa, the merchandise exports to the low- and middle-income economies in South Asia and the merchandise imports from the low- and middle-income economies in South Asia, the merchandise exports to the low- and middle-income economies in Sub-Saharan Africa and the merchandise imports from the low- and middle-income economies in Sub-Saharan Africa. The results of the impact of innovation on export trade by the selected African countries to some economic regions in the world are presented in Tables 4 and 5.

Table 4. Impact of innovation on export trade to economic regions

Variables	MEAW	WEEA	MEECA	MELC	MEMEN
ECT	-0.26***	-0.51***	-0.0253	-0.562***	-0.366***
	(0.0358)	(0.0384)	(0.073)	(0.0398)	(0.0417)
D.IND	0.000713	0.000114	4.03E-06	6.78E-05	8.31E-05
	(0.0016)	(0.0012)	(0.0004)	(0.0005)	(0.0007)
D.PAT	-0.00475	0.00406	-0.00081	-0.00121	-0.00251
	(0.005)	(0.0038)	(0.0014)	(0.0017)	(0.0023)
D.lnTRD	-0.368	-0.351	0.0439	0.439**	-0.305
	(0.638)	(0.487)	(0.175)	(0.218)	(0.296)
D.RAD	8.416	-1.127	1.663	-1.111	2.566
	(6.554)	(5.05)	(1.819)	(2.262)	(3.075)
D.ALPI	1.155	-0.4	-0.903	-1.228	0.681
	(2.186)	(1.685)	(0.606)	(0.759)	(1.025)

Variables	MEAW	WEEA	MEECA	MELC	MEMEN
D.lnRWGDP	-0.532	-0.569	-1.763	4.323	-4.152
	(12.12)	(9.345)	(3.369)	(4.191)	(5.683)
D.EXR	-0.00536	-0.0011	-0.00042	-0.00029	0.000492
	(0.0036)	(0.0028)	(0.001)	(0.0013)	(0.0017)
IND	-0.00552	-0.00128	-0.00313	-0.00037	-0.00075
	(0.0056)	(0.0022)	(0.0173)	(0.0009)	(0.0018)
PAT	0.0197	0.0164***	0.0137	-0.00058	0.00896**
	(0.0126)	(0.0049)	(0.0515)	(0.0020)	(0.0042)
lnTRD	3.323**	-0.00397	-0.359	0.0937	0.0283
	(1.426)	(0.544)	(4.254)	(0.224)	(0.461)
RAD	-5.139	0.943	19.48	0.911	4.610*
	(7.193)	(2.779)	(56.7)	(1.131)	(2.358)
ALPI	-4.522	3.897**	-18.74	1.173*	-1.358
	(4.158)	(1.598)	(56.07)	(0.65)	(1.377)
lnRWGDP	9.802*	5.313**	-18.59	2.144**	-0.106
	(5.291)	(2.075)	(56.29)	(0.847)	(1.758)
EXR	0.0065*	-8.7E-05	-0.00339	0.000525	0.000171
	(0.0034)	(0.0013)	(0.0144)	(0.0005)	(0.0011)
D.lMEAW	0.118***				
	(0.044)				
D.lWEEA		0.267***			
		(0.0417)			
D.lMEECA			0.0665		
			(0.0692)		
D.lMELC				0.0552**	
				(0.0281)	
D.lMEMEN					-0.308***
					(0.0403)
Constant	-81.67*	-88.06***	-15.98	36.84**	3.79
	(43.32)	(33.42)	(11.82)	(14.82)	(19.98)

Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Source: Extracts from STATA.

From the results in Table 4, the estimated positive and significant effect of trademark applications (3.323), real world GDP (9.802) and exchange rate (0.0065) on long-term merchandise exports to economies in the Arab World explains the strong impact of branding and income on exports to Arab countries. The coefficient for trademark applications suggests that focused efforts to establish distinctive product identities amplify the attractiveness of exported goods, fostering sustained demand. Additionally, the strong positive coefficient for real world GDP shows how robust economic growth generates greater consumer spending power, driving increased imports from the Arab world. This combined effect indicates that a well-established brand identity and strong world income create a mutually reinforcing cycle, contributing to the enduring growth of merchandise exports to Arab economies. The positive effect of the exchange rate indicates that as the value of a country's currency decreases, it correlates with an increase in merchandise exports. That is, in the long run, exchange rate depreciation enhances the competitiveness of exports, making them more appealing to Arab world economies and ultimately contributing to sustained export growth.

The results further showed the estimated positive and significant effects of patent applications (0.0164), the overall logistic performance index (3.897), and real world GDP (5.313) on merchandise exports from Africa to low- and middle-income economies in East Asia and Pacific in the long-run. This indicates the key drivers of export growth to the low- and middle-income economies in East Asia and Pacific. The positive coefficient for patent applications indicates that fostering innovation through patents contributes to sustained export growth by creating valuable products or processes. The strong coefficient for the logistic performance index highlights the significance of efficient trade infrastructure in facilitating exports, while the significant coefficient for real world GDP suggests that strong world income enhances the purchasing power of these economies, driving demand for African export goods.

The study revealed no significant effect of innovation on merchandise exports to low- and middle-income economies in Europe and Central Asia. The absence of a significant effect of innovation on merchandise exports to low- and middle-income economies in Europe and Central Asia can be justified by the unique economic and structural characteristics of the region. Many of these economies may rely primarily on traditional industries or commodities for exports, making them less responsive to innovation-driven improvements. Additionally, these countries might face challenges related to limited technological infrastructure, market constraints, and resource dependency. These factors collectively diminish the direct impact of innovation on regional export performance.

The estimated positive and significant effect of the overall logistic performance index (1.173) and real world GDP (2.144) on merchandise exports from Africa to low- and middle-income economies in Latin America and the Caribbean over the long run highlights critical determinants of trade growth. The significant coefficient for the logistic performance index explains the role of efficient infrastructure in sustaining export growth, while the significant coefficient for real world GDP indicates that world income fuels demand for African exports in the destination region. In the short run, the effect of trademark applications (0.439) on merchandise exports from Africa to the same economies emphasises branding's immediate impact. A higher coefficient signifies that the effective use of trademarks boosts the attractiveness of African goods, potentially leading to a short-term increase in demand. This explains the swift influence of branding strategies in enhancing the performance of merchandise exports from Africa to low- and middle-income economies in Latin America and the Caribbean region in the short term.

The estimated positive and significant effect of patent applications and research and development expenditures on merchandise exports from Africa to low- and middle-income economies in the Middle East and North Africa in the long run can be justified by the innovation-driven dynamics of trade relationships. Patents protect intellectual property, encouraging businesses to invest in new products and technologies that can enhance export competitiveness. These novel offerings could cater to specific demands in the MENA region, fostering sustainable trade growth. Moreover, R&D investments lead to advancements that improve product quality, production processes, and adaptability to regional preferences, making African exports more attractive to MENA consumers. This aligns with the region's increasing focus on technological development. This positive relationship explains how innovation fortifies the foundation of enduring trade connections, ultimately contributing to increased merchandise exports from Africa to the MENA region in the long run.

The estimated positive and significant effects of lagged merchandise exports to economies in the Arab world, lagged merchandise exports to low- and middle-income economies in East Asia and Pacific, and lagged merchandise exports to low- and middle-income economies in Latin America and the Caribbean on merchandise exports to the respective regions in the short-run imply a self-reinforcing trade dynamic. These effects suggest that past export levels play a significant role in shaping current export performance within the same region. A higher level of lagged exports indicates established trade relationships, market familiarity, and possibly ongoing demand. This relationship explains the immediate impact of historical trade ties in driving present export trends. The positive coefficients reflect the interconnectedness of trade networks and the potential for self-propagating trade growth between these regions, emphasising how historical export volumes contribute to short-term merchandise export patterns. In contrast, the estimated negative and significant effects of lagged merchandise exports to low- and middle-income economies in the Middle East and North Africa on merchandise exports to the same region in the short run suggest a potential trade adjustment process. These effects indicate that prior export levels within MENA have an impact on current export trends. A decrease in lagged merchandise exports may reflect shifts in demand, changing market dynamics, or temporary trade disruptions.

Table 5. Impact of innovation on export trade to economic regions

Variables	MESA	MESSA	lnMACE
ECT	-0.245***	-0.376***	-0.161***
	(0.0289)	(0.0358)	(0.0248)
D.IND	0.000259	-0.00137	4.19E-05
	(0.0007)	(0.0024)	(0.0001)
D.PAT	0.00307	0.00287	0.000163
	(0.0022)	(0.0077)	(0.0002)
D.lnTRD	0.614**	0.207	0.0482*
	(0.285)	(0.985)	(0.0276)
D.RAD	2.041	7.139	0.0249
	(2.948)	(10.22)	(0.286)
D.ALPI	-0.65	-0.0757	0.0725
	(0.984)	(3.415)	(0.0962)
D.lnRWGDP	6.597	7.237	3.649***
	(5.473)	(18.97)	(0.536)
D.EXR	0.00184	0.00025	0.000332**
	(0.0016)	(0.0057)	(0.0002)
IND	-0.00065	0.00423	-0.00037
	(0.0027)	(0.006)	(0.0004)
PAT	0.0101*	-0.0105	-0.00142
	(0.006)	(0.0133)	(0.0009)
lnTRD	0.692	1.665	0.397***
	(0.66)	(1.495)	(0.113)
RAD	8.304**	14.57*	0.604
	(3.384)	(7.63)	(0.5)
ALPI	3.081	-2.281	-0.147
	(1.938)	(4.395)	(0.287)
lnRWGDP	10.30***	6.233	3.179***
	(2.564)	(5.757)	(0.373)
EXR	-0.00253	-0.00033	0.000499**
	(0.0016)	(0.0037)	(0.0002)
D.lMESA	0.0593		
	(0.0424)		
D.lMESSA		-0.00057	
		(0.0427)	
D.llnMACE			-0.0681*
			(0.0412)
Constant	-81.17***	-71.57	-12.34***
	(20.06)	(68.33)	(2.725)

Standard errors are in parentheses. *** p < 0.01, ** p < 0.05, and * p < 0.1.

Source: Extracts from STATA.

From the results in Table 5, the estimated positive and significant effect of patent applications, research and development and real world GDP on merchandise exports from Africa to low- and middle-income economies in South Asia in the long run is substantiated by their roles in driving trade expansion. Patents reflect innovation and technological progress, enhancing the quality and competitiveness of products. This stimulates demand from South Asian countries. As these innovations gain traction, they contribute to sustainable export growth, reinforcing the positive relationship between patent applications and merchandise exports to South Asia. The notable coefficient for research and development suggests that investments in technological advancements and product enhancements enhance the quality and competitiveness of African exports, catering to evolving demands in the South Asian market. The significant coefficient for real world GDP explains how world income translates into increased purchasing power, driving demand for goods from Africa. In the short run, the effect of trademark applications (0.614) on merchandise exports from Africa to the same economies underscores branding's immediate influence. A higher coefficient implies that establishing distinct product identities through trademarks makes African goods more appealing and sought after in South Asia, potentially leading to a short-term surge in demand.

The estimated positive and significant effect of research and development expenditure on long-term merchandise exports from Africa to low- and middle-income economies in Sub-Saharan Africa is substantiated by its vital role in enhancing trade competitiveness. The substantial coefficient for R&D signifies that investments in innovation and technological advancement lead to the creation of higher-quality, innovative, and value-added products. These improvements make African exports more attractive and relevant to the unique preferences of Sub-Saharan African markets, thus fostering consistent and sustainable demand. Moreover, R&D-driven innovations often boost production efficiency, allowing exporters to offer competitive prices. This positive relationship aligns with global trends, highlighting the significance of innovation in shaping successful trade strategies. Ultimately, the positive effect of research and development shows how it serves as a key driver in the enduring growth of merchandise exports from Africa to Sub-Saharan Africa's low- and middle-income economies.

The estimated positive and significant effects of trademark applications and real world GDP on merchandise exports in the long run and short run. The significant coefficient for trademark applications highlights how branding enhances the appeal and recognition of exported products, fostering sustained demand. The significant coefficient for real world GDP explains how economic growth boosts consumer purchasing power, driving increased demand for merchandise exports. Similarly, the significant positive coefficient for real world GDP in the short run can be justified by its immediate effect on boosting consumer demand for goods due to heightened purchasing power. Increased world income leads to increased spending, which can lead to a short-term surge in imports, thereby temporarily driving merchandise exports. This relationship explains the swift influence of economic growth on short-term export trends. The estimated positive and significant effect of the exchange rate (0.000499) on merchandise exports in the long run indicates that a depreciation of the domestic currency, leading to a higher exchange rate, is associated with increased merchandise exports. A weaker currency makes exports more competitively priced in international markets, stimulating demand from foreign buyers. This relationship is statistically robust, implying that exchange rate fluctuations have a meaningful and lasting impact on export growth. It explains the role of exchange rates in influencing a country's trade dynamics and competitiveness on the global stage.

The results of the impact of innovation on import trade by the selected African countries from some economic regions in the world are presented in Tables 6 and 7.

Table 6. Impact of innovation on import trade from economic regions

Variables	MIAW	MIEA	MIECA	MILC	MIMNA	MISA
ECT	-0.554***	-0.371***	-0.186***	-0.442***	-0.73***	-0.247***
	(0.0472)	(0.0393)	(0.034)	(0.0386)	(0.0443)	(0.0352)
D.IND	0.000479	0.000308	-0.000893***	0.000647**	0.000152	-4.3E-06
	(0.0012)	(0.0009)	(0.0003)	(0.0003)	(0.0004)	(0.0005)
D.PAT	0.00393	-0.00438	0.00101	-0.00111	-0.00075	0.00144
	(0.0037)	(0.0028)	(0.001)	(0.0009)	(0.0013)	(0.0015)
D.lnTRD	-0.392	0.335	0.287**	0.621***	-0.0355	0.207
	(0.47)	(0.357)	(0.128)	(0.111)	(0.17)	(0.195)

Variables	MIAW	MIEA	MIECA	MILC	MIMNA	MISA
D.RAD	-0.951	-3.335	-0.632	-0.422	1.911	-0.819
	(4.889)	(3.718)	(1.322)	(1.142)	(1.762)	(2.02)
D.ALPI	-1.569	-0.326	-0.0142	-0.314	0.115	0.927
	(1.625)	(1.244)	(0.442)	(0.38)	(0.586)	(0.673)
D.lnTPOP	104.2*	132.3***	-8.855	-11.9	-0.372	-15.79
	(63.19)	(48.5)	(17.03)	(14.67)	(22.6)	(26.12)
D.EXR	0.00329	-0.00267	-0.00071	-0.00071	-0.00056	-0.00243**
	(0.0027)	(0.0021)	(0.0007)	(0.0006)	(0.001)	(0.0011)
IND	-0.00183	-0.00121	-9.7E-05	0.000561	2.47E-05	0.000486
	(0.002)	(0.0022)	(0.0016)	(0.0006)	(0.0005)	(0.0018)
PAT	-0.00511	-0.00077	0.000188	0.000335	0.00158	-0.00044
	(0.0043)	(0.005)	(0.0035)	(0.0013)	(0.0012)	(0.004)
lnTRD	0.794	-0.471	0.418	-0.338**	-0.172	-0.0381
	(0.493)	(0.56)	(0.399)	(0.146)	(0.134)	(0.46)
RAD	2.719	-3	-2.517	0.942	-0.363	-0.201
	(2.506)	(2.852)	(2.094)	(0.735)	(0.691)	(2.345)
ALPI	-0.18	5.871***	0.319	0.517	0.101	0.764
	(1.38)	(1.566)	(1.12)	(0.405)	(0.378)	(1.309)
lnTPOP	3.873*	22.06***	7.359***	-0.522	0.963	6.745***
	(2.274)	(2.579)	(1.902)	(0.681)	(0.621)	(2.119)
EXR	0.000371	0.00136	-0.00191*	9.64E-05	-0.00017	-0.00052
	(0.0013)	(0.0014)	(0.0011)	(0.0004)	(0.0003)	(0.0012)
D.lMIAW	-0.0767*					
	(0.0424)					
D.lMIEA		-0.09**				
		(0.0431)				
D.lMIECA			-0.172***			
			(0.0433)			
D.lMILC				-0.0799**		
				(0.0403)		
D.lMIMNA					0.0364	
					(0.0383)	
D.lMISA						-0.0633
						(0.0437)
Constant	-35.36*	-130.5***	-22.06***	5.326	-9.252	-26.04***
	(20.68)	(20.01)	(6.003)	(4.768)	(7.279)	(8.932)

Standard errors are in parentheses. *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.1$.

Source: Extracts from STATA.

From the results in Table 6, the estimated positive and significant effect of the total population on merchandise imports from economies in the Arab world in the long run reflects the demographic underpinnings of trade dynamics. A higher coefficient for the total population indicates that a greater population creates sustained and expanded consumer demand for imports from specific regions. This relationship is justified by the understanding that a larger population can lead to increased economic activity, industrialisation, and urbanisation, driving long-term demand for various goods. As economies evolve and populations grow, the demand for imports from certain regions tends to persist over time. This aligns with the notion that demographics play a fundamental role in shaping the trajectory of imports, illustrating how the size of a country's population influences its long-term trade patterns. The positive and significant effect of the total population on Africa's merchandise imports from low- and middle-income economies in Arab and East Asia and Pacific in the short-run and long-run can be attributed to demographic-driven demand. A larger coefficient indicates that more populous regions create heightened consumer demand for various goods, including imports from these specific regions. For example, higher populations are correlated with increased economic activity and consumption needs, driving short-term import growth. These effects show how logistical efficiency and demographic factors contribute to the rapid dynamics of short-term imports in Africa.

The positive and significant effect of overall logistics performance on Africa's merchandise imports from low- and middle-income economies in East Asia and Pacific in the long run can be attributed to the lasting impact of efficient trade infrastructure. The significant coefficient shows how optimised transportation, logistics, and trade-related processes contribute to the seamless flow of goods, reducing costs and delays. This relationship is justifiable because robust logistics support a thriving import-export ecosystem, leading to sustained trade relationships with East Asia and Pacific. In sum, both effects explain the role of branding and efficient logistics in shaping long-term import trends for Africa.

The estimated positive and significant effect of the total population on Africa's merchandise imports from low- and middle-income economies in East Asia and Pacific, both in the short and long term, can be attributed to several factors. With increasing purchasing power, Africa's growing population implies an increasing consumer base. This drives demand for a wide range of goods, many of which are sourced from East Asia and Pacific countries. Additionally, Africa's demographic expansion often leads to increased urbanisation and industrialisation, further boosting demand for imported products. This trade relationship is expected to persist in the long term as Africa's population continues to grow, making it a key driver of imports from the region.

The study also revealed a negative and significant effect of the exchange rate on Africa's merchandise imports from low- and middle-income economies in East Asia and Pacific in the long run. This suggests that as Africa's domestic currency increases against the currencies of its trading partners in East Asia and Pacific over time, it leads to a decline in imports from that region. A weaker domestic exchange rate can make foreign goods more expensive, dampening the affordability of imports. This finding emphasises the role of exchange rate dynamics in shaping long-term trade relationships and explains how currency depreciation can impact Africa's import patterns from East Asia and Pacific, potentially promoting domestic industries.

The results from Table 6 further show that the estimated positive and significant effect of resident trademark applications on merchandise imports from low- and middle-income economies in Europe and Central Asia in the short run and the positive effect of the total population on these imports in the long run underline distinct drivers of trade dynamics. The higher coefficient for trademark applications suggests that immediate consumer preferences influenced by branding lead to heightened short-term import demand. This is justified by the fact that robust branding enhances product appeal and recognition, impacting consumer choices. Conversely, the positive effect of the total population in the long run reflects the sustained demographic-driven demand that shapes import trends over time. Larger populations create consistent consumer needs, driving imports over the long term. This aligns with the idea that regions with larger populations generate stable economic activity and demand. Moreover, the negative and significant effect of short-term residential industrial design applications on Africa's merchandise imports from Europe and Central Asia can be attributed to temporary design-related factors influencing import preferences. This suggests that design-specific trends might lead to fluctuations in short-term import patterns, highlighting the potential for swift changes in consumer preferences.

The estimated positive and significant effect of resident trademark applications and residential industrial design applications on Africa's merchandise imports from low- and middle-income economies in Latin America and the Caribbean in the short run can be interpreted as the swift influence of branding and design on immediate import preferences. The higher coefficients for both trademark and design applications suggest that unique branding and appealing designs drive consumer choices, leading to increased short-term import demand. This is justified by the impact of distinct branding and design on consumer perception and purchasing decisions. Conversely, the negative and significant effect of resident trademark applications on Africa's merchandise imports from low- and middle-income economies in Latin America and the Caribbean in the long run might indicate that branding's influence diminishes over time. This can be explained by factors such as changing consumer preferences, market saturation, or evolving competitive landscapes. Over the long term, the effect of branding on imports might wane as markets and consumer behaviour transform, contributing to the observed negative relationship.

The nonsignificant influence of innovation on merchandise imports from low- and middle-income economies in the Middle East and North Africa can be interpreted within the context of several factors. While innovation plays a pivotal role in driving trade competitiveness, its limited impact on MENA's merchandise imports might be attributed to various reasons. First, the region's current focus might be more on other aspects of trade, such as traditional industries or natural resource-based sectors. Second, MENA economies could be at varying stages of technological development, impacting their ability to generate and implement innovative products. Additionally, the existing institutional and regulatory frameworks might not be conducive to fostering innovation-led imports. Finally, other macroeconomic factors or trade relationships could exert stronger influences on MENA's imports.

The positive and significant influence of the total population on Africa's merchandise imports from low- and middle-income economies in South Asia reflects the demographic-driven demand for goods. A higher coefficient shows that larger populations lead to increased consumer needs and preferences for a diverse range of products, fostering heightened import demand. This relationship is justified by the recognition that regions with larger populations exhibit greater economic activity and consumption patterns, driving sustained imports. As population size correlates with a broader consumer base, it creates a consistent demand for goods, contributing to the positive effect observed in trade between Africa and South Asia. This underlines the substantial role of demographic factors in shaping import patterns and highlights how the size of a population can significantly impacts trade relationships.

Table 7. Impact of innovation on import trade from economic regions

Variables	MISSA	lnMACI
ECT	-0.449***	-0.149***
	(0.0339)	(0.0255)
D.IND	0.003**	6.72E-05
	(0.0013)	(0.0001)
D.PAT	-0.00118	-5.2E-05
	(0.0042)	(0.0002)
D.lnTRD	-0.128	0.0027
	(0.538)	(0.021)
D.RAD	-3.762	-0.0363
	(5.543)	(0.216)
D.ALPI	-2.717	0.0875
	(1.848)	(0.0722)
D.lnTPOP	128.4*	-0.221
	(71.15)	(2.804)
D.EXR	-0.00556*	-0.000554***
	(0.0031)	(0.0001)
IND	0.00961***	-0.00026
	(0.0028)	(0.0003)
PAT	0.0213***	0.000336
	(0.0066)	(0.0007)
lnTRD	-2.753***	-0.214**
	(0.693)	(0.0875)
RAD	5.836*	0.196
	(3.505)	(0.413)

Variables	MISSA	lnMACI
ALPI	-0.514	0.0929
	(1.937)	(0.237)
lnTPOP	12.33***	2.745***
	(3.258)	(0.416)
EXR	0.00391**	7.74E-05
	(0.0019)	(0.0002)
D.lMISSA	-0.0109	
	(0.0385)	
D.llnMACI		0.0529
		(0.044)
Constant	101.8***	-3.149**
	(23.16)	(1.383)

Standard errors are in parentheses. *** p < 0.01, ** p < 0.05, and * p < 0.1.

Source: Extracts from STATA.

From the results in Table 8, the estimated positive and significant effect of residential industrial design applications and total population on Africa's merchandise imports from low- and middle-income economies in Sub-Saharan Africa in the short and long-run underscores key drivers of trade dynamics. The coefficients for industrial design applications and total population suggest that appealing designs and larger populations drive consumer preferences, leading to increased import demand. This is justified by the role of design in influencing consumer choices and the demographic-driven demand for goods. Furthermore, the positive and significant effect of resident patent applications, research and development, and resident trademark applications on Africa's merchandise imports from low- and middle-income economies in Sub-Saharan Africa in the long-run reflects the enduring impact of innovation and branding on trade. These higher coefficients indicate that protected innovation, R&D and strong branding enhance the appeal and distinctiveness of imported goods, fostering sustained demand over time. This is justified by recognising that patents and trademarks create a competitive edge and evoke consumer trust, driving import preferences. Collectively, these effects emphasise the multifaceted role of design, innovation, branding, and demographic factors in shaping import trends within Sub-Saharan Africa.

The research findings reveal a positive and statistically significant relationship between the exchange rate and Africa's merchandise imports from low- and middle-income nations within Sub-Saharan Africa over the long term. These results suggest that as Africa's exchange rate appreciates in value over time, it tends to result in an increase in imports from Sub-Saharan Africa. This observation aligns with economic theory, as a higher domestic exchange rate often renders imported goods more competitively priced, stimulating increased trade with neighbouring countries. It is important to note, however, that this dynamic might not hold for countries heavily reliant on imports for essential goods. This finding explains the role of exchange rate dynamics in shaping long-term trade relationships and highlights how currency appreciation can boost imports from nearby regions, promoting economic cooperation.

The results of this study further revealed that the estimated positive and significant effect of the total population on Africa's merchandise imports in the long run highlights the role of population size in driving sustained demand for various trade activities. A larger population indicates increased consumer needs and economic activity, fostering ongoing imports and exports over time. This relationship is justified by recognising that population growth fuels higher consumption and economic expansion. In contrast, the negative and significant effect of resident trademark applications on merchandise imports in the long run suggests a significant negative relationship between resident trademark applications and merchandise imports in the long run. This implies that an increase in trademark applications within a country is associated with a decrease in the imports of merchandise. Several factors can explain this trend. First, a greater number of resident trademark applications may indicate a boost in domestic production, fostering self-sufficiency and reducing the need for imports.

Additionally, stronger intellectual property protections, which encourage trademark applications, can lead to more competitive domestic markets, further reducing the reliance on foreign goods and services. This finding shows the role of intellectual property and domestic market competitiveness in shaping a nation's trade dynamics, as it potentially leads to reduced import dependence in the long term.

The study findings reveal a strong negative and significant relationship between a country's exchange rate and its merchandise imports in the long run. This suggests that as a country's exchange rate increases over time, there is a corresponding reduction in the imports of various categories. Several key factors contribute to this phenomenon. A higher exchange rate makes foreign goods and services relatively more expensive, reducing their attractiveness and demand. Domestic products and services become more competitive in comparison, leading to a shift towards self-sufficiency and reduced reliance on imports. Additionally, a higher exchange rate can positively impact a nation's trade balance by improving the terms of trade, thereby lessening the need for imports. This finding explains the influence of exchange rate dynamics on a country's import patterns and their long-term implications for economic self-sufficiency and trade balance improvements. The study findings reveal a significant positive effect of the total population on Africa's merchandise imports in the short run. This indicates that as Africa's population increases, there is a corresponding surge in the demand for both domestic and imported goods, as well as services. A larger population can signify increased consumer activity and economic expansion, leading to greater import volumes.

5. Conclusion and recommendations

5.1. Conclusion

It was also inferred that trademark applications and research and efficient logistics are key to long-term export growth within the African region, while industrial design, patents, world income, and efficient logistics are vital for strengthening African trade in the global market. Thus, the study concludes that trademarks and patent applications are crucial for enhancing global market presence, industrial design applications enhance product competitiveness, and innovation may limit imports, while research and development foster advanced technological imports for African countries.

5.2. Recommendations

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 recognising 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 incentivises 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 prioritise 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 relations.

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.

Given the significant impact of trademark applications on both exports and imports, policymakers should encourage businesses to focus on brand identity. This includes investing in brand development, marketing, and consumer awareness campaigns to enhance the appeal of domestic products in international markets.

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.

African countries should prioritise regional economic integration efforts. This includes fostering trade agreements, customs unions, and harmonising regulations to promote intra-African trade and create a larger market for goods and services. The governments of African countries should invest in data collection and analysis to better understand trade patterns, innovation trends, and economic dynamics. Informed policy decisions can be made based on accurate and up-to-date information.

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