African Continental Free Trade Area and Regional Trade in ICT and Digital Technologies

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ABSTRACT

This study examines the impact of the African Continental Free Trade Area (AfCFTA) on regional trade in the Information and Communication Technology (ICT) and Digital Technologies (DT) sector across 43 African countries from 2014 to 2021. Employing the augmented gravity model and confidence-level estimations, it highlights AfCFTA's mediating role in enabling ICT&DT trade on the continent. Using hierarchical regression analysis of a panel dataset comprising 5,160 observations, the findings imply that trade openness and productive capacities not only facilitate trade in the ICT&DT sector but also result in positive spillover effects across various economic sectors. This study contributes to the international business literature by refining the application of the gravity model to capture the need for sector-specific analyses to unpack institutional dynamics and dis-enablers of trade. It identifies AfCFTA as a pivotal yet underexplored element in the global trade landscape, highlighting its potential as Africa seeks a more prominent role on the global stage. The research stresses the significance of digital empowerment and policy reforms to maximise the benefits of regional integration under AfCFTA.

1. Introduction

The speed and scope of international trade have been faster and broader than global output since the turn of the century, yet Africa's share has been abysmal despite its abundant natural resource endowment. The regional trade literature (e.g., Rugman and Verbeke, 2004; Dunning and Lundan, 2008; Asmussen and Goerzen, 2013; Rosa et al., 2020) argues that globalisation, in itself, is an exaggerated concept and that most multinational enterprises (MNEs) earn revenues from countries within their home regions. Using global sales and revenues, the regional trade literature agrees that most MNEs are predominantly regio-centric when designing locational strategy. Moreover, the contemporary international business (IB) literature also measures the dynamics and implications of regional trade and MNEs' global characteristics using firm-level data (Asmussen, 2009; Zhang et al., 2019; Nachum et al., 2023). The main argument has been that world trade predominantly occurs within regions, rather than between them – e.g., Asia-Pacific, EU, and North American geographic regions (Rugman and Verbeke, 2004).

However, relying on firm-level data implies that our understanding of how the differences and similarities in regional trading blocs

(intraregional homogeneity or interregional heterogeneity) could *enable* or *dis-enable* trade between nations, or even for those in the same region is not understood. This study departs from the extant literature that relies on firm-level data by using the Augmented Gravity Model (AGM) to capture how productive capacities and trade openness enable trade flows within and between regional blocs. Consequently, three crucial gaps would be filled. Firstly, while firm-level data justifies the regiocentric nature of MNE activity, this study expounds on the dynamics of trade flow in Africa. Secondly, although existing studies used aggregated MNE sales and revenues to depict trade flows, this study amplifies the enablers of sectoral trade flow. Thirdly, debates on the role of regional trading blocs (Kohl and Brouwer, 2014), free trade zones (Krugman, 1991), growth zones and continental trading blocs (Frankel et al., 1997; Wei and Frankel, 1998) tend to focus on the North American Free Trade Agreement (NAFTA), US–Mexico-Canada Agreement (USMCA), European Union, Association of Southeast Asian Nations (ASEAN) (Frankel et al., 1995; Fischer, 1998; Rugman, 2003; Chase, 2009; Dulcich, 2022) and BRICs (Lohani, 2020). This leaves gaps in our understanding of the mediating role of other under-researched trading blocs such as the AfCFTA and its enabling influence on trade.

The unique application of the AGM in the context of AfCFTA aims to enrich IB theory and practice. By integrating AGM's theoretical foundations, the study shows how AfCFTA has improved trade in the ICT and digital technologies sector (hereinafter ICT&DT). The AGM is one of the most successful empirical models in the IB literature, illustrating its wide acceptance and application in analysing trade flows. The success of the AGM lies in its ability to provide a rich and accurate estimation of the spatial relationship between trade in different sectors and the overall trade potential (Martinez-Zarzoso, 2003; Andersson et al., 2008; De Benedictis and Taglioni, 2011; Falk, 2016). This approach uncovered the nuanced effects of AfCFTA on sector-specific trade and its implications for the broader trade landscape in Africa. Whilst previous studies (e.g., Demirguc-Kunt et al., 2018; Karakara and Osabuohien, 2020; Ayim et al., 2022) associate gross national product (GDP) with trade flows, this study shows that openness to trade and productive capacities increases sectoral trade in ICT&DT. Thus, openness and an increase in productive capacities would increase trade in ICT&DT which underpins significant improvements in financial inclusion, agricultural exports, mobile banking, stock market development, and healthcare in Africa.

Despite the transformative role of ICT&DT in bolstering regional trade within Africa under AfCFTA, widespread institutional weakness is a major problem (Jordan, 2014; Opeyemi et al., 2019; Adomako et al., 2021; Amankwah-Amoah et al., 2022; Gyamfi et al., 2022). Pervasive corruption and inefficient regulatory frameworks impede business operations and innovation. For instance, Adomako et al. (2021) highlighted the detrimental effect of perceived corruption on SMEs' internationalisation. They advocated for digitised business processes as a remedy to foster trade. Franczak et al. (2023) also indicated that digital infrastructure can mitigate institutional voids, enhancing entrepreneurial alertness and opportunity recognition. The present study links the virtues of economic integration and the institutions that enable trade (Narula and Duysters, 2004; Rugman and Verbeke, 2005). To deal with fundamental African-specific barriers (i.e., market dynamism, institutional quality, and macroeconomic policies) requires digital transformation (Collier and Venables, 2007; Kayizzi-Mugerwa et al., 2014). AfCFTA's goal to unify Africa's 54 countries into a single market is a crucial step towards overcoming these barriers, but leveraging trade in ICT&DT is vital for achieving socioeconomic benefits (UNCTAD, 2021; Mene, 2023). Thus, digital empowerment combined with institutional reforms is essential for harnessing AfCFTA's full potential. Given the boundaryless and borderless nature of ICT&DT in knowledge creation and trade facilitation (Florida, 1995), how trade openness and productive capacities could increase trade in the ICT&DT and overall trade in other sectors is a timely subject for IB scholarship on Africa.

Instructively, we analysed data from 43 African countries, covering 5160 data points from 2014 to 2021. Our findings show that for trade in ICT&DT to grow, countries need to open up their economies which supports earlier research by Rugman and Verbeke (2004) and Asmussen (2009). We also found that trade in ICT&DT helps boost trade in other sectors, especially when countries fully join AfCFTA. This shows how different sectors can work together to achieve economic growth. Based on these findings, our research adds to the IB literature in four ways. First, we show the importance of how MNEs operating within the ICT&DT sector can grow by looking beyond economic indicators and institutional gaps (Venables, 2006; Di Giovanni et al., 2022). Second, we argue that it is important to look at trade sector by sector for a clearer picture. The net gain from technology adoption in Africa lies in its ability to overcome institutional voids by using technology to achieve economic growth – which also builds on Posner's (1961) technological gap theory. Third, we explore AfCFTA – a new and not much talked about trading bloc, highlighting its potential impact on global trade patterns (World Trade Organisation, 2013). Fourth, our study implies that AfCFTA could change Africa's role in enabling trade by making economies more open. Therefore, a shift towards reforming local institutions and productive capacities is necessary to enable regional trade and integration (Posner, 1961; WTO, 2013; Adams et al., 2023a, 2023b). Though the timelines of our data overlapped with the COVID-19 pandemic, the association between the enablers of trade remains unchanged.

The rest of the paper is structured and proceeds as follows: Section 2 presents the literature, Section 3 explains the methods and data used to execute this study, Section 4 presents the analysis and findings whilst the implications, limitations and areas for future research are presented in Section 5.

2. Literature review

2.1. Technological gap theory and regional trade in ICT&DT in Africa

In his technological gap model, Posner (1961) argued that technological change is a constant process and that continuous innovations can force an expansion of productive capacities at the national, regional and global levels. Posner (1961) suggested that innovation and imitation are especially important for exporting technology services because technology is not the same everywhere. Thus, when firms develop new technologies, they become profitable because it gives them temporary capacity and monopoly. This,

according to Posner (1961), offers easy access to nearby markets. Consequently, MNEs with technological advantages usually exploit them by going to nearby markets, especially in countries where that technology may be new, and the cost of exploiting it in that market is also relatively low. Inferring from Posner's (1961) technology gap theory, regional trade in ICT&DT among African countries presents compounding implications for increasing the productive potential of nations.

On the one hand, engaging in regional trade in ICT&DT increases a nation's productive capacities which creates employment and income growth as local firms gain access to new technology from MNEs (Zhao et al., 2022). For example, the imports of ICT&DT create local competition which benefits consumers due to lower prices and a greater variety of products in domestic markets. More so, the imports and exports of ICT&DT create non-conventional markets for domestic production and encourage national integration into the global economy (Montalbano, 2011; Porter, 1990). Regional commerce in ICT&DT can also promote efficiency in other sectors by exposing local businesses to best practices and the higher regulatory expectations of MNEs that have mastered their game at the global level (Porter, 1990). Regional trade in technology can provide access to technology and innovation diffusion which increases productive capacities (Aghion and Howitt, 1992; Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991; Romer, 1990).

On the other hand, the positive link between regional trade in physical goods and technological diffusion has been widely observed because imports and exports serve as channels for technology exchange and lead to growth in economic capacity (see Coe and Helpman, 1995; Coe et al., 1997; Eaton and Kortum, 1996, 1997; Keller, 2004). Intriguingly, even though the critical role of regional trade in ICT&DT has been increasingly emphasised (Jin and Cho, 2015), the traditional IB firm-level theories on regional trade and even Posner's (1961) technological gap theory fail to explain the enablers of trade in under-researched contexts. Moreover, similar to other regional trading blocs, our understanding of how recent regional trade agreements (e.g., AfCFTA) are enabling trade is very limited. By using the AGM, this study contributes to enhancing our understanding of how production capacities and openness facilitate trade in ICT&DT at the country and regional levels. Subsequently, the mediating impacts of AfCFTA in enhancing regional ICT&DT trade in Africa will be examined.

2.2. Augmented gravity model and enablers of regional trade in ICT&DT

AGM is a widely adopted theoretical model for analysing and explaining why trade occurs. It assumes and validates that trade between nations is pushed by (a) the mass of goods produced, (b) the production capacities of each nation and (c) the demand for goods (Anderson, 2011). However, it is also hindered by costs of trade incurred by the geographical and cultural distance between countries (Isard and Peck, 1954; Beckerman, 1956; Anderson, 1979, 2011). Following this logic, most studies applying the AGM adopt economic gravity indicators, such as a country's market size (Tinbergen, 1962; Poyhonen, 1963), GDP per capita (Berstrand, 1989), population (Linnemann, 1966) and resource endowment as key enablers. A country's productive capacities are commonly overlooked by the AGM. To extend the AGM, we argue that a country's productive capacities should be considered as a core enabler of regional trade, not only in ICT&DT but also in every sector.

UNCTAD (2006, p.10) refers to "*productive resources, entrepreneurial capabilities and production linkages to determine a country's ability to produce goods and services that will help it grow and develop*". Productive resources include financial capital and physical capital such as machinery, equipment and infrastructure (UNCTAD, 2021). Entrepreneurial capabilities broadly refer to the skills, knowledge and information possessed by enterprises in a country and indicate the entrepreneurial and technological capabilities of a country (Adomako et al., 2015; UNCTAD, 2021). Production linkages are flows among productive units and resources including exchanges among various productive units from different sectors of various sizes and ownership structures (UNCTAD, 2021). The productive capacities are measured based on eight main pillars including (1) human capital, (2) natural capital, (3) energy, (4) institutional quality, (5) private sector (entrepreneurship), (6) structural changes (labour movement), (7) transport, and (8) ICT accessibility (UNCTAD, 2021).

Due to the trend of *digital transitions* across the world (Kimani et al., 2020; Bertani et al., 2021), regional trade in ICT&DT occupies an increasingly critical portion of any country's overall trading capabilities. In their model, Martinez-Zarzoso (2003) show that continuous improvement of productive capacities increases importable goods, maximises export earnings and fosters trade which can be applied to the exploration of regional trade in ICT&DT at two main levels. Firstly, resource endowment and productive capacities are often associated with cheaper and differentiated trade in ICT&DT and related goods satisfying differentiated customer preferences in foreign countries and increasing the size of domestic production factors in other sectors while concurrently meeting domestic market demands (Bilbiie et al., 2012). The market-based effective pricing system and appropriate incentive mechanisms enabled by a country's better productive capacities can lead to more digital production efficiency, surplus and comparative advantage and stimulate an incentive for exporting ICT&DT goods and services. For example, Rodríguez and Matschke (2023) showed that Haiti's diminished production capacity caused by the 2010 earthquake led to an inability to meet domestic demand and a significant increase in Dominican exports to Haiti.

Secondly, productive capacities and regional trade for achieving socio-economic development are mutually reinforcing. This reinforcing mechanism is more likely to be influenced and further strengthened by the imports and exports of ICT&DT. Consequently, a country with higher productive capacity often signals a superior production efficiency, higher quality of education and medical services with reasonable costs, technical base and technological capacity (Posner, 1961) and private investment along with timely government interventions (Rahman, 2005; Alhassan and Payaslioğlu, 2023). Similarly, country-specific technological infrastructures make a country an attractive place for international investment and can lead to mutual trade in other goods and services (Cheng and Kwan, 2000; Fu and Balasubramanyam, 2005; Helpman et al., 2008; Liu, 2008; Masood, 2019; Meyer and Sinani, 2009). Essentially, regional trade in ICT&DT stimulates innovations, improves production efficiency in other economic sectors via technological diffusion and brings differentiated products to foreign countries.

To fortify our argument with empirical evidence from the African context, the discourse primarily shows the influence of infrastructure, digital innovations, institutional integrity and production capabilities on regional trade. Drawing upon panel data encompassing 51 African nations from 2003 to 2015, Tandrayen-Ragoobur et al. (2022) advocated that tangible infrastructures such as transportation, ICT&DT and power supply are pivotal for strengthening intra-regional trade. Furthermore, Bankole et al. (2013), utilised data from 28 African countries between 1998 and 2007 to show that institutional frameworks and telecommunications infrastructure enhanced trade flows. Although these studies delved into general trade dynamics, our paper distinctly explores the nexus between productive capacity and sector-specific trade within the realms of ICT&DT. In light of the discrepancies identified amidst these studies, our paper posits the following hypothesis.

Hypothesis 1. There is a positive association between each of the eight production capacities of a country and regional trade in ICT&DT.

2.3. The association between openness and regional trade in ICT&DT

Consistent with the AGM, the trade openness of a country is another key enabler of regional trade in ICT&DT because it reduces marginal trading costs – a key barrier to trade. Countries that are more restricted to international trade in ICT&DT often have many technical trade barriers and restrictive standards and regulations for exchanging varieties of products with foreign countries (Romer, 1994; Wade, 2010). Such barriers directly increase trade costs by increasing procedural costs related to ICT&DT and related services. Openness also motivates MNEs to increase trade in digital financial services (Baldwin and Forslid, 2010), e.g., credits, export insurance and Fin-tech services, which are prerequisites for promoting any kind of trade. Businesses and investors can attain accounting and regulatory information with lower costs when trading with countries that are more open to international markets (Lane and Milesi-Ferretti, 2008). Evidence from international development economists supports this argument. For example, Brülhart (2011) found that regions with less costly reach and access to foreign markets, such as border and port regions, have lower trade barriers. Del Gatto et al. (2008) found that regions with better access to distant markets are more likely to have smaller average costs and smaller dispersion of costs.

In our review, empirical studies that explicitly examine the relationship between trade openness and regional trade in ICT&DT in the African context are scant. The study by Shuaibu (2015) underlines that the removal of trade restrictions and openness to international markets enhances mutual trade among the Economic Community of West African States (ECOWAS). It is even more difficult for African countries to do business within Africa than with other countries outside Africa (Alden and Soko, 2005; Eifert et al., 2008; Hartzenberg, 2011). Although trading in digital technology goods/services may suffer less custom procedural costs and logistic costs, the digital default risks and fraud risks are not negligible and bring additional costs to firms, especially in countries with information asymmetry caused by their lack of openness to international markets. Therefore, we hypothesise that the positive role of trade openness can be a significant and positive factor in increasing regional trade in ICT&DT.

Hypothesis 2. There is a positive association between the trade openness of a country and regional trade in ICT&DT.

2.4. The moderating effect of AfCFTA as a regional free trade agreement

The inception of AfCFTA in 2018 is a crucial development in the African economic integration agenda with a significant influence on regional trade dynamics. AfCFTA also offers a new paradigm for examining the nuanced interplay between institutional demands and strategic business adaptations (Roberto et al., 2022). AfCFTA encompasses a broad negotiation remit, targeting the harmonisation of investment policies, intellectual property rights, and the implementation of entrepreneur-friendly regulations. These efforts foster a fair, efficient marketplace conducive to trade and entrepreneurship support for socio-economic advancement (Adomako et al., 2020; Roberto et al., 2022). AfCFTA's objectives include the creation of a unified African market, the facilitation of capital and labour mobility, and the establishment of a continental customs union, enhanced by trade facilitation measures. Such initiatives, including the Free Movement of Persons and the Pan-African Payments and Settlements System (PAPSS), although in nascent stages, are indicative of AfCFTA's commitment to eradicating trade barriers and fostering a seamless economic landscape. Such efforts at promoting preferential trade within the African continent as indicated could serve as an enabler of trade if it is augmented by the gravity model (Martínez-Zarzoso and Nowak-Lehmann, 2003).

Historical precedents set by regional trade agreements globally underscore their pivotal role in the international trade ecosystem through the reduction of tariffs, quotas, and other trade impediments (Baier et al., 2008; Fratianni and Oh, 2009). Research has documented that such agreements can double regional trade within a decade (Baier and Bergstrand, 2007; Sheng et al., 2014). In the context of OECD countries, Tadesse and White (2019) analysed data from 1995 to 2009, involving 35 OECD countries and 137 trading partners to find that regional integration significantly reduced trade costs and increased economic interconnectivity. The World Bank (2020) predicts substantial economic benefits from AfCFTA for Africa, with potential income increases of 9 % by 2035, improvements in living standards, and poverty reduction. This aligns with theoretical perspectives positing that regional trade integration attracts foreign direct investment (FDI) and fosters entrepreneurial ventures, offering businesses expansion opportunities into new markets (Kirzner, 1973). Bosma et al. (2009) highlighted that regional trade agreements standardise trading protocols and regulatory frameworks, enhancing productivity. Moreover, Moore et al. (2021) demonstrated that trade integration serves as a countermeasure to hyper-protectionist policies, facilitating cross-border mobility and business exploration opportunities.

Recent simulations by Fusacchia et al. (2022) support AfCFTA's role in reducing intra-regional trade costs. This suggests an equitable distribution of economic benefits across sectors. It also underscores AfCFTA's capacity to not only enhance productive

capacities and trade openness but also rejuvenate intra-African trade by approximately 40 %, as projected by the Economic Commission for Africa (2022). The burgeoning digital commerce revolution in Africa, characterized by the rise of tech cities and innovation hubs, positions digital products and services as increasingly viable for domestic and international markets (Lemma et al., 2022; Friederici et al., 2020). AfCFTA's framework promotes digital trade with the potential to unlock opportunities in Africa's burgeoning ICT&DT sector. Despite the extensive literature on global regional trade agreements, the specific impact of AfCFTA on African trade dynamics, especially within the ICT&DT sector, remains under-explored. This gap presents an opportunity to extend AGM by assessing AfCFTA's influence on regional trade through cost reduction and trade barrier elimination (Kamuganga, 2012; Witt, 2019).

AfCFTA is posited to benefit consumers and firms by diversifying and reducing the cost of product offerings (Sheng et al., 2014). Furthermore, an IMF (2018) report highlights AfCFTA's potential to streamline business operations, reduce trade-related costs, and facilitate technology transfer. This analysis positions AfCFTA as a crucial inflexion point for African regional trade, particularly within the ICT&DT sector. By facilitating a comprehensive understanding of trade openness and its influence on trade, AfCFTA emerges as a catalyst for increasing Africa's productive capabilities. Therefore, AfCFTA needs to be seen as a significant driver of digital innovation and market expansion across the continent.

Hypothesis 3a. A country's involvement in AfCFTA positively moderates the relationship between productive capacities and trade in ICT&DT.

Hypothesis 3b. A country's involvement in AfCFTA positively moderates the association between trade openness and trade in ICT&DT.

Fig. 1 presents the conceptual framework of the study.

3. Methodology

3.1. Data and sample selection

Following studies such as Xing (2018) and Abendin et al. (2022), we collected country-level and moderating factor data from the UNCTAD database because it provides one of the largest collections of credible data on global trade. Moreover, the UNCTAD database is regularly updated and covers all geographical regions and countries. Particularly, trade data pertaining to developing economies including Africa is well recognised by UNCTAD. To overcome data duplication problems, the UNCTAD data site offers harmonised and integrated navigation browsers that allow easy selection of graphic presentations and data reorganisation.

To attenuate potential endogeneity and multicollinearity problems, we operationalised the data collection process in three stages. First, to overcome the problem of data duplications and limitations, we used UNCTAD's navigation browser to scan through the entire data on trade in ICT&DT in Africa. This helped to ensure that our variables of interest across the entire African sub-regions were consistent. We retrieved consistent and available data on our corpus of variables across the sub-Saharan African region, except North Africa where countries were not signatories to AfCFTA at the time of data collection. Against this backdrop, therefore, we had to limit the data collection to countries in West, East, Central and Southern Africa.

Second, given the novel evidence by Asongu et al. (2021) and Asafo-Agyei and Kodongo (2022) showing the moderating effect of human capital and trade openness on trade in Sub-Saharan Africa, we decided to extend our data search. We did this to understand how AfCFTA moderates the effects of UNCTAD's eight Productive Capacity Index (PCI) components and regional trade in ICT&DT. The initial sample contained countries from the 4 regions in Africa (East–16, West–16, Central–6 and Southern–5). It is worth mentioning that the reason for the disproportionality in the number of countries in each region is due to data availability. The sample data were cleaned by removing countries with inconsistent and missing data.

We encountered outliers in variables including balance of payments deficit, inflation, FDI, and GDP. To address the issue of outliers
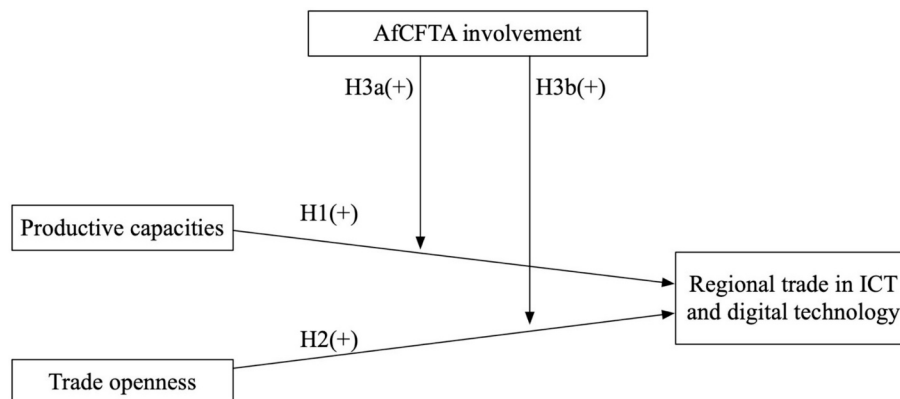

Fig. 1. Conceptual framework predicting the positive association between The Trade enablers and RTICTDT.

and ensure a normal distribution of the dataset, two actions were taken. First, we winsorized all the data at the 1st and 99th percentiles to reduce the effect of outliers that can bias the results following the work of Baldini et al. (2018). This normalisation technique helped mitigate the impact of extreme values in the results. Including these outliers in the empirical models would have violated the assumption of normal data distribution in linear regression and could have led to misleading and inconsistent results. Secondly, in dealing with missing data, we employed complete case deletion since the variables affected by these missing values were not the primary focus of this study. In line with the work of Baldini et al. (2018) removing these cases entirely from the models did not compromise the validity of the findings. Addressing the issue of outliers and missing data in this manner ensured the robustness and reliability of the data and analysis. The final sample after the data cleaning exercises, a panel dataset containing 43 countries with 5160 total observations from 2014 to 2021, was used as the basis for testing our hypotheses.

3.2. Measures

3.2.1. Dependent, independent variables and enablers of trade

Our dependent variable is regional trade in ICT&DT (RTICTDT). The RTICTDT represents the import and export of all ICT&DT equipment and associated services in a country measured in millions of US dollars. We operationalised the independent variables by categorising them into enablers and dis-enablers. The enablers include the production capacity index (PCI), which represents a country-specific multidimensional index that measures the productive capacities in all economies across Sub-Saharan Africa. The PCI used in this study is also based on UNCTAD's (2006) analytical pillars, which help developing nations understand how to strengthen their respective productive capacities. These include (1) human capital, (2) natural capital, (3) energy, (4) institutional quality, (5) private sector (entrepreneurship), (6) structural changes (labour movement), (7) transport, and (8) ICT accessibility.

3.2.2. Human capital (HUMC) and natural capital (NTC)

HUMC represents a productive resource category of the PCI that measures the level of education, skills, and health conditions of the country's labour force. It also captures other key human capital attributes such as fertility rate and the research and development capabilities of the workforce. The HUMC is a composite measure that provides a score between 0 and 100 %. NTC is a productive resource category that estimates the natural resources endowment of a country usually measured yearly. NTC also estimates the availability of mineral resources and the rent generated minus the cost of extraction. To ensure unbiased and correct interpretations, and to be in line with the theoretical foundations of AGM, some of the indicators in the NTC are measured by assigning weights in accordance with the size of a country's economy and its corresponding resource availability and size. Thus, it is a composite measure in percentage score from 0 to 100.

3.2.3. Energy (ENRG) and transport (TRNSP)

ENRG estimates the availability, efficiency, and sustainability of power supply for production. Thus, ENRG comprises the use of and access to a sustainable energy supply. It also estimates losses in the distribution and renewability of energy sources and components. It captures the GDP generated by each unit of energy source, thereby highlighting the energy sufficiency and sustainability of a given country. The ENRG is a composite measure in percentages that provides a score from 0 to 100. *TRNSP* captures roads, railway networks and air transport connectivity of a country in a given period. It also captures the movement of goods and services by sea and the overall capacity and capability of a transport system to move people and goods from one location to another. The TRNSP is a composite measure in percentages that provides a score from 0 to 100.

3.2.4. ICT accessibility (ICTA) and institutional quality (INSTQUL)

ICTA in our corpus of variables estimates the accessibility and integration of ICT&DT available to the population. It also includes fixed lines, mobile phone users, internet accessibility and server security. The *ICTA* is a composite measure in percentages that provides a score from 0 to 100. The *INSTQUL* variable captures the level of institutional quality of a country over a given period. It is a composite index that measures institutional factors such as political stability, regulatory quality, rule of law, level of corruption, success in fighting criminality, freedom of expression, welfare and safeguards of citizens and level of terrorism, among others. The *INSTQUAL* is a composite measure in percentages that provides a score from 0 to 100.

3.2.5. Trade easiness (TRDESS), labour movements (LABMV) and trade transparency (TRDTRNP)

TRDESS is a composite variable that measures the ease of cross-border trade among countries. TRDESS captures factors including domestic support to entrepreneurs or private sector businesses such as access to credit, the time required to start a business, contract enforcement and monetary costs of import and export. *TRDESS* is a composite measured in percentages that provides a score from 0 to 100. The LABMV variable captures the movement of labour and other key productive resources from low-productivity sectors of the economy to highly productive economic sectors. LABMV also captures the ability of a country to identify and effectively address economic constraints and other structural rigidities in the economy that stifle key economic activities. *LABMV* is a composite measure in percentages that provides a score from 0 to 100. The *TRDTRNP* variable measures the level of transparency in regional trade (both export and import of goods and services) among countries. *TRDTRNP* is measured by summing up all exports and imports (of both goods and services), dividing the total by the average of all exports and imports (of both goods and services) and multiplying the results by the percentage of nominal gross GDP of the given period. The combination of these factors determines the capacity of businesses in that country to partake in the production, transportation and distribution of goods and services in any sector. While we examined the enabling factors, we also took cognisance of the key factors which could impede regional trade such as inflation.

3.2.6. Disenablers: Inflation (CPI)

CPI represents an inflationary index which measures the changes in price of a weighted average basket of consumer goods and services purchased by households/consumers. The CPI calculations in our study considered the price changes associated with a household's cost of living by measuring the monthly price changes for each item in a basket of goods and services of African countries under AfCFTA.

3.3. Control variables

Following previous studies such as De Groot et al. (2004) and Kere and Zongo (2023), we used three key control variables in this study including balance of payment current accounts (BOPCA), real gross domestic product (GDPRL) and foreign direct investment (FDI). Given the nature of the dataset and the country-level variables, we included BOPCA, GDPRL and FDI as a means to control possible sample selection biases as well as differences in the size of countries in our dataset. Please refer to the variable definitions in Table 1 for the measurement of BOPCA, GDPRL and FDI. To be able to investigate if AFCFTA moderates the association between each of the eight productive capacities and regional trade in ICT&DT, we included AfCFTA as a moderating factor. This was done by operationalising the moderating variable using a dummy variable that provides a value of 1 if a country has signed up for AfCFTA membership, otherwise 0.

3.4. Empirical model and estimation

Following previous similar empirical estimations such as Osabuohien et al. (2019) and Guan and Sheong (2020), we approached

Table 1
Variable description table.

Variables	Description	Source
Regional Trade in ICT	Annual Regional trade flows by ICT goods categories in millions of dollars: These include exports, imports, re-exports and re-imports of ICT products, digital technology equipment, accessories and software	UNCTAD Database
ICT as a percentage of total Trade	Share of ICT goods as a percentage of annual total trade in millions of dollars. The current account balance measures, in general, the difference between current receipts and expenditures for internationally traded goods, services and income payments in millions of dollars	UNCTAD Database
Balance of Payment	Annual Balance of payment current accounts. These include current account balance, expressed in millions of United States dollars and as a percentage of GDP	UNCTAD Database
FDI- Foreign Direct Investment	Foreign direct investment (FDI) is an investment made by a resident enterprise in one economy (direct investor or parent enterprise) to establish a lasting interest in an enterprise that is resident in another economy (direct investment enterprise or foreign affiliate)	UNCTAD Database
DISENABLER		
Inflation – (CPI)	An inflationary indicator that measures the weighted average of prices of a basket of consumer goods and services, purchased by a consumer.	UNCTAD Database
ENABLERS		
Trade Openness	Annual Trade openness indicator. The indicators are calculated for trade in goods, trade in services and total trade in goods and services. It measures the sum of imports and exports divided by average imports and exports x GDP	UNCTAD Database
Production Capacity Index (Agg)	Measure the overall PCI score using the geometric average of the values of the eight PCI categories, namely, natural capital, human capital, energy, transport, ICT, institutions, the labour movement, and the private sector.	UNCTAD Database
Human Capital	A score that captures the education, skills and health of the population	UNCTAD Database
Natural Capital	A score that measures the availability of extractive and agricultural resources, including rents generated from the extraction of the given natural resource, minus the cost of extracting the resource	UNCTAD Database
Utility supplies	A score measures the availability of sustainable and efficient energy supply including renewable energy	UNCTAD Database
Transport	A score that measures the capability of a system to take people or goods from one place to another. It is defined as the capillarity of roads and railway measures network, and air connectivity	UNCTAD Database
ICT Accessibility	Estimates the accessibility and integration of communication systems within the population. It includes fixed line and mobile phone users, internet accessibility and server security.	UNCTAD Database
Institutional Quality	Measuring political stability and efficiency through regulatory quality, effectiveness, success in fighting criminality, corruption, and terrorism, and safeguarding of citizens' freedom of expression and association	UNCTAD Database
Trade Easiness Index	Measure the easiness of cross-border trade, which includes time and monetary costs to export and import, and the support to business in terms of domestic credit, the velocity of contract enforcement and time required to start a business	UNCTAD Database
Labour Movement	Measures the movement of labour and other productive resources from low-productivity to high-productivity economic activities	UNCTAD Database
GDP (Real)	Real gross domestic product - total and per capita, annual growth rates in millions of US dollars	UNCTAD Database
FREE TRADE AGREEMENT		
AFCFTA Dummy	A dummy variable that provides a value of 1 if a country has signed up for the Africa free trade association (AfCFTA) membership, otherwise 0	Authors Construction

Table 2
Descriptive Statistics and Correlation.

Variables	Mean	Std Dev	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
Regional Trade ICT	3.131	0.807	0.119	10.348	1.000														
ICT as (% of Trade)	0.303	1.379	0.000	12.798	0.263*	1.000													
Balance of Payment	16.992	27.666	5.000	183.449	0.630*	0.024	1.000												
FDI	10.301	25.484	3.001	408.888	0.382*	−0.013	0.546*	1.000											
Inflation	10.500	40.537	4.008	557.210	−0.031	−0.042	−0.026	−0.020	1.000										
Trade Openness	9.139	18.936	2.049	131.000	0.805*	0.518*	0.765*	0.596*	0.512*	1.000									
Human capital	37.885	5.124	24.789	51.063	0.413*	0.350*	0.284*	0.295*	0.323*	0.192*	1.000								
Natural Capital	57.952	8.885	32.883	85.123	0.410*	0.231*	0.467*	−0.022	−0.182*	0.064	−0.311*	1.000							
Utilities and Supplies	19.367	4.418	7.945	31.395	0.414*	0.280*	0.191*	0.161*	0.073	0.366*	0.559*	−0.389*	1.000						
Transportation	12.800	5.697	4.434	42.563	0.381*	0.172*	0.119*	−0.060	0.297*	−0.051	0.418*	−0.414*	0.410*	1.000					
ICT Accessibility	6.665	2.736	3.079	17.135	0.308*	0.286*	0.466*	0.070	0.173*	0.181*	0.647*	−0.465*	0.734*	0.568*	1.000				
Institutional Quality	42.361	12.480	17.165	74.361	0.198*	0.023	0.189*	0.057	0.004	0.161*	0.285*	0.019	0.145*	−0.037	0.201*	1.000			
Trade Easiness	71.601	7.955	53.228	87.703	0.239*	0.216*	0.388*	0.013	−0.105	0.132*	0.512*	−0.084	0.452*	0.197*	0.517*	0.239*	1.000		
Labour Movement	14.782	3.581	4.099	24.194	0.469*	0.242*	0.127*	0.122*	0.083	0.243*	0.586*	−0.109*	0.551*	0.357*	0.499*	0.151*	0.365*	1.000	
GDP (Real)	3.230	3.326	0.008	29.868	−0.082	0.016	−0.064	−0.004	0.013	−0.079	−0.043	0.031	−0.023	0.068	−0.015	−0.034	0.015	0.057	1.000

* Please note that Table 2 is comprised of the descriptive statistics table and the correlation matrix. The first four columns of Table 2 capture the mean, standard deviation, minimum and maximum values respectively of our sample dataset *.

the baseline estimation model with caution. First, given the nature of the dependent variable that captures trade flows in Sub-Saharan Africa, we used the gravity model that considers regional trade as a function of the economic mass of countries divided by the inverse relationship of the distance between them. Additionally, following studies such as Filippini and Molini (2003) we used the augmented gravity model with the AfCFTA dummy variable. This enabled us to analyse the degree to which AfCFTA moderates the association between the PCI factors (trade enablers) and bilateral trade in ICT&DT. We then deployed the econometric model in Eq. (1) below in capturing the gravity equation.

$$\text{RTICTDT}_{ij} = EC \, \frac{M_i^{\beta 1} M_j^{\beta 2}}{D_{ij}} \, \varepsilon_{ij} \qquad (1)$$

The $RTICTD_{ij}$ (Eq. (1)) represents the bilateral trade flow of ICT&DT between countries i and j. EC represents the size of the country's economy and D_{ij} represents the distance between countries i and j. M represents the GDP of the country, β represents the unknown parameter that can be estimated through regression analysis and ε_{ij} represents error term. We used the gravity equation to operationalise the baseline regression model. The gravity equation model is premised on the argument that regional trade flows among countries are a product of a log-linear function of the distance between the trading countries and their resources and income potentials as argued by Feenstra et al. (2001). Against this backdrop, we define the gravity regression model by taking the natural logarithms of the dependent variable and all the explanatory variables in the panel data using Eq. (2) below:

$$\ln\text{RTICTDT}_{i,t} = \alpha + \beta_1 \ln\text{HUMC}_{i,t} + \beta_2 ln\text{NTC}_{j,t} + \beta_3 \ln\text{ENRG}_{i,t} + \beta_4 ln\text{TRNSP}_{j,t} + \beta_5 \ln\text{ICTA}_{i,t} + \beta_6 ln\text{ISTQUAL}_{i,t}$$
$$+ \beta_7 \ln\text{TRADESS}_{i,t} + \beta_8 ln\text{LABMV}_{j,t+} + \beta_9 ln\text{TRDTRNP}_{j,t} + \beta_{10} \ln\text{CPI}_{i,t} \sum_{i=1}^{n=3} \beta_n \text{Contrvar}_{i,t} + \gamma + \varepsilon_{i,t} \qquad (2)$$

Where α represents the constant or the intercept of the dependent variable, ln represents the natural log of the explanatory variable, i,t represent a period, β represents the regression of the explanatory variable and $\sum_{i=1}^{n=3} R_n Contrvar_{i,t}$ represent the control variables, γ represents the year effect and ε represents the error term. It is worth mentioning that we augment the gravity model with the AfCFTA dummy variable to assess if the association between the trade enablers (PCI factors) and ICT&DT are moderated by the newly launched AfCFTA. Additionally, given the composite and incremental effects nature of the PCI variables, we decided to use a hierarchical regression model as part of the robustness test. This helped in ascertaining the effect of each of the PCI variables on regional trade in ICT&DT. Studies such as Lewis (2007) and Pedhazur (1997) show that the hierarchical regression method has stronger capabilities in examining the variability of the dependent variable with each predictor variable added. Further, Pedhazur (1997) argued that the hierarchical regression model is appropriate for studies that involve possible predictor variables that are correlated with each other as is the case in this study.

Regarding the robustness of our findings, studies such as Doucouliagos and Laroche (2009) and Ugur et al. (2016) argued that the hierarchical regression model considers both within-study and between-study dependence explicitly thereby accounting for possible overlaps between the explanatory variables. Although our model estimation accounted for the overlaps between the independent variables, we used Eq. (3) below in estimating the hierarchical regression model.

$$\text{RTICTDT}_{i,t} = \alpha + \beta_1 \text{HUMC}_{i,t} + \beta_2 \text{NTC}_{j,t} + \beta_3 \text{ENRG}_{i,t} + \beta_4 \text{TRNSP}_{j,t} + \beta_5 \text{ICTA}_{i,t} + \beta_6 \text{INSTQUL}_{i,t} + \beta_7 \text{TRDESS}_{i,t} + \beta_8 \text{LABMV}_{j,t+}$$
$$+ \beta_9 \text{TRDTRNP}_{j,t} + \beta_{10} \text{CPI}_{i,t} \sum_{i=1}^{n=3} \beta_n \text{Contrvar}_{i,t} + \varepsilon_{i,t} \qquad (3)$$

3.5. Descriptive statistics and pairwise correlation

Table 2 represents the descriptive statistics and the pairwise correlation matrix results. The mean value for the annual regional trade flows in ICT&DT for the countries in the dataset in millions of dollars is 3.131 with minimum and maximum values of 0.119 and 10.348 million dollars respectively. We noted that ICT&DT represents approximately 30 % of the average total trade of our sample data which is quite remarkable. These findings corroborate previous studies such as Kere and Zongo (2023) who discovered ICT&DT to represent a significant proportion of trade flows in Africa.

Accordingly, trade in ICT&DT has become a vital nexus between the AfCFTA agenda and economic prosperity of the entire African sub-region (Kere and Zongo, 2023; Xing, 2018). Indeed, several African countries continue to witness an influx of diverse ICT&DT, e-commerce products, fintech products, smartphones, and 3G and 4G technologies. For example, according to a Global System for Mobile Communications (2021) white paper, the smartphone adoption rate in Africa was 64 % and this is estimated to reach approximately 75 % by 2025. Additionally, it is estimated that by 2025, mobile phone subscribers in Africa could reach 600 million with 75 % of the population having 3G or 4G internet access.

Although the results from the descriptive statistics in Table 2 revealed that the average real GDP and the average percentage value of inflation for our sample countries are 3.23 and 10.5 % respectively, it is worth mentioning that the relatively high inflation rate of 10.5 % may be due to the COVID-19 pandemic since the sample data (from 2004 to 2021) overlapped with the COVID-19 period. The average value of FDI and the average value of trade transparency for our sample data represent 10.5 and 9.14 % respectively. Although we noted a significant positive correlation between trade transparency and regional trade in ICT&DT, the mean value of 9.14 is extremely low and requires significant improvement. Our results show improvements in trade transparency and production capacity index can bolster the significant association between AfCFTA and regional trade in ICT&DT in sub-Saharan Africa.

Table 3
Baseline regression- hierarchical regression and gravity model.

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	HIRC Model Gravity model		HIRC Model Gravity model		HIRC Model Two-Step GMM		East Africa	West Africa	Central Africa	South Africa
	2014–2021- ALL		Pre AFCTFA/Pre-Covid 19		Post AFCTFA/-Mod effect					
ICT as (% of Trade)	0.5718**	0.8166***	5.4795*	3.8076*	29.6223*	30.6123**	108.5792**	110.0453***	31.9849	54.1388**
	(0.3464)	(0.0661)	(2.9836)	(3.5222)	(1.8444)	(1.6435)	(3.6365)	(3.1465)	(3.2156)	(3.2923)
Balance of Payment	−0.0237***	−0.3972***	0.1129*	0.1050*	−0.0278***	−0.1268***	−0.1140**	−0.1094**	−0.1021**	−0.1003**
	(0.0044)	(0.0995)	(0.0029)	(0.0099)	(0.0046)	(0.0015)	(0.0026)	(0.0066)	(0.0026)	(0.0018)
FDI	0.0484***	0.5258***	−0.0163	−0.0307*	0.0175**	0.5258***	0.0981	1.0321*	0.1020	1.1021*
	(0.0029)	(0.0940)	(0.0051)	(0.0169)	(0.0031)	(0.0940)	(0.0937)	(0.0248)	(0.0041)	(0.0031)
Inflation	−1.7485**	−0.0541	−0.0106	−0.0388	−4.1047***	−0.0541	−5.8544	−4.9166*	−0.0951	−1.2280
	(0.4212)	(0.1157)	(0.1342)	(0.1132)	(1.2109)	(0.1157)	(6.0993)	(2.7331)	(0.2318)	(0.8940)
Trade Openness	3.8722**	5.8722***	0.1039**	0.1096**	0.1105***	0.1085***	0.1320***	0.1003**	0.1002**	0.1014**
	(0.5711)	(0.0311)	(0.0015)	(0.0021)	(0.0009)	(0.0023)	(0.0023)	(0.0001)	(0.0021)	(0.0008)
Prod. Cap. Index	1.7722*	1.8762*	1.0288*	1.7449*	11.0262***	7.5105***	4.6127***	8.6755***	4.2505***	3.5400***
	(0.5711)	(0.4710)	(0.5775)	(0.6984)	(0.1285)	(0.5164)	(0.6905)	(0.5584)	(0.7842)	(0.7144)
Human Capital	2.7134*	0.3972***	2.9121	0.7421	4.8833***	5.4982***	13.7464	1.6730*	0.6229	1.1851
	(0.0997)	(0.0995)	(9.7206)	(2.2071)	(1.6774)	(1.3242)	(14.1893)	(0.9534)	(16.6121)	(18.7026)
Natural Capital	3.5680**	2.4982*	20.7231	3.9451	0.1686	4.3811***	60.4844	0.4564	0.9391	1.9900
	(0.3343)	(1.3242)	(22.3629)	(3.9616)	(0.5482)	(0.9759)	(49.0049)	(0.6978)	(39.7987)	(8.9131)
Utilities and supplies	2.7330**	4.3811***	1.1100	0.0637	10.0261***	0.9568**	18.3550	3.2921	−0.0652	6.1099*
	(2.9713)	(0.9759)	(3.3243)	(1.9285)	(3.0448)	(0.6035)	(19.3991)	(2.3941)	(3.1270)	(2.9786)
Transportation	3.4616**	5.9568**	3.3107*	4.2881*	8.3452***	11.9828***	4.3200**	5.9387**	5.0787**	7.4257**
	(0.5764)	(0.6035)	(0.2622)	(0.5105)	(1.3172)	(0.0506)	(0.6020)	(0.5095)	(0.2590)	(0.2590)
ICT Accessibility	0.6741*	0.7741**	0.3320*	0.2037*	0.9183**	1.1771**	1.4081***	1.0486***	2.7343***	7.6618***
	(0.1076)	(0.0685)	(0.5112)	(0.7216)	(3.3368)	(0.5376)	(0.0676)	(0.0509)	(0.0244)	(0.0155)
Institutional Quality	0.5735*	1.1771**	0.9955	−0.1111	3.0650***	−0.0282	2.4280**	9.5359**	3.5997**	8.3973***
	(0.7247)	(0.5376)	(1.0002)	(1.3234)	(0.8851)	(0.4169)	(1.3858)	(0.4675)	(1.1220)	(0.6032)
Trade Easiness Index	0.8083*	0.9173**	3.6640**	1.5562	3.9609***	4.0069***	31.3684***	28.0201	17.9500***	10.4234***
	(0.3698)	(0.2648)	(1.5834)	(5.0777)	(1.1547)	(1.1987)	(0.0941)	(0.0960)	(0.1842)	(0.3446)
Labour Movement	9.5724***	6.4419***	−1.0492	−1.5502	2.6676***	6.3713***	−17.8279	9.6995*	0.2348	0.5275
	(4.0225)	(0.7358)	(1.5079)	(3.7078)	(0.6145)	(0.4370)	(21.0396)	(5.6330)	(0.6440)	(0.6003)
GDP (Real)	0.7023*	0.6174**	2.6040**	1.4563	2.6405***	2.0269***	2.3654***	3.1220	3.4501***	2.4230***
	(0.1690)	(0.2648)	(1.0833)	(3.0237)	(1.1346)	(1.1964)	(1.1540)	(0.5461)	(0.4840)	(1.1445)
Constant	15.4177	17.2221	17.6832**	−66.4157	1230.9089	26.8995	25.4167	37.2531	1005.0162	385.1810
	(6.5823)	(9.0829)	(6.7499)	(236.2678)	(1140.0148)	(45.2843)	(0.0000)	(0.0000)	(1330.8129)	(1107.5459)
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared/Wald chi	0.6324	0.8389	0.5146	0.5166	0.5912	92.73	0.5321	0.5412	0.5285	0.5313

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

4. Results

Both the Pearson correlation and the regression results revealed interesting findings. First, the results from the correlation matrix show a positive association between each of the eight PCI variables (enablers) and regional trade in ICT&DT. Second, we noted a significant positive association between trade openness and trade in ICT&DT in the correlation matrix. Conversely, the correlation method recorded a negative association between inflation (dis-enabler) and regional trade in ICT&DT.

We used the results from models 1 and 2 in Table 3 in testing hypothesis 1. First, following previous studies such as Osabuohien et al. (2019); Ochieng et al. (2020); Doumbe and Belinga (2015), we tested hypothesis 1 using the augmented gravity model as baseline regression. Second, given the hierarchical nature of the PCI variables (the enablers of RTICTDT) we used the hierarchical regression model to validate the findings from the gravity regression model 1. We used hierarchical regression in validating the baseline regression due to the hierarchical nature of the corpus of variables involved in the PCI. Besides, studies such as Doucouliagos and Laroche (2009) and Ugur et al. (2016) argue that the hierarchical regression model partially considers both within-study and between-study unobserved factors as well as accounting for possible overlaps between the explanatory variables. Additionally, it is worth mentioning that the results were not any different after conducting a two-step system GMM in model 6 in Table 3 to ascertain if there are any possible endogeneity or reverse causality problems in both the gravity and hierarchical regression models.

4.1. Impact of COVID-19

It is worth mentioning that to overcome the problem of data availability and missing data, the data collection from 2014 to 2021 (inclusive) overlapped with the COVID-19 pandemic periods. Consequently, a section of our results suffers minor intractable negative effects from the COVID-19 pandemic effects. In addressing this anomaly, we decouple the COVID-19 pandemic periods to ascertain if it has any effects on the results. We operationalised this phenomenon by using our baseline regression model in Table 3 by separating our results into different periods. We discovered that except for the pre-COVID periods (presented in models 3 & 4) of Table 3, there is a negative association between the balance of payment deficit and regional trade in ICT&DT. Additionally, and more interestingly, we noted that the COVID-19 period did not distort the positive association between each of the PCI variables (enablers) and regional trade in ICT&DT. Similarly, the positive association between trade transparency and bilateral trade in ICT&DT was not distorted during the pandemic periods. Drawing from the above two remarkable observations, our study lends weight to the Africa Free Trade argument espousing that harnessing the productive resources and the entrepreneurial capabilities as well as institutional transparency can yield mutual benefits for firms competing in the region and growth for African nations. The next sections outline the results and discussions after testing the hypotheses.

4.2. Association between PCI and trade in ICT&DT (RTICTDT)

We used models 1–4 in Table 3 in testing the relationships between each of the eight factors for production capacities and RTICTDT. Models 1 and 2 in Table 3 represent the baseline gravity model while models 3 and 4 show the robustness test from the hierarchical regression model. Accordingly, the empirical findings from models 1–4 reveal a positive association between each of the eight production capacity variables and RTICTDT. Interestingly, we noted a weak positive association between transportation, labour movements and RTICTDT. We included Tables 3 and 6 in the analysis as part of the robustness test to examine further if the results will remain the same pre- and post-AfCFTA. Surprisingly, we noted that the significant positive association between each of the productive capacity indexes and RTICTDT were more pronounced in the post-AfCFTA periods (see models 1–10 in Table 5). Overall, the results confirm a positive association between all production capacity variables and RTICTDT (i.e., hypothesis 1). This finding corroborates with Feenstra et al. (2001) and Filippini and Molini (2003) who contended that the presence of differing production capacities and natural resource endowment could determine the gravity of trade between countries. Whilst Filippini and Molini (2003) argue that natural resource endowment can lead to positive beneficial trade flows in several industries and areas of trade, African countries are yet to experience this.

In addition, although Xing (2018); Abendin et al. (2022); Billon and Rodriguez-Crespo (2020) show that ICT&DT exerts significant influence on regional trade in most sectors of the economies in Africa, there is presently no study that explores how AfCFTA could increase regional trade in this sector. Drawing on the work of Posner (1961), the vast *technological gap* that exists between the advanced countries and Africa presents huge market opportunities for high-tech companies to invest in Africa (Xing, 2018). This finding has significant implications for MNEs' strategic behaviours and response to new institutional demands. Thus, sub-Sahara African countries can leverage their diverse productive natural resources endowment and idiosyncratic production capacities to extract significant benefits from the growing ICT&DT market through regional trade (Filippini and Molini, 2003; Xing, 2018; Abendin et al., 2022; Billon and Rodriguez-Crespo, 2020).

4.3. Production capacity index as enablers of RTICTDT

Consistent with the results of the present study, other studies such as Coe and Helpman (1995); Longo and Sekkat (2004) and Ochieng et al. (2020) agree that to be able to maximise the potential benefits associated with innovation and ICT&DT, developing countries must extract economic dividends by improving productive capacities (i.e., human capital, natural resources capital, institutional quality and trade openness) at the national level. Thus, whilst our results support the regional trade literature (Kohl and Brouwer, 2014; Krugman, 1991; Frankel et al., 1997; Wei and Frankel, 1998; Rugman and Verbeke, 2004), there are serious

Table 4

Pre-AfCTFA regression results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ICT per T Trade (%)	27.5548***	21.2308***	27.7056***	26.5628***	25.3182***	24.5749***	27.6119***	27.5120***	22.4242***	27.5548***
	(4.6763)	(5.0060)	(4.5947)	(5.0152)	(4.7477)	(5.0589)	(4.6456)	(4.7530)	(4.5275)	(4.5817)
Balance of Payment	0.0146***	0.0150***	0.0147***	0.0151***	0.0150***	0.0153***	0.0148***	0.0149***	0.0149***	0.0149***
	(0.0044)	(0.0042)	(0.0044)	(0.0044)	(0.0043)	(0.0043)	(0.0045)	(0.0044)	(0.0041)	(0.0044)
FDI	−0.0360***	−0.0323***	−0.0352***	−0.0356***	−0.0344***	−0.0345***	−0.0358***	−0.0357***	−0.0322***	−0.0355***
	(0.0070)	(0.0068)	(0.0070)	(0.0069)	(0.0069)	(0.0069)	(0.0072)	(0.0070)	(0.0066)	(0.0069)
Inflation	−0.0115	−0.0876	0.0420	−0.0352	−0.3100	−0.1780	0.0008	−0.0018	−0.1146	−0.0039
	(0.2329)	(0.2259)	(0.2464)	(0.2407)	(0.2980)	(0.2636)	(0.2330)	(0.2327)	(0.2195)	(0.2299)
Trade Openness	0.1082***	0.1076***	0.1081***	0.1080***	0.1081***	0.1078***	0.1081***	0.1081***	0.1074***	0.1081***
	(0.0007)	(0.0006)	(0.0006)	(0.0007)	(0.0006)	(0.0007)	(0.0007)	(0.0007)	(0.0006)	(0.0006)
Prod. Capacity Index	0.6293									
	(2.2150)									
Human Capital		5.2882***								
		(1.9065)								
Natural Capital			0.5007							
			(1.0343)							
Utilities and Supplies				1.0762						
				(2.2410)						
Transport					3.0334					
					(1.8848)					
ICT Accessibility						5.2914				
						(3.9247)				
Institutional Quality							0.0126			
							(0.6878)			
Trade Easiness Index								0.0260		
								(1.0931)		
Labour Movement									9.8653***	
									(2.4958)	
GDP (Real)										1.4140
										(2.7366)
Constant	−49.8939	−228.4587***	−65.2899	−54.4146	−70.6210***	−65.8675***	−35.4563	−37.4581	−173.3274***	−30.9629**
	(55.7836)	(70.3411)	(62.2498)	(40.6389)	(24.3288)	(24.9583)	(32.2873)	(77.6202)	(36.3625)	(14.2401)
R-squared	0.7710	0.7828	0.7706	0.7706	0.7746	0.7733	0.7701	0.7702	0.7944	0.7707
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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

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Table 5

Post-AfCTFA regression results.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ICT per Trade (%)	48.1720***	34.4851***	48.0185***	44.6868***	36.9022***	40.3961***	46.0638***	44.0380***	32.7462***	45.9263***
	(10.9322)	(10.8226)	(11.0420)	(10.9713)	(10.3769)	(11.0018)	(10.6131)	(10.7156)	(10.3610)	(10.8221)
Balance of Payment	−0.0192***	−0.0147***	−0.0183***	−0.0177***	−0.0146***	−0.0158***	−0.0179***	−0.0172***	−0.0145***	−0.0182***
	(0.0047)	(0.0045)	(0.0046)	(0.0047)	(0.0044)	(0.0047)	(0.0046)	(0.0046)	(0.0043)	(0.0046)
Foreign Direct Investments (FDI)	0.0030	0.0025	0.0029	0.0030	0.0022	0.0029	0.0029	0.0028	0.0021	0.0029
	(0.0023)	(0.0022)	(0.0023)	(0.0023)	(0.0023)	(0.0023)	(0.0023)	(0.0023)	(0.0021)	(0.0023)
Inflation	−1.3986**	−1.3743**	−1.5350**	−1.4382**	−3.3311***	−1.8056***	−1.1429*	−1.2588*	−1.3277**	−1.3395**
	(0.6442)	(0.6125)	(0.7083)	(0.6506)	(0.7892)	(0.6717)	(0.6471)	(0.6385)	(0.5923)	(0.6449)
Trade Openness	0.1075***	0.1069***	0.1074***	0.1072***	0.1072***	0.1071***	0.1073***	0.1072***	0.1067***	0.1074***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
Prod. Capacity Index	2.0331									
	(2.0363)									
Human Capital		4.6507***								
		(1.3711)								
Natural Capital			0.5492							
			(0.9176)							
Utilities and Supplies				1.2126						
				(1.5472)						
Transport					5.4164***					
					(1.3954)					
ICT Accessibility						5.0421**				
						(2.5352)				
Institutional Quality							0.9596*			
							(0.5498)			
Trade Easiness Index								1.5529*		
								(0.9146)		
Labour Movement									9.1142***	
									(2.0480)	
GDP (Real)										1.0485**
										(2.3519)
Constant	−67.8215	−195.6639***	13.6906	−40.7654	−75.7043***	−50.0409***	−63.1428**	−131.7722*	−151.1699***	−21.9682*
	(51.0332)	(53.0257)	(54.8799)	(29.9031)	(17.3576)	(18.5193)	(27.2893)	(67.3434)	(31.1281)	(12.3652)
R-squared	0.8006	0.8174	0.7986	0.7990	0.8226	0.8050	0.8034	0.8032	0.8292	0.7983
Year Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0$.

Table 6

Regression results showing how AFCTFA moderate the effects between variables and regional trade in ICT and Digital Technology.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ICT per T Trade (%)	33.6837***	33.6488***	33.6834***	33.6653***	33.6854***	33.5922***	33.6378***	33.6718***	33.6001***
	(4.2223)	(4.2173)	(4.2155)	(4.2192)	(4.2341)	(4.2202)	(4.2092)	(4.2127)	(4.2134)
Balance of Payment	−0.0064***	−0.0064***	−0.0064***	−0.0064***	−0.0065***	−0.0064***	−0.0065***	−0.0064***	−0.0064***
	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)	(0.0019)
FDI	−0.0027***	−0.0027***	−0.0027***	−0.0027***	−0.0027***	−0.0027***	−0.0027***	−0.0027***	−0.0027***
	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)	(0.0007)
Inflation	0.0277	0.0260	0.0283	0.0241	0.0019	0.0134	0.0280	0.0263	0.0256
	(0.3418)	(0.3411)	(0.3413)	(0.3413)	(0.3449)	(0.3421)	(0.3406)	(0.3409)	(0.3407)
Trade Openness	0.0053***	0.0053***	0.0053***	0.0053***	0.0054***	0.0053***	0.0053***	0.0053***	0.0053***
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
FT x PRDCI	0.0324**								
	(0.3023)								
AF x HMC		0.0666***							
		(0.2118)							
AF x NTC			0.0283**						
			(0.1383)						
AF x ENRG				0.0875***					
				(0.3786)					
AF x TRNSP					0.2642**				
					(0.5202)				
AF x ICTA						0.4148***			
						(0.9347)			
AF x INSQ							0.1160***		
							(0.1857)		
AF x TRADESS								0.0224**	
								(0.1108)	
AF x LABMV									0.2817***
									(0.5229)
Constant	−22.6008	−25.0298	−23.8359	−23.9981	−26.5267*	−25.6641	−28.2779*	−23.7434	−27.4756
	(16.8496)	(16.7853)	(16.8807)	(16.4524)	(15.6726)	(15.6349)	(15.5740)	(16.7942)	(16.7361)
R-Square	0.4723	0.4672	0.4528	0.4772	0.4523	0.4677	0.4536	0.4672	0.4721
Number of cid	36	36	36	36	36	36	36	36	36
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Please note: AF represents the AfCFTA dummy variable, PRDCI is the production capacity index, HMC is human capital, NTC represents natural capital, ENRG, is utility supplies (efficient energy supplies), TRP is transport, ICTA represents ICT accessibility, INSQ is institutional quality, TRADESS represents trade easiness and LABMV is labour movement Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

implications for MNE strategic behaviours and responses to weak institutional contexts or newly established trading blocs. Consequently, this study argues that it is about time African countries engage in regional trading agreements through AfCFTA to exploit their unique production capacities to induce optimal economic benefits and overall regional growth. According to DiMaggio and Powell (1991), this would force MNEs to develop collective rationality in dealing with local institutions.

In furtherance to the above arguments, studies such as Coe and Helpman (1995); Connolly (1998) contend that trade in ICT&DT is more likely to promote technological capital and lead to innovation diffusion to stimulate national and regional economic growth. Overall, the results from models 1 and 2 on Table 3 revealed the following crucial findings: (a) a significant positive association between natural capital and RTICTDT, (b) a significant positive association between utilities and supplies and RTICTDT, (c) a weak positive association between transport and RTICTDT, (d) a significant positive association between ICT&DT accessibility and RTICTDT, and (e) a significant positive association between institutional quality, trade easiness and RTICTDT.

4.4. Robustness of the findings across the African-sub-region

As part of robustness, we decided to investigate if the above findings reflect similar situations across the four Africa sub-regional economies including (a) East Africa, (b) West Africa, (c) Central Africa and (d) South Africa. Our gravity regression models 7 and 8 in Table 3 revealed a positive association between the PCI and the RTICTDT. Nonetheless, we noted that the positive association between transportation and RTICTDT is weaker. Overall, the findings from models 7 and 8 lend weight to hypothesis 1 arguing for a positive association between productive capacity variables and RTICTDT. Further, our results are consistent with other empirical studies such as Akowuah et al. (2020), implying that a relative natural resource endowment which is prevalent in Africa needs to be harnessed to exert a positive influence on trade within and outside Africa.

4.5. DisEnabler of trade in ICT&DT

To be able to ascertain if there are possible disenabling factors to RTICTDT, we included inflation and FDI in the corpus of variables in our baseline regression model in Table 3. We also controlled for the differences in the sizes of the countries in our dataset by including variables such as balance of payment and GDP in all the models. We noted consistently in all the regression models that higher inflation represents a significant setback to RTICTDT across Africa. This finding agrees with Akowuah et al. (2020) and Uysal and Mohamoud (2018) who contended that higher inflation has negative effects on imports and exports. Our results lend weight to the imperativeness of macro-economic policies (e.g., fiscal and monetary) in promoting regional trade – something that the AfCFTA region struggles to deal with.

4.6. The association between trade openness and trade in ICT&DT

To test our hypothesis 2, we used the baseline regression model in Table 3 and proceeded to use the regression model in Table 4 to validate our findings. Our empirical results from Table 3 show a significant positive association between trade openness and RTICTDT. Similar results were found when we separated the data into pre-AfCFTA and post-AfCFTA which is quite remarkable. Accordingly, our results from models 1–10 in Table 3 and models 1–10 in Tables 4 and 6 respectively confirm hypothesis 2 which argues for a positive association between trade openness and regional trade in ICT&DT. We included Table 4 and Table 5 in the analysis as part of the robustness test to ascertain if the results will remain the same post-AfCFTA. Interestingly, the positive association between trade openness and RTICTDT was consistent and significantly positive across all the 1–10 models in both Tables 4 and 5. This finding is consistent with previous empirical studies such as Ngouhouo et al. (2021) who confirm that the existence of trade openness can bolster inter-regional trade. For example, they argued that the biggest economies in Africa including South Africa and Nigeria have increased their trade in the Sub-Saharan African region because of their trade openness policy.

Additionally, whilst other studies show that trade openness represents one of the underpinning factors that underscore the increase in trade in Africa from 1990 to 2017 (World Bank Report, 2020), we contend that the increase in regional trade in Africa in comparison to East Asia is still relatively small. That is why The World Bank (2020) argues that trade openness across sub-Saharan Africa has the potential to lift a significant number of Africans from moderate poverty by the year 2035. Specifically, the estimated figures on poverty reduction provided by the World Bank because of trade openness included 8.2 million from Ethiopia, 7.1 million from Nigeria, 6.3 million from Tanzania, 4.8 million from the Democratic Republic of Congo, 4.4 million from Kenya and 4.2 million people from Niger (World Bank report, 2020). These remarkable figures support our empirical findings and our hypothesis as we argue that a significant positive association exists between trade openness and RTICTDT. Hence it is in the interest of African countries who have not yet signed up for the AfCFTA regional trade agreement to do so to improve economic growth and improved living standards on the continent.

4.6.1. Association between PCI and trade in ICT&DT (RTICTDT)

Tables 5 and 6 were included in the robustness test to investigate the relationship between the PCI and regional trade in ICT&DT (RTICTDT). First, we decided to divide the dataset into two: pre, and post – AfCFTA. In Table 4, the findings from the pre-AfCFTA period revealed a significant positive relationship between human capital and trade easiness and RTICTDT. However, we noted a positive relationship between the remaining six sectors and RTICTDT (natural capital, utilities and supplies, transportation, ICT&DT accessibility, institutional quality, and labour movement). However, these positive associations were not statistically significant. Interestingly, we discovered in Table 5 (models 1 and 5–10) that the positive relationship between six of the PCIs (human capital,

transport, ICT accessibility, institutional quality, trade easiness and labour movements) was statistically significant post-AfCFTA. These findings agree with the key tenet of the AGM. Further, the World Bank Report (2020); Woode (2021) agree that AFCTFA has the potential to increase wealth in multiple sectors in Africa. Also, these findings support the World Bank Report (2020) suggesting that regional trade in Africa can lead to positive outcomes in various sectors.

Before the AfCFTA agreement, only human capital and labour mobility notably enhanced ICT&DT trade, despite positive impacts from all eight productive capacity indices (Table 4). Post-AfCFTA, six indices, excluding transportation and utilities, significantly correlated with increased trade in these sectors. This shift highlights AfCFTA's crucial role in enhancing trade across productive sectors, marking a departure from previous trends and demonstrating the agreement's significant influence on the ICT and digital technology trade landscape in Africa.

In examining the different effects of the productive capacities, we noted that each had a positive effect on regional trade in ICT&DT. However, we discovered that only human capital and free movement of labour had a *significant* positive association with regional trade in ICT&DT before the AFCTFA agreement, as shown in Table 4. Conversely, we observed a *significant* positive association between six of the eight productive capacities (excluding transportation, utilities and supplies) and regional trade in ICT&DT post-AFCTFA agreement.

4.7. The moderation effects of AfCFTA PCI and trade in ICT&DT

To test hypotheses 3a and 3b, we moderated the AfCFTA dummy variable with each of the eight PCI variables to identify if AfCFTA moderates the positive association between each of the PCI variables and RTICTDT. We used models 2–9 in testing hypothesis 3. We noted that the positive association between each of the PCI variables and RTICTDT is pronounced as a result of the moderating impact of the AfCFTA. This result shows that AfCFTA represents a nexus of trade opportunities that can improve regional trade and economic prosperity in Africa. Woode (2021) and Ofori et al. (2022) argue that AfCFTA will deepen regional integration and advance growth and prosperity among all member states. Accordingly, AFCFTA would address the problems associated with trade barriers and the prevailing economic fragmentation problems in Africa. In addition, the World Bank Report (2020) highlights that the successful implementation of the AfCFTA agenda would yield a combined GDP of US$3.4 trillion to the African economic bloc and could be a game changer in global trade dynamics. As far as we are aware, this study is among the first to examine the strengthening role of AfCFTA on the association between each of UNCTAD's PCI and the regional trade in ICT&DT.

4.8. Further tests for robustness

Our findings are robust and consistent across both the baseline gravity model and the hierarchical regression model. As part of the robustness test, we performed a series of initial analyses and post-regression results validations on the baseline gravity model and the hierarchical regression model. First, we used the variance inflation factor (VIF) to examine if any of the models suffer from possible multicollinearity issues. The highest VIF value in all the regression models was 3.2 which is significantly below the conservative threshold average VIF value of >5 (Thompson et al., 2017; Hair et al., 2019). This result implies that none of the models suffered from any multicollinearity problem. Second, we used the Haussmann Test to ascertain if either the random effect or the fixed effect model provides a better alternative regression model for our study. The Haussmann Test results favour the random effects regression model.

The Hausman test results are consistent with previous empirical studies such as Oparanya et al. (2019) who argued that the random effect is preferred to fixed effects in studies such as this because in dealing with regional trade data across different countries, there are inherent unobserved factors that vary across countries over time which cannot be modelled explicitly using the fixed effects regression model. Therefore, we address heterogeneity problems by implementing (a) individual country analysis and (b) year effect analysis in the models (Oparanya et al., 2019; Mátyás, 1997). Although we operationalised the AGM using natural log transformation of both dependent variables, to avoid model misspecification we followed Mátyás (1997) who argued for the inclusion of year effect and country-specific effect in the gravity model to account for possible time and country-specific unobserved factors. Additionally, we used a hierarchical regression model to validate the baseline regression model. Finally, we ran a two-step system GMM on model 6 in Table 3 to test if it suffers from any possible endogeneity, heterogeneity or reversed causality issues. The results from the two-step-system GMM suggest these models do not suffer from any such problems. In addition, we used linear prediction graphs in predicting the positive association between the trade enablers (a) Trade openness and (b) PCI and RTICTDT. Also, we used linear prediction graphs to demonstrate how AfCFTA moderates the positive association between the PCI and RTICTDT.

5. Implications for theory

The unique contribution of this study arises from undertaking a sector-specific analysis within the broader context of economic integration facilitated by AfCFTA. Unlike previous studies, this research delves into the ICT&DT sector to understand its potential spillover effects on other economic sectors. This sector-specific focus provides deeper insights into the mechanisms through which AfCFTA could stimulate not only trade in ICT&DT but also catalyse broader economic integration and development across Africa.

5.1. Implications for international business theory

First, the foremost literature on regional trade (e.g., Rugman and Verbeke (2004); Rugman (2003); Dunning and Lundan (2008); Hennart et al. (2017); Rosa et al. (2020) mostly relied on firm-level data to argue that most MNEs earn revenue from countries within

their home country regions due to easy access to markets. Our country-level UNCTAD data confirms that trade in ICT&DT of the 43 African countries increased when there were no trade restrictions. This is particularly interesting as we used AfCFTA as a mediating variable to investigate if regional efforts towards trade openness would yield comparable results. Our analysis lends weight to the extant firm-level IB literature by showing that regional-level institutional transparency yields mutual benefits for MNEs that compete in the same region.

Second, whilst the existing IB literature indicates a positive relationship between trade openness and regional trade (Yanikkaya, 2003; Onyeiwu and Shrestha, 2004; Zahonogo, 2016; Keho, 2017), our study extends this by showing that trade in ICT&DT increases the attraction of FDI inflows from other sectors. As argued from the outset, we did not rely on patterned sales and/or revenue, yet our findings also confirm the positive relationships between trade complementarity and FDI flows. This finding reinforces Posner's (1961) technological gap theory whereby MNEs exploit temporary monopolies in ICT&DT in nearby markets among countries in a bloc due to the cheaper cost of exploitation.

Third, we find that MNEs behave differently in responding to new institutional demands when operating within newly established regional trading blocs. For example, leading IB studies such as Chan and Makino (2007) argue that MNEs would normally take a lower ownership structure to conform to local institutional pressures. Holm et al. (2017) also show that MNE subsidiaries will take a longer time to reconcile local institutional demands with pressures from headquarters. In fact, Kano and Verbeke (2016) argued that time-related dynamics in a regional context could compound the distance and knowledge gap between MNE's home country and the host nation. However, the positive mediating relationship between AfCFTA and trade in ICT&DT in our empirical analysis provides three fresh insights: (a) MNEs who do business in Africa use regional knowledge to meet diverse regulatory demands from complex regimes; (b) the increase in FDI inflows in ICT&DT suggests that the launch of AfCFTA has enabled MNEs to overcome time, regional limitations, and multilevel psychic distances; (c) for a continent well known in most scholarly fields as having relatively weaker institutions, AfCFTA has reduced knowledge gaps, uncertainties, information asymmetries and transaction costs of doing business in Africa.

Fourth, for many years, institutional voids have been identified as a source of cost for MNEs because of the gap that usually exists between a firm's level of knowledge and its new environment. Therefore, MNEs trading in ICT&DT which in most cases do not require a physical presence in the host country could learn and develop new capabilities to reduce or remove the time it takes to understand new structures to operate. Consequently, MNEs trading in ICT&DT would not need to change their structure to reflect institutional demands from different trading blocs.

Fifth, we extend the applicability of the AGM by incorporating productive capacities which is largely ignored by most empirical IB studies. Most studies use the AGM by adopting economic indicators (largely GDP) as the indicator of the "gravitational force" that attracts trade flows. However, our findings indicate that the elements of productive capacities are linked to each country's productivity in each of the economic sectors including transport, energy, natural and human capital vis-à-vis institutional quality. Given the lack of studies that show how African countries can increase trade in goods and services across the board, this study insightfully shows that whilst natural capital is useful, due to the abundant natural resources in Africa, the eight enablers of trade are necessary to achieve a sustained increase in trade in other economic sectors. Henceforth, scholars should consider the AGM along with newly formed trading blocs such as the AfCFTA and BRICs that can significantly impact regional trade when advancing new IB ideas.

Sixth, whilst most studies tend to lump economic sectors together, we argue that examining regional trade sectorally can generate a nuanced and convincing understanding. Thus, prior IB literature including Krugman and Venables (1995); Venables (2006); di Giovanni et al. (2022); Yotov (2022) tend to focus on two things: (a) either complex stylised trade equilibriums, aggregated models, or (b) broad macro-economic indicators to measure trade flow without a critical examination of the specific sectors in newly formed blocs in emerging economies.

Finally, the IB literature tends to focus on existing regional blocs such as NAFTA, EU, and ASEAN (Frankel et al., 1995; Fischer, 1998; Rugman, 2003; Chase, 2009; Dulcich, 2022) leaving gaps in our understanding of less developed blocs. Even though recent works have attempted to draw attention to AfCFTA with promising estimations (Economic Commission for Africa, 2022; Friederici et al., 2020; World Bank report, 2020; Azmeh et al., 2020), none of these have empirically examined AfCFTA as an enabler of regional trade. Moreover, given the unique empirical focus, this study argues that prioritising trade in ICT&DT would drive economic integration and spillover effects to advance economic development on a continent that has been described as a latecomer in global trade.

5.2. Societal implications

First, in line with studies including Baier et al. (2008); Baier et al. (2019); Baldwin and Forslid (2010); Montalbano (2011) and Yilmazkuday and Yilmazkuday (2014) we argue that trade in ICT&DT can promote social welfare, gender equality and poverty alleviation by establishing an efficient market for the mutual exchange of goods and services and facilitating the diffusion of accessible market knowledge (Adams et al., 2023a, 2023b). Second, as argued by Deardorff and Stern (1997); Krugman (1991); Maggi (1999) the efficient mutual exchange of ICT&DT creates gains from product specialisation and market intermediaries. Thus, end-users of ICT&DT can obtain significant welfare benefits borne out of product differentiation which can transform communities. In line with Bussmann (2009), we argue that regional trade in ICT&DT can improve women's access to primary and secondary education, and employment in the technology-driven industrial revolution (Kimani et al., 2020). Third, regional trade in ICT&DT helps build the norms for global trading integration and improves local institutional quality. National governments participating in trading agreements often negotiate and establish new broader institutions for competitive negotiations which is beneficial for businesses and consumers. Finally, in our current digitally-transformed world, trade in ICT&DT could play an important role in Africa's economic growth.
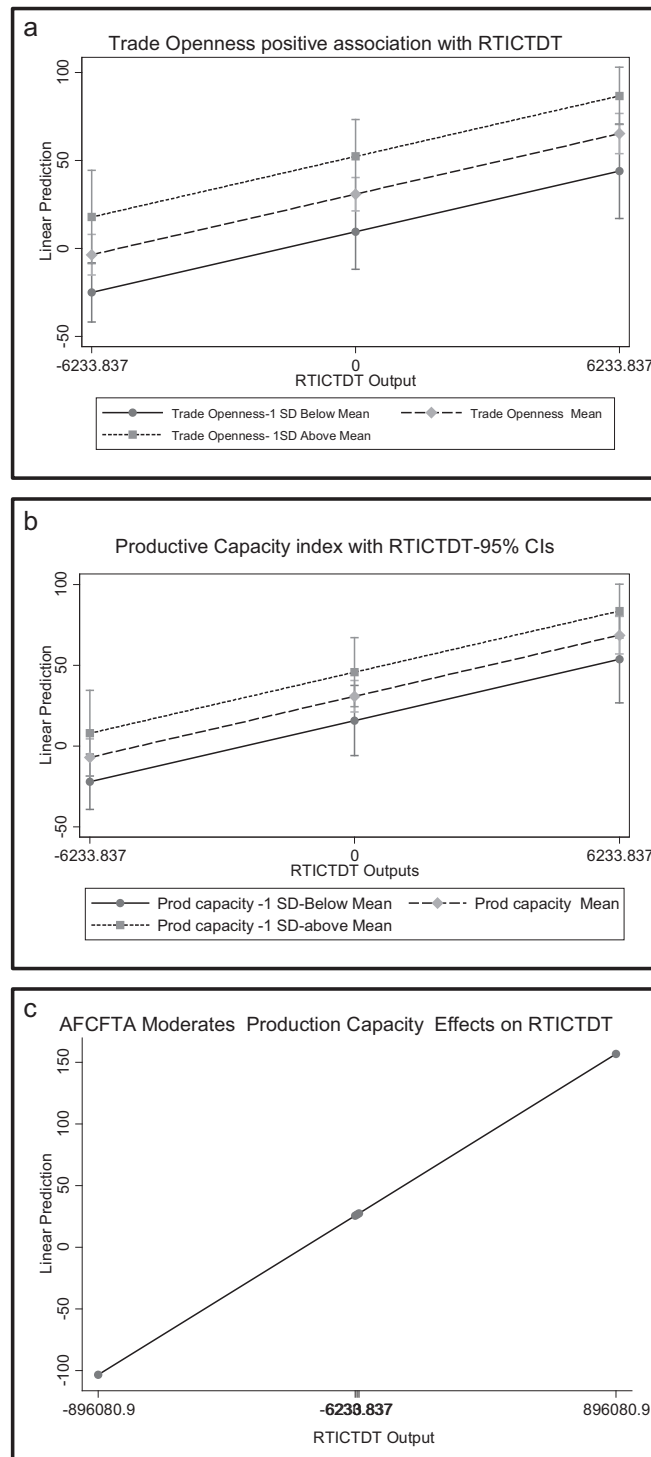
Fig. 2. Graphs predicting the positive association between The Trade enablers and RTICTDT. Graph a predicts a significant positive association between Trade Transparency and RTICTDT with a 95 % confidence level. b predicts a significant positive association between the Production Capacity index and BRTICTDT with a 95 % confidence Level. Please note that the production capacity index represents the aggregate combinations of the eight production capacity index variables. Graph c shows how AFCFTA significantly moderates the positive association between the production capacity index and BTICTDT. This Prediction is based on a 95 % Confidence Level.

5.3. Economic implications

ICT&DT trade can increase the production and selling of other knowledge-intensive products across Africa. It could also increase productivity by maximising the production of machines and tools. In line with Kathuria (2000); Adams et al. (2023a, 2023b), we argue that regional trade in ICT&DT is likely to enhance managerial competencies and promote innovation diffusion and technological capital stocks which stimulate national economic growth. Regional trade in ICT&DT would positively influence domestic innovation and total factor productivity at the country level. The relationship between ICT&DT development and national economic growth is commonly framed by Kraemer and Dedrick (2001) as a "respectability accumulated relationship between ICT&DT investment and economic growth" and a "virtuous circle structure". Therefore, the significant positive association between human capital, free movement of labour and RTICTDT implies that most of the unemployed youths and graduates who have no work can freely move across the continent for job prospects thereby reducing the youth unemployment in Africa. This may lower the number of unemployed African youths who risk their lives in crossing the Mediterranean Sea to Europe in search of non-existent jobs.

5.4. Implications for practice and policy

Given that our findings attest positively to the strengthening impact of the newly established AfCFTA, African businesses from all 54 countries need to invest in ICT&DT to facilitate trade. Fig. 2a–c predict the positive association between trade enablers, regional trade in ICT&DT and the positive association between trade openness showing a 95 % confidence level. These findings imply that all 54 African countries must sign to join the AfCFTA. The 95 % confidence level in our analysis representing the aggregate combinations of the eight PCI and trade in ICT&DT enjoin countries to strengthen local institutional frameworks to facilitate regional trade. The AfCFTA Secretariat based in Ghana should re-develop and disseminate the strategic frameworks for strengthening the growth of ICT&DT. Despite Africa's huge natural resources, attracting FDI has been classified as absolute progress, relative decline and minimal success (Asideu, 2002; Cleeve, 2008; Adams et al., 2015, 2023a, 2023b). The importance of promoting regional trade in ICT&DT which has been advanced by global policymakers such as the European Union Commission (2021) and WTO (2017) to prioritise the digital agenda could help African firms innovate. This could facilitate the integration of African MNEs into the global market as affordability would lead to lower costs and higher adoption rates.

5.5. Limitations and areas for future research

The exclusion of North African countries due to data limitations and the disproportionate representation of some countries necessitate future research incorporating primary data collection for a more comprehensive analysis. Additionally, the period of data collection overlapping with the COVID-19 pandemic introduces potential biases that future studies should aim to isolate. Investigating the extent to which increased trade in ICT is paralleled by improvements in innovation at the firm level within African countries could offer deeper insights into the AfCFTA's impact on the continent's economic trajectory.

CRediT authorship contribution statement

Kweku Adams: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Writing – original draft, Writing – review & editing. **Rexford Attah-Boakye:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Writing – original draft, Writing – review & editing. **Honglan Yu:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Irene Chu:** Conceptualization, Investigation, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review & editing. **Dafydd Mali:** Investigation, Methodology, Supervision, Visualization, Writing – original draft, Writing – review & editing.

Data availability

Data will be made available on request.

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