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The Impact of Information and Communication Technologies on International Trade: A Case of Sub-Saharan Africa

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ABSTRACT

The aim of this research is to analyze the effect of information and communication technologies (ICT) on the bilateral trade flows of the countries of Sub-Saharan Africa (SSA). We use **the method** of generalized least squares (GLS) panel to correct for correlation and heteroskedasticity problems. We have employed the gravity model extended to ICT to examine the effects of key ICT indicators on bilateral exports and imports. The sample includes 44 African countries of the subcontinent, including 43 countries as partners (importers/exporters) and one reporter country (exporter/importer) and covers the period 2010 to 2019. **The results** show that access to mobile telephony and the internet, as well as the development of e-commerce, have a great potential for improving intra-African bilateral trade and that the effect of ICT is not unequivocal according to the category of flow considered. However, it emerges from these results that the development of ICT as it is today has not yet succeeded in overturning the argument of physical distance as a barrier to trade in sub-Saharan Africa. **The key conclusion** is that the establishment of better-quality ICT services and infrastructure is more critical to intra-African trade. African policymakers should accommodate sufficient support to establish the ICT infrastructure and expand ICT penetration by reducing the costs of communication, transactionы and access to ICT.

Keywords: ICT; information and communication technologies; international trade; innovation; bilateral trade; gravity model; general least square; Sub-Saharan Africa; SSA

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ОРИГИНАЛЬНАЯ СТАТЬЯ

Влияние информационно-коммуникационных технологий на международную торговлю: исследование в странах Африки к югу от Сахары

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АННОТАЦИЯ

Целью данного исследования является анализ влияния информационно-коммуникационных технологий (ИКТ) на двусторонние торговые потоки стран Африки к югу от Сахары (SSA). Авторы используют **метод** обобщенных наименьших квадратов (GLS) для коррекции проблем корреляции и гетероскедастичности. Также авторы использовали гравитационную модель, расширенную для ИКТ, для изучения влияния клю-

чевых показателей ИКТ на двусторонний экспорт и импорт. Выборка исследования включает 44 африканские страны субконтинента, в том числе 43 страны в качестве партнеров (импортеров/экспортеров) и одну страну-респондента (экспортера/импортера), и охватывает период с 2010 по 2019 г. **Результаты** показывают, что доступ к мобильной связи и интернету, а также развитие электронной коммерции имеют большой потенциал для улучшения внутриафриканской двусторонней торговли. Кроме того, влияние ИКТ не является однозначным и зависит от категории рассматриваемого потока. Однако из результатов исследования следует, что развитие ИКТ в его нынешнем виде еще не смогло преодолеть аргумент о физической удаленности как барьере для торговли в странах Африки к югу от Сахары. **Основной вывод** заключается в том, что создание более качественных услуг и инфраструктуры ИКТ имеет важное значение для внутриафриканской торговли. Африканские политики должны обеспечить достаточную поддержку для создания инфраструктуры ИКТ и распространения ИКТ за счет снижения затрат на связь, транзакции и доступ к ИКТ.

Ключевые слова: ИКТ; информационно-коммуникационные технологии; международная торговля; инновации; двусторонняя торговля; гравитационная модель; обобщенный метод наименьших квадратов; Африка к югу от Сахары; SSA

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Introduction

Technological changes play a key role in the process of economic development, although, within the traditional economic and theoretical framework for analyzing economic growth, technological change was an unexplained residue (Solow, 1957).[1] Technological advancement can take place through various channels that involve the transformation of ideas and the adoption of new technologies, thus making economic activities efficient both in the credit market and in the real market when using a technology. State-of-the-art communication relies on the continuous and ubiquitous availability of information [1–2]. Information and communication technologies (ICT)[2] in general and the Internet have contributed significantly to the globalization of the world economy [3–7]. Indeed, in an increasingly globalized environment, the business landscape has profoundly changed and been reshaped by innovations based on information and communication technologies (ICT), which give companies access to larger markets, allowing them to expand their customer base, increase their scale, and increase their profits [8–10]. It also forces companies to face world-class competitors, exposes them to new ideas and expertise, and encourages them to keep abreast of market trends [11]. These remarkable changes are contributing to accelerated productivity growth and an increase in international trade [2].

The relationship between ICT and commerce has long fueled debate in economic literature. Three main analyses can be deduced. First, the development of ICTs has overturned the argument of physical distance as a barrier to trade [12–13, 9]. Thus, the debate on the "death of distance" has been current, showing that proximity can no longer be a requirement or a necessary condition for face-to-face interaction between business partners because innovations in ICT such as telephone, email and virtual conferencing have become substitutes for face-to-face interactions [14–13]. These innovations enabled by ICTs have helped poor and developing countries with considerable geographic distances and cultural and political barriers with their trading partners to strengthen their trade links by compensating for the lack of strong historical trade links [15]. Second, the mechanisms by which ICTs can affect the flow of international trade [16, 8] make markets more competitive and efficient by improving information flows and lowering transaction costs, such as fixed market entry costs, communication and information costs, and negotiation and coordination costs associated with trade [17]. Third, with respect to communication costs, telecommunications create a way to maintain fast, cheaper, and ef-

[1] Solow R. M. Technical change and the aggregate production function. The review of Economics and Statistics, 1957;39(3): 312–320. URL: https://doi.org/10.2307/1926047

[2] ICT is a term that includes any communication device or application like radio, television, mobile phones, computers, network hardware and software, etc., as well as the various services and applications related to them such as videoconferencing and distance education URL: https://www.techtarget.com/searchcio/definition/ICT-information-and-communications-technology-or-technologies.

ficient communication with business partners to maintain the competitiveness of businesses [18, 4, 10]. All these explanations indicate that there would be a positive impact of ICT on trade between countries.

Historically, the performance of sub-Saharan Africa has steadily deteriorated. The integration of these countries in world trade is extremely weak. The market share of sub-Saharan Africa in 1999 (1.4%) was lower than that of Malaysia alone (1.6%) and much lower than that of Mexico (2.5%). The share of its merchandise exports in world trade (in current dollars) decreased from 4.1% in 1980 to 2% in 1990 and 1.4% in 1999, according to the World Bank Indicator (2001). Comparatively, we can highlight the dynamism of Asian countries: the value of Asian exports increased by 142.7% between 1990 and 1999. The South American continent recorded an increase of 54.1% over this same period, approaching the growth rate of world trade (59.9%). As a result, sub-Saharan Africa's weight in world trade remains the lowest of all regions (2.1% in 2010). On the other hand, the share of intraregional trade in sub-Saharan Africa's total trade did not exceed 16% in 2019, a level well below that of developing countries, Asia (around 45%) and Latin America (nearly 20%), despite the proliferation of free trade areas and the establishment of two monetary and customs unions.

In this context, the development of information and communication technologies (ICT) was an effective means of improving the level of sub-Saharan trade. ICTs, especially high-speed internet and the mobile industry, now play a leading role in economic development by contributing to the emergence and diffusion of innovations in commerce, agriculture, financial services, or transport, and the modernization of public administrations, in particular fiscal administrations, the digitization of the economy is revolutionizing economic exchanges and stimulating growth, employment and poverty reduction [19–20, 6–7]. According to data from the International Telecommunications Union (ITU), sub-Saharan Africa (SSA) lags in terms of Internet penetration among the population, a delay that is particularly noticeable vis-à-vis East Asia and North Africa. If Asia, South America, and North Africa were quickly connected by submarine fiber optic cables (CSM) to the countries of the North, SSA remained relatively isolated until 2010. Since then, the digital infrastructure has expanded rapidly, facilitating access, and reducing the cost of high-speed internet and mobile telephony. Currently, almost all coastal countries, including African ones, are connected directly to the global internet through CSMs.

In such a context, can the argument of the death of distance still be applicable? Faced with the growth in ICT development observed in recent decades, what are the impacts on the dynamics of trade and bilateral trade? How can the progress observed through access and use relating to ICTs help to better diversify countries' exports? Is there a way for this development to change the import structure, which heavily contributes to the trade imbalance in finished goods? Our work will attempt to address all these questions. This study aims to analyze the impact of ICT on bilateral SSA exports and imports for the period 2010–2019 using an augmented gravity model on panel data. More specifically, the study aims to (i) determine the effect of distance on trade in the context of the growth of ICTs, and (ii) identify the flow of trade and the channel through which we observe a dynamic due to ICTs.

The paper revisits the literature on the interaction of ICT and trade and assesses the associated benefits for the economies of sub-Saharan Africa. Specifically, it explains how the different components of ICT and trade costs hamper trade performance, and how the removal of these barriers could boost both exports and imports of various products within the subcontinent. This could help prioritize different policy options in the context of limited government budgets. Also, the paper incorporates indicators of trade facilitation by distinguishing between cost elements of trade in countries at each end of the bilateral trade relationship, suggesting that exporters and importers may not benefit equally from the trade. Trade facilitation occurring at a given end.

The article enriches the literature in many important ways, particularly in the context of sub-Saharan Africa. First, as the measurement of ICT development steadily improves, more recent data can be expected to provide more relevant and accurate information than previous ones. These improvements could offer relatively new and better insight into how the ICT environment affects business performance. Second, by developing a unified framework that combines all disaggregated trade facilitation measures and the detailed struc-

ture of trade products, the document will reveal which ICT indicators are most relevant to trade flows and which measures need to be implemented to make the required improvements.

The empirical approach is based on a gravity model that links ICT indicators to bilateral trade flows. We retain three main indicators: access to mobile phones, the number of internet users and e-business, which considers three sub-indicators (availability of the latest technologies, absorption of technology by companies and business scope) obtained from the Global competitiveness report (GCR) of the World Economic Forum (WEF). Resistance to multilateral trade is controlled through various sets of country- and time-fixed effects. Additional controls include traditional severity variables, such as gross domestic product (GDP), distance, fares, languages, and border. With data on 43 sub-Saharan African countries trading with South Africa, various model specifications combining disaggregated measures of trade and ICT are estimated using generalized feasible least squares. This approach is particularly effective when dealing with autocorrelation and heteroscedasticity issues.

The results suggest that ICTs do indeed promote trade in sub-Saharan Africa and that bilateral imports are more sensitive to improving internet access than bilateral exports, which, on the other hand, are more sensitive to the development of mobile telephony. Distance continues to be a barrier to trade despite recent efforts in both ICT and the business environment. Indeed, the weak development of ICT remains imperative to be improved to hope for significant positive effects.

The remainder of the document proceeds as follows. Section 2 presents the literature review. Section 3 outlines the research methodology, explaining the variables we use in our analysis, detailing our data sources; this is followed by a detailed discussion of our econometric estimation approach. In section 4, we present the results of this research, and in Section 5 — the conclusion.

Literature review

International trade theory and gravity model

The idea that trade is a vital factor in the economic growth of a country is not new and dates to the literature of Adam Smith (1723–1790) in his book entitled "An Inquiry into the Nature and Causes of the Wealth of Nations".[3] In the literature, Adam Smith has often pointed out that trade between countries would improve economic productivity by expanding the size of markets and increasing the scale of economies, thereby increasing economic performance. In 1821, Ricardo introduced the theory of comparative advantage, which explained why it is advantageous for two countries to trade, even though one of them may be able to produce both goods and services at a better price than the other. According to his theory, a country can reap welfare gains by specializing in the production of a good or service in which it has the lowest opportunity cost compared to the others. Since then, extensive studies of developing and least developed countries have long focused on how international trade can best contribute to a country's overall economic growth and why countries participate in the economy and world trade (see Paul Krugman, 1982)[4] in the presence of non-complementarity of economies and highly differentiated products.

Following a specification reminiscent of Newton's theory of gravity, gravity models relate bilateral trade to the mass of these two countries (generally measured as the size of the countries concerned) and to the distance between them. This standard formulation of the model, which is consistent with standard models of international trade, is generally extended to include other factors generally perceived to affect bilateral trade relations. Indeed, the concept of distance does not only concern geographical distance (i.e., transport costs) but also other factors affecting the transaction made. In addition to or instead of the distance variable, some other variables can also be used, such as a dummy variable for each of the variables having a common language, a common border, being in the same territory and the same free trade arrangement [22]. There are several reasons, however, for including distance as an

[3] Smith A. An Inquiry into the Nature and Causes of the Wealth of Nations: By Adam Smith. 1793. Vol. 1. William Porter.

[4] Krugman P. Trade in differentiated products and the political economy of trade liberalization. In Import competition and response. 1982:197–222. University of Chicago Press. URL: http://www.nber.org/chapters/c6005

explanatory variable. Batra (2004)[5] cited by [23] has some of these reasons as follows:

- Distance is an approximation of costs.
- Distance is an indicator of the elapsed time during the expedition. For perishable goods, the probability of surviving intact is a decreasing function of transit time.
- Synchronization cost: when factories combine several inputs, the timing of these must be synchronized to avoid the emergence of bottlenecks. Synchronization costs increase with distance.
- Transaction costs: Distance can be correlated with the costs of finding business opportunities and building trust between potential business partners.
- Cultural distance: It is possible that greater geographic distance correlates with greater cultural differences. Cultural differences can hamper trade in several ways, such as inhibiting communication, conflict in negotiating styles, etc.
- To study the magnitude of trade flows between countries, the trade gravity model is considered an effective analytical tool.

ICT development: what effects on bilateral trade flows?

During the 1990s, information and communications technologies became a subject of increasing interest to governments and industry [5]. After fundamental research by [24] and [25], several studies have analyzed the impact of ICTs on international trade. Recently, many researchers have studied the influence of information technologies on international trade [8, 11, 16, 26–27].

It is widely recognized that trade is a crucial factor in economic growth. For developing and least developed countries, income from the export of their goods and services to the Global North is seen as a vital source of foreign exchange that alleviates pressure on the balance of payments and creates investment opportunities and employment [5–7]. The study [25] further examines the role of Internet adoption in two-way merchandise trade flows. The authors find that a 10-percentage point increase in Internet adoption leads to a 0.2 percentage point increase in merchandise trade. Likewise, study [28], applying the framework of the panel gravity model, examines the impact of ICT on bilateral trade between 64 countries for the years 1985 to 2005 and obtains a positive and significant impact of ICT on international exchanges. Indeed, a 10% increase in Internet use leads to a 2% increase in bilateral trade. In the same vein, [29] studies how the use of different means of telecommunications affects US imports of differentiated goods from 1975 to 2000. Using a fixed-effect model approach, the study finds that adoptions of landlines, mobile phones and Internet connections among exporting countries have a significant impact on U.S. imports of differentiated products, indicating that a 10% increase in the rate of Internet adoption by exporters is increasing by 1% of total merchandise exports to the United States. [14] uses the Business Internet Use Index to estimate the effect of the Internet on total goods exports in 2011 for 40 countries (OECD countries plus Brazil, China, India, Indonesia, Russia and South Africa). It finds that the use of the Internet by business circles in exporting and importing countries has a positive link with export flows between these countries. While [14] indicates that a doubling of Internet use would increase a country's service exports by 2–4% among 151 countries from 1990 to 2006, [31] find that subscriptions to Internet and Internet hosts are positively and significantly related to business performance in 40 emerging market economies in 1995–2010.

In the related literature, a few recent studies use panel data gravity models to estimate the impact of ICT on trade. A panel data study estimates the impact of Internet users on the two-way trade of 200 countries from 1990 to 2006 in a panel gravity model [4]. Internet use has a positive and statistically significant impact on international trade, and its effect on exports is stronger than that on imports. Study [3] also uses Internet users per 100 people to examine the impact of ICT on trade in services for 151 countries from 1990 to 2006 and finds that an increase in the number of Internet users promotes trade and total services, as well as the export and import of services.

Furthermore, using a panel gravity model, [32] uses different indicators as indicators of ICT and research their impacts on bilateral trade between Malaysia and its 36 trading partners from 1980

[5] Batra A. India's Global Trade Potential: The Gravity Model Approach. ICRIER Working Paper. 2002. No. 151, New Delhi: Indian Council for Research on International Economic Relations. URL: http://www.icrier.org/pdf/wp151.pdf

to 2008. The results favor positive and significant impacts of ICT on bilateral trade. In another study, [25] examines the impact of the Internet on two-way merchandise trade between 56 countries from 1995 to 1999 by first using a theoretical model, then using both a cross-section and a panel data severity model. They find that the Internet stimulates two-way trade between countries. However, instead of using one or more indicators at a time of telecommunication infrastructure development, some studies have developed aggregate composite indices or sub-indexes of ICT to limit multicollinearity problems. Among them we have: [9] using a panel data gravity model, examines the effects of four ICT indices on Turkish bilateral exports and imports for the period 2000–2014. The sample includes 35 countries which import Turkish products and 34 countries which export products to Turkey. The results indicate that ICTs have positive and significant impacts on Turkish import and export volumes. In addition, ICTs have a quantitatively larger effect on imports than on exports. A study [33] analyzes the impact of the ICT development index on trade within the European Union (EU) and between the EU and its main trading partners for the period 1995–2007. The results indicate that ICTs have a significant impact on inter- and extra-European trade. In another study, [31] estimates the effect of ICT on exports and imports in 40 emerging markets from 1995 to 2010. Their results show that Internet subscriptions and Internet hosts have significant positive effects on consumers, exports and imports.

In contrast, for a similar ICT development index also used in [34], applying a dynamic panel data model to examine the effects of ICT on exports and imports and total trade of five service items by using panel data for 19 Middle East and North Africa (MENA) countries from 2005 to 2019. The results suggest that the development of ICT has a negative and statistically significant effect on exports of information technology services, and a positive and statistically significant effect on imports and total trade in financial services. The author [35] uses a panel gravity model to assess the role of Internet adoption on commerce in 34 OECD countries over the period 1990–2010. He finds that the Internet has less impact on international trade. Subsequently, using cross-sectional data on total exports of goods in 2001 for 26 developed and 72 developing countries. The study [11] finds that greater Internet penetration favors trade flows from developing countries to developed countries, but no significant effect is seen when trade flows from developed to developing countries. According to the study [36], the specific case of Malaysia is that the effects of financial and ICT developments on growth depend on economic leadership. They conclude that Malaysia should foster competent economic leadership, financial development and a comprehensive ICT infrastructure network to stimulate long-term economic growth. To test whether internet use affects exports, [11] used national data to assess whether internet availability increased trade and, in this regard, compared developed countries and countries in development. They found that higher internet penetration in developing countries correlates with increased exports to industrialized countries, but not to trade among developing countries or to exports from industrialized countries.

ICT and bilateral trade: What mechanisms of action?

Previous studies have shown that ICTs have trade-creating or trade-enhancing effects. Indeed, thanks to exchanges organized with several buyers and sellers on the Internet and through powerful search engines allowing sellers and buyers to find themselves at low cost, ICTs have the potential for fixed entry costs, such as those of research, advertising and establishing a distribution network in a market [4, 15, 27].

Regarding communication costs, telecommunications create a means of maintaining fast and efficient communication with business partners to maintain the competitiveness of enterprises [18, 36]. In addition, cheaper and faster communication can stimulate business transactions and expand the reach of international trade [7, 17]. In summary, in the case of information costs, ICTs provide an inexpensive channel for the collection, processing and dissemination of information. It also leads to improved well-being by reducing information asymmetries, as all members of a given exchange share the same information [32, 25]. In addition, information acquisition and transmission times are reduced, and planning is more efficient and accurate thanks to advances in ICT [31, 18, 27, 7].

Research Methodology

Model and definition of variables

This study uses an augmented version of the gravity model as a standard analytical tool for the prediction of bilateral trade flows. Gravity models are commonly used to predict bilateral trade flows in international trade. Using gravity models, the researchers mainly examined the effects of economic size and distance to analyze bilateral trade flows between countries [37, 25, 11]. Based on Newtown's law of universal gravity, the basic shape of the gravity model can be expressed as follows:

$$T_{ij} = A\frac{(Y_i \times Y_j)^a}{D_{ij}^{\gamma}}, \tag{1}$$

where T_{ij} is the volume of bilateral trade between country *i* and country *j*; *A* is a constant; Y_i and Y_j are the economic sizes of country *i* and *j*; D_{ij}^{γ} is the distance between countries.

The study [37] was the first to propose a gravity equation for bilateral trade as an empirical specification, of course taking clues from Newton's universal law of gravity. In the international trade gravity model, bilateral trade flows between countries are proportional to the size of the markets (economic masses) of the exporting and importing economies and are inversely related to the distance between these countries. In addition, GDP is used as a proxy for the size of the economy and should have a positive coefficient. The distance between the countries is expected to have a negative impact on bilateral trade due to transportation costs. The original version of the gravity model in the study [37] is defined in log-logarithmic form so that the parameters are the elasticities of trade flows with respect to the explanatory variables. The variables in our model are like those in the studies by [9, 8, 16]. Based on this, we specify our model in the equation (2) as an extended version of the original gravity equation.

$$\begin{aligned}\ln Y_{ijt} = {} & \alpha_0 + \alpha_1 \ln\left(100 + Tariff_{jt}\right) + \alpha_2 \ln\left(PIB_{it} \times PIB_{jt}\right) + \alpha_3 \ln\left(POP_{it} \times POP_{jt}\right) + \\ & + \alpha_4 \ln\left(MOB_{it} \times MOB_{jt}\right) + \alpha_5 \ln\left(I_{it} \times I_{jt}\right) + \alpha_6 \ln\left(RE_{it} \times RE_{jt}\right) + \\ & + \alpha_7 \ln\left(HI_{it} \times HI_{jt}\right) + \alpha_8 \ln\left(EB_{it} \times EB_{jt}\right) + \alpha_9 \ln Dis\tan ce_{ij} + \alpha_{10} Frontiere_{ij} + \\ & + \alpha_{11} ComLang\_off_{ij} + \alpha_{12} Comlang\_eth_{ij} + \alpha_{13} ACR_{ij} + \alpha_{14} SADC_j + \\ & + \alpha_{15} CEMAC_j + \alpha_{16} CEDEAO_j + \alpha_{17} COMESA_j + \alpha_{18} UEMOA_j + \beta_i + \gamma_t + \varepsilon_{ijt},\end{aligned} \tag{2}$$

where *i* and *j* denote South Africa and the 43 sub-Saharan African trading partner countries, respectively, while *t* is the period and αk the elasticities. Moreover, β_i and γ_t are individual (country) and time effects, and ε_{ijt} is an error term that is assumed to be normally distributed with a zero mean.

$\mathbf{Ln}\boldsymbol{Y_{ijt}}$ denotes the volume of exports (respectively imports) from country *i* to country *j* during period *t*.

$\mathbf{Ln}\left(100 + \boldsymbol{Tariff_{jt}}\right)$ is the tariff applied in bilateral trade. The linearization form forces us to adjust the tariff to 100.

$\mathbf{Ln}\left(\boldsymbol{PIB_{it}} \times \boldsymbol{PIB_{jt}}\right)$ is the mass of GDP which measures the real GDP of country *i* and country *j* during period *t*. It is expected to have positive effects on exports and imports.

$\mathbf{Ln}(\boldsymbol{POP_{it}} \times \boldsymbol{POP_{jt}})$ is the mass of the population, which is used as an indicator of the size of the country and measures the populations of country i and country j during period t. The impact of the population on exports is not clear a priori (see [31]). A growing population can increase domestic production and exports by increasing the supply of labor. However, by creating domestic demand, it can also reduce exports. Likewise, its impact on imports is not certain either. On the one hand, increased domestic demand may increase demand for imports. On the other hand, the country may decide to produce locally instead of importing, which will lead to a decrease in the volume of imports.

Ln($MOB_{it} \times MOB_{jt}$) measures the subscription to mobile telephony (per 100 inhabitants) of country *i* and country *j* during period *t* and is expected to have positive impacts on exports and imports.

Ln($I_{it} \times I_{jt}$) denotes the number of internet users (in % of the population) of country *i* and country *j* during period *t* and should have positive impacts on exports and imports.

Ln$\left(RE_{it} \times RE_{jt}\right)$ measures the score of the regulatory environment of country *i* and country *j* during period t and should have a mixed effect on trade flows.

Ln$\left(HI_{it} \times HI_{jt}\right)$ refers to the score for the quality of physical infrastructure (port, road, airport, train, etc.) that can facilitate the mobility of goods and people. It should have a positive effect on trade flows.

Table 1
Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max	Observation
Exports	568.3265	1035.135	0.223258	5047.832	430
Imports	243.5986	633.4155	0.001804	5431.64	430
distcap	3671.998	1934.631	256.25	7199.892	430
Front	0.1395349	0.3469074	0	1	430
Comlang_off	0.4651163	0.4993626	0	1	430
Comlang_ethn	0.3953488	0.489495	0	1	430
ACR	0.2325581	0.4229549	0	1	430
Tariff_ij	6.7268	6.706122	0	27.9984	430
PIB_j	2.65e+10	6.58e+10	1.97e+08	4.77e+11	430
PIB_i	4.10e+11	1.77e+10	3.75e+11	4.30e+11	430
POP_j	1.99e+07	3.18e+07	87441	2.01e+08	430
POP_i	5.49e+07	2368468	5.12e+07	5.86e+07	430
AcMOB_j	74.4699	36.46467	5.843835	198.1522	430
AcMOB_i	142.5664	19.49184	98.35023	165.5999	430
UseINT_j	16.72608	14.98243	0.58	75	430
UseINT_i	48.71565	12.47821	24	68.2	430
EBusiness_j	3.085969	1.711987	0.01	5.666667	430
EBusiness_i	5.263333	0.1561375	5.033333	5.433333	430
Hard_infrastructures_j	2.605136	1.484449	0.01	4.975	430
Hard_infrastructures_i	4.735	0.1158932	4.575	4.925	430
Regulatory_environment_j	2.637151	1.472564	0.01	5.675	430
Regulatory_environment_i	3.233256	0.5926668	0.01	3.6	430
SADC	0.3255814	0.4691375	0	1	430
CEMAC	0.1395349	0.3469074	0	1	430
CEDEAO	0.3488372	0.4771575	0	1	430
COMESA	0.3488372	0.4771575	0	1	430
UEMOA	0.1860465	0.3895975	0	1	430

Source: Authors' calculation.

$\mathbf{Ln}(EB_{it} \times EB_{jt})$ refers to the extent of the market thanks to new technologies in terms of availability and absorption capacity. It should have a positive effect on trade.

$Distance_{ij}$ is the weighted distance from country i to country j which is calculated using the population weights of these countries [14].

The binary variables from equation (2) are included in the gravity model to capture trade costs, such as transport costs and information costs [38]. Among them, common borders are used to reflect shipping costs, which are higher for landlocked and island countries and lower for neighboring countries. In addition, binary variables such as common official language and ethnicity indicate the cultural proximity between countries and the capture of information costs that go hand in hand with sharing a common language.

Estimation methods

Standard gravity models typically use cross-sectional data to estimate trade effects for a period, such as a year, or on average data. However, panel data models can provide additional information, capture relevant relationships over time, and avoid the risk of choosing an unrepresentative year [23]. In addition, panels allow monitoring unobservable individual effects between trading partners. Therefore, to study the impact of gravitational factors on the bilateral trade of SSA countries, we will use a panel gravity model. Panel data models have three basic approaches: they are pooled and estimated by ordinary least squares (OLS), or they are assumed to be driven by a fixed-effects model (FEM). The third approach concerns random effects models (REM). Each approach has its own advantages and disadvantages. As pointed out in [23], the REM would be more suitable for estimating trade flows between a random sample of trading partners belonging to a larger population. On the other hand, the FEM would be a better choice than the REM if one is interested in the estimation of trade flows between a predetermined selection of countries. Since our sample contains trade between SSA countries, the REM specification might be the most appropriate. However, the result of the Hausman specification test will validate our choice. Thus, we first estimate the effect of ICT (Internet users and mobile phone subscriptions) on the trade flow of SSA countries. Then the effect of electronic commerce on bilateral trade. In cases of multi-collinearity problems between the variables, we will estimate the data by generalized least squares. This estimator fits linear models of panel data. This estimator allows estimation in the presence of AR(1) autocorrelation within panels and cross-sectional correlation and heteroskedasticity between panels.

Data and data sources

Tables 1 and 2 show descriptive statistics for the variables selected from 43 sub-Saharan African trading partner countries in their trade with South Africa.

We chose South Africa for the following three reasons: (i) South Africa is the 3rd importing country (6.12% of trade share) and the 2nd exporting country (6.83% of trade share) in sub-Saharan Africa in 2019 (see *Table 3*); (ii) The preponderance of this country in intra-African trade shows that most of the subcontinent's trade takes place with it, thus making our results generalizable; (iii) South Africa has one of the largest information and communications technology (ICT) markets in Africa. As an increasingly important contributor to South Africa's GDP, the country's ICT and electronics sector is both sophisticated and developing. The South African ICT products and services industry is entering the growing African market. South African companies and local subsidiaries of international companies have supplied most of the new fixed and wireless telecommunications networks established on the continent in recent years. It is considered a regional hub and a supply base for neighboring countries.[6] In addition to avoiding zero exchanges between countries, the South Africa buffer allows us to have a balanced panel where 43 out of the 48 African countries have their data updated.

We use 5 data sources. We use cross-country trade (export and import) data from the IMF's Trade Statistics Directorate (DOTS, 2021). ICT is derived from the International Telecommunication Union (ITU, 2021) and the World Development Indicators (WDI, 2021). The gravity data comes from CEPII's gravity dataset (2021). The data on trade facilitation come from the Global Competitiveness Report (GCR) of the World Economic Forum from 2010 to 2019. Note that in 2018 and 2019,

[6] International Trade Administration of USA. 2021.

Table 2
Correlation test between the main variables

	Exports	**distcap**	**ACR**	**Tariff~j**	**AcMOB_j**	**UseINT_j**	**EBusin~j**
Exports	1.0000						
distcap	−0.6497	1.0000					
ACR	0.7584	−0.7367	1.0000				
Tariff_ij	−0.3528	0.2214	−0.3244	1.0000			
AcMOB_j	0.2465	0.0941	0.0629	−0.0736	1.0000		
UseINT_j	0.1257	0.0693	0.0705	−0.0715	0.7480	1.0000	
EBusiness_j	0.2734	−0.0707	0.2301	−0.0718	0.4265	0.3604	1.0000
	Exports	**distcap**	**ACR**	**Tariff~j**	**AcMOB_i**	**UseINT_i**	**EBusin~i**
Exports	1.0000						
distcap	−0.6497	1.0000					
ACR	0.7584	−0.7367	1.0000				
Tariff_ij	−0.3528	0.2214	−0.3244	1.0000			
AcMOB_i	−0.0063	0.0000	0.0000	−0.0177	1.0000		
UseINT_i	−0.0098	0.0000	−0.0000	−0.0157	0.9625	1.0000	
EBusiness_i	0.0181	−0.0000	−0.0000	0.0173	−0.6538	−0.7430	1.0000
	Exports	**distcap**	**Tariff~j**	**PIB_j**	**POP_j**	**PIB_i**	**POP_i**
Exports	1.0000						
distcap	−0.6497	1.0000					
Tariff_ij	−0.3528	0.2214	1.0000				
PIB_j	0.0367	0.0194	0.1301	1.0000			
POP_j	−0.0018	−0.0169	0.1337	0.8583	1.0000		
PIB_i	−0.0122	0.0000	−0.0148	0.0458	0.0609	1.0000	
POP_i	−0.0174	−0.0000	−0.0160	0.0455	0.0605	0.9681	1.0000
	Exports	**distcap**	**Tariff~j**	**Hard_i~j**	**Hard_i~i**	**Regula~J**	**Regula~i**
Exports	1.0000						
distcap	−0.6497	1.0000					
Tariff_ij	−0.3528	0.2214	1.0000				
Hard_infra~j	0.3074	−0.0413	−0.1080	1.0000			
Hard_infra~i	−0.0018	0.0000	0.0058	0.0015	1.0000		
Regulatory~J	0.2975	−0.0857	−0.1193	0.9383	0.0021	1.0000	
Regulatory~i	0.0808	−0.1784	0.1323	0.2409	0.4280	0.2380	1.0000

Source: Authors' calculations.

Table 3
Main trading partners of Sub-Saharan Africa in 2019

Importer	Trade (US$ Mil)	Partner share(%)	Exporter	Trade (US$ Mil)	Partner share(%)
China	25.987	10.77	China	45.548	17.98
India	18.494	7.66	South Africa	17.303	6.83
South Africa	14.765	6.12	India	17.087	6.74
United States	12.460	5.16	United States	16.407	6.47
Netherlands	11.338	4.7	Germany	12.397	4.89

Source: World Integrated Trade Solution (WITS), 2021.

the method of calculating the GCR changed. In order not to lose information and since the year-to-year variations between scores are between 0.1 and 0.9, we use the top-adjustment method for the past two years. The same method is used for other types of data. *Table 4* summarizes the definitions of the variables, the expected signs and their sources.

Results

The results are consigned in *Tables 5 and 6*. We use a sample of 43 African countries[7] of the subcontinent as partners (importers/exporters) and a rapporteur country (exporter/importer). There is a relatively high level of collinearity between aggregate severity indicators on the one hand and between the constituent elements of each aggregate indicator on the other. To correct for these problems, the estimator used is generalized least squares (GLS). Five separate regressions are therefore considered for the ICT indicators and for the constituent elements of regional trade agreements, considering the bilateral flows of exports and imports from the countries of sub-Saharan Africa to South Africa.

We regress two models: one model considers the bilateral exports of country *i* to countries *j* of sub-Saharan Africa, and the second model considers the bilateral imports of country *i* to countries *j* of sub-Saharan Africa. For each of these models, we regress five (5) equations. The first (I) regresses a standard gravity model, the second (II), third (III) and fourth (IV) regress all roles in addition to trade facilitation indicators, a standard indicator of ICT, as well as follows: mobile phone access, the number of internet users as a percentage of the population and the feasibility of electronic commerce. Finally, the fifth (V) equation, in addition to the three ICT indicators, integrates the effect of the trade potential of five different regional trade agreements.

Confirmation of the gravity model and effects of ICT

First, the results obtained are consistent with the literature and therefore correspond to the predictions. Indeed, distance has a significant negative impact on bilateral trade, whatever the model or even the equation. The estimated distance coefficient is significantly greater than unity in absolute value for the import model, which broadly corresponds to what is found in the literature (see, for example, [39–41]). The effect of distance is stronger for imports than for exports. In quantitative terms, these results show that a 1% increase in the distance between two countries leads to a drop in import trade of around 1.30%, 1.25%, 1.20%, depending on whether the ICT integrated into the equation of the mobile phone, the internet and e-commerce respectively. We can see that the development of ICT has not yet canceled the argument of physical distance as an obstacle in sub-Saharan Africa. However, this effect is weaker for the export model where 0.79%, 0.72% and 0.70% reduction in export trade occurs when the distance increases by 1 point.

[7] Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Comoros, Congo (Brazzaville), Côte d'Ivoire, Djibouti, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Guinea Bissau, Equatorial Guinea, Kenya, Liberia, South Africa, Madagascar, Malawi, Mali, Mauritius, Mozambique, Namibia, Niger, Nigeria, Uganda, Central African Republic, Democratic Republic of Congo, Rwanda, Senegal, Seychelles, Sierra Leone, Sudan, Tanzania, Chad, Togo, Zambia, Zimbabwe.

Table 4
Summary of variables and data sources

Variables Definitions	Expected signs		Data sources
Exports$_{ijt}$ / Imports$_{ijt}$	**Total Exports / Imports from country *i* to country *j* (constant 2010 US $)**		**DOTS (2021)**
	Macroeconomic variables		
PIB	Gross domestic product, GDP (constant 2010 US $)	+	World Development Indicator (WDI 2021) de la Banque mondiale
POP	Total population: used as an indicator of the size of the country	+/–	
Tariff	AHS tariffs on all products applied to bilateral trade	-	World Integrated Trade Statistics (2021)
	ICT indicators		
MOB	Mobile phone use subscription for 100 people	+	(WDI, 2021)
INT	Internet users (% of the population)	+	(WDI, 2021)
E-business	E-business is the simple average of 3 scores from the GCR related to (i) the availability of the latest technologies, (ii) the company's ability to absorb these technologies and (iii) the extent of marketing. If the score is close to 7, e-business is developed, close to 1, the opposite is true.	+	Global competitiveness Report of World Economic Forum (2010–2020)
	Gravity indicators		
ACR	Regional trade agreements: binary dummy variable which is the unit if there is an RTA. To measure the isolated effect, we integrate the variables UEMOA, COMESA, ECOWAS, SADC, CEMAC	+	*CEPII Gravity Dataset* (2021)
DistanceCap	Weighted distance between country *i* and country *j*, in km	-	GeoDist / CEPII Gravity Dataset (2021)
Frontière	A binary variable which is the unit if country *i* and country *j* share a common border	+	GeoDist / CEPII Gravity Dataset (2021)
ComLangue	Language is a binary variable which is the unit if a language is spoken by at least 9% of the population of country *i* and country *j*	+	GeoDist / CEPII Gravity Dataset (2021)
ComLangue_ Ethnie	Ethnicity: is a binary variable which takes the value 1 if country *i* and country *j* have been jointly an ethnic group	+	GeoDist / CEPII Gravity Dataset (2021)
	Trade facilitation indicators		
Hard infrastructures	Physical infrastructures measure the quality of 4 infrastructures: port, roads, rails and the airport for each country, obtained by averaging the scores from the GCR: The infrastructures are efficient and of quality if the score is close to 7, no developed so close to 1	+	Global competitiveness Report of World Economic Forum (2010–2020)
Regulatory custom and environment	The regulatory and customs environment of each country is designed from 4 scores from the GCR by simple average: These are (i) irregular payment and corruption in public contracts, (ii) favoritism in government decisions (iii) transparency in the government's political strategy and (iv) public confidence in politics. When the value is close to 7, the regulatory environment facilitates trade and when the value is close to 1, the environment is harmful to trade	+	Global competitiveness Report of World Economic Forum (2010–2020)

Source: Developed by the authors. 2021.

This effect is more reduced when all three indicators are included in the model evaluated at 0.39%. This indicates potential for reducing the negative effects of distance on trade through ICT. Even if this result calls into question the argument of the death of distance, efforts to develop ICT in the subcontinent remain palpable.

We can see that the development of ICT has not yet canceled the argument of physical distance as an obstacle in sub-Saharan Africa. Efforts still need to be made to ensure that innovations in ICT such as telephone, e-mail, virtual conferencing, and e-commerce become substitutes for face-to-face interactions.

The results also clearly show that there is a positive relationship between the level of trade between the two countries and the GDP of the destination country. For example, a 1% increase in the GDP of this country leads to an increase in bilateral imports of 0.70%. This result certainly captures a market effect. On the other hand, the effect of the GDP of the country of origin and of the population is not significant or of negative sign, thus justifying that the growth of the population can be a factor of the increase of the local production [31]. We also see that countries that have a common border and a common ethnic language exchange much more often. These results are in line with expectations. Indeed, the

Table 5

Results of estimates of the bilateral export model

	(I)	(II)	(III)	(IV)	(V)
Lndistcap	−0.5610*** (0.1407433)	−0.798647*** (0.1352459)	−0.7257643*** (0.1390125)	−0.7040709*** (0.1421988)	-0.3964434*** (0.1223383)
Frontière	1.1730*** (0.294226)	0.3728759 (0.2820369)	0.7752345*** (0.2842011)	0.7447372** (.2933616)	1.146108*** (0.2514546)
Comlang_off	−0.0506729 (0.2299639)	−0.0834302 (0.2110199)	−0.3218896 (0.2152224)	−0.3707367* (.2232609)	0.0677923 (0.1683062)
Comlang_ethno	0.8996356*** (0.2232961)	0.754611*** (0.2021973)	0.9080373*** (0.2071288)	1.012312*** (0.217234)	0.7631496*** (0.1611441)
ACR	1.230533*** (0.2329186)	1.261777*** (0.2093181)	1.21504*** (0.2160477)	1.198424*** (0.2200654)	
LnTariff_ij	−0.049054*** (0.9345523)	−0.069773*** (0.8995497)	−0.0619256*** (0.9209979)	−0.0506766*** (0.9150219)	-0.0298042*** (0.7603003)
LnPIB_j	0.9320*** (0.0618627)	0.5176934*** (0.0692418)	0.5550767*** (0.079316)	0.7860919*** (0.0627901)	0.7096722*** (0.0697269)
LnPIB_i	0.2791 (4.813084)	4.054432 (10.01064)	4.848237 (6.462661)	2.624387 (5.970609)	2.470516 (7.798894)
LnPOP_j	−0.0209 (0.0545457)	0.322564*** (0.0665759)	0.3191021*** (0.087754)	0.0195821 (0.0527069)	0.2228287*** (0.0701991)
LnPOP_i	-0.37794 (4.893608)	-8.017621 (6.806545)	-14.67828** (6.436782)	-4.029027 (7.952703)	-7.022141 (10.16699)

Source: Developed by the authors. 2021.

Table 6
Estimation results of the bilateral import model

	(I)	(II)	(III)	(IV)	(V)
Lndistcap	−0.971312*** (0.2382021)	−1.302272*** (0.2467367)	−1.256784*** (0.2455797)	−1.201979*** (.2500201)	−1.496473*** (0.2518688)
Frontière	0.8051213 (0.497965)	0.1294338 (0.5231651)	0.203754 (0.5020702)	0.2246873 (0.5158013)	0.0639651 (0.517692)
Comlang_off	−0.096919 (0.3892042)	0.0633322 (0.390003)	−0.4244762 (0.3802122)	−0.4385729 (0.3925471)	−0.3112493 (0.346507)
Comlang_ethno	0.4437684 (0.3779192)	0.207196 (0.3754704)	0.5212219 (0.365914)	0.6029333 (0.3819505)	0.148088 (0.3317619)
ACR	1.739049*** (0.3942049)	1.261777*** (0.2093181)	1.726053 *** (0.3816702)	1.691473*** (0.3869287)	–
LnTariff_ij	−0.052957*** (1.58169)	−0.075470*** (1.641099)	−0.07322294 (1.627036)	−0.0583490*** (1.608832)	−0.0431923*** (1.565298)
LnPIB_j	1.824059*** (0.1047)	1.401406*** (0.1263217)	1.322135*** (0.1401197)	1.64618*** (0.1104004)	1.418939*** (.143553)
LnPIB_i	0.2481098 (8.145941)	8.297634 (18.26297)	6.36659 (11.41695)	1.510278 (10.49779)	4.987033 (16.05628)
LnPOP_j	−0.509491*** (0.0923162)	−0.1514398 (0.1214582)	0.0041959 (0.1550264)	−0.4367476*** (0.0926715)	−0.0109374 (0.1445251)
LnPOP_i	−1.517199 (8.282224)	−8.39674 (12.41756)	−17.56755 (11.37123)	1.457168 (13.98279)	−9.836023 (20.93169)
LnAccèsMoB_j	–	0.8930549*** (0.2505896)	–	–	0.2865185 (0.2769561)
LnAccèsMob_i	–	−1.410388 (2.722507)	–	–	−2.106342 (4.282573)
LnInt_j	–	–	0.0433146*** (.0122731)	–	0.5567015*** (0.162843)

Table 6 *(continued)*

	(I)	(II)	(III)	(IV)	(V)
LnInt_i	–	–	0.0116516 (0.0406839)	–	0.7439181 (3.218176)
LnEbusiness_j	–	–	–	-0.157937 (0.5002699)	0.1413419 (0.4386264)
LnEbusiness_i	–	–	–	9.312746 (11.51685)	7.935119 (16.66207)
LnHardInf_j	–	2.382778*** (0.6254909)	2.143392*** (0.6240286)	2.29509*** (0.7159076)	1.570523** (.6555663)
LnHardInf_i	–	–5.42876 (4.822226)	–3.637092 (4.741971)	–9.153412 (7.930405)	–9.858413 (9.923911)
LnRegulatory_j	–	–2.400874*** (0.6401913)	–2.11787*** (0.6207366)	–2.003449*** (0.6526718)	–1.906345*** (0.5963375)
LnRegulatory_i	–	0.2930428** (0.1136779)	0.2437417) ** (0.1109466)	0.1815044 (0.1115877)	0.2701699*** (0.1011773)
SADC	–	–	–	–	2.363435*** (0.2891487)
CEMAC	–	–	–	–	–0.8699883** (0.3712042)
CEDAO	–	–	–	–	1.823215*** (0.3952677)
COMESA	–	–	–	–	0.1583708 (0.2708639)
UEMOA	–	–	–	–	–1.567904*** (0.3225982)
Constante	20.31872 (83.96116)	–43.51144 (287.2637)	162.2328 (274.071)	–60.32446 98.6636	49.50743 (385.7266)
Observations	430	430	430	430	430
Wald chi2	1089.83 (10) (0.0000)	1225.50 (16) (0.0000)	1224.39 (16) (0.0000)	1180.29 (16) (0.0000)	1777.33 (24) (0.0000)

NB: *, **, *** significance at 10%, 5%, 1%. () are the standard errors

Source : Authors, 2021

results show that countries with a common ethnic language trade 76% more than others, especially for exports. Likewise, when two countries share a border, their trade improves, especially for the flow of exports.

The tariff is negative and significantly associated with trade in both models. This means that for African countries, the tariff continues to be a constraint on trade as well as non-tariff barriers which appear to be the main challenge for African countries [39].

Effect of ICT development

Second, the results indicate that access to and development of ICTs has great potential for improving bilateral intra-African imports. For example, a one-point improvement in mobile and internet access could lead to an improvement in bilateral exports by 0.95% and 0.029% respectively. Likewise, for bilateral imports, where the points of improvement increase this trade flow by 0.89% and 0.043% respectively, due to the improvement of one point of access to the mobile phone and to the Internet. These two results agree with most of the work on the subject, that of [35] who found that the Internet has a less clear impact on international trade than access to mobile phones. In addition, it should be noted that the effect of ICT is not unequivocal depending on the category of flow considered. We observe that the impact of the Internet is more pronounced on the imports of country i from countries j; while for exports from country i to country j, it is rather the effect of mobile access that is more pronounced (see *Table 3 and 4*). In other words, bilateral imports are more sensitive to improved internet access than bilateral exports, which are more sensitive to the development of mobile telephony.

However, an improvement in e-commerce has an insignificant effect in both models, unlike found in the work [40]. This result can be understood given the relatively recent development of e-commerce in the countries of sub-Saharan Africa [20]. In addition, the constraints as identified in the literature may justify its negative effect on trade. Because for a developed e-commerce, you need internet access that is neither characterized by low Internet penetration, particularly broadband, nor poor coverage of the mobile telephone network, and nor high telecommunications pricing.

Table 7

List of countries by Regional Trade Agreements

SADC	CEMAC	ECOWAS	COMESA	WAEMU
Angola	Cameroon	Benin	Burundi	Benign
Botswana	Central African	Burkina Faso	Comoros	Burkina Faso
Democratic	Republic Republic	Cape Verde	Djibouti	Côte d'Ivoire
Republic of the	of the Congo	Côte d'Ivoire	Egypt	Guinea Bissau
Congo	Gabon	Gambia	Eritrea	Mali
Lesotho,	Equatorial Guinea	Ghana	Ethiopia	Niger
Madagascar	Chad	Guinea	Mauritius	Senegal
Malawi		Guinea Bissau	Kenya	Togo
Mauritius Island		Liberia	Libya,	
Mozambique,		Mali	Madagascar	
Namibia		Niger	Malawi	
Seychelles		Nigeria	Uganda	
South Africa		Sierra Leone	Democratic	
Eswatini		Senegal	Republic of Congo	
Tanzania		Togo	Rwanda	
Zambia			Seychelles	
Zimbabwe			Sudan	
			Eswatini	
			Tunisia	
			Zambia	
			Zimbabwe	

Source: Compiled by the authors.

Effects of trade facilitation

Third, the results clearly indicate that trade facilitation in the subcontinent has great potential for improving trade. For example, a one-point improvement in physical infrastructure could result in an increase ranging from 1.08% to 1.36% for export flows and between 1.57% and 2.38% for import flows. On the other hand, a similar improvement in the regulatory environment generates a persistent negative impact for the country of destination while for the country of origin the effect is positive and encourages bilateral trade by around 0.25% on average. This result matches that of [40] and [39]. Indeed, these authors show that the regulatory environment of the importer has a significant and positive effect on trade while the regulatory environment of the exporter has a significant and negative effect. The negative effect recorded may come from the low level of the regulatory framework in Africa, whose average score is around 2.63 while it is 3.2 in the country of origin of South Africa.

The effect of regional trade agreements (RTA)

In both models, belonging to the same RCA contributes to improving trade and this effect is robust in all equations at 1% significance. However, this effect is more pronounced in the import model than in the export model. This is understandable as the sub-Saharan region has the most RTAs which have between 5- and 20-members economies with a composition tending to overlap (see *Table 7*). This overlap will tend to boost trade between countries. However, taken individually, some RTAs appear to be more effective than others. Indeed, in the export model, the CEMAC agreement is significant and negatively linked to trade while UEMOA and ECOWAS have non-significant positive effects, the effect becomes significant for ECOWAS in the import model. In contrast, the RTAs of Southern and South Africa (SADC, COMESA) have significant positive effects in both models. These results call for three main comments: (i) the improvement in trade can be linked to the size of the RTA, the larger the number of countries the greater the potential for trade. For example, COMESA has 20 members countries while CEMAC has only 6; (ii) the geographical area of integration or even seems to have a significant impact, we note that the RTAs of West and Central Africa are less dynamic than those of southern Africa; (iii) trade facilitation rules are not really applied. For example, in ECOWAS or UEMOA, several provisions are made with well-structured regulatory frameworks, but they are hardly applied, particularly in the case of TEC-UEMOA and TEC-ECOWAS.

As a result, interregional trade remains relatively low between African RTAs. According to data from the United Nations Conference on Trade and Development (UNCTAD), between 2015 and 2017, the share of intra-continental trade represented 15% of trade, compared to 49% in America, 61% in Asia and 67% in Europe. Intra-RTA trade represents between 2% and 11% of total exports, except in the case of SADC, where it represents 19% of exports. Increasing intraregional trade in sub-Saharan Africa faces obstacles such as poor infrastructure and high export and import costs, which prevent African economies from taking full advantage of their proximity to markets. However, the entry into force of the African Continental Free Trade Area (AfCFTA) Agreement should help increase trade in this area of Africa.

Conclusion

The gap between the subcontinent and the outside world with respect to any element of the business environment is strongly indicative of the potentially significant impact of further improving the ICT environment.

The results suggest that the development of telecommunications infrastructure has positive and significant effects on the import and export volumes of intra-African trade. However, their weak development, especially internet access (an important prerequisite for the development of e-commerce), suggests that the physical distance argument is still relevant as a barrier to trade. As a result, technological innovations must be more pronounced to be able to help developing countries to move away from geographical distances. Also, the improvement of physical infrastructure and the regulatory environment must be stimulated to increase trade links by compensating for the lack of solid historical trade links, and thus make markets more competitive and efficient by improving information flows and lowering transaction costs. Likewise, the tariffs are still too high

on regional imports and should be considerably reduced or even eliminated.

The policy implications of this study are threefold: (i) invest massively in ICT development to reduce the impact of distance on trade, with a particular focus on high-speed internet; (ii) provide sufficient support for the development of ICT infrastructure through regional agreements, regulatory and environmental frameworks, and the reduction of tariffs; (iii) expand ICT/internet penetration by reducing communication, transaction and access costs. In the perspective of broader results, this study could be extended to all African countries in bilateral trade.

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