

Akpa, Armand Fréjus; Chabossou, Augustin Foster

## Article

# Effect of information and communication technology on cashew nut export in Benin

Research in Globalization

## Provided in Cooperation with:

Elsevier

*Suggested Citation:* Akpa, Armand Fréjus; Chabossou, Augustin Foster (2024) : Effect of information and communication technology on cashew nut export in Benin, Research in Globalization, ISSN 2590-051X, Elsevier, Amsterdam, Vol. 8, pp. 1-7, <https://doi.org/10.1016/j.resglo.2024.100197>

This Version is available at:

<https://hdl.handle.net/10419/331124>

### Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

### Terms of use:

*Documents in EconStor may be saved and copied for your personal and scholarly purposes.*

*You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.*

*If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.*



<https://creativecommons.org/licenses/by/4.0/>



# Effect of information and communication technology on cashew nut export in Benin

Armand Fréjuis Akpa<sup>a,b,\*</sup>, Augustin Foster Chabossou<sup>a</sup>

<sup>a</sup> Laboratoire d'Economie Publique (LEP), Faculté des Sciences Economiques et de Gestion, Université d'Abomey-Calavi (UAC), Abomey-Calavi, Benin

<sup>b</sup> Centre for Economic Policy and Development Research (CEPDeR), Covenant University, Ota, Nigeria

## ARTICLE INFO

### JEL Codes:

F10  
O30  
Q17

### Keywords:

ICT  
Export  
Agricultural commodities  
Cashew nut international trade

## ABSTRACT

The introduction of information and communication technology (ICT) has altered the way society operates things. ICT is used in various sectors, including agriculture. It can be used in the agricultural sector to distribute pricing and encourage agricultural commodity exports. The study aims to investigate the effect of ICT on cashew nut export in Benin using an autoregressive distributed lag (ARDL) approach. Data were collected over the period of 31 years (1990–2020) in Benin. The estimated results showed that mobile cellular telephone subscription is negatively and significantly correlated with cashew nut export in the short-run. However, in the long-run, it exhibits a positive and significant correlation. On the other hand, internet usage had no significant effect on cashew nut export in the short-run, but negatively influenced cashew nut export in the long-run. These results suggest that to increase its cashew nut export, the Beninese government should invest in technological infrastructure to improve internet access by reducing the cost of internet and increasing education that will allow farmers to better understand and use ICT.

## Introduction

Countries have always exchanged goods and commodities among themselves. Although, in the literature, these are thought to have laid the international trade foundations. But these theories are sources of debate. Smith (1776) developed the absolute advantage theory, which stated that a country must concentrate on the production of commodities for which it has an absolute advantage and purchase all other goods produced by other countries at a cheaper cost. On the other hand, Ricardo (1817) described how a country might gain by specializing in commodities for which it gets a comparative advantage, even if it gets an absolute disadvantage for all other produced goods.

Several factors favor trade between two or more countries. One of these factors is ICT, whose introduction into the economy has transformed it globally through the increasing of economic agent's access to production factors, information, knowledge, market intelligence, and large-scale markets (Arvin, Pradhan, & Nair, 2021). Likewise, it is obvious that ICT and greater trade flows constitute primary factors of the current globalization drive (Baldwin, 2017; Rodríguez-Crespo & Martínez-Zarzoso, 2019). Nevertheless, trade liberalization is accompanied by high entry costs into external markets, allowing only the most

productive firms to participate (Adegboye et al., 2020; Melitz, 2003; Rodríguez-Crespo & Martínez-Zarzoso, 2019). ICT helps firms to internationalize costs by lowering transaction costs (Abramovsky and Griffith, 2006; Rodríguez-Crespo & Martínez-Zarzoso, 2019) and improving logistical efficiency (Rodríguez-Crespo & Martínez-Zarzoso, 2019; World Bank, 2016).

Managing enormous volumes of information and resources in a highly competitive and vital for the success of agricultural producers and a knowledge-based economy (Dong et al., 2021; Fan et al., 2021). For Dong et al. (2021), the constant growth and ICT usage facilitate the management of a huge amount of data and resources. They are increasingly used for e-agriculture development by allowing farmers to access useful data to boost production (Amarnath et al., 2018; Dong et al., 2021). Similarly, they are mainly used in the production process, product inventory collection, market price dissemination, product quality control, and especially, agricultural export. Agricultural practices monitoring, information provision and forecasting constitute three major ICT applications used to enhance agriculture production (Liu, Shao, Wu, & Qiao, 2021). In addition to data monitoring, rural areas households get access to additional production-related data, which improves their knowledge, their production planning and finally their

\* Corresponding author.

E-mail address: [frejuisakpa@gmail.com](mailto:frejuisakpa@gmail.com) (A. Fréjuis Akpa).

<https://doi.org/10.1016/j.resglo.2024.100197>

Received 1 October 2023; Received in revised form 31 January 2024; Accepted 31 January 2024

Available online 1 February 2024

2590-051X/© 2024 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

practical decisions about which kind of crops to grow (Radoglou-Grammatikis et al., 2020).

According to Kaila and Tarp (2019), greater yields are related to internet connection due to more efficient fertilizer application. This is also similar to the findings of Osabohien (2023). Subsequent research has concentrated on mobile phone and its impact on food production. Nakasone, Torero, and Minten (2014) explored mobile phone impacts at macro and micro levels. The study assumed that mobile phone availability can increase market performance at the macro level, but it has mixed consequences at the micro level. Aker and Fafchamps (2015) have shown that mobile phone coverage reduced the producers' spatial price dispersion for semi-perishable commodities. For Tadesse and Bahiigwa (2015), although farmers are increasingly utilizing mobile phones for business choices, an important information deficit has hampered mobile phone use. Aker and Ksoll (2016) found that mobile phone coverage had no effect on agricultural sales or farm prices. Rodríguez-Crespo and Martínez-Zarzoso (2019) showed that internet use boosts trade and segmentation by product complexity is more susceptible to internet users than segmentation by income level.

Several studies showed that ICT improves international trade. For example, Lin (2015) and Bensassi, Márquez-Ramos, Martínez-Zarzoso, and Suárez-Burguet (2015) found that ICT is favorable for trade. Barbero and Rodríguez-Crespo (2018) found that broadband infrastructures improve European Union regional trade. Portugal-Perez and Wilson (2012) showed both in developed and developing nations that the ICT infrastructure index improves trade in developing countries than developed countries. Abeliansky and Hilbert (2017) demonstrated that telecommunication subscriber's quality and quantity enhance trade. Rodríguez-Crespo, Marco, and Billon (2021) discovered a positive association between three ICT forms and trade, as well as how this relationship changes by national income level. However, a few studies focused on the ICT's effect on agricultural exports. Oyelami, Sofoluwe, and Ajeigbe (2022) found in sub-Saharan African (SSA) countries that mobile subscription improves agricultural exports while internet users worsen agricultural exports. Also, Chung, Fleming, and Fleming (2013) found that fixed-telephone line penetration and internet users largely improve fruit and vegetable trade values.

After cotton, the cashew nut sector is Benin's second major cash crop. The cashew nut industry contributes 3 % to Benin's GNP, 7 % to Benin's agricultural GNP, and accounts for 8 % of Benin's export earnings (Gbaguidi, 2020). Cashew nut exports increased significantly by 156 % from 2011 to 2015 and rose from 51,348 tons in 2011 to 131,241 tons in 2015, with an annual average of 102,127 tons and earned the country more than CFAF 148,250 million (Plan, de Développement, & Agricole, 2017). In a decade, internet users number has more than tripled, moving from 1 billion in 2005 to an estimated 3.2 billion in 2015 (World Bank, 2016). In Benin, there has been recently a rapid increase in ICT and its use in various economic sectors. Indeed, according to ITU data, mobile cellular telephone subscriptions have experienced a boom, at 0 % between 1990 and 1994, it has increased and reached about 96 % in 2013. However, internet users did not experience a high rate compared with mobile cellular telephone subscriptions. Indeed, until 1995, Benin did not have any internet users, but experienced a low increase between 1995-2014 and a rapid expansion from 2015 and reached about 26 % in 2020.

In the agricultural sector, a survey conducted by Amessinou (2018) on the mobile technologies used in agricultural settings in southern Benin by pineapple producers revealed that cell phone use is basic. The study, basing their analysis on the production actors and fresh pineapple sale, found that two-thirds of pineapple producers use the phone to announce product availability, but the said phones and other mobile equipment are therefore almost not involved in collecting cultivation information or financial transfer. This ICT low use in the agricultural sector according to MAEP et al. (2019) is explained by the fact that ICT is still a luxury in Benin. Indeed, the mobile cellular sub-basket was US \$13.8/month compared to a sub-Saharan average of US\$11.7/month,

while correspondently, the broadband sub-basket was US\$50.6/month compared to US\$44.9/month. However, by increasing ICT in its agricultural sector, Benin can diffuse information about its cashew nut production worldwide through a digital platform. This will reveal the country in the international trade market as well as allowing Benin to more readily sell its cashew nut production and thus participate in the global trade. On the other hand, thanks to the development of ICT, the distance between Benin and other countries in the world is reduced and this brings Benin closer to other countries and in this way facilitates more exchanges.

Many studies have analyzed the ICT effect on trade (Bensassi et al., 2015; Lin, 2015; Rodríguez-Crespo et al., 2021), however little of them are focused on agriculture exports (Chung et al., 2013; Oyelami et al., 2022). Oyelami et al. (2022) analyzed agricultural sector performance in SSA using macro-data and did not find conclusive results about ICT's effect on agriculture exports. This can be explained by the proxy used to measure agricultural export (agriculture products as a percentage of total merchandise export). To address this issue, this study used the quantity of agricultural products exported to analyze the ICT's effect on Cashew nut export. This study has taken a new dimension to argue that one of the factors that can increase cashew export in Benin is ICT infrastructure. This is hinged on the fact that; ICT can reduce transaction costs between sellers (farmers) and buyers. Therefore, the objective of the study is to ascertain the extent to which ICT influences cashew nuts export, using an econometric model. The results should contribute to the subject's better understanding and stimulate new studies and policies. Thus, this paper contributes to shed light on the empirical link between ICT and cashew nut export in Benin. It's intended to provide more in-depth information to analyze the ICT's effect on cashew nut export. Moreover, with an increasing number of activities engaged to make Benin an important digital platform in West Africa, it's important to analyze ICT influence on agricultural exports.

The research goal is to use the ARDL model to evaluate ICT's impact on Beninese cashew nut export. As a result, this paper adds to the empirical work that has previously been confined, to examine the export drivers. For the rest of this study, the second section presents the methodology, then results and their discussion are presented in section three and, finally, we conclude and give policy implications in section four.

## Methodology

### Theoretical foundations

This study looks to analyze the technology adoption effect in the food export context. Theoretical foundations for new technology adoption have been significantly recognized by Yousafzai, Foxall, and Pallister (2010) and recently by Asongu (2018) and Asongu, Nwachukwu, and Aziz (2018) when they analyzed the factors which influence in SSA countries (i) mobile phone/banking and, (ii) mobile phone penetration, respectively. The authors mobilized three theories of new technology adoption: the theory of reasoned action (TRA), the theory of planned behavior (TPB), and the technology acceptance model (TAM); which are the most commonly used. For Asongu et al. (2018), these theories' common view is that technology adoption is complex and multifaceted.

Firstly, related to Yousafzai et al. (2010), the TRA undertaken by Fishbein and Ajzen (1975), Ajzen and Fishbein (1980) and Bagozzi (1982), assumes that customers become rational when they have to consider their actions involvement. As a grounded model, it is stingy, aware, and spontaneous in explaining attitudes, focusing on factors that lead to consciously intended attitudes (Asongu, 2018; Asongu et al., 2018). Then, Ajzen (1991) TPB which is an extension of the TRA differs from it in that it doesn't distinguish between customers who have an aware control over their actions and those who do not. The TPB assumes that a third aspect or perceived behavioral control (PBC) also influences current behavior and behavioral targets, the first two factors being

normative and attitudinal influences. Thus, the TRA extension by the TPB considers the scenarios in which individuals have constrained situational control. According to the theoretical foundations, three key thoughts guide human action: (a) behavioral beliefs about the possible outcomes of a given attitude and evaluations, (b) 'normative beliefs about the normative prospects of others and the incentive to conform to them' (Yousafzai et al., 2010) and (c) control beliefs about the occasions and resources that individuals possess and don't possess as soon as the anticipated barriers to performing an anticipatory attitude. From a gathered viewpoint, 'behavioral beliefs' lead to unfavorable or favorable attitudes towards the fundamental behavior, 'normative beliefs' lead to a perceived subjective norm or social pressure and 'control beliefs' lead to perceived behavioral control (Asongu, 2018; Asongu et al., 2018).

Finally, the TAM undertaken by Davis (1989) assumes that technology adoption is explained by the customer's deliberate willingness to undertake and use the technology. According to Yousafzai, Foxall, and Pallister (2007); Yousafzai, Foxall, and Pallister, (2007), the TAM has evolved into a tight and powerful model. According to the authors, the TAM adapts the TRA's framework and assumes that technology adoption is explained by individuals' deliberate intent to believe and use the underlying technology. Asongu (2018) defines intention as the individual's perception of the usefulness of technology or attitude towards its use.

*Conceptual framework*

Fig. 1 illustrates the pathways by which ICT affects agricultural exports. Market participation by farmers to sell their production is faced with many obstacles such as transaction cost, primarily through information asymmetry which in most developing countries still prevails (Svensson and Yanagizawa, 2008). As a result, there have been information-related problems such as moral hazard and adverse selection (Akerlof, 1970; Horowitz & Litchenberg, 1993) that in turn increase transaction costs, hence limiting farmers' participation in the market (Okello et al., 2012). To solve this problem, ICT introduction in the agricultural export sector remains a better way. Thus, for neoclassical economists, ICT use changes the general equilibrium conditions and reduces transaction costs by reducing asymmetry information. In this study, ICT use is measured by mobile-cellular telephone subscriptions and individuals using the internet. Indeed, farmers who operate in markets with cell phone coverage or fixed line internet access can search across different suppliers, benchmark prices, and sell in a greater number of markets. ICT supports farmers by facilitating access to many kinds of information including price (Aker, 2008; Liu et al., 2021), descriptions of supply chain networks and marketing practices (Halewood & Surya, 2012; Majumdar & Singh, 2019). Better data visibility can help farmers and wholesale buyers connect with geographically dispersed producers and trace products from the farm gate to the market. ICT use increases access to regional/international markets by reducing the distance between the farmers and the buyers and in turn improves agricultural export.

*Theoretical*

Source: Authors' compilation

This paper employed the theoretical model published by Armington

(1969) to evaluate ICT's impact on Beninese cashew nut export, which is based on a two-stage consumer utility maximization program. In the first stage, a country, considered as the decision entity, determines the total demand per product necessary to satisfy the country's consumption. In the second stage, the country allocates its production share to each individual supplier, seeking to minimize its costs. In Armington's model, the utility function maximized by consumers is with substitution constant elasticity.

The resultant demand functions are described by aggregate income or a proxy for activity in the importing country, foreign prices of traded items, and their local price equivalent. Furthermore, customers aren't vulnerable to the monetary illusion, which contributes to the demand function homogeneity. As a result, the function is represented by equation (1):

$$P_x X = g(wd, p_x, p^*) \text{ with } \frac{\partial g}{\partial wd} + \frac{\partial g}{\partial p_x} + \frac{\partial g}{\partial p^*} = 1 \tag{1}$$

X indicates the export demand amount, wd represents the rest of the world's demand for a country, p\_x the price of the exported product and p^\* its price abroad. Considering degree 1 homogeneity, Armington (1969) finds the volume export function specification in equation (2):

$$X = g(Wdr, rpr_x) \tag{2}$$

Wdr represents the real-world demand targeted at the nations under consideration and rpr\_x the price competitiveness term, i.e. the relative price index.

*Empirical model*

To analyze the ICT's effect on cashew nut export in Benin, ARDL approach is used. Because of its several benefits, the Pesaran, Shin, and Smith (2001) ARDL bounds test is used over Johansen and Juselius (1990) cointegration test to determine whether there is a long-run relationship between ICT and cashew nut export in Benin. Indeed, this technique's benefits are as follows: (i) it can be applied whether variables are a mixture integrated of zero I(0) or one I(1) order; (ii) both long and short run impacts may be quantified (Bentzen and Engsted, 2001) and; (iii) it can be used even if the sample sizes are small (Ghatak and Siddiki, 2001).

ARDL approach is chosen because it has been used in several studies, notably by Sertoglu and Dogan (2016) to determine empirically factors that influence agricultural trade in Turkey and by Oyelami et al. (2022) to analyze the ICT infrastructure effect on agriculture sector performances in SSA.

The F-test for joint significance of lagged level variables is the first stage in the ARDL boundary testing technique (Muibi et al., 2016; Olaniyi, 2017). For this, we suppose that H0: λ1 = λ2 = 0 is long-run relationship's nonexistence null hypothesis versus Ha: λ1 ≠ λ2 ≠ 0 as a long-run relationship's existence alternative hypothesis. If the estimated F-statistic is less than the lower bound, nullity is not rejected; but if the calculated F-statistic is greater than the upper critical constraint, nullity is rejected. The second stage in the ARDL boundary testing technique consists of estimating both long and short-run parameters by using an error correction model. The ARDL approach used to evaluate ICT's impact on cashew nut export is described in equation (3)

$$\begin{aligned} \ln(qexport_t) = & \alpha_0 + \alpha_1 \ln(qexport)_{t-1} + \alpha_2 \ln(prod)_{t-1} + \alpha_3 \ln(prodm)_{t-1} + \alpha_4 \ln(tdfcfa)_{t-1} \\ & + \alpha_5 mo100_{t-1} + \alpha_6 internet_{t-1} + \beta_1 \sum_{i=0}^q \Delta \ln(qexport)_{t-i} + \beta_2 \sum_{i=0}^q \Delta \ln(prod)_{t-i} + \beta_3 \sum_{i=0}^q \Delta \ln(prodm)_{t-i} \\ & + \beta_4 \sum_{i=0}^q \Delta \ln(tdfcfa)_{t-i} + \beta_5 \sum_{i=0}^q \Delta mo100_{t-i} + \beta_6 \sum_{i=0}^q \Delta internet_{t-i} + ECT_{t-1} + \epsilon_t \end{aligned} \tag{3}$$

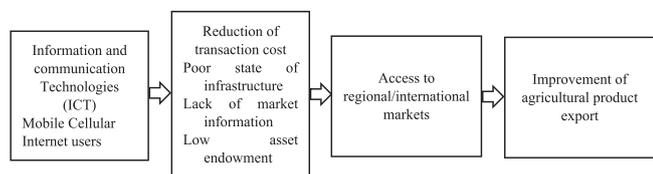


Fig. 1. A framework for analyzing the role of ICT in Agricultural product export. Source: Authors.

with  $q_{export}$  the quantity of raw cashew nut exported by Benin in year  $t$ ;  $prod$  is Benin’s cashew nut production in year  $t$ ;  $prodm$  is the world cashew nut production in year  $t$ ;  $tdfcfa$  is the US dollar to CFA franc exchange rate in year  $t$ ;  $mo100$  captures mobile-cellular telephone subscription and  $internet$  refers to individual using the internet.  $a_0$  refers to the constant term;  $\epsilon$  is the maximum length of lag;  $\Delta$  refers to the first difference operator;  $\varepsilon$  is residuals of white noise and ECT represents the estimated error correction term.

Data sources

This study covers Benin country from 1990 to 2020. Data are extracted from several sources. The dependent variable which is the cashew nut quantity exported by Benin was provided by the Food and Agriculture Organization database. The interest variable is ICT use, measured respectively by mobile-cellular telephone subscription and individual using the internet are obtained from the International Telecommunication Union (ITU) database. This variable choice is sourced from Oyelami et al. (2022) and Chung et al. (2013). The expected sign is positive, meaning that ICT use increases the cashew nut quantity exported. The control variables used in this study are Benin cashew nut production in tons, world cashew nut production in tons and exchange rate. All control variables data are sourced from the FAO database. The exchange rate measured by US dollar to CFA franc exchange rate provided by Eshetu and Mehare (2020) and Bereket (2020) and the expected sign is positive. The Benin cashew nut production expected sign is positive, meaning that the rise in domestic cashew production increases the cashew nut quantity exported. The variable used is provided by Boansi, Lokonon, and Appah (2014). World cashew nut production is expected to be positive, meaning that the rise in world cashew production increases cashew nut quantity exported.

Table 1 summarizes all the variables used in the estimation as well as their measurement and expected sign.

Results and discussion

Descriptive analysis

Descriptive statistics are performed on all variables included in the ARDL model (Tables 2 and 3). The cashew nut exported average quantity is around 54124.29 tons, while the average national production is around 80156.16 tons. World cashew nut production, including Benin, is 2,355,685 tons. Then, the average exchange rate of the dollar in CFAF

Table 1 Model variables description.

Variables	Measures	Sources	Sign
lnQEXPORT	Cashew nut quantity exported by Benin in tons	FAO	
lnPROD	Benin cashew nut production in tons	FAO	+
lnPRODM	World cashew nut production in tons	FAO	+
lnTDFCFA	US dollar to CFA franc exchange rate	FAO	+/-
MO100	Access to ICT, measured by mobile-cellular telephone subscription (per 100 people)	ITU	+
INTERNET	Usage of ICT, measured by individuals using the internet (% of population)	ITU	+

Source: Authors’ compilation.

Table 2 Data descriptive analysis.

Variables	Mean	Std. Dev.	Min.	Max.
QEXPORT	54124.29	41233.37	1200	131,241
PROD	80156.16	67899.06	3000	225,230
PRODM	2,355,685	1,023,871	831,356	4,027,932
TDFCFA	519.566	117.3043	264.6918	733.0385
MO100	35.28156	39.66123	0	96.23029
INTERNET	4.73151	7.40925	0	25.8

Source: Authors’ computation,

is 519.566 CFAF. In other words, one dollar goes for an average of 519.566 CFAF. The dollar being a flexible currency, implies that the more it appreciates, the more currency Benin makes from cashew nut sales and its depreciation also reduces the currency inflow from the cashew nut sale. Finally, per 100 people, about 35.28 % have subscribed to mobile cellular phones while 4.73 % of the Benin population use the internet.

Fig. 2 presents ICT evolution (MO100 and internet) and the cashew nut quantity exported. During the period 1990–2020, cashew nut quantity exported, and ICT (both MO100 and internet) have shown an increasing evolution with some instabilities during certain periods for the variables cashew nut quantity exported and MO100. Between 1996 and 1997, an increase in both MO100 and the internet was followed by an increase of 7979 tons in cashew nut quantity exported. Between 1999 and 2000, cashew nut quantity exported experienced an increase of 7162 tons due to an increase in MO100 and internet, respectively. Between 2005 and 2006, an increase in both MO100 and the internet was followed by an increase of 26,485 tons in cashew nut quantity exported. Between 2008 and 2011, cashew nut quantity exported experienced an increase of 65,011 tons due to an increase in MO100 and internet, respectively. Finally, despite an increase both in MO100 and the internet during the period 2018–2020, cashew nut quantity exported experienced a decrease. This can be explained by the fact that, since 2018, the Beninese government applied tax on social networks, driving up internet access prices.

Econometric results

Dicker and Fuller’s Augmented stationary test is used to determine whether or not our variables contained a unit root (Table 4). The findings reveal that the cashew nut amount exported (lnQEXPORT) and the cashew nut national production (lnPROD) are stationary in level, respectively at 1 % and 5 %. The world cashew nut production (PRODM), the dollar in CFAF exchange rate (TDFCFA) and the mobile cellular telephone subscription are stationaries at the first difference while the individual using the internet is stationary at the second difference. These results showed a long-run relationship existence and suggested bounds test application.

Table 5 displays bounds test results, which demonstrate that the estimated F-statistic is greater than the upper critical bound at the different significance levels. As a result, the null hypothesis is rejected and confirms a long-run relationship existence.

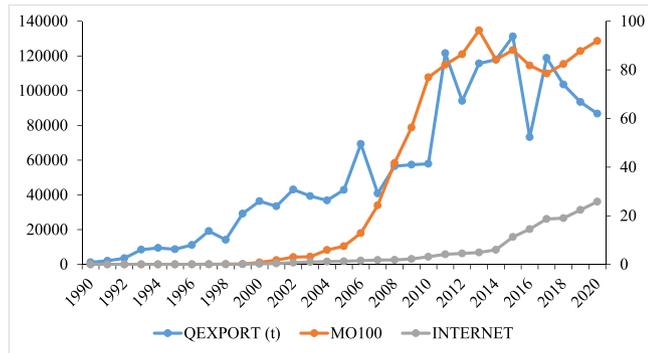
Following the bounds test, which reveals a long-run relationship existence, the ARDL (3, 3, 2, 1, 3, 2) model is estimated to determine short and long-run parameters. Table 6 presents the long-run coefficients for the ARDL (3, 3, 2, 1, 3, 2) model and for the ARDL (3, 3, 2, 1, 3, 2) error correction model estimation results of short-run dynamics. The error correction term is significant and negative, suggesting that the system corrects for previous period shocks and disequilibrium with an annual speed of adjustment of around 266.4 %.

Empirical results suggest that mobile cellular telephone subscription reduces cashew nut export in the short-run but improves cashew nut export in the long-run. The results suggest that, in the long-run, a rise of mobile cellular telephone subscriptions by one person increases cashew nut export by 0.004 %. However, individuals using the internet had no

**Table 3**  
Correlation matrix.

	QEXPORT	PROD	PRODM	TDFCFA	MO100	INTERNET
QEXPORT	1.0000					
PROD	0.9435	1.0000				
PRODM	0.8895	0.8501	1.0000			
TDFCFA	0.2824	0.2105	0.3343	1.0000		
MO100	0.9046	0.9425	0.8728	0.1053	1.000	
INTERNET	0.6670	0.6541	0.7554	0.2330	0.7494	1.000

Source: Authors' computation.



**Fig. 2.** Evolution of ICT and cashew nut quantity exported. Source: Authors' computation.

**Table 4**  
Stationarity test on variables.

Variable	ADF unit root test		Order
	Stat.	Prob.	
lnQEXPORT	-3.429***	0.0100	[0]
lnPROD	-3.003**	0.0346	[0]
lnPRODM	-6.645***	0.0000	[1]
lnTDFCFA	-5.351***	0.0000	[1]
MO100	-3.134**	0.0241	[1]
INTERNET	-8.710***	0.0000	[2]

Source: Authors' computation (\*\*\*, \*\*, \*): 1%, 5% and 10% level of significance respectively.

**Table 5**  
Bounds test.

F-statistics	Significance level	I(0)	I(1)
26.314	10 %	2.26	3.35
	5 %	2.62	3.79
	2.5 %	2.96	4.18
	1 %	3.41	4.68

Source: Authors' computation.

significant effect on cashew nut export in the short-run but negatively influenced cashew nut export in the long-run. Indeed, an increase of 1 % of internet users decreases cashew nut export by 0.030 %.

Among the control variables, world cashew nut production and exchange rate are the other cashew nut export determinants. Indeed, an increase in global cashew nut output has a considerable and beneficial the long-run impact on its exports but a negative effect in the short-run. In other words, a 1 % increase in global cashew nut output in long-run increases cashew nut export by 1.986 %. The dollar-CFAF exchange reduces cashew nut export in the short-run but has a considerable and favorable impact on cashew nut export in the long-run. This conclusion suggests that, while the exchange rate increases by 1 %, this improves cashew nut export by 0.73 % in the long-run. In other words, as the value of the dollar rises, the country will be more inclined to export its agricultural goods.

**Table 6**  
Estimated coefficients of long run for the ARDL (3, 3, 2, 1, 3, 2) model.

Variables	Coefficient	Std. error	T-statistic	P-value
<b>Long-Run</b>				
MO100	0.004**	0.002	2.52	0.036
INTERNET	-0.030***	0.006	-5.19	0.001
lnPROD	0.100	0.097	1.04	0.330
lnPRODM	1.986***	0.124	15.97	0.000
lnTDFCFA	0.735***	0.113	6.49	0.000
Constante	-63,748***	6.748	-9.48	0.000
<b>Short-Run</b>				
ECT(-1)	-2.664***	0.262	-10.18	0.000
D(lnQEXPORT(-1))	0.892***	0.158	5.63	0.000
D(lnQEXPORT(-2))	0.432**	0.136	3.19	0.013
D(MO100)	-0.037***	0.005	-7.33	0.000
D(MO100 (-1))	-0.033***	0.005	-6.05	0.000
D(MO100 (-2))	-0.026**	0.006	-4.11	0.003
D(INTERNET)	0.027	0.031	0.86	0.415
D(INTERNET(-1))	-0.052	0.032	-1.63	0.142
D(lnPROD)	0.214	0.213	1.00	0.344
D(lnPRODM)	-3.358***	0.664	-5.05	0.001
D(lnPRODM(-1))	-2.498***	0.478	-5.22	0.001
D(lnPRODM(-2))	-1.539**	0.496	-3.10	0.015
D(lnTDFCFA)	-0.690**	0.281	-2.49	0.040
D(lnTDFCFA(-1))	-0.257	0.215	-1.20	0.266

Source: Authors' computation (\*\*\*, \*\*, \*): 1%, 5% and 10% level of significance respectively.

**Discussion**

The ARDL model estimation demonstrates that mobile cellular telephone subscription had a significant impact on cashew nut export in the long-run and a negative relationship in the short-run. The plausible explanation is that in the short-run, farmers need time to understand ICT and use it. The long-run results are in line with [Oyelami et al. \(2022\)](#) who found that the mobile subscription variable improves agricultural export, but contrasts with [Chung et al. \(2013\)](#) who found no relationship between mobile cellular telephone subscription and the value of international trade in fruit and vegetables. However, internet users deteriorate cashew nut export in the long-run. A plausible explanation is due to their weakness rate compared to mobile cellular telephone subscriptions. For example, in 2014 while about 84 % of people subscribed to mobile cellular telephones, only 6 % of individuals use the internet. Another explanation is the high ICT cost which for the mobile cellular sub-basket was US\$13.8/month compared to a sub-Saharan average of US\$11.7/month. The internet service cost is very high for farmers and this does not encourage agricultural export through internet use. These results are supported by [Oyelami et al. \(2022\)](#) who found a negative relationship between internet users and agricultural export but on contrary, [Chung et al. \(2013\)](#) found that an increase in internet users will stimulate agricultural trade between APEC trading partners. According to [Oyelami et al. \(2022\)](#), the situation in the long-run may simply reflect the underutilization of the internet for agricultural marketing and sales at the global level. This may be traceable to a low level of awareness and education on internet use for productive engagement in marketing and agricultural sales.

The dollar-CFAF exchange rate has a considerable and favorable impact on cashew nut export in the long-run but has a negative effect in the short-run. Theoretically, a country that had a low device had a commercial advantage compared with those that had a high device. However, this is possible if the country produces a lot and has a surplus that can be exported. Benin's government didn't realize that having a low device is an advantage for it, this explains the negative relationship found in short-run. This trend can be changed in the long-run if Benin's government takes some policies to increase the cashew nut domestic production. The results are supported by Eshetu and Mehare (2020) and Bereket (2020), who discovered that exchange rate enhances export amounts. And contrary to Sertoglu and Dogan (2016) and Zeray and Gachen (2014) who found that the exchange rate decreased exports amount but was concomitant with short-run results. According to Eshetu and Mehare (2020), this positive link exists because currency depreciation or a rise in exchange rate reduces export relative price, which leads to a greater export value.

### Conclusion and policy implications

ICT represents in recent years an important asset for the development of any nation because of its importance of promoting business activities by reducing distances. Their application in various economic sectors is increasing year after year. The agricultural sector is also not spared by the innovations due to ICT. Therefore, sectoral ICT can promote agricultural trade. Thus, to analyze the ICT's effect on cashew nut exports, an ARDL model is used based on FAO and ITU data. The findings showed that mobile cellular telephone subscription lessens cashew nut export in the short-run but improves cashew nut export in the long-run while individual using the internet had no significant effect on cashew nut export in the short-run but negatively influenced cashew nut export in the long-run. Other cashew nut export determinants include world cashew nut production and exchange rate. World cashew nut production positively influenced cashew nut export while the exchange rate had a positive effect on cashew nut export in long-run but a negative effect in short-run.

Our findings support the statement that ICT is a key element in international trade, especially for agricultural export because it reduces the distance between countries and facilitates exchange and price diffusion through online platforms. However, the establishment of an enabling framework for cashew nut export is the result of a combination of several policy instruments put together. To benefit from ICT's positive effect on its economy through cashew nut export, Beninese's government must (i) put in place safeguards to control people's access to the internet to avoid cybercrime activities that in the long-run, can negatively affect cashew nut export and (ii) invest in technologies infrastructures to improve internet access and lower the internet access costs. Also, the government must invest in farmers' education because education will allow them to better understand and use ICT. Beninese government must invest more in agricultural institutions to increase cashew nut production and profits of the lowest of its devices to export more cashew nuts on the international market through ICT use.

Investment in ICT infrastructures plays a crucial role in lowering the internet cost to improve agricultural exports. However, the limitation of this paper is that it didn't consider the role of investment in ICT infrastructures in the ICT adoption – cashew nut export nexus and this opens doors for future researches. Future study could for example explore the effect of ICT on cashew nut export with a focus on the role of investment in ICT infrastructures. Also, another limitation of this study is that it is focused on Benin. Therefore, future research can extend it to other countries.

### CRedit authorship contribution statement

**Armand Fréjuis Akpa:** Conceptualization, Data curation, Writing – original draft, Writing – review & editing, Formal analysis,

**Methodology. Augustin Foster Chabossou:** Conceptualization, Writing – original draft, Writing – review & editing, Supervision.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

### References

- Abeliansky, A. L., & Hilbert, M. (2017). Digital technology and international trade: Is it the quantity of subscriptions or the quality of data speed that matters? *Telecommunications Policy*, 41(1), 35–48. <https://doi.org/10.1016/j.telpol.2016.11.001>
- Abramovsky, L., & Griffith, R. (2006). Outsourcing and Offshoring of Business Services: How Important is It? *Journal of the European Economic Association*, 4(2–3), 594–601. <https://doi.org/10.1162/jeea.2006.4.2-3.594>
- Adeboye, F. B., Osabohien, R., Olokoyo, F. O., & Matthew, O. A. (2020). Foreign direct investment, globalisation challenges and economic development: An African sub-regional analysis. *International Journal of Trade and Global Markets*, 13(4), 414–433. <https://doi.org/10.1504/IJTM.2020.111124>
- Ajzen, I. (1991). The theory of planned behaviour. *Organizational Behavior and Human Decision Processes*, 50(2), 179–211. [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)
- Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, NJ: Prentice-Hall.
- Aker, J. C., & Fafchamps, M. (2015). Mobile phone coverage and producer markets: Evidence from West Africa. *World Bank Economic Review*, 29(2), 262–292. <https://doi.org/10.1093/wber/lhu006>
- Aker, J. C., & Ksoll, C. (2016). Can mobile phones improve agricultural outcomes? Evidence from a randomized experiment in Niger. *Food Policy*, 60, 44–51. <https://doi.org/10.1016/j.foodpol.2015.03.006>
- Akerlof, G. A. (1970). The market for 'lemons': Quality uncertainty and the market mechanism. *The Quarterly Journal of Economics*, 84(3), 488–1450.
- Amarnath, G., Simons, G. W. H., Alahacon, N., Smakhtin, V., Sharma, B., Gismalla, Y., Mohammed, Y., et al. (2018). Using smart ICT to provide weather and water information to smallholders in Africa: The case of the Gash River Basin, Sudan. *Climate Risk Management*, 22, 52–66. <https://doi.org/10.1016/j.crm.2018.10.001>
- Amessinou, K. (2018). *Technologies Mobiles En Milieu Agricole Au Sud Bénin: Cas Des Producteurs d'Ananas*.
- Armington, P. S. (1969). A Theory of Demand for Products Distinguished by Place of Production (Une théorie de la demande de produits différenciés d'après leur origine) (Una teoría de la demanda de productos distinguiendolos según el lugar de producción). *Staff Papers - International Monetary Fund*, 16(1), 159. <https://doi.org/10.2307/3866403>
- Arvin, M. B., Pradhan, R. P., & Nair, M. (2021). "Uncovering interlinks among ICT connectivity and penetration, trade openness, foreign direct investment, and economic growth: The case of the G-20 countries", *Telematics and Informatics. Elsevier Ltd*, 60(December), Article 101567. <https://doi.org/10.1016/j.tele.2021.101567>
- Asongu, S. A. (2018). Conditional determinants of mobile phones penetration and mobile banking in Sub-Saharan Africa. *Journal of the Knowledge Economy*, 9(1), 81–135. <https://doi.org/10.1007/s13132-015-0322-z>
- Asongu, S. A., Nwachukwu, J. C., & Aziz, A. (2018). Determinants of mobile phone penetration: Panel threshold evidence from Sub-Saharan Africa. *Journal of Global Information Technology Management*, 21(2), 81–110. <https://doi.org/10.1080/1097198X.2018.1462069>
- Bagozzi, R. (1982). A field investigation of causal relations among cognitions, affect, intentions, and behaviour. *Journal of Marketing Research*, 19(4), 562–584. <https://doi.org/10.2307/3151727>
- Baldwin, R. (2017). The great convergence: Information technology and the New Globalization. *Ekonomicheskaya Sotsiologiya*, 18(5), 40–51. <https://doi.org/10.17323/1726-3247-2017-5-40-51>
- Barbero, J., & Rodriguez-Crespo, E. (2018). The effect of broadband on European Union trade: A regional spatial approach. *World Economy*, 41(11), 2895–2913. <https://doi.org/10.1111/twec.12723>
- Bensassi, S., Márquez-Ramos, L., Martínez-Zarzoso, I., & Suárez-Burguet, C. (2015). Relationship between logistics infrastructure and trade: Evidence from Spanish regional exports. *Transportation Research Part A: Policy and Practice*, 72, 47–61. <https://doi.org/10.1016/j.tra.2014.11.007>
- Bentzen, J., & Engsted, T. (2001). A revival of the autoregressive distributed lag model in estimating energy demand relationships. *Energy*, 26(1), 45–55. [https://doi.org/10.1016/S0360-5442\(00\)00052-9](https://doi.org/10.1016/S0360-5442(00)00052-9)
- Bereket, I. (2020). The determinate of agricultural export in Ethiopia: An error correction Modle and Cointegration approach. *Journal of Economics and Sustainable Development*, 11(3), 51–57. <https://doi.org/10.7176/JESD/11-3-05>
- Boansi, D., Lokonon, B. O. K., & Appah, J. (2014). Determinants of agricultural export trade: Case of fresh pineapple exports from Ghana. *British Journal of Economics, Management & Trade*, 4(11), 1736–1754. <https://doi.org/10.9734/bjemt/2014/10773>
- Chung, K.C., Fleming, P., and Fleming, E. (2013). "The impact of information and communication technology on international trade in fruit and vegetables in APEC", doi: 10.1111/apel.12028.

- Davis, F. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13(3), 319–340. <https://doi.org/10.2307/249008>
- Dong, S., Yang, L., Shao, X., Zhong, Y., Li, Y., & Qiao, P. (2021). How can channel information strategy promote sales by combining ICT and blockchain? Evidence from the agricultural sector. *Journal of Cleaner Production*, 299. <https://doi.org/10.1016/j.jclepro.2021.126857>
- Eshetu, F., & Mehare, A. (2020). Determinants of Ethiopian agricultural exports: A dynamic panel data analysis. *Review of Market Integration*, 12(1–2), 70–94. <https://doi.org/10.1177/0974929220969272>
- Fan, J., Zhang, Y., Wen, W., Gu, S., Lu, X., & Guo, X. (2021). The future of Internet of Things in agriculture: Plant high-throughput phenotypic platform. *Journal of Cleaner Production*, 280, Article 123651. <https://doi.org/10.1016/j.jclepro.2020.123651>
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.
- Gbaguidi, I. (2020). “Commerce et chaînes de valeur dans les activités porteuses d’emplois (TRAVERA): Cas de l’anacarde au Bénin”, No. 16.
- Ghatak, S., & Siddiki, J. U. (2001). The use of the ARDL approach in estimating virtual exchange rates in India. *Journal of Applied Statistics*, 28(5), 573–583. <https://doi.org/10.1080/02664760120047906>
- Halewood, N. J., & Surya, P. (2012). *Mobilizing the agricultural value chain*. World Bank.
- Horowitz, J. K., & Litchenberg, E. (1993). Insurance, moral hazard and chemical use in agriculture. *American Journal of Agricultural Economics*, 75(4), 926–935.
- Johansen, S., & Juselius, K. (1990). Maximum likelihood estimation and inference on Cointegration - With. *Oxford Bulletin of Economics and Statistics*, 2(52), 169–210.
- Kaila, H., & Tarp, F. (2019). Can the Internet improve agricultural production? Evidence from Viet Nam. *Agricultural Economics (United Kingdom)*, 50(6), 675–691. <https://doi.org/10.1111/agec.12517>
- Lin, F. (2015). Estimating the effect of the Internet on international trade. *Journal of International Trade and Economic Development*, 24(3), 409–428. <https://doi.org/10.1080/09638199.2014.881906>
- Liu, W., Shao, X. F., Wu, C. H., & Qiao, P. (2021). A systematic literature review on applications of information and communication technologies and blockchain technologies for precision agriculture development. *Journal of Cleaner Production*, Elsevier Ltd, 298, Article 126763. <https://doi.org/10.1016/j.jclepro.2021.126763>
- MAEP. (2017). *MAEP Plan Stratégique de Développement Du Secteur Agricole (PSDSA) 2025 et Plan National d'Investissements Agricoles et de Sécurité Alimentaire et Nutritionnelle PNIASAN 2017-2021*.
- MAEP, MENC, ITU and FAO. (2019). *Stratégie Nationale Pour l'e -Agriculture Au Bénin 2020-2024*.
- Majumdar, K., & Singh, R. K. (2019). Impact of information and communication technology on marketing of rice A study of Uttar Pradesh. *International Journal of Social Economics*, 46(9), 1061–1080. <https://doi.org/10.1108/IJSE-02-2019-0105>
- Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), 1695–1725. <https://doi.org/10.1111/1468-0262.00467>
- Muibi, S. O., Osi, A. R., Evans, O., & Seun, T. (2016). Determinants of stock trading volume in Nigeria: Money demand approach. *Journal of Empirical Economics*, 5(2), 74–89.
- Nakasone, E., Torero, M., & Minten, B. (2014). The power of information: The ICT revolution in agricultural development. *Annual Review of Resource Economics*, 6(1), 533–550. <https://doi.org/10.1146/annurev-resource-100913-012714>
- Okello, J. J., Kirui, O. K., Njiraini, G. W., & Gitonga, Z. M. (2012). Drivers of use of information and communication technologies by farm households: The case of smallholder farmers in Kenya. *Journal of Agricultural Sciences*, 4(2), 111–124.
- Olaniyi, E. (2017). Back to the land: The impact of financial inclusion on agriculture in Nigeria. *Iranian Economic Review*, 21(4), 885–903. <https://doi.org/10.22059/ier.2017.64086>
- Osabohien, R. (2023). ICT adoption and youth employment in Nigeria’s agricultural sector. *African Journal of Economic and Management Studies*. <https://doi.org/10.1108/AJEMS-03-2022-0111>
- Oyelami, L. O., Sofoluwe, N. A., & Ajeigbe, O. M. (2022). ICT and agricultural sector performance : Empirical evidence from sub - Saharan Africa. *Future Business Journal*. <https://doi.org/10.1186/s43093-022-00130-y>
- Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, 16(3), 289–326. <https://doi.org/10.1002/jae.616>
- Portugal-Perez, A., & Wilson, J. S. (2012). Export performance and trade facilitation reform: Hard and soft infrastructure. *World Development*, 40(7), 1295–1307. <https://doi.org/10.1016/j.worlddev.2011.12.002>
- Radoglou-Grammatikis, P., Sarigiannidis, P., Lagkas, T., & Moscholios, I. (2020). A compilation of UAV applications for precision agriculture. *Computer Networks*, 172, Article 107148. <https://doi.org/10.1016/j.comnet.2020.107148>
- Ricardo, D. (1817). *Principles of Political Economy and Taxation*, London.
- Rodriguez-Crespo, E., Marco, R., & Billon, M. (2021). ICTs impacts on trade: A comparative dynamic analysis for internet, mobile phones and broadband. *Asia-Pacific Journal of Accounting and Economics*, 28(5), 577–591. <https://doi.org/10.1080/16081625.2018.1519636>
- Rodriguez-Crespo, E., & Martínez-Zarzoso, I. (2019). The effect of ICT on trade: Does product complexity matter? *Telematics and Informatics*, 41(May), 182–196. <https://doi.org/10.1016/j.tele.2019.05.001>
- Sertoglu, K., & Dogan, N. (2016). Agricultural trade and its determinants: Evidence from bounds testing approach for Turkey. *International Journal of Economics and Financial Issues*, 6(2), 450–455.
- Smith, A. (1776). *Recherche Sur La Nature et Les Causes de La Richesse Des Nations*, *Recherche Sur La Nature et Les Causes de La Richesse Des Nations*, doi: 10.1522/cla.sif.sma.rec6.
- Svensson, J. and Yanagizawa, D. (2008), *Getting Prices Right: The Impact of the Market Information Service in Uganda*.
- Tadesse, G., & Bahiigwa, G. (2015). Mobile phones and farmers’ marketing decisions in Ethiopia. *World Development*, 68, 296–307. <https://doi.org/10.1016/j.worlddev.2014.12.010>
- World Bank. (2016). *Digital Divide, Computer Graphics World*, Vol. 24.
- Yousafzai, S., Foxall, G. R., & Pallister, J. (2007). Technology acceptance: A meta-analysis of the TAM. Part 1. *Journal of Modelling in Management*, 2(3), 251–280.
- Yousafzai, S., Foxall, G. R., & Pallister, J. (2007). Technology acceptance: A meta-analysis of the TAM. Part 2. *Journal of Modelling in Management*, 2(3), 281–304.
- Yousafzai, S. Y., Foxall, G. R., & Pallister, J. G. (2010). Explaining internet banking behavior: Theory of reasoned action, theory of planned behavior, or technology acceptance model? *Journal of Applied Social Psychology*, 40(5), 1172–1202. [https://doi.org/10.1111/\(ISSN\)1559-1816](https://doi.org/10.1111/(ISSN)1559-1816)
- Zeray, N., & Gachen, D. (2014). Determinants of Bilateral Trade between Ethiopia and Its Major Trading Partners: A Gravity Model Approach. *Journal of Economics and Sustainable Development*, 5(15), 82–89.