SOCIOECONOMIC DETERMINANTS OF INFORMATION AND COMMUNICATION TECHNOLOGY ADOPTION AMONG RICE FARMERS IN EBONYI STATE, NIGERIA

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ABSTRACT

Adoption and utilization of information and communication technology (ICT) is paramount for improved agricultural productivity. This study employs a combination of descriptive statistics, logit model, and analysis of variance to examine the factors that drive ICT adoption among rice farmers in Ebonyi State, South-East Nigeria. A sample of 476 rice farmers was identified and selected using the snowball sampling technique. The results of the study established that degree of awareness, farmer's perception, educational attainment, income level, age, training, cost of ICT device are significant determinants of ICT adoption by farmers. On the other hand, differences in gender do not significantly determine ICT adoption. Findings also show that there are income improvements among ICT adopters. The study recommends greater focus on ICT training of farmers to improve adoption and boost rice output in the state.

JEL classification: D8, Q16, N5

1. Introduction

Rice is a staple food for about 50% of the world's population but predominant in the Asian and African continents (FAO, 2016). In Nigeria, agriculture is arguably the backbone of the rural economy, while rice production commands a significant position in the farming lives of numerous communities in the eighteen rice-growing states (Ani, Gift & Ecoma, 2017). Ebonyi State, known for the production of the famous *Abakaliki rice,* is synonymous with locally grown rice. Though the state is geographically and naturally endowed for rice production, rice production in the state has been largely inconsistent (Umeh & Chukwu, 2015). Ebonyi State experienced increases in rice yield from 2.7 MT/ha, to about 3.6 MT/ha between 2009 and 2011, followed by a 1 MT/ha dip in 2012. As of 2015, rice yield in Ebonyi State was 2.6 MT/ha (EBADEP, 2016). Despite this, Ebonyi State has about 72,000 hectares capacity for rice production (six tonnes per hectare) with targets to reach half a billion tons per hectare annually. This translates into ₦48.4bn revenue annually from rice production (Ukoh, 2017) and highlights the importance of staples such as rice in the state. This projection can be substantially achieved with the adoption of information and communication technology (ICT).

In the context of this study, ICT symbolizes all technologies that are utilized for the acquisition, organization, and propagation of information used in farm businesses. ICT is acknowledged globally as an essential tool that empowers farmers, promotes their skills, enhances agricultural output, and boosts their standard of living through enhanced earnings. Thailand, for instance, one of the world's leading rice exporters, developed and implemented different approaches to enhance agricultural information access and utilization. The Ministry of Agriculture and Cooperatives (MoAC) of the Royal Thai Government (RTG) in 1995 championed ICT utilization to make agricultural information more accessible to Thai farmers. The MoAC established a web-based statistical database on essential agricultural information, including rice cultivation (MoAC, 2014) that enhanced rice output. Similarly, farmers in Ghana utilize E-Soko, a 'mobile and web-enabled repository of current market prices' and a platform for interactions between buyers and sellers. Results show improved revenue for farmers by 10% since the adoption of the platform in northern Ghana (Halewood & Surya, 2012). Farmers in Rwanda use ICT to compare grain market prices, and fishermen can sell their catch daily, and minimize waste and spoilage through easy customer location.

In rural Niger, agricultural price information gotten via mobile phones minimizes search costs by roughly 50% (Aker & Mbiti, 2010). In Senegal, a website assists vulnerable communities to access information on adaptation to climate change. It supports a community of practice where farmers share updates of their adaptation and work methods. Cameroon's AgroSpaces and Kenyan M-Farm provide price information to eliminate price asymmetry between consumers and farmers, hence enabling farmers to gain more (Ekekwe, 2017). Ghana-based AgroCenta and Farmerline deploy web and mobile technologies that bring weather forecasts, farming recommendations, financial tips, and market information to farmers who are usually not accessible due to language, literacy, and connectivity barriers (Ekekwe, 2017). In Kenya, Sokopepe uses web tools and SMS to provide farm management record services and market information to farmers (Ekekwe, 2017).

In Nigeria, the e-wallet system introduced in 2012 was designed to remove middlemen and provide the latest agricultural information directly to farmers' mobile phones, and the Smart Farmer Scheme was subsequently introduced to boost agricultural production. In general, the advantages of using ICT in encouraging access to price data in Africa have resulted in increases of about 36% of farmers' income, such as in Morocco, Uganda, and Ghana (Halewood & Surya, 2012). However, some barriers associated with ICT use among rice farmers in Nigeria (Ebonyi State inclusive) include lack of awareness, high cost of ICT equipment, access to finance, shortage of ICT related training, epileptic power supply, high cost of interconnectivity/access, maintenance costs among others (Akpabio, Okon, & Inyang, 2007).

In the literature, farmer's socio-economic features have featured significantly in explaining farmers' ICT adoption decisions. Farmer's education, income, gender, farm size, age, on-farm/off-farm earnings, access to credit, and extension contact have been identified to be significantly connected to ICT adoption in agriculture (Ghimire, Huang & Shrestha, 2015; Mittal & Mehar, 2015; Simtowe, Asfaw & Abate, 2016). However, previous studies have restricted the assessment of adoption preference by farmers to one ICT (Nyamba & Mlozi, 2012; Maina 2015; Akinola, 2017; Sikundla, Mushunje & Akinyemi, 2018) such as radio or mobile phone, while only a few studies have focused on two or more ICTs (Sobalaje & Adigun, 2013; Ezeh, Eze & Aleke, 2015; Mittal & Mehar, 2015). Also, existing studies do not consider the existence or otherwise of a difference between the earnings from pre- and post ICT-adoption. Hence, this study focuses on the determinants of ICT adoption by rice farmers in Ebonyi State. It is imperative to understand the factors that determine ICT adoption by rice farmers in order to develop targeted policies and programmes that can facilitate ICT adoption to enhance their productivity and standard of living.

Against this background, the next section discusses the rice economy in Ebonyi State in particular. Section 3 contains a review of literature. Section 4 presents the methodology utilized to achieve the study objectives. Section 5 presents the empirical results, and section 6 concludes the paper.

2. Rice Economy in Ebonyi State

According to a report by the National Bureau of Statistics in 2011, annual household expenditure on rice accounts for 10% of household food expenditure and 6.6% of aggregate household expenditure. Similarly, the annual per capita consumption of 32kg of rice is the highest of any staple in Nigeria. Between 1961 and 1990, rice consumption rose from 240,000 tons to 2.1 million tons, increasing at an annual average of 7.8% annually. The rapid increase in rice demand started in the 1970s, coinciding with crude oil discovery. The resultant economic growth improved per capita incomes and general consumption. In addition, the attention focused on the oil sector led to neglect of the agricultural sector, resulting in slower growth in food production. Also, urban consumers preferred imported rice owing to perceived higher quality, fuelling further rice importation to meet rising demand. However, rice imports have dropped by 33.3% (a five-year record) reaching 2.7 million tons in 2017, due to policies on import substitution – import tariffs and inclusion of rice in the list of 41 items barred from foreign exchange in the official market (Pwc, 2018). Despite these, Nigeria remains the single largest rice importer in Africa and third largest globally, with India and Thailand as its main import sources (Gyimah-Brempong, Johnson, and Takeshima, 2016).

In Ebonyi State, rice is the main staple food crop and home to the popular *Abakaliki rice*. It is commonly cultivated across the three agro-ecological regions of the state and constitutes a key income source for rural farm households (Okereke, Ndukwe, Oroke & Onwe, 2017; Olawale, 2017). Since the creation of the state in 1996, successive administrations have implemented various programmes and policies targeted at stimulating increased production of rice. Some of the notable policies in this regard include the creation of the Ebonyi State Fertilizer and Chemical Company in 2004, and the construction and installation of an 80 MT/day capacity modern mill in each of the state's three agro-ecological regions in 2013 (Okorie, Onyeabor & Okereke, 2013). Following these efforts, data on rice production in the state has been somewhat mixed as depicted in table 1.

Table 1. Key Rice Production Variables in Ebonyi State, 2008-2015

Year	Area crop yield (MT/ha)	Cropped land area (000ha)	Output (000MT)	Output price/MT (N'000)
2008	3	97.89	293.67	225
2009	2.74	108.14	296.35	246.3
2010	3.65	111.31	406.61	130
2011	3.606	113.02	407.55	143.83
2012	2.665	110.6	294.8	143.3
2013	2.673	116	310.1	135
2014	2.393	-	-	NA
2015	2.654	-	-	NA

Source: Ebonyi State Agricultural Development Programme (2016). (NA = Not available)

Table 1 portrays an increase in crop yield from 2009 to 2011. In addition to the aforementioned efforts of the state government, this increase can be ascribed to the impact of the presidential initiative on rice introduced in 2002 by the Federal Government of Nigeria. The initiative provided farmers with some incentives, such as improved seed and fertilizer, which enhanced rice production (Anyanwu, Amoo, Odey, & Adebayo, 2010). There was also an aggressive sensitization drive by the federal government to encourage farmers to adopt rice production as a viable means of livelihood. The downward trend noticed between 2011 and 2012, on the other hand, can be linked to the floods of 2012, lack of ICT adoption, and negative impacts of politics on rice production[1].

In 2013, the federal government launched the Agricultural Transformation Agenda in the state. As a result, input subsidies were given to farmers through the Growth Enhancement Scheme (GES) programme, resulting in improved rice yield for the period (Okorie et al., 2012). The upward trend reduced slightly to

[1] There are suggestions that most farmers in the state tend to participate in election-related activities (rallies, party meetings etc) at the expense of farming activities (Okereke et al., 2017).

2.393MT/ha in 2014 but increased to 2.654MT/ha in 2015. Following the establishment of three modern rice mills in strategic zones of the state in 2013, farmers were encouraged to increase rice production activities and boost their agricultural practices. Again, since 2013, Ebonyi State government has been consistent in counterpart fund payment for development partner-assisted projects, such as FADAMA III and the International Fund for Agricultural Development (IFAD). Hence, some of the rice farmers have profited from the enhanced input subsidies given by these agencies, thereby increasing rice yield (Okereke et al., 2017).

In 2016, the sale of foreign rice in the state was banned by the state government to guarantee attractive commodity pricing for locally-produced rice, lessen competition, and encourage local consumption (Okereke et al., 2017). The government equally rolled out a number of input support services to local farmers and timely payment of counterpart funds to international development partner-assisted projects, focusing mainly on rice production (Ituma, 2016). As noted by Ituma (2016), about 10,837 farmers (35% of which are female) are profiled under the state government's direct rice production project, International Fund for Agricultural Development (IFAD)-Assisted Project and Fadama III Additional Financing Project.

There is also the 'one man, one-hectare' programme launched by the state government in September 2016, aimed at motivating youths to participate in agriculture and boost rice production in the state (Okoro, 2018). Under this programme, the state government acquired plots of land in various communities across the state and allocated them to young farmers to boost crop production, especially rice. Assistance was given to such farmers in the form of agricultural extension services and capital inputs. This encouraged many farmers in the state to further embrace rice production (Okereke et al., 2017). The state government also purchased over 40 tractors and different units of other rice production implements and machinery in 2016 for rent to interested farmers and institutional use (Olawale, 2017). This not only lowered drudgery and labour cost but also encouraged the youth of the state to take up rice farming as an occupation.

3. Literature Review

There is a large body of literature on the factors that drive ICT adoption by farmers. However, there are also many factors underlying farmers' choice of

ICT, which in turn influence the use of such technologies. Existing literature shows that the ICTs that farmers adopt tend to vary according to educational level, gender, income, age, household size, farming experience, among others, and these variables differ between individuals and within communities, regions, and countries.

Basically, agriculture literature highlights two main factors behind effective ICT adoption, especially in developing nations – the affordability and availability of ICT and farmers' anticipation of long-term profitability. Furthermore, determinants of ICT adoption are grouped based on three factors – economic, social, and institutional. According to Akudugu, Guo, and Dadzie (2012), the economic factors include access to credit, farm size, adoption cost, expected benefits, and off-farm income generation activities. The social factors include the gender of the farmers, age, and educational level, while the institutional factor includes access to extension services.

With regard to age, young and old people exhibit different preferences and risk attitudes. Morris and Venkatesh (2000) reveal that ICT usage among younger people is more likely to be influenced by their ability to acquire and use the devices, whereas idiosyncratic customs and perceived behavioural expertise are likely to influence the use of such devices for older people. The value attached to ICT devices is also influenced by age as young people tend to attach higher value to ICT devices. Moreover, young people are generally perceived as more pragmatic, knowledgeable, aware, and open to new technologies (Cant & Shen, 2006). While Akinola (2017) reports that age is not a significant factor in ICT adoption, Mittal and Mehar (2015), Sobalaje and Adigun (2013), Umeh and Chukwu (2015), Ezeh et al (2015), and Onyeneke (2017) all corroborate Musa, Githeko, and El-siddig's (2014) findings that age is an important factor that determines ICT adoption.

Farmer's decision to adopt ICT can be viewed along gender lines. Women are more risk-averse, and male farmers tend to engage in more geographically dispersed social networks, hence creating higher opportunities for them to access information and embrace ICT (Croson & Gneezy, 2008). The literature shows mixed pieces of evidence on the gender effect of ICT adoption. While Nyamba and Mlozi (2012), Umeh and Chukwu (2015), and Wawire, Wangia, and Okello (2017) report gender as a significant determinant for ICT adoption, studies conducted by Doss and Morris (2001) and Overfield and Fleming (2001) report otherwise. Educational level also influences the capacity to adopt and use ICT devices. Agricultural information can be properly exploited by farmers who have certain levels of formal literacy. Farmers with fundamental education are more probable to embrace new technologies and increase their productivity. Education boosts the capacity to obtain, decode, and assess helpful information for agricultural production. Henri-Ukoha, Chikezie, Osuji, and Ukoha (2012) examined the determinants of ICT use among livestock farmers in Ukwa West LGA, in Abia State of Nigeria, and their findings showed that education significantly influences ICT adoption. Similar results were obtained by Sobalaje and Adigun (2013), Jiriko, Obianuko, and Jiriko (2015), Chukwu, Eze, and Osuafor (2016), Onyeneke (2017) for Nigeria, Wawire et al. (2017) for Kenya, and Ali (2012) and Mittal and Mehar (2015) for India.

A number of studies have sought to ascertain the impact of farm size on ICT adoption. Evidence shows that farm size effect on ICT adoption can be negative, positive, or neutral. For example, while Feder, Just, and Zilberman (1985), McNamara, Wetzstein, and Douce (1991), Abara and Singh (1993), Fernandez-Cornejo (1996), Kasenge (1998), Onumadu and Osahon (2014), Mittal and Mehar (2015), and Onyeneke (2017) find farm size to be positively related to ICT adoption, Harper et al. (1990) and Yaron, Dinar, and Voet (1992) found a negative relationship between farm size and ICT adoption. Mugisa-Mutetikka et al. (2000) reported a neutral relationship between farm size and ICT adoption. The literature explains the negative and positive effects of social network on ICT adoption (Foster & Rosenberg, 1995; Bandiera & Rasul, 2002; Katungi & Akankwasa, 2010). Furthermore, access and availability of extension services has been found to be an important ICT adoption factor (Muwangi & Kariuki, 2015; Saliu, Ibrahim & Eniojukan, 2016; Chukwu et al., 2016; and Onyeneke, 2017).

Previous studies in Ebonyi State are limited in scope and methodology. Studies by Ezeh (2013), Ezeh et al. (2015), Umeh and Chukwu (2015), and Chukwu et al. (2016) are the only related studies conducted in the study area. While these studies conducted in Ebonyi State made important contributions to literature, there are observable gaps, which the present study covered. First, Ezeh (2013) studied only farmers in Ebonyi North and Ebonyi Central using descriptive statistics, whereas this study samples farmers from the three senatorial zones of Ebonyi State. In addition, Ezeh (2013) sampled 91 respondents using the random sampling technique. We consider this sampling size too small and the sampling technique grossly inadequate. Therefore, we sampled 500 respondents and considered the snowball sampling technique very apt for a study of this kind. Some other important variables (such as training and cost of ICT devices), which have theoretical and empirical plausibility are identified and examined in this study. Again, our focus is on rice farmers and not farmers that produce diverse agricultural commodities contrary to previous studies. Our study also estimates and compares the earnings of rice farmers pre- and post ICT adoption to enrich expected findings, as this has not been attempted in previous studies.

4. Methodology

4.1 Study area and sampling procedure

Ebonyi State is one of Nigeria's thirty-six states and one of the five states in the South-East geopolitical zone of the country. The state is split into three agro-political areas – Ebonyi South, Ebonyi North, and Ebonyi Central. Ebonyi South consists of five local government areas while Ebonyi Central and Ebonyi North zones have four local government areas each. The state has a population of roughly 2.8 million (CBN, 2018), with the majority residing in rural areas engaging actively in agriculture (Igboji, Anozie & Nneji, 2015).

The study utilized a combination of probability and non-probability sampling. First, the study purposively selected the three senatorial districts of Ebonyi South, Ebonyi Central, and Ebonyi North. In each of the senatorial districts, two local government areas that are actively involved in rice farming were purposively selected. The selected local government areas are: Afikpo South LGA, Ezza North LGA, Ikwo LGA, Izzi LGA, Onicha LGA, and Ohaukwu LGA. From each local government area, two towns were randomly selected. In the selection of the wards, the random sampling technique was utilized to select twelve wards while the respondents were selected using the snowball sampling technique. A questionnaire was utilized as the main instrument for data collection. A total of 500 copies of the questionnaire were distributed. In some cases, the research assistants dropped the questionnaire with literate respondents with an agreed date for pick-up. This method of drop and pick has proven to be effective for survey studies in Nigeria (Metu, 2017; Ekesiobi, Ude & Nwokolo, 2017).

4.2 Theoretical framework/model

Following Agarwal and Prasad (1999) and Tambotoh, Manuputty, and Banunaek (2015), the Technology Acceptance Model (TAM) is adopted as a theoretical framework for this study. In technology adoption studies, users' acceptance of technology are targeted. It is no surprise that this model has been widely embraced by researchers (Lin, 2008; Lin & Chou, 2009). TAM can provide empirical support to explain the determinants of behavioural intention of rice farmers' ICT adoption. According to Engle et al. (2010), behavioural intention refers to the individual's intention strength to use a particular behaviour. Extending Engle et al., behavioural intention refers to farmers' intention to use ICT in farm activities.

In a study of the factors that are germane to the adoption of new technology, Agarwal and Prasad (1999) suggested a discrete model specified as follows:

$$BI = f\,(AT, PEOU, PU) \qquad (1)$$

where:

BI = behavioural intentions

AT = attitude

$PEOU$ = perceived ease of use

PU = perceived usefulness

As noted by Agarwal and Prasad (1999), TAM includes the causal link between perceived usefulness (PU), perceived ease of use (PEOU), behavioural intention (BI), and attitude (AT). As noted by TAM, PU and PEOU are the major factors in BI, which is explained by AT. Furthermore, TAM suggests that several external variables, like user traits and environmental factors influence PU and PEOU. By affecting beliefs (PU and PEOU) and AT, external variables are likely to influence BI and then influence actual behaviour. Perceived usefulness is the degree to which a farmer believes that their performance will be improved by using ICT. Gong, Xu, and Yu (2004) specified support for people to improve technology acceptance, stressing that it was essential to enhance the perception of 'farmers' usefulness and prepare logical arguments', such as an explanation of the benefit of a particular ICT device to the farmer. Studies show that PU effectively justifies ICT system usage intention. For instance, King and He (2006) found that PU and behavioural intention have a strong relationship.

In the same vein, perceived ease of use (PEOU) can be explained as how easy it is for the handlers to use the technology. PEOU is the degree to which a farmer thinks that it is easier to use ICT than another system, which farmers are expected to accept. The model suggests that if farmers perceive they can use a given ICT with ease, then there is a greater tendency that they adopt the use of that ICT. The claim that PEOU is a key determinant of the intention to use new technology has been corroborated by a number of empirical studies (Lepervanche, 2006; Sentosa & Mat, 2012; Teo & Noyes, 2011). Although AT is identified by various studies as one of the variables in ICT acceptance and behavioral intention to use ICT (Shiro, 2008; Zhang & Aikman, 2007), some other studies contend that AT should be omitted from the model (Gong, Xu, and Yu, 2004; Sánchez-Franco & Roldan, 2005; Mahmood, Burn, Gemoets & Jacquez, 2000). The opponents of AT as a TAM model variable argue that AT is rather a mediating variable than a direct variable in the model. Tambotoh et al. (2015), however, observed that actual system use is another important variable that is essential in explaining the decision to adopt a new technology. Actual system underscores the regularity and extent to which farmers utilize a specified or available ICT. Intuitively, equation (1) could be re-specified as follows:

$$BI = a_1AT+a_2PEOU+a_3PU+a_4ASU+ U \qquad (2)$$

where:

ASU is the actual system use,

PEOU is the perceived ease of use,

PU is the perceived usefulness, and

U is the error term.

Users' perception concerning usability and convenience can be assessed by how often they use the new technology. The error term is said to *inter alia* capture other non-trivial effects by other variables that are not contained in the model. This is in tandem with Teo's (2013) assertion that there are other variables that are not included in the TAM. He identified such factors to include beliefs, individual differences, situational influences, and social influences. As noted by Suki and Suki (2011), the variables in the TAM are not sacrosanct. The actual variables germane to the model could depend on the technology of interest, geographical, and individual peculiarities.

Overall, whether a given ICT will be accepted by farmers depends on the expected utility. As probability of perceived usefulness, perceived ease of use among other factors increases, the expected utility also increases. If the expected utility is perceived to be greater than the economic cost, then farmers are expected to widely use the ICT device. But there are apparent difficulties in measuring expected utility and probabilities. In this regard, Wooldridge (1997) noted that the use of discrete models (such as probit or logit models) that estimate probabilities and odds in favour (or against) could be a potential remedy, as they offer proximate values for such expected values.

4.3 Empirical model specification

The broad objective of this study is to evaluate the factors that prompt the adoption of ICT by rice farmers in Ebonyi State. Being a survey research, a questionnaire was designed to elicit cross-sectional data of interest. In order to enhance the inferential process, regression procedure was utilized to obtain parameter estimates for the likelihood of the factors. Recall that following Davis (1989) TAM, Tambotoh et al. (2015) investigated the factors that influence technology adoption using equation 2.

We proceed to modify the above model as follows: Suki and Suki (2011) suggest that there could be other elements which induce the adoption of ICT by farmers. These comprise gender, educational level, income level, training, and type of agricultural activity. Again, as Sánchez-Franco and Roldan (2005) noted, attitude is a mediating variable. For example, both PU and PEOU are defined by attitude. From the foregoing, equation (2) could be re-specified as:

$$FAI = a_1PEOU + a_2PU + a_3GED + a_4EDU + a_5INCO + a_6TRA + a_7COD + a_8AWA + a_9HHS + a_{10}YOE + a_{11}AGE + U \quad (3)$$

where:

FAI	=	farmer adopts ICT
PEOU	=	perceived ease of use
PU	=	perceived usefulness
GED	=	gender,
EDU	=	educational level,
INCO	=	income level,
TRA	=	training,
COD	=	cost of ICT device,
AWA	=	awareness,
HHS	=	household size,
YOE	=	years of experience in farm business,
AGE	=	age of respondents

As contended by Gujarati (2004) and Wooldridge (1995), the major problem with equation (3) is the estimation. Notice that the dependent variable is a discrete binary choice variable that takes the values 1 for adoption and zero (0) for non-adoption of ICT by rice farmers but a key implicit assumption in classical regression procedure is the continuous nature of the explained variable. Thus, estimating equation (3) using OLS or any other classical or time-series regression framework is tantamount to a serious breach of the continuous variable assumption. For instance, using OLS to estimate equation (3) could gravely miscalculate the degree of the effect of the predictors on the predictand. Second, all of the standard statistical inferences (e.g. construction of confidence intervals, hypothesis tests) are unjustified, and finally, regression estimates will be extremely susceptible to the range of specific values observed (hence making extrapolations or predictions beyond the data range particularly unjustified). Gujarati (2004) notes that to circumvent the aforementioned problems, equation (3) should be estimated using binary choice models such as logit, probit, or tobit models. In this study, we adopt a binary logit model. Although, there is hardly any theoretical superiority of logit over probit, logit is widely used because of its simplicity and ease of interpretation. It is also adjudged to be more efficient than probit when some explanatory variables have more than two choices.

5. Presentation of Results

5.1 Summary of descriptive statistics

During the survey, 500 questionnaires were distributed to the respondents. However, only 476 (95%) questionnaires were returned. The descriptive statistics show that about 25.42% of the respondents were less than 35 years. In other words, about 75% were above 35 years. This statistic suggests that farm activities are dominated by the older population. There is also a fair distribution of men and women in farm business, with female farmers totalling 55.25%. Furthermore, the majority of the farmers were married. The proportion of married farmers was 60.08% while 21.64% were single. About 44.96% of the respondents indicated that they had household sizes ranging from 4 to 6 persons. Another 31% had household sizes of 7 to 9 persons, while 15.97% of the respondents had household sizes ranging from 1 to 3 persons.

For years of farming experience 8.19%, 18.49%, 24.58%, and 48.74% indicated less than 3 years, 4-6 years, 7-9 years, and 10 years and above respectively. Also, about 60.08% had other sources of income apart from rice farming. The remaining 39.92% of the respondents reported that they did not have an alternative source of income other than rice farming. The statistics also indicate that 39.71% of the respondents earned in excess of ₦400,000 in a year. Another 27.31% earned between ₦301,000 and ₦400,000 in a year. In addition, 6.51%, 12.18%, and 14.29% of the respondent's annual earnings from rice farming was less than ₦100,000, ₦100,000 to ₦200,000, and ₦201,000 to ₦300,000 respectively.

A total 62.2% of the respondents indicated that they were aware of the use of ICT for agricultural purposes while 32.8% of the respondents said they were not aware of the use of ICT for farming activities. The major sources of awareness were largely informal. For example, about 30% of the 320 respondents who were aware of the use of ICT, indicated that they learnt about the use of ICT in agriculture through their neighbours. Another 27.5% of the respondents claimed that they obtained the information from their friends and associates while 16.25%, 6.25%, 3.13%, 1.56%, 6.25%, and 9% learnt about the use of ICT through their families, social media, extension agents, agricultural development project, government sensitization programmes, and mass media respectively.

There are several ICT devices that could be used by farmers in carrying out their farm activities. Respondents identified as many as they were familiar with. About 82.2% were familiar with phones as ICT device. Another 48.2% and 25.9% of the respondents were familiar with radio and television. About 5.3%, 14.7%, and 2.1% were familiar with print media, CD recorders/players and geographical positioning system. Although over 67% of the respondents claimed to be aware of the use of ICT for agricultural purposes, only 38.1% indicated that they were actually using ICT for agricultural purposes. The remaining 295 respondents (61.9%) claimed that they were not using ICT for farm-related activities. In addition, about 118 (65.2%) out of the 181 respondents who were ICT users were male farmers while the remaining 32 respondents (34.8%) were female.

Rice farmers ranked cost of ICT device as the topmost factor in making buying decision. Out of the 181 farmers that use ICT, 159 (88%) agreed that they considered cost of an ICT device in making buying decision. About 62% of the respondents also indicated that they consider ease of use. That is, if the ICT is considered complex, many rice farmers may not go for it. Another important factor is availability (58%) and ease of access of the ICT (32%). ICT that cannot be easily accessed may not be used by rice farmers. Other factors include quality of information that an ICT device can offer (31%) and possession of relevant content by an ICT device (33%).

About 71% of the 295 non-users of ICT claimed that they were not using ICT because they could not access ICT that would be relevant to their operation. In other words, the ICT infrastructure for the required use is either non-existent or non-functional. Another 67% of the non-users of ICT noted that the cost of acquisition and maintenance is prohibitive. In this case, affordability is the main problem. About 41% of the non-users of ICT noted that lack of electricity to power the ICT device discourages them from using ICT devices. Also, 36% of the non-users of ICT indicated that they do not use ICT because they do not have the required skill for operating ICT. However, 38% of the non-users of ICT said that they are not using ICT because they do not know that ICT can be used for any farm operation. The use of ICT may be enhanced by the requisite training aimed at increasing awareness and building rice farmers' capacity and skill for the use of ICT devices. On this, about 31% of the ICT users claimed that they had received training on ICT. The remaining 65% indicated that they had not received any form of training that has to do with ICT usage for farm activities.

5.2 Logistic Regression of the Determinants of ICT Adoption

To ascertain the determinants of ICT adoption behaviour among farmers, a logistic regression model was estimated using the maximum likelihood procedure. The logit model was optimized using Newton-Raphson optimization algorithm. In addition, optimization was achieved after 4 iterations. The result is shown in table 2.

Table 2. Summary of Logit Coefficients

Independent Variable: Farmers Adopt ICT (FAI)					
Variable	Coefficient	Std. Error	z-Statistic	Odd Ratio	Probabilities
Educational attainment (EDU)	0.816706	0.190881	4.278593	2.263033	0.6935
Perceived ease of use (PEOU)	0.531280	0.219380	2.421761	1.701108	0.6298
Perceived usefulness (PU)	0.255000	0.062670	4.069100	1.290462	0.5634
Income (INCO)	0.339200	0.002567	13.209590	1.403824	0.5840
Training (TRA)	0.173660	0.030964	5.608530	1.189651	0.5433
Gender (GED)	-0.031151	0.028125	-1.107607	0.969329	0.4922
Costs of device (COD)	-0.403160	0.028040	-14.378150	0.668205	0.4006
Awareness (AWA)	0.588140	0.209400	2.808624	1.800636	0.6429
Household size (HHS)	0.002499	0.014930	0.167370	1.002502	0.5006
Years of experience (YOE)	-0.048744	0.030229	-1.612461	0.952425	0.4878
Age (AGE)	-0.128290	0.015617	-8.215010	0.879598	0.4680
C	0.144463	0.166831	0.865924	1.155419	0.5361
McFadden R-squared 0.697					
LR statistic 122.68					
Prob(LR statistic) 0.000000					
H-L Statistic 0.725					
Prob. (H-L)* 0.4310					

*the H-L statistics follows Chi-square distribution

Source: Author's computation using Eview 10.1

The result of the logit model shown in table 2 indicates that the log odd for education, perceived ease of use, perceived usefulness, income, training, and awareness are 0.817, 0.531, 0.255, 0.339, 0.173, and 0.588 respectively. Gender and cost of device have negative log odds. The log odds of gender and cost of the device are -0.031 and -0.403 respectively. Negative gender coefficients suggest that female farmers are less likely to adopt ICT compared with male farmers. Negative cost coefficient also suggests that increasing cost reduces the likelihood of adopting ICT. Other variables, such as household size, years of experience and age entered the model with log odds of 0.0025, -0.049 and -0.128 respectively. This result suggests that young farmers are more likely to adopt ICT than older farmers. In the same vein, it suggests that new entrants into agriculture are more likely to adopt ICT than those who have been in the farming business for a longer period.

According to Gujarati (2004), the mechanical interpretation is not very appealing. For example, the partial slope coefficient INCO is interpreted as follows. For a unit (₦1000) increase in annual income, the log of the odds in favour of adopting ICT goes up by 0.339 units. Gujarati therefore suggested that the coefficients should be interpreted in terms of odd ratio. The odd ratios are computed and reported in table 2. In interpreting odd ratios, values less than 1 indicate a negative relationship. Thus, for a unit increase in EDU, the odds in favour of adopting ICT increases by 126%. In the same vein, a unit increase in PEOU, PU, INCO, TRA, and AWA leads to 70%, 29%, 40%, 19%, and 80% increase in the odds in favour of adopting ICT. For a unit increase in cost of device, the odds in favour of adopting ICT decreases by 32.2%.

In terms of probabilities, the result shows that the probability that a farmer will adopt ICT if he is educated is 0.69. Also, the probability that a farmer will adopt ICT due to PEOU, PU, income and training are 0.63, 0.56. 0.58, and 0.5433 respectively. The result also indicates that the probability of adopting ICT is 0.49 for gender, 0.40 for cost of devices, 0.64 for awareness, 0.50 for household size, 0.49 for years of experience, and 0.47 for age.

It should be noted that the determinants of ICT adoption are calibrated in different units. Some variables are calibrated as binary options (e.g., gender), some are measured in monetary units (e.g., income in naira), and others are measured in years (e.g., years of education). This makes it difficult to compare the effects of the various determinants of ICT. However, Wooldridge (2003) suggested that to compare the estimates, there will be a need to use standardized coefficients. In table 3, the standardized coefficients are reported. It ranked the determinants according to the magnitude of their effects. As shown in the table, the most important determinant is education, with a standardized coefficient of 4.02. Following education is awareness, with a standardized coefficient of 3.17. Other determinants in order of their ranks are perceived ease of use (3.00), perceived usefulness (0.411), cost of device (-0.29), training (0.139), age (-0.052), years of experience (-0.038), gender (-0.023), income (0.022), and household size (0.00096).

Table 3. Ranking of Determinants of ICT Adoption Based on Standardized Coefficients

Independent Variable: Farmers Adopt ICT (FAI)				
Rank	Variable	Coefficient (log odds)	Std. Error of Estimates	Standardized Coefficients
1	Educational attainment (EDU)	0.816706	0.190881	4.016946
3	Perceived ease of use (PEOU)	0.531280	0.219380	3.003226
4	Perceived usefulness (PU)	0.255000	0.062670	0.411782
10	Income (INCO)	0.339200	0.002567	0.022436
6	Training (TRA)	0.173660	0.030964	0.138556
9	Gender (GED)	-0.031151	0.028125	-0.02258
5	Costs of device (COD)	-0.403160	0.028040	-0.29129
2	Awareness (AWA)	0.588140	0.209400	3.173401
11	Household size (HHS)	0.002499	0.014930	0.000961
8	Years of experience (YOE)	-0.048744	0.030229	-0.03797
7	Age (AGE)	-0.128290	0.015617	-0.05162
	S.E. = 0.880903			

Source: Author's computation using Eview 10.1

Table 4 shows that there is a significant difference between the mean pre- and post-adoption income of ₦372, 631.60 and ₦507, 496.80. This is indicated by a p-value of ANOVA F-test (and other test statistics) that is less than 0.05. We therefore reject the null hypothesis of no difference in income and conclude that there is a significant difference in the income of farmers who adopted ICT.

Table 4. Summary of ANOVA Statistics

Test for Equality of Means Between Series				
Method		df	Value	Probability
t-test		948	8.293722	0.0000
Satterthwaite-Welch t-test*		929.8116	8.293722	0.0000
ANOVA F-test		(1, 948)	68.78583	0.0000
Welch F-test*		(1, 929.812)	68.78583	0.0000
Analysis of Variance				
Source of Variation		df	Sum of Sq.	Mean Sq.
Between		1	4.32E+12	4.32E+12
Within		948	5.95E+13	6.28E+10
Total		949	6.39E+13	6.73E+10
Category Statistics				
Variable	Count	Mean	Std. Dev.	Std. Err. of Mean
INCOME AFTER	181	507496.8	267552.2	12276.14
INCOME BEFORE	181	372631.6	232416.3	10663.99
All	362	440064.2	259396.5	8415.933

Source: Author's computation using Eview 10.1

5.3 Discussion of findings

The main thrust of this study is to ascertain the drivers of ICT adoption by rice farmers in Ebonyi State. Analysis of responses obtained from the respondents indicates that there is low ICT usage in farm activities by farmers. However, most farmers obtained information on the utilization of ICT in agriculture through neighbourhood interaction and network of friends and associates. Evidence also shows that the most used ICT device is the mobile phone. The main determinants of device preference include cost of the device, availability of, and access to ICT infrastructure as well as ease of use.

The findings indicate that education and training are key to ICT adoption. Farmers who received training on ICT availability and use had higher tendency to adopt ICT than farmers who were not exposed to training. In the same vein, farmers with higher educational qualifications were found to adopt ICT more than those with lower education. A significant number of previous studies have established that highly educated workers tend to embrace new technologies quicker than less educated employees (Krueger, 1993; Lleras-Muney & Lichtenberg, 2002). Usually, a new ICT involves uncertain yields and upfront adoption costs. How rapidly farmers can adapt to an evolving set of production possibilities depends partially on their human capital and new technology understanding. Wozniak (1987) argued that education and information (which can be gained through training) decrease uncertainty and adoption costs, and thus increase the likelihood of early adoption. Krueger (1993) found that in the 1980s, which was a period of rapid growth in workplace ICT adoption, more highly educated workers were more likely to use ICT on the job.

ICT adoption can also be seen as a decision on reallocation taken in reaction to changing financial conditions, enabling farmers to take advantage of the opportunities offered by introducing innovative inputs into farm activities. Since the development of the human capital concept in the 1960s, scholars have asserted that highly-educated employees have a comparative advantage in addressing economic change and applying new technology such as ICT (Wozniak, 1984; Bartel and Lichtenberg, 1987). The findings of this study corroborate Wozniak (1984), who established that more-educated farm operators are more likely to adopt innovations than less-educated operators, although education did not impact the use of an innovative input several periods after its introduction.

Another important finding is that ICT adoption by rice farmers in Ebonyi State is largely affected by perceived ease of use and perceived usefulness. Farmers' ICT adoption depends on farmers' judgment of the value of the technology to them as well as ease of use of the technology. Conversely, farmers would be reluctant to accept technologies that are not relevant to their needs, not suited to their work environment, not easy to learn, and one that may interfere with other activities that are considered to be important. Baker-Eveleth and Stone (2015), in a study of the adoption of electronic textbooks by students, obtained evidence that perceived usefulness is a significant factor. Similarly, Abbas and Hamdy (2015) obtained evidence that perceived ease of use is an essential factor in determining whether farmers adopt the use of e-commerce in agricultural marketing.

Another unsettled issue in literature is the implication of gender for technology adoption. There are a lot of myths about the gender role in technology adoption. This study found that in Ebonyi State, there is no significant gender difference in ICT adoption among rice farmers. This finding concurs with Doss and Morris (2001) who concluded that gender variable has no explanatory power concerning the decision to adopt innovative technologies in maize farming. However, there is a prevailing opinion that there is a gender divide in ICT adoption. This belief, which has been supported by Doss, Mwangi, Verkuijl, and De Groote (2003) and Ragasa, Sengupta, Osorio, Haddad, and Mathieson (2014) posits that the gender divide in ICT adoption disadvantages the women. Proponents of the gender divide view predicate this argument on certain pillars. First, poverty tends to affect women in a multi-dimensional manner. Women earn less than men globally for equal jobs and have less access to financial assets such as credit or land. This restricts their opportunity to use all technology types, including ICT (Kituyi-Kwake & Adigun, 2008; Ragasa et al., 2014).

Secondly, women and girls make up nearly two-thirds of the globe's illiterates. This could limit their ICT use. It places the burden on ICT users for development strategies to include training and information appropriate for those with low literacy levels. Thirdly, language is an impediment to mobile phone use and the Internet. In rural regions and among ethnic minorities, where girls and women are less educated, with poor exposure to the surrounding society and the global arena, they can only communicate in local dialects or languages. Hence, they encounter difficulties using mobile phones and accessing the Internet, as English is the predominant language. Fourthly, in some climes, science and technology are seen as more appropriate for boys and men. This can make girls reluctant to study computer science or embrace new technology. Nevertheless, this is not clear cut, as computer science is seen in some South and West Asian countries as a field in which women can excel. Also in Nigeria, there is no evidence that more men study computer science than women (Kituyi-Kwake & Adigun, 2008; Johnson et al., 2017).

Lambrecht, Vanlauwe, Merckx and Maertens (2014) also justified the gender divide in ICT adoption based on the adoption dynamics implicit in the three technology adoption phases – awareness, tryout, and continued adoption. According to Lambrecht et al. (2014), each stage poses specific difficulties for women farmers. Awareness is restricted by variables like women's information access, mobility and extension services that would assist them learn availability of technologies, how to obtain them and how to use them (Doss, Mwangi, Verkuijl & De Groote, 2003; Ragasa et al., 2014). Tryout is restricted by access to and control over the inputs, land, labour, and water and other technology-related assets (Ragasa et al., 2014; Johnson et al., 2017), access to credit or capital to invest in the technology (Tiwari, 2010; Ragasa et al., 2014), social network access, learning and social capital to decrease perceived risks connected with technology adoption (Conley & Udry, 2001; Hunecke, Engler, Jara-Rojas & Poortvliet, 2017), and suitability of design, including affordability, cultural acceptability, and appropriateness for particular agricultural and physical requirements of women (Quisumbing & Pandolfelli, 2010).

In contrast to the gender divide in technology adoption and in support of our findings, there is compelling evidence that the gender divide has waned in many societies. For example, some studies did not find significant variations in computer education attitudes of male and female students. Adenuga, Owoyele, and Adenuga (2011) for instance found no significant differences in the attitudes of the gender groups towards ICT education. Wong and Hanafi (2007) also found no significant difference in the male and female student's attitudes towards ICT adoption. In South-East Nigeria, the gender divide is fast closing up. Although there appears to be a prevailing gender divide in the nature of crops grown by male and female farmers, there is hardly any cultural orientation that could limit equal access to ICT technology.

Evidence obtained also shows that there is income improvement among ICT adopters. Technically, improvement in farmers' incomes could arise from two main sources, namely an increase in output and increased prices. Suppose prices are assumed to be constant over time, then increase in income would be ascribed to farm output increase. In other words, ICT adoption could be a solution to declining farm output. ICT could raise farm output through various ways, such as pricing and demand information, operational efficiency, and reduction of production risks (Awuor, Kimeli, Rabah & Rambim, 2013). Pricing data here refers to market accessibility data, selling price, retention price, production, distributors, and warehouse. Information on demand includes range of crops, soil health, land use, soil nutrients, irrigation, and weather report among others. Availability of knowledge comprises dedicated website, emails, text messages, customer care agents/voice calls, e-learning/training, and telecenter. Pricing information facilitated by ICT could help farmers to obtain early information on where to obtain affordable inputs as well as markets where they can maximize sales.

It can also enhance operational efficiency. Through ICT, farmers can obtain information on how to carry out certain farm operations. It could also provide information for farmers on how to handle large and complex farm operations. Farmers could also learn new and innovative technologies through ICT. Furthermore, some other means through which ICT can assist to address main issues in the growth of the agricultural value chain are applications to assist buyers handle transactions with the thousands of small-scale farmers who supply to them, mobile banking and apps that enable fast payments, initiatives to increase the reach of farm extension services through telephones, personal computers, internet, radio, or text messaging campaign for conducive environment. Nin-Pratt and Yu (2010), Fuglie and Rada (2013), and Longa (2014) also obtained evidence that technology adoption leads to an increase in farm output among farmers.

6. Recommendations and Conclusion

The following recommendations were made based on the findings of this paper. First, given that access and availability of ICT infrastructure is a recognized challenge, it is recommend that governments and affiliated groups (such as farmers' unions) should focus on providing ICT infrastructure to farmers. ICT facilities such as GPS, internet connection, and agricultural DVDs should be provided to rice framers for ease of access. Thus, ICT villages can be established for rice farmers in designated clusters. Such ICT villages would be able to, among other things, provide rice farmers with internet connection for sourcing, sharing, storing, and retrieving information. It could also provide facilities for conference calls.

Second, education and training are key drivers of ICT adoption and utilization among rice farmers. However, low level of education is characteristic of rice farmers in Ebonyi State. In addition, only few rice farmers were exposed to informal training on ICTs. It is therefore recommended that government focus on training rice farmers. Improved training would no doubt lead to an increase in ICT adoption. Evidence obtained in this study also indicated that the effect of agricultural extension in disseminating information about ICT adoption is quite minimal. Thus, agricultural extension workers should organize more sensitization trainings, which would help to expose farmers to the relevance of ICT. Finally, evidence obtained in this study also indicated that high cost of acquiring ICT devices may undermine farmers' ICT adoption tendencies. We therefore recommend that government designs subsidy packages that target critical ICT devices for rice farmers. This will incentivize the farmers to acquire critical ICT devices. From the study findings, we conclude that ICT adoption has interesting potentials that can increase output by rice farmers in Ebonyi State nay the nation.

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