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Does ICTs Usage Facilitate Access to Market? An Empirical Evidence of Market Gardeners in Benin

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ABSTRACT

Imperfect information is a major obstacle for agricultural businesses in developing countries. The resulting information asymmetry increases transaction costs and affects the behavior of market stakeholders. In Benin, market gardeners' participation is limited by geographical isolation and poor communication and transport infrastructures. Information and communication technologies (ICTs) now offer a fast and less costly means of accessing and disseminating information for more active market participation. The aim of this article is to measure the contribution of ICTs to market participation by testing whether they improve participation. Using a recursive bivariate probit model, our results indicate that market gardeners who use ICT to access information have a higher frequency of market participation than those who do not. Cell phones, radios, and televisions lead to a 35.3%, 25.6% and 8% higher probability of market participation respectively than those who don't use them. These results suggest that a platform for disseminating knowledge via ICT could be set up to increase market participation.

KEYWORDS

Agriculture; ICT; market participation; transaction costs; Benin

1. Introduction

Information plays a key role in the proper functioning of markets and is a major concern of economic theory following Stigler's seminal article (Stigler, 1961) on the economics of information (Ogutu et al., 2014). Stigler views information as a valuable resource as it drives knowledge and promotes better coordination among market players. For neoclassical economists, the functioning of the market is based on the strong assumption that market players have sufficient information to engage in optimal arbitrage. However, information is rarely free due to the high searching cost and the excessive dispersion of prices in the markets (Brown & Goolsbee, 2002; Goldfarb & Tucker, 2019; Stigler, 1961). This price dispersion is particularly acute in developing countries and leads to imperfect information (Jensen, 2007).

Imperfect information problems represent a major obstacle for smallholders, mainly in the agricultural sector of developing countries (Ouma et al., 2010). They result from information asymmetry which generates higher information search costs, which affect

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the negotiation behavior of economic agents (Brown & Goolsbee, 2002; Stigler, 1961). Obtaining information on prices, sales strategies, potential buyers, and brokers can therefore be difficult and costly for farmers in developing countries (Mmbando et al., 2015; Rajkhowa & Kornher, 2023).

Limited access to information combined with poor quality infrastructure constitute barriers to farmer participation in the market (Ismael et al., 2015). Nwafor et al. (2020), also note lack of knowledge and understanding of the market are significant barriers to market participation. Indeed, it reduces opportunities for smallholder farmers to connect to commercial value chains (Krone & Dannenberg, 2018). Thus, farmers who wish to sell their products must seek the best price, the right buyer, and the standards in force (Tadesse & Bahiigwa, 2015). They then invest in the search for information to improve their turnover. Such investment is costly and hinders agricultural development in Africa (Aker, 2010). Advances in information and communication technology (ICT) are helping to overcome these barriers and connect rural farmers through various channels to sources of market information.

ICTs are channels for the rapid dissemination of vital market information to smallholder farmers (Ibitoye et al., 2016; Kountios et al., 2023). They reduce information search costs while improving farmers' access to relevant market information (Tack & Aker, 2014; Yao & Sun, 2023). Farmers then access information on different markets through ICTs and make trade-offs to take advantage of it (Chete & Fasoyiro, 2014). The use of this information by farmers allows them to make agricultural marketing decisions by increasing their bargaining power (Aker, 2010). Thus, they can negotiate fair prices and better manage their stock (O'Donnell, 2013).

In Africa, negotiation between farmers and their partners is difficult due to insufficient resources to circumvent high transaction costs (Barrett, 2008; Komarek, 2010). As a result, farmers in African countries find it difficult to sell their products in local markets (Lefèvre & Tharakan, 2018). This difficulty is linked to the lack of transport infrastructure, and the long distances between production and consumption areas, not to mention the costs of marketing the products (Handley, 2009).

In Benin, producers face transaction costs, the most important of which are related to the search for information and transport (Fafchamps & Gabre-Madhin, 2001). These costs are largely due to the lack of connection between farmers and markets (Fiamohe, 2010; Galtier, 2002). The distance between the place of production and the markets is detrimental to farmers because of the costs it generates (Disdier & Mayer, 2004). The availability of market garden products requires good information at the right time because these market garden products are seasonal and perishable (Anoop et al., 2015). ICT can contribute to removing these constraints by providing the various market players with decision-making support information at a lower cost.

Access to the market for producers from ICT is highlighted in most works by the mobile phone. This article goes beyond and targets other channels like radio and television which were widely used before the advent of the mobile phone in developing countries. Better, the methodology used made it possible to capture the direct and indirect effects of the use of these channels of access to information on the participation of producers in the market. The article evaluated the effect of the use of ICT on the participation of market gardeners. It is organized as follows.

Section 1 presents empirical work on the effects of ICT use. Section 2 presents the methodology, model, and data. Section 3 presents and discusses the results. Section 4 concludes the article with policy implications.

2. Access to market: the role of ICTs

Access to information enables farmers to make decisions about market choices and the timing of sales (Shepherd, 1997). Market participants in developing countries are often prevented from accessing distant markets due to asymmetric price information and costly research (Rajkhowa & Kornher, 2023). Better market information then has a positive effect on the probability of participating in the market (Goetz, 1992). Indeed, farmers' decision to participate in the market is positively determined by market price information (Geoffrey et al., 2013). Thus, the likelihood of a farmer to participate in the market depends on his ability to access market information (Osebeyo & Aye, 2014). The availability of information allows the producer to know the level of demand for his products (Honja et al., 2017). Information supplied affects the efficiency of competitive markets as it affects price dispersion, arbitrage, and farmer welfare (Yao & Sun, 2023). In addition, it allows them to make a choice between the different sales channels (Sheng & Lu, 2020) but also to carry out productive marketing (Zhang et al., 2021). Furthermore, Jensen (2010) showed that farmers with access to market information sell at high prices. Producers who want to have high prices must access the market by investing in information research. Access to better information by farmers imposes a cost on farmers which can be a handicap to their participation. Thus, the costs associated with finding information affect the decision of farmers to participate in the market when they decide to sell their product directly in a physical market.

The various costs borne by farmers to access the market, those related to the transport and storage of products and those related to the search for information, are referred to as transaction costs (Goetz, 1992). Most of the work that has identified barriers to farmer participation in the market has identified transaction costs as a major obstacle (Alene et al., 2008; Goetz, 1992; Key et al., 2000; Mmbando et al., 2015; Musara et al., 2018). These studies indicate that the decision of the farmer to participate in the market is strongly influenced by transaction costs. Thus, the nonparticipation of farmers, especially smallholders, in the market can be attributed to high transaction costs, especially fixed costs that farmers cannot avoid if they want to participate in the market (Goetz, 1992). Access to better information has a cost. For Shepherd (1997), the most important cost concerns the transaction cost for farmers because of its importance in market participation (Jagwe et al., 2010).

In the agricultural sector, the negative effect of transaction costs translates into the high cost of transport that the producer must bear before accessing the market (Alene et al., 2008; Fischer & Qaim, 2012; Jagwe et al., 2009; Osebeyo & Aye, 2014). For some authors, this high level of transport costs results from the quality of the roads that connect the farms and the markets on the one hand, but also from the distance between the markets and the farms on the other hand. Indeed, the poor condition of rural roads and the distance increase the loss of time, which increases transport costs. By integrating transport costs into the total cost function, the farmer perceives a reduction in the gain from market participation, thus reducing his incentive to opt for selling in the market and therefore to participate in the market. High transport costs then push producers to

opt for local sales or forward sales, which does not guarantee a better price (Ismail et al., 2015; Mwangike & Mdoe, 2015; Tura & Hamo, 2018).

For other studies, the high level of transaction costs in the agricultural sector is linked to the costs of seeking information by farmers. They justify this on the grounds that access to market information allows farmers to make more appropriate decisions about market choices. Indeed, farmers need complete market information to make the right decision on how much produce and at what price to sell (Rutatola, 2018). Goetz (1992) showed that better market information has a significant positive effect on the probability of being a seller and therefore a participant. The likelihood of a farmer participating in the market and selling directly to buyers without going through intermediaries depends on their ability to access market information (Geoffrey et al., 2013; Mwangike & Mdoe, 2015; Osebeyo & Aye, 2014; Rossignoli & Ricciardi, 2015). Indeed, market price information informs the farmer about the current price conditions and helps him to assess the market situation, in this case the level of demand for his products (Honja et al., 2017).

In view of the various constraints to farmers' participation in the market, ICTs appear as an alternative solution. Thus, ICT has the potential to significantly reduce transaction costs, including information search costs (Freeman & Mubichi, 2017). Better use of ICT indirectly leads to a reduction in information asymmetries between the different market players (Aker & Fafchamps, 2015; Ogutu et al., 2014). ICTs allow farmers to exchange information quickly and cheaply and to compare prices efficiently (Aker & Mbiti, 2010; Chikaire et al., 2015). Through ICT, farmers can easily access information on product supply and demand, and consumers of agricultural products can send information on market demand (Yao & Sun, 2023). ICTs thus connect buyers and sellers of agricultural products. According to Freeman and Mubichi (2017), farmers who do not have access to ICTs are exposed to information search costs because ICTs significantly reduce transaction costs (Deichmann et al., 2016).

Indeed, thanks to mobile phones for example, market actors can easily communicate and access information on the prices and availability of products on the market (Byamukama et al., 2023; Dlamini-Mazibuko et al., 2019). Mobile phones allow individuals and businesses to exchange information quickly and inexpensively on a variety of economic topics (Aker & Fafchamps, 2015; Aker & Mbiti, 2010). The rapid spread of mobile phones has reduced the costs associated with accessing price information, allowing farmers, traders and consumers to send and receive information faster and more cheaply (Aker & Mbiti, 2010; Minkoua Nzie et al., 2018). Indeed, Aker (2011) notes that mobile phones significantly reduce communication and information costs for the rural poor. Furthermore, he argues that reducing search costs associated with mobile phones could increase farmers' access to information through private sources, such as social media (Aker, 2010; Aker & Mbiti, 2010; Baye et al., 2007). This contribution of information to market performance can be assessed through the methodology adopted here.

3. Methodology

3.1. Estimation strategy

We hypothesize that the participation of market gardeners would be linked to the non-access or the difficulties of access to market information, which can be solved using ICT. However, market participation is linked to factors other than ICT use such

as distance, condition of rural roads and producer factors. These same factors also influence ICT adoption. Thus, a problem of endogeneity may arise. We simultaneously model the decision to use ICT and market participation. Based on the work of Maddala (1983) and Green (2003), and considering that ICT usage and market participation ($Pmarch$) are all dichotomous variables, we specify the simultaneous latent equation models as follows:

$$\begin{cases} Pmarch_i = 1 \{ \alpha_1 X_{1i} + \beta_1 ICT_i + \varepsilon_{1i} > 0 \} \\ ICT_i = 1 \{ \alpha_2 X_{2i} + \beta_2 Pmarch_i + \varepsilon_{2i} > 0 \} \end{cases} \quad (1)$$

Where $\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \rightarrow \left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}; \begin{pmatrix} 1 & \rho \\ \rho & 1 \end{pmatrix} \right]$

The use of ICT is a binary variable that takes the value 1 if the producer adopts ICT and 0 otherwise. A producer is considered an adopter if he uses ICT to access market information. To participate in the market, smallholders must make two decisions. First, they need to decide on their choice of market and second, they need to determine their offer (Camara, 2017). Thus, participation ($Pmarch$) takes the value 1 for the producer who sells his products on a physical market and 0 otherwise. X is a matrix of variables that affect ICT use and/or market participation.

Since equations (1) contain endogenous regressors, we cannot use the simple probit model to obtain unbiased estimators. For this, we estimate these equations using the *SUR probit model*. This model has the advantage of resolving unobserved heterogeneity, endogeneity and correlation issues. Equations (1) can also be estimated directly by Heckman’s two-step method, but the interpretation of the estimated coefficients can be cumbersome (Maddala, 1983). Therefore, we follow the following alternative approaches. The first consists in estimating the reduced forms of equations (1).

$$Pmarch_i = \pi_1 X_{1i} + \mu_{1i} \quad (2a)$$

$$ICT_i = \pi_2 X_{2i} + \mu_{2i} \quad (2b)$$

Where $Pmarch_i = 1$ if the producer participates in the market and 0 otherwise; $ICT_i = 1$ if the individual has adopted ICT and 0 otherwise; X_{1i} and X_{2i} contain all the exogenous variables that respectively explain market participation and ICT adoption. The estimation of equations (3a) and (3b) with the bivariate probit is specified as follows:

$$Pmarch_i = \begin{cases} 1 & \text{if } Pmarch_i^* > 0 \\ 0 & \text{if } Pmarch_i^* < 0 \end{cases} \quad (3a)$$

$$ICT_i = \begin{cases} 1 & \text{if } ICT_i > 0 \\ 0 & \text{if } ICT_i < 0 \end{cases} \quad (3b)$$

The covariance of the reduced form is $cov(\mu_{1i}, \mu_{2i}) \neq 0$. To test the correlation between the dependent variables, we test whose significance ρ , represents the correlation between the errors of the two probit models. If $\rho = 0$, estimating each of the equations by the standard probit method would give the same result as the simultaneous estimation. In the case where $\rho \neq 0$. In the first step, simultaneous estimation by the bivariate probit procedure is required, so we must go to the second step.

The second alternative consists in examining the equation where ICT appears as an exogenous variable among the explanatory variables in the participation equation (*Pmarch*), while the *Pmarch* variable does not appear in the ICT adoption equation. This procedure is known as the recursive bivariate probit model (Green, 2003; Maddala, 1983). In this case, the ICT equation is considered in a reduced form while the *Pmarch* equation is in a structural form with ICT as an explanatory variable. The recursive bivariate probit model looks like this:

$$Pmarch_i = \alpha_1 X_{1i} + \beta_1 ICT_i + \varepsilon_{1i} > 0 \quad (4a)$$

$$ICT_i = \alpha_2 X_{2i} + \varepsilon_{2i} > 0 \quad (4b)$$

The parameter of interest (β_1) is called the average treatment effect and is calculated as follows:

$$\beta_1 = E_N[P(\varepsilon_{1i} > -\alpha_1 Z_{1i} - \beta_1) - P(\varepsilon_{1i} > -\alpha_1 Z_{1i})] \quad (5)$$

The joint probability distribution of $Pmarch_i$ and ICT_i (subject to X_{1i} et X_{2i}) contains four elements:

$$P(Pmarch_i = 0, ICT_i = 0 | X_{1i}, X_{2i}) = P(\varepsilon_{1i} \leq -\alpha_1 Z_{1i}, \varepsilon_{2i} \leq -\alpha_2 Z_{2i}) \quad (6a)$$

$$P(Pmarch_i = 1, ICT_i = 0 | X_{1i}, X_{2i}) = P(\varepsilon_{1i} > -\alpha_1 Z_{1i}, \varepsilon_{2i} \leq -\alpha_2 Z_{2i}) \quad (6b)$$

$$P(Pmarch_i = 0, ICT_i = 1 | X_{1i}, X_{2i}) = P(\varepsilon_{1i} \leq -\alpha_1 Z_{1i} - \beta_1, \varepsilon_{2i} > -\alpha_2 Z_{2i}) \quad (6c)$$

$$P(Pmarch_i = 1, ICT_i = 1 | X_{1i}, X_{2i}) = P(\varepsilon_{1i} > -\alpha_1 Z_{1i} - \beta_1, \varepsilon_{2i} > -\alpha_2 Z_{2i}) \quad (6d)$$

This distribution is completely determined. The joint probability distribution of ε_{1i} and ε_{2i} is known. In the bivariate probit model, the error terms are assumed to have the following joint distribution function: $F(\varepsilon_{1i}, \varepsilon_{2i}) = \Phi(\varepsilon_{1i}, \varepsilon_{2i} | \rho)$ where Φ denotes the cumulative density function of the standard bivariate distribution, and ρ the correlation coefficient. In this case, the joint probability function $f(Pmarch_i, ICT_i | X_{1i}, X_{2i})$ can be written as follows.

$$f(Pmarch_i, ICT_i | X_{1i}, X_{2i}) = \Phi[s_1(\alpha_1 X_{1i} + \beta_1 ICT_i), s_2(\alpha_2 X_{2i}), s_1 s_2 \rho] \quad (7)$$

Where $s_1 = 2Pmarch_i - 1$ and $s_2 = 2ICT_i - 1$

Since the above model is fully determined, it can be estimated by the *Full Information Maximum Likelihood (FIML)* and treated as a two-variable probit model that does not account for simultaneity (Green, 2003). The equations to be estimated are as follows:

$$Pmarch_i = 1 \{ \alpha_1 X_{1i} + \beta_1 ICT_i + \varepsilon_{1i} > 0 \} \quad (8a)$$

$$ICT_i = 1 \{ \alpha_2 X_{2i} + \varepsilon_{2i} > 0 \} \quad (8b)$$

However, the estimation of a recursive bivariate probit model requires several restrictions to identify the parameters of the model. Maddala (1983) suggests excluding at least one exogenous variable from the reduced-form model of the structural model. Wilde (2000) shows that Maddala focused on a specific case where the constant term is the only

exogenous regressor. For this author, the parameters of the model are identified if there is at least one non-constant explanatory variable. Consequently, following Maddala (1983), we allow an exclusionary restriction in the model. This is first done by including the variables in both equations and then omitting them from equations in which they are not significant. To this end, we exclude the distance variable in the ICT adoption equation and include it in the participation equation (P_{march}).

3.2. Definition of variables

To estimate the effect of ICT on market participation of market gardeners, we used as a dependent variable, the market participation of the producer. It is denoted in the participation equation by P_{march} and is equal to 1 if the household has sold its production on a physical market, and 0 in otherwise. The explanatory variables were grouped into two categories. Variables that capture transaction costs and the socio-demographic characteristics of the producer.

Referring to Alene et al. (2008), transaction costs can be measured through three variables: distance to market, access to communication devices (radio, mobile phone, television) and ownership of means of transport. (bicycle, motorbike and cart). In this article, access to communication devices (cell phone, radio, and television) and distance are used as variables to measure transaction costs. The socio-demographic characteristics of the household used are the age, sex, education, and labor force of market gardeners. To understand the contribution of ICT to market access for market gardeners, three ICT devices, namely mobile phones, radio, and television were used. Indeed, the results of several studies indicate that the nonparticipation of farmers in the market is associated with their inaccessibility to information (Fan & Salas Garcia, 2018). However, ICTs through the telephone, radio or television make it possible to disseminate information to producers at a lower cost and in a shorter time. Thus, the contribution of ICT to market participation will be analyzed through these three information channels.

3.3. Data

The data used for the study were collected from market gardeners who had or had not benefited from agricultural credit as part of the research project on agricultural credit by Participatory Microfinance Group for Africa (PAMIGA) and National Network of Village Savings Banks and self-managed Credit of Benin (RENACA) and financed by the European Investment Bank. The objective of this program is to have data to analyze the role of market factors (access to the market, access to credit) and non-market factors (access to information, training, socio-environmental aspects) in investment decisions, market gardeners and the effects resulting from the adoption of irrigation technologies. The market gardeners are members of associations and partner groups of RENACA-BENIN, a microfinance institution. The target populations of the program are market gardeners in the departments of Atlantique (Kpomassè, Ouidah and Allada), Mono (Grand-Popo, Comè, Athiémè and Lokossa), Zou (Bohicon and Covè) and Borgou (Parakou and Pèrèrè). These different municipalities represent, according to the agro-ecological zones, the most representative municipalities in terms of vegetable production. The number of market gardeners surveyed per municipality is determined according to

Table 1. Characteristics of Market Gardeners.

Variables	Market Participation		Correlation coefficient	Percent (%)	
	Access (%)	Non Access (%)			
Phone	Yes	75.56	24.44	4.403**	60.93
	No	68.75	31.25		39.07
Radio	Yes	84.85	15.15	18.728***	43.71
	No	67.06	32.94		56.29
Television	Yes	67.5	32.5	4.662**	26.49
	No	77.48	22.52		73.51
Distance	<5 km	75.00	25.00	0.002	29.14
	>5 km	74.77	25.23		70.86
Education	Uneducated	78.57	21.43	6.873*	18.54
	Primary	80.85	19.15		31.13
	Secondary	69.12	30.88		45.03
	University	18	25		5.30
Sex	Female	90.32	9.68	14.906***	20.78
	Male	70.83	29.17		79.22
Place of residence	Urban	76.00	24.00	0.64	66.23
	Rural	72.55	27.45		33.77
Agricultural credit	Yes	68.52	31.48	5.341**	35.74
	No	78.35	21.65		64.24

Observations : 453

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source : Authors, 2023.

the weight of each area among the farmers who attended the information sessions on irrigation techniques. A total of 462 market gardeners were surveyed in the different study areas.

Table 1 presents the characteristics of market gardeners and the Pearson coefficient in order to analyze the link between the market participation variable and certain explanatory variables. From the analysis of the correlation coefficient, it appears that there is a link between the market participation variable, respectively, with the use of telephone, radio and television. The analysis also reveals that more than 70.86% of basic market gardeners are more than 5 km from the nearest market against only 29.14% who are less than 5 km away. Most market gardeners have to walk a long distance before entering a physical market, but they have a minimum level of education as only 21.43% are registered as uneducated.

4. Résultats et discussion

This section presents the empirical results followed by a discussion. Tables 2, 3 and 4 present the probability for a market gardener to participate in the market according to the use of ICT through three different estimates from three models: first, we estimate the probability of participating in the market (column 1) with a simple univariate probit model regardless of correlation and simultaneity issues. The marginal effects of the probit model are presented in column 2 of the tables. Due to the endogeneity of the ICT usage variable in the participation model, we estimate the reduced form of the participation and ICT usage equations (columns 3 and 5) with a bivariate probit model. The conditional marginal effects arising from the bivariate probit estimation are presented in columns 4 and 6 of the same tables. For simplicity, we present only the bivariate probit and the recursive bivariate probit estimate in Tables 2, 3 and 4. All other results are presented in

Table 2. Recursive Bivariate Probit Estimation Results (Mobile Phone as ICT Indicator).

Variables	Part	EMD	EMI	Uport	EM
	(1)	(2)	(3)	(4)	(5)
Phone	1.257*** (0.458)	0.353*** (0.119)	0.375*** (0.132)		
Income	0.108 (0.144)	0.030 (0.041)	0.058 (0.042)	0.618** (0.243)	0.082** (0.032)
Size of household					
]5;10]	-0.460** (0.190)	-0.124*** (0.048)	-0.132*** (0.050)	0.007 (0.248)	0.001 (0.036)
]10;15]	-0.146 (0.287)	-0.036 (0.071)	-0.015 (0.073)	0.939* (0.529)	0.088** (0.040)
Age					
]30;40]	0.052 (0.241)	0.015 (0.072)	0.016 (0.075)	0.000 (0.394)	0.000 (0.051)
]40;50]	0.000 (0.252)	0.000 (0.076)	-0.019 (0.078)	-0.375 (0.368)	-0.057 (0.052)
]50;more]	0.547* (0.297)	0.140* (0.079)	0.161** (0.080)	0.494 (0.407)	0.051 (0.045)
Sex	-0.527** (0.229)	-0.148** (0.065)	-0.172*** (0.066)	-0.367 (0.284)	-0.049 (0.038)
Education					
Primary	0.147 (0.243)	0.038 (0.063)	0.083 (0.068)	0.712** (0.310)	0.130** (0.059)
Secondary	-0.270 (0.233)	-0.078 (0.065)	-0.028 (0.068)	1.041*** (0.303)	0.168*** (0.055)
University	0.002 (0.359)	0.000 (0.096)	0.059 (0.099)		0.186*** (0.065)
Agricultural credit	-0.341** (0.149)	-0.096** (0.042)	-0.103** (0.043)	-0.044 (0.237)	-0.006 (0.031)
Total area covered	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.001 (0.000)	0.000 (0.000)
Total production	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)		
Main source of income					
Public Information (No)			-0.080** (0.037)	-1.430*** (0.315)	-0.224*** (0.046)
Yes					
Type of workforce (Family)					
Employee	0.152 (0.307)	0.043 (0.084)	0.046 (0.090)		
Family and Salaried	0.305* (0.177)	0.083* (0.046)	0.088* (0.049)		
Type of farm ownership (Owner)					
Tenant			0.026** (0.011)	0.629*** (0.234)	0.083*** (0.030)
Place of residence	-0.073 (0.162)	-0.020 (0.045)	-0.004 (0.047)	0.436 (0.265)	0.058* (0.035)
Household structure			0.022* (0.013)	0.531* (0.301)	0.070* (0.039)
Department					
Atlantic			0.058 (0.064)	0.657 (0.585)	0.161 (0.158)
Zou			-0.019 (0.062)	-0.161 (0.543)	-0.046 (0.154)
Mono			0.104 (0.067)	1.844*** (0.636)	0.307* (0.157)
Constant	0.231 (0.516)			-0.637 (0.623)	

(Continued)

Table 2. (Continued).

Variables	Part	EMD	EMI	Uport	EM
Wald			129.11		
R ²					
Rho			Prob > chi2 = 0.0549		
LL			-340.73728		
Observations			453		

Note: Standard errors in parentheses. Share = Market Participation, EM = Marginal Effect, uport = Mobile Phone Use, EMI = Indirect Marginal Effect of Phone Use on Participation, EMD = Direct Marginal Effect of Phone Use on Participation. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source: Authors, 2021.

supplementary material. However, as suggested by Maddala (1983), the use of the bivariate probit must meet a certain number of criteria, including the consistency condition. This condition assumes that the product of the coefficients associated with the two endogenous variables of the structural form models is zero. To facilitate the analysis, we assume that the participation coefficient in the ICT use equation is equal to zero. We estimate a recursive simultaneous equations model using the recursive bivariate probit model (columns 1 to 5 of Table 2). In columns 2 and 4, the direct and indirect marginal effects of the participation equation are presented and those derived from the ICT usage equation are presented in column 5 of the same table. From the estimated values of Rho (ρ), we can conclude that only the recursive model supports the simultaneous estimation of the probability of participating in the market and the decision to use ICT to gather information. Thus, the non-significance of Rho (ρ) in the reduced-form equations suggests that it is preferable to estimate the probability of participating in the market separately from the decision to use ICT. This does not allow us to correct for the likely endogeneity that might arise in the univariate probit model. To do this, we consider for this analysis the recursive bivariate probit model for which the coefficient Rho (ρ) is significant.

In the case of the television equation, the estimated values of Rho indicate that only the bivariate probit model can be used to explain the contribution of television use to market gardener participation. The results of the recursive bivariate probit model in Table 2 also show that mobile phone use positively affects the probability of participating in the market at the 1% level. By examining the participation equation, it appears that mobile phone use has both a direct and indirect effect on the probability of market gardeners participating in the market. Mobile phone use produces a higher indirect effect than the direct effect. Indeed, the use of the mobile phone directly and indirectly increases the probability that a market gardener participates in the market by 35.3% and 37.5% respectively due to the different information that the market gardener receives from the use of the telephone.

A market gardener who uses his mobile phone has a 37.5% higher probability of participating in the market than one who does not. Market gardeners decide to produce and generate a marketable surplus as soon as they know where to sell and how much they will earn from the sale. Better still, some producers only enter the sector if they are convinced that inputs are available to fight against pests, which in the context of market gardening are very harmful and responsible for the destruction of several hectares of

Table 3. Recursive Bivariate Probit Estimation Results (Radio as ICT Indicator).

Variables	Part	Marginal effect			
		EMD	EMI	Uradio	EM
	(1)	(2)	(3)	(4)	(5)
Radio use	0.849* (0.442)	0.256* (0.137)	0.131** (0.060)		
Income	-0.186 (0.146)	-0.056 (0.043)	-0.035 (0.021)	-0.064 (0.144)	-0.021 (0.047)
Size of household					
]5;10]	0.445** (0.180)	0.129*** (0.048)	0.042 (0.029)	-0.284 (0.185)	-0.094 (0.060)
]10;15]	0.272 (0.283)	0.075 (0.081)	-0.030 (0.025)	-0.980*** (0.301)	-0.297*** (0.081)
Age					
]30;40]	-0.160 (0.241)	-0.051 (0.077)	0.030 (0.029)	0.608** (0.248)	0.184*** (0.069)
]40;50]	-0.027 (0.253)	-0.009 (0.082)	0.046 (0.033)	0.541** (0.264)	0.162** (0.073)
]50;more]	-0.590** (0.282)	-0.167** (0.082)	-0.000 (0.040)	0.994*** (0.291)	0.314*** (0.085)
Sex	0.940*** (0.215)	0.284*** (0.063)	0.048 (0.047)	-1.090*** (0.220)	-0.353*** (0.065)
Education					
Primary	-0.277 (0.260)	-0.081 (0.076)	-0.052 (0.038)	-0.159 (0.212)	-0.052 (0.070)
Secondary	0.066 (0.220)	0.021 (0.069)	-0.003 (0.035)	-0.139 (0.222)	-0.045 (0.073)
Higher	-0.295 (0.351)	-0.086 (0.099)	-0.018 (0.056)	0.342 (0.377)	0.113 (0.123)
Place of residence	0.029 (0.182)	0.009 (0.055)	0.023 (0.026)	0.211 (0.192)	0.068 (0.062)
Credit Agricole	0.231 (0.147)	0.070 (0.044)	0.050** (0.021)	0.166 (0.148)	0.054 (0.048)
Total production	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Total area covered	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Type of farm ownership	0.092 (0.145)	0.028 (0.044)	-0.002 (0.020)	-0.178 (0.153)	-0.057 (0.049)
Public Information	0.251 (0.157)	0.077 (0.049)	0.035 (0.027)	-0.063 (0.182)	-0.020 (0.059)
Residence Department					
Atlantic			0.033 (0.038)	0.392 (0.500)	0.127 (0.151)
Zou			0.093** (0.041)	0.960** (0.475)	0.316** (0.142)
Mono			0.010 (0.039)	0.138 (0.534)	0.043 (0.163)
Type of labour					
Employee	-0.359 (0.355)	-0.104 (0.095)	0.032 (0.053)	1.025*** (0.380)	0.330*** (0.108)
Family and waged	-0.279* (0.164)	-0.083* (0.047)	-0.022 (0.023)	0.226 (0.160)	0.074 (0.053)
Distance					
Less than 5 km	0.113 (0.189)	0.035 (0.058)	0.033 (0.029)	0.148 (0.192)	0.048 (0.063)
Household structure					
Main source of income					
Constant	-1.827*** (0.328)			0.030 (0.520)	
Wald	147.44				

(Continued)

Table 3. (Continued).

Variables	Part	Marginal effect			
		EMD	EMI	Uradio	EM
R ²					
Rho	Prob > chi2 = .0794				
LL	-483.25				
Observations	453	453	453	453	453

Note: Standard errors in parentheses. Share = Market Participation, EM = Marginal Effect, Uradio = Use of Radio, EMI = Indirect Marginal Effect of Radio Use on Participation, EMD = Direct Marginal Effect of Radio Use on Participation. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source : Authors, 2021.

crops. Our results corroborate those found by Zanello (2012) in Ghana which indicate that receiving market information via mobile phones has a positive and significant impact on market participation, with a greater impact for households with surplus crops, food crops. Endorsing this positive finding of the telephone on market participation, Katengeza et al. (2014) report that farmers who accessed market information through mobile phones in Malawi incurred lower transaction costs because they were able to reduce the cost of finding information. For Owusu et al. (2018), this result is justified because the recent growth of information services through the mobile phone offers the potential to reduce the dissemination of costly and incomplete information in the agricultural sector and ensure the efficient functioning steps. Similarly, Chikuni and Kilima (2019) showed that the effect of phone use improves farmers' market participation by providing them with price information but does not immediately promote smallholder farmers' participation in the market. For him, knowing the prices is different from having the ability to take advantage of this information.

Work by Tadesse and Bahiigwa (2015) and Nakasone et al. (2014) found an insignificant effect of mobile phone use on farmers' market participation. For these studies, the insignificant effect is mainly due to low mobile phone penetration rates, poor infrastructure in rural areas, low literacy among farmers, and market dynamics challenges such as inability of farmers to access lucrative markets, which cannot be fully resolved to provide market information alone (Steinfeld et al., 2015). Furthermore, the results highlighted the indirect effect of mobile phone use on market participation. The transmission channels of this effect are in the case of mobile phone use highlighted by household size, gender, access to agricultural credit.

The analysis of Table 3 reveals through the recursive bivariate probit model that the use of the radio as an information channel positively affects market gardeners' participation in the market. Examination of the participation equation shows that the use of the radio has both a direct and indirect effect on the probability of participation of market gardeners in the market. Radio has a stronger direct effect on the probability of participating in the market than its indirect effect. Indeed, the use of the radio increases the probability of participating directly in the market by 25.6% against 13.1% indirectly. These results confirm those found by Zanello (2012) which indicate that radio information has a greater impact on participation and on the volume of products exchanged. The positive effects of information from the radio on the participation of producers can be explained by the fact that in some rural areas,

Table 4. Bivariate Probit Estimation Results (Television as ICT Indicator).

Variables	Part (1)	EM (2)	UTELE (3)	EM (4)
Age				
]30;40]	-0.036 (0.257)	0.0143 (0.0960)	-0.525** (0.255)	-0.185* (0.0954)
]40;50]	0.068 (0.269)	0.0487 (0.100)	-0.436 (0.281)	-0.161 (0.104)
]50;more]	-0.544* (0.309)	-0.156 (0.1000)	-0.341 (0.299)	-0.0986 (0.114)
Sex	0.830*** (0.240)	0.262*** (0.0842)	0.662** (0.261)	0.183** (0.0857)
Education				
Elementary level	-0.460* (0.236)	-0.216** (0.0945)	1.051*** (0.259)	0.318*** (0.0735)
Secondary level	-0.044 (0.229)	-0.0626 (0.0917)	0.767*** (0.258)	0.191*** (0.0578)
Higher Level	-0.243 (0.359)	-0.157 (0.132)	1.256*** (0.392)	0.387*** (0.134)
Place of residence	0.114 (0.186)	0.0734 (0.0686)	-0.634*** (0.180)	-0.219*** (0.0645)
Credit Agricole	0.347** (0.154)	0.126** (0.0555)	-0.047 (0.160)	-0.0325 (0.0548)
Size of household				
]5;10]	0.448** (0.195)	0.124* (0.0647)	0.625*** (0.219)	0.174*** (0.0605)
]10;15]	0.059 (0.296)	-0.00202 (0.0929)	0.436 (0.319)	0.127 (0.0976)
Distance	0.283 (0.192)	0.171** (0.0836)	-1.197*** (0.214)	-0.337*** (0.0572)
Total production	-0.000 (0.000)	4.04e-07 (1.07e-06)	-0.000*** (0.000)	-5.86e-06*** (1.85e-06)
Total area covered	0.000 (0.000)	2.68e-05 (8.41e-05)	-0.000 (0.000)	-6.46e-05 (0.000136)
Income	-0.270* (0.149)	-0.0991* (0.0535)	0.053 (0.153)	0.0308 (0.0526)
Type of labour				
Employee	-0.139 (0.330)	-0.00800 (0.122)	-0.780* (0.418)	-0.213** (0.0854)
Family and Salaried	-0.195 (0.182)	-0.0493 (0.0631)	-0.375** (0.179)	-0.114** (0.0556)
Main source of income	-0.186 (0.244)	-0.0735 (0.0873)	0.140 (0.243)	0.0560 (0.0822)
Type of farm ownership	0.048 (0.156)	0.0170 (0.0557)		-0.00228 (0.00745)
Constant	-1.321*** (0.379)		-1.341*** (0.413)	
Wald	116.04 Prob > chi2 = .000			
Rho	4.542			
LL	-44.225			
Observations	453	453	453	453

Standard errors in parentheses. Share = Market Participation, EM = Marginal Effect, UTELE = Use of television.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Source : Authors, 2021.

farmers through community radios can access market days in peripheral markets as well as prices products in these markets. Indeed, radio seems to be the oldest and most popular information technology tool in developing countries, partly because of its accessibility, affordability and also because of local language broadcasts that take

place on these radios (Rao, 2018). Farm households can use the radio even if they do not have access to electricity.

The results obtained from the different information channels on market participation suggest that ICTs improve the market participation of vegetable producers. Indeed, market gardeners decide to produce and generate a marketable surplus once they have information on where to sell and what they will get from the sale. Even better, some farmers only enter the value chain if they are convinced that inputs are available. Thus, thanks to ICT, market gardeners have all this information at their disposal by interviewing other market gardeners or by interviewing extension agents without going to the market. The results are consistent with those found by Katengeza et al. (2014) and Dlamini-Mazibuko et al. (2019) who indicate that the use of ICT improves farmers' participation in the market by reducing the costs of finding information and that farmers who cannot access ICT are more likely to be exposed to transaction costs in general, which hinders their participation in the market.

On the other hand, the analysis of the participation equation also shows that age is a main driver of market participation. Indeed, market gardeners who are 50 years old and over and who access information via mobile phone are more likely to participate in markets than younger people, while those of the same age group who use the radio have less chance of participating in the market. Indeed, the use of mobile phones by market gardeners aged 50 and over increases the probability by 14% and 16.1% respectively directly and indirectly, while this probability decreases by 99.4% if they use the radio, and 13.5% if informed by television.

Another determinant of market participation for market gardeners is the level of education. In the recursive bivariate probit equation, it is not significant but has an overall marginal effect for the three levels of education. The insignificance can be explained by the fact that market participation does not necessarily depend on the education level of the market gardener but rather on his ability to use a mobile phone to access market information. Thus, a primary, secondary, and higher-level market gardener is respectively 13%, 16.8% and 18.6% more likely to participate in the market than an unschooled market gardener. These results are identical to those found by Tura and Hamo (2018) and Osebeyo and Aye (2014) who showed that the more educated farmers are, the more they participate in sales channels because they have a higher bargaining power than farmers uneducated.

Contrary to Awotide et al. (2013), market participation is also determined by the sex of the producer. The results highlighted that men are less likely to participate in the market than women when using mobile phones to obtain information, while through radio they are more likely to participate in the market than women. The probability of participating in the market using the mobile phone decreases by 14.8% while it increases by 28.4% with the use of the radio. Thus, market gardeners whose household size is between 5 and 10 members are less likely to participate in the market with the use of the mobile phone as an information channel while using radio and television, the probability of participating in the market increases by 12.9% and 11.4% more than market gardeners with smaller household size, respectively. These results can be explained by the fact that radio and television are commonly used in a household. Around a radio and a television, a discussion can take place between the members of the household to align themselves on the same understanding, which

would be difficult in the case of mobile phone use. Thanks to the mobile phone, household members can access varied and sometimes contradictory information, which can explain the conflict of information that can result and in turn produce a negative effect. These results corroborate those obtained in the literature. The negative effect related to the use of the telephone is like that obtained by Alene et al. (2008); Macharia et al. (2014) who explain the negative effect by the fact that the large size of the household reduces the marketable surplus due to domestic consumption. On the other hand, other studies note that height is an asset for the household in terms of work. Thus, for Tura and Hamo (2018) members contribute to production and help transport products to markets, hence the positive effect of household size on the participation of producers in the market. These results from Tura and Hamo are consistent with those found for radio and television use and those found by Honja et al. (2017) who notes that a large household can circumvent distance constraints and choose a better outlet for his product.

In addition to these results, the simple probit model reveals that income, distance and farm size are also factors in the decision of producers to participate or not in the market. Indeed, the results reveal that market gardeners who are more than 5 km away do not participate in the market compared to those who are closer, less than 5 km away. These results are in line with the literature on transaction costs on the one hand, which indicate that the further producers are from markets, the less they participate in them (Alene et al., 2008; Goetz, 1992). On the other hand, the results are also consistent with those found by Getahun (2020); Nabintu and Gaspart (2017) and Tura and Hamo (2018) who showed that the degree of participation is high when producers are closer to the market. They also point out that being closer to the market, producers bear less transport costs, which constitute a barrier to their participation. In addition to the distance that explains the decision to participate, income is also a factor. In accordance with the results of Getahun (2020) and Musara et al. (2018), it appears from the results that income positively affects the participation of market gardeners in the market. Thus, an increase in income favors a broad participation of market gardeners. Income appears as a motivating element that stimulates the choice of participation.

Overall, the results show that ICTs promote market access for market gardeners through the various information they make available to producers. In addition to this result, gender, age, household and farm size, income and distance are also determinants in market gardeners' decision to participate in the market.

This article has shown that in Benin, the use not only of the telephone but also of radio and television allows market gardeners to access relevant information which facilitates their access to the market. Radio is a dominant tool for accessing information in rural areas because electricity is not a constraint to its use. Community radios then serve as information relays in areas that are difficult to access for extension agents to disseminate information on farming practices and technical itineraries. By accessing this different information through the radio, market gardeners improve their productivity to market it. Thus, for better use of the radio, the executives of the Ministry of Agriculture, the ATDA agents, in collaboration with the promoters of the radios, will define and set up interactive programs in the local language on all the farming techniques and the days of activity of the local markets and the various agricultural products exchanged on these

markets. In addition to radio, the results show that the use of television also induces easy access to the market. Dissemination on the various televisions of agricultural information through images in the local language and the existence of local markets would further improve market participation. Public policies can consider the promotion of thematic television programs on agricultural issues such as BBTV for the effective sharing of information to reduce the costs of seeking information.

5. Concluding remarks

The article analyzed the contribution of ICTs to the participation of market gardeners in the market. The results reveal that the use of mobile phones, radio and television positively affect the decision to participate in the market gardeners' market. Indeed, through the information they receive through ICTs, market gardeners are encouraged and reassured of the income gain they can derive from participating in the market to meet their household needs. The results obtained in this article indicate that Information and Communication Technologies promote market access for market gardeners. Thus, where information is imperfect, ICTs can be used to enable market actors to access information at lower cost.

In addition to these findings, gender, farm size, income, and age are factors in the decision to participate in the market. The same is true of the level of education of market gardeners. Household size is an asset for market gardeners because it implies an active labor force for them in terms of improving production and transporting products to markets. Similarly, the proportional transaction costs associated with market access, such as distance to the nearest market, have significant negative effects on market participation and marketed supply.

The results suggest many policy implication. Thus, providing better access to markets by improving road infrastructure could be an important policy option to reduce transaction costs and allow small producers to take advantage of the benefits of marketing their products. Similarly, improving market information and telecommunications services could also increase smallholder participation in markets. Improving human capital through basic school education also seems to be crucial for smallholder market participation and marketed supply. The effects of geographic location on market participation and marketed supply are also important. To remedy this, it would be good to define and set up value chains because geographic location causes huge losses of market garden produce.

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