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# Effect of Mobile Phone Ownership on Agricultural Productivity in Benin: The Case of Maize Farmers

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**Abstract**

Given the importance of maize in the diet of citizens and country's objectives in terms of food security and export, a study on maize production is of great importance. This paper examines the effect of mobile phone ownership on agricultural productivity in Benin: The case of maize farmers. It uses a micro-data from Benin by adopting a two stages regression strategy. As previous studies, the results show significant evidence that mobile phone ownership improves maize farmers' productivity in Benin. Specifically, the findings show that the mobile phones ownership enhances the production of 0.21 and 0.04 respectively in the two models. This implies that through phones, extension agents without moving can inform farmers about farming techniques and national leaders should seek to promote the telecommunications so that a greater number of citizens can benefit from better services that enhance their productivity and that of the country.

**Keywords:** Mobile phone, Agricultural productivity, Maize, Benin, OLS, Poisson model

JEL classification codes: O13, Q16, Q18

## 1. Introduction

A lack of non-market information is considered as one of the main factors justifying the low level of agricultural productivity in developing countries (Otter and Theuvsen, 2013). Farming production processes require a lot of different information which can play a key role in the farming outcome. The failure to get the information needed can limit the farming performance. During the planting stage, information about high yield varieties and timing to plant are crucial, information on fertilizer, pesticides and new techniques can cause significant yield differences in planting and growing stages. More, information on appropriate harvesting time, climate and weather can allow farmers to achieve better results (Aker, 2011; Mittal and Tripathi, 2009).

Information and Communication Technologies (ICTs) are associated with high costs and need of adequate infrastructure and capabilities to use them, they are also seen as an effective tool for overcoming non-market information asymmetries and, thus, can contribute to increase farm productivity (Aker, 2011; Asenso-Okyere andAyalewMekonnen, 2012; Okello et al., 2012). The most important ICTs for rural areas of developing countries in terms of use are mobile phones and the internet (Otter and Theuvsen, 2013). The ownership of a phone gives farmers the opportunity to connect with others people to share and access information that can affect positively their farming performance (Arokoyo, 2005; Mittal, 2012; Aker andMbiti, 2010). Internet provides access to a large amount of agricultural data that can be easily stored and the possibility to connect with others across regions or even internationally via email or social networks (Chavula, 2014).

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Sife et al. (2010) and Mtega (2008) described ICTs as the most appropriate tools for information services provisions and furthermore most ICTs provide two-way communication and can provide simultaneously more than one service.

Benin's economy is slightly diversified and it is highly dependent on agricultural sector, which contributes up to 32.4% of the country's Gross Domestic Product (GDP) and 80% of its official export earnings (World Bank (WB), 2010). The modernization and diversification speed of the agricultural sector in Benin is slow. Indeed, Benin's agricultural sector is dominated by the cotton sub-sector, which contributes between 25% and 40% of total exports and 34.7% of the country official export earnings (WB, 2010). However, the performance of the cotton sub-sector is weakened by organizational problems, climatic hazards and the archaic state of the production technologies. Furthermore, the crisis that occurred in the cotton sub-sector since the 1999-2000 campaign has affected seriously the Beninese economy and showed its vulnerability due to its reliance on one export product (Programme de ProfessionnalisationAgricole du Bénin (PPAB)[4], 2001).

Agricultural diversification and increase of food production have therefore become a priority for agricultural development actors. The government of Benin has decided to promote several other promising crops, including maize. In fact, maize is today the first food commodity in Benin ahead of rice and sorghum (EMICoV[5], 2011). This shows the importance of this cereal for food security. Given its importance for food security and the national economy, the government has prioritized maize in the growth and poverty reduction strategy. The Government targeted the goal of increasing maize production from 841,000 tons in 2005 to 1,100,000 tons by 2011 in order to reach a food balance of at least 250,000 tons. Maize is also selected as a priority crop in boosting the agricultural sector: the government forecasted that by 2021 Benin would produce an average of 1,800,000 tons of maize per year and sustainably participate in cereals trade at sub-regional level and elsewhere (SCRP[6], 2007; PAG[7], 2016). A major dilemma in the current situation (food prices rise and an ever-growing population) is to strike a balance between food security policies and farmers' income improvement policies. With an agriculture constrained by land availability and climate hazards, improving productivity remains a crucial factor for the future of food security in Benin.

Thus, increasing productivity and agricultural production programs were implemented through distributing fertilizers and improved seed to farmers and by allocating them agricultural plots (SCRP, 2007). However, these policies had a limited effect since at the end of the period (2011-2015), the national goal for maize production was not achieved. Maize production was 1,438,918 kg in 2015 (ONASA[8], 2016) and all the economic potential of the sector are still not released. Despite the failure to meet the targeted goal, maize yield has improved. It increased from 600 kg/ha on average in 1970 to reach 1400 kg/ha in 2009 (ONS[9], 2010), 1103 kg/ha in 2010; 1422 kg/ha in 2011; 1251 kg/ha in 2012, and 1346 kg/ha in 2013 (FAOSTAT, 2015). But these yields are still lower than the levels achieved by neighbored countries. The maize yields were 1434 kg/ha in 2010; 1536 kg/ha in 2011; 1839 kg/ha in 2012, and 1799 kg/ha in 2013 in Burkina Faso (FAOSTAT, 2015). Despite the improvement in maize performance, it is clear that the maize yields followed an uneven trend, which made the country's food balance fluctuate in often worrying proportions. This poses threats to both food security and farmers' incomes and indirectly to their poverty level, since to reduce poverty in Benin, it would be necessary to increase the incomes of the 70% employed in agriculture (PEA[10], 2012). This is because each 1% increase in agricultural productivity in Africa reduces poverty by 0.6% while each 1% increase in production reduces the number of people living with less than one US dollar a day by 6 million (Thirtle et al., 2003).

Mobile phones services subscribers per 100 inhabitants increased from 0.08% in 2006 to 85.64% in 2011 (ATRPT, 2012). This shows a mobile phone ownership increasing in Benin in general and particularly in rural area. This massive appropriation is explained in large part by the low costs associated with the mobile phones use. Does this massive appropriation in Benin translate into in agricultural activities? Do farmers use the ICTs to share non-market information with technical partners (extension agents, pairs) and commercial partners?

[4]*Programme de ProfessionnalisationAgricole du Bénin* (AgriculturalProfessionalizationProgram in Benin)
[5]*EnquêteModulaireIntégrée sur les Conditions de Vie des ménages* (Integrated Modular SurveyonHousehold Living Standard)
[6]*Stratégie de Croissance et de la Réduction de la Pauvreté* (Growth and PovertyReductionStrategy)
[7]*ProgrammeAgricole du Gouvernement*(GovernmentAgriculturalProgram)
[8]*Office Natonal de SécuritéAlimentaire* (NationalFood Security Agency)
[9]*Office National de Soutien des revenusagricoles* (National Bureau fortheSupport of agriculturalincome)
[10]*Perspectives Economiquesd'Afrique* (Economic Outlook for Africa)

Does the use of ICTs affect agricultural productivity? The ICT effects on agricultural productivity have little been analyzed in Benin. This is mainly due to the lack of data necessary for such a study. This study therefore aims to fill this gap by identifying the factors that can improve agricultural productivity. This study aims to assess the effect of mobile phones ownership on maize farmers' productivity in Benin. Specifically, the study aims to : (1) identify the socio-economic variables that determine farmers' mobile phone ownership, (2) estimate mobile phones ownership effect on farmers' productivity, and (3) identify technical variables that can improve maize farmers productivity.
The rest of the analysis is organized around the following sections. Section 2 presents the literature on the subject. The methodology and data are presented in section 3. The analysis of the results is presented in section 4. Finally, the conclusion and implications are presented in section 5.

## 2. Literature review

The complexity of agricultural production function requires that farmers get information on a variety of topics, at almost every step, before adopting a new technology. da Silva and Ratnadiwakara (2008) think that farmers need different types of information during each stage of the production process, from weather forecasting to pest attacks, inputs acquisition (seeds and fertilizers), farming practices improvement as well as disease outbreaks and pricing management. Farmers can get this information from a number of sources, including the use of ICTs. In this regard, several authors have approached the question in different ways. Some researchers analyzed the role of ICTs at the aggregate level instead on the development of agricultural sector while others did it at the individual level.

### 2.1. The determinants of ICTs adoption in rural areas

Mobile phones adoption in developing countries has undergone a spectacular development in recent years. However, gender plays a role in mobile phone ownership and use. Indeed, women are still less likely to own a mobile phone than a man and this difference is even more pronounced for women living in Africa (GSMA, 2013). Beyond the sex, the age of the individual plays an important role in the use of mobile phones. According to Okello et al. (2012), young people are more addicted to technology regardless of their locality and young ages are positively correlated to the use of mobile phones. Therefore, it is expected that young farmers are likely to use this technology for most routine transactions. Falola and Adewumi (2011) suggested that non-membership in a farm-based organization, inadequate extension services, fluctuating telecommunications services, inadequate access to mobile services and lack of electric power are some factors constraining farmers' ownership of mobile phones. According to Akpabio et al. (2007), constraints affecting ICTs use by agricultural extension agents within the context of their activities include: weak development of ICT infrastructures, high cost of broadcasting equipment, high costs for radio/television services, high access/interconnectivity cost and electric power availability. Similarly, Yakubu et al. (2013) revealed that education, income, training, awareness, access, age and agricultural organizations membership are important factors in ICT adoption by extension agents. To these factors, it must be added the weak preparation of farmers and the adapting difficulty to technological cultures (Hadi and Lee, 2010).

### 2.2. Transmission channels of the effects of ICT use on agricultural productivity

The rapid growth of mobile telephony in developing countries over the last decade has introduced a new form of information use and distribution, which offers several advantages in terms of cost (Aker and Mbiti, 2010). In most developing countries, the information search costs are an important part of (around 11%) the total production cost supported by farmers during the agricultural cycle from sowing decision to products marketing (Bhatnagar, 2008). The impact of information can be classified in quantifiable terms (increased income, improved yield, etc.) and non-quantifiable terms (social benefits of improved communications, information on education and health, etc.) (Mittal et al., 2010).

In developing countries in general, agricultural extension refers to a form of education that introduces new knowledge in technology to farmers. Extension services use ICTs (national and local radio and television) to disseminate information such as weather and agricultural information (Goyal, 2010). Houghton (2009) notes that the consideration of all the information disclosed especially on radio and television allows farmers to maximize their income and efficiency. In Kenya, mobile phones were used for livestock identification and disease management and greater participation in the meetings of farmers' based organizations (FARM-Africa, 2007; Martin and Abbott, 2011).

The ICT efficiency in the transmission of information to farmers, especially smallholders, determines the successful means of delivery mechanism of information to extension services (Mittal, 2012). Moreover, Arokoyo (2005) concludes that the use of ICT can stimulate agricultural production significantly in developing countries. It is in this same context that Aker and Mbiti (2010) gave an overview of the mechanisms through which mobile phone can affect economic development in sub-Saharan Africa. The authors believe that mobile phones can increase access to information and improved management of farmers in terms of timely supply and therefore improved productivity.

Baye et al. (1999) found that mobile services can facilitate transactions by connecting farmers with various buyers and traders, thereby reducing communication costs. It allows farmers to identify potential buyers of their products over wider geographic areas (Mbiti, 2010). Improving communication between farmers and traders could also facilitate the provision of inputs in rural areas, avoiding unavailability of inputs. It can also help them decide where and at which price to sell their products (Abraham, 2007). Farmers can get their inputs such as fertilizers, herbicides, improved seeds through a Simple Message Service (SMS) or voice note without having to move. This allows them to have the desired inputs on time and therefore improve their productivity. Karamagi and Nalumansi (2009) noted that in central Uganda, farmers who used mobile phones were able to connect to FoodNet, a service that provides information on the current selling prices of agricultural products, as well as contacts of potential buyers through SMS. Aker (2008) and Muto and Yamano (2009) demonstrated that farmers realize positive price gains due to the introduction of mobile phones in the case of products or regions where the asymmetry of information on prices is very high and that markets have not been well developed for specific products with high added value. The use of ICTs, by increasing the access and participation to markets, allows the production of perishable crops such as bananas and helps farmers obtain better prices (nearly 20% of increase) by reducing the information asymmetry that existed between farmers and traders (Muto and Yamano, 2009).

Similar results were obtained by Aker and Fafchamps (2010) who showed that the introduction of mobile telephony reduces by 6% the dispersion of producer prices for cowpeas. They emphasized especially on the fact that the introduction of mobile phone services or mobile information in the agricultural sector has a greater impact in poorer and remote areas. Furthermore, the ICTs by expanding the available markets contribute to build farmers confidence in the system and the increase of farm investments. Farmers with relevant information are more equipped to take responsibility for themselves and their activities. Jensen (2007) suggested that the introduction of mobile phones decreased price dispersion and wasting by facilitating the dissemination of information to fishermen. Similarly, in Ghana, the adoption of mobile phones by farmers and agricultural traders helped reduce both transportation costs and transaction. But Overa (2006) came to the conclusion that this revolution of mobile telephony in Ghana has reduced only the information asymmetry. Abraham (2007) will join previous authors showing that the use of mobile phones has led to savings in transaction costs. Thus, we can say that the use of mobile phones by farmers can reduce the information search costs, significantly lowering transaction costs and enabling greater participation of farmers in commercial farming (da Silva and Ratnadiwakara, 2008). Aker and Mbiti (2010) supported this assertion by identifying mobile phones as a new search technology that reduces search costs for farmers by almost 50% in Niger.

It is also important to note that ICTs play an important role in the adoption of technologies that are at an early stage of adoption and the technology revolution (Fischer et al., 2009). Beyond all these benefits of ICT in agriculture, Gough and Grezo (2005) revealed that mobile phones offer new business opportunities and allows easy contact with relatives and friends of farmers. However, Fafchamps and Minten (2011) found that the use of ICTs in India has no statistically significant effect on the prices received by farmers or on post harvests losses due to climatic factors.

Glendenning and Ficarelli (2012) then pointed out that although ICT initiatives try to provide relevant content to local farmers and help reduce the gap of information among farmers, gaps in assessments and users' participation in order to improve the relevance of the content still remain. For Fischer et al. (2009), ICTs, beyond the great potential, have a big challenge in the relevance of the information provided. It is the reason why Surabhi et al. (2012) thought that in the case of India, the impact of mobile phones as an agricultural information providing mode will depend on how mobile networks are able to link farmers to market information and production technologies timely and accurately.

## 3. Research Methodology

Let us consider that the agricultural production $(Q)$ is function of ICTs (mobile phones), the agricultural technology level $(T)$, human resources $(H)$ and physical capital $(P)$. Following Antle (1983) approach, we assume a Cobb-Douglas agricultural production function with $(A)$ the level of Hicks-neutral productivity which depends on ICT and the literacy status and $\varepsilon$ a random variable identically and independently distributed. Thus, the agricultural production function takes the following functional form:

$$Q = AT^{\alpha}H^{\beta}P^{\delta}\varepsilon \quad (1)$$

Where $\alpha, \beta et \delta$ are constant coefficients so that the concavity of $(Q)$ be assured. With this functional form, the agricultural production function to be estimated could be specified as follows:

$$\log Q_i = \log A_i + \alpha \log T_i + \beta \log H_i + \delta \log P_i + \varepsilon_i \quad (2)$$

Note that $T, HetP$ include conventional agricultural inputs in the literature on agricultural production function. The level of agricultural technology $(T)$ is captured by variables such as fertilizer NPK (kg/ha), seeds (kg/ha), urea (L/ha) and herbicide (L/ha) which aim to measure the effects of technical inputs on production. Physical capital $(P)$ is represented by the land measured by the cultivated area (Ha). Human capital is measured by the labor (man/day). Agricultural production $(Q)$ is measured by the yield (in kg/ha).

The most relevant variable is the Hicks-neutral productivity level $(A)$. As noted above, this variable is captured by mobile phones and the literacy status. People can buy mobile phones because they are rich, rather than to get rich as a result of their purchase, and causality cannot be assigned. The ideal analysis would be to observe the productive outcomes of two identical households, one of which has a mobile phone and the other which does not. This would generate a direct measure of the added productivity of mobile telephony. However, this is impossible, so that the effect must be estimated in other ways. Following Houghton (2009), it is possible, for example, to break mobile phone ownership down into two distinct components: One consumptive and the other productive.

Purchasing a mobile phone only to call friends and play games would make it a consumptive good. This increases the utility of an individual without necessarily make the individual more productive. However, the functions of mobile phones can also be productive, for example, by allowing people to better keep track of market prices of agricultural goods at different times and locations, to have non-market information on new practices and production techniques, etc. It can be assumed that households are more likely to use mobile phones as they increase in wealth and education, because they can better afford them and have more exposure to them at that stage.

Thus, in order to measure the productivity associated with mobile phones, a separate measure of mobile phone ownership that is distinct from such factors is necessary. It is this measure that can be pitted against a household's productive output to estimate the mobile telephony value in improving productivity. If the econometrics are undertaken carefully, this random measure could well be estimated by the error term of the first step regression below:

Farmer mobile phone ownership regression function:

$$Mobileownership_i = f(Wealth_i; education_i; sex_i; \ldots\ldots) + \mu_i \quad (3)$$

ConsmptiveProductive

Farmer Productivity regression function:

$$\log Q_i = \hat{\mu_i} + \alpha \log T_i + \beta \log H_i + \delta \log P_i + \varepsilon_i \quad (4)$$

Each unit of the data set has a residual error $\ll \mu \gg$ from the first regression. The residual is equal to the difference between the farmer's actual and predicted mobile ownership outcome, given its characteristics. Since it's a binary variable, the farmer demand regression function is run as a Logit function. The estimation of the demand equation (3) allows on the one hand to identify the variables that determine the ownership or not of the mobile phone by farmers. On the other hand, it allows to recover its residual and by keeping it in the second regression as an explanatory variable, an estimate of the effect of the mobile phone ownership on the farmer productivity is developed.

It is obvious that there are other factors such as the amount of credit (formal or informal) obtained, climate, maize selling price, use of improved seeds and the production area which affect production too, and those must also be included in the second regression to account for their effect. So, substituting $\mu$ in equation (4), the residual productive component of mobile phone ownership is accounted for. Our dependent variable in the second regression is a continuous and positive variable since it is the agricultural production. Thus, this equation is estimated using ordinary least squares (OLS). To analyze the robustness of the results obtained, we will also use the Poisson model to estimate this equation. Accordingly, this estimation will allow us to identify not only the effect of mobile phone use on agricultural productivity but also to identify the technical variables that improve the farmers' productivity. Thus, our analysis seeks to isolate and capture the effect of demand not linked to consumption. However, be aware that the residual will also be correlated with other relevant variables that are not present in the first step regression.

This study used secondary data mainly including data about maize, rice and vegetable crops collected in 2012 by *PAPA-INRAB*[11] in collaboration with the sub-regional Program for the Integrated Management of Production and Pests (*Programme sous régional de la GestionIntégrée de la Production et des Déprédateurs, GIPD*). These data provide information on the practices of production, harvest and post-harvest which characterize the Maize, rice and vegetable crops farms in Benin's six departments (administrative districts), namely Collines, Couffo, Mono, Ouémé, Plateau and Zou. Specifically, the data concern 209 farmers and provide economic information such as the price (in FCFA) of inputs and of the output, the quantity (in kg) of inputs (fertilizer, urea, labor, etc.) and of the output, whether afarmer belongs or not to a group, whether he is or not in contact with an extension agent, etc. They also provide information on household characteristics such as household size, sex, literacy status and age of the household head, the distance from his home to his farm, etc. Table A1 illustrates the definition of the variables of the models and Table A2 presents the main characteristics of those variables, as well as the sample size.

## 4. Results and discussions

We estimate the models in two stages. In the first stage, we estimate only the farmer's demand function for mobile phone ownership. This estimation allows on the one hand to identify variables that determine a possession or not of mobile phones by farmers. On the other hand, it allows to recover its residual which is used as an explanatory variable in the model at the second stage. In the second stage, we estimate the farmer productivity function that allows identification of the mobile phone ownership effect on agricultural productivity in Benin but also other factors that determine agricultural productivity.

### 4.1. Determinants of the farmer's mobile phone ownership

Table 1 shows the results of farmer demand model. The estimated coefficients of the different variables are presented in column (1), while the marginal effects associated with each variable are presented in column (2). The probability associated to the Chi2 statistic indicates that the model is overall significant at 1%. In other words, the variables included in the model significantly contribute to the explanation of the farmer's mobile phones ownership.

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**Table 1: Farmers mobile phone ownership estimation results**

| VARIABLES | (1) Coefficients | (2) Marginal effects |
|---|---|---|
| Income | 0.0001*** | 9.79e-06 *** |
| | (0.000) | (0.000) |
| Literate status (1= yes) | 1.9528* | 0.4397* |
| | (1.076) | (0.238) |
| Contact with extension agent (1= yes) | -1.1277 | -0.1803 |
| | (0.834) | (0.126) |
| Contact with an NGO (1 = yes) | 0.3518 | 0.0709 |
| | (0.870) | (0.186) |
| Share of non-farm income | 4.4698* | - 0.8415* |
| | (2.444) | (0.473) |
| Farmer's Sex (1 = Male) | -0.4597 | -0.0936 |
| | (0.883) | (0.188) |
| Farmer's age | -0.0442 | -0.0083 |
| | (0.174) | (0.033) |
| Farmer'sagesquare | 0.0002 | 0.0000 |
| | (0.002) | (0.000) |
| Access to informal credit (1 = yes) | 0.4567 | 0.0939 |
| | (1.709) | (0.378) |
| Access to formal credit (1= yes) | -0.1603 | 0.0292 |
| | (1.139) | (0.199) |
| Membership of a farmer's grouping (1 = yes) | -1.2543 | -0.1772 |
| | (0.896) | (0.098) |
| Bar land zone | -4.8017*** | -0.3532*** |
| | (1.434) | (0.073) |
| Depression zone | -2.1940** | -0.2594 |
| | (0.982) | (0.088) |
| Fisheries zone | -3.2423*** | -0.3346*** |
| | (0.972) | (0.082) |
| Benin cotton zone | Reference | |
| Constant | -12.5275*** | |
| | (4.378) | |
| Observations | 209 | 209 |
| Wald chi2(14) | 54.56 | |
| Prob> chi2 | 0.0000 | |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

A close look at the results of the model reveals that the major determinants of the farmer's mobile phones ownership are income, the literacy status, the non-farm income and production area. According to the results, the farmer's income positively affects the farmer's probability to own mobile phone at 1%. This result is similar with those obtained by Falola and Adewumi, (2011) and Houghton (2009). This result indicates that when farmer's income increases, his probability to own mobile phone within the context of his agricultural activities is higher and this because of the ownership cost of mobile phones. Under these conditions, only farmers who have a substantial income are likely to own a phone. But note that in our study, farmer use income from agriculture to purchase mobile phones since their income is mainly from agriculture. Better, given the results of the estimation farmers do not expect credit both formal and informal to adopt mobile. The estimated marginal effect shows that the probability of a farmer to adopt mobile increases for 9.79. $10^{-6}$ when their income increases.

This result is strengthened by the fact that the more the non-farm income is important, the lower is the farmer's likelihood of adopting mobile phone in the context of its activities. The results further indicate that literate farmers have higher probability to adopt mobile phones. This result is in line with those found by Zahonogo (2011), Falola and Adewumi (2011). This would suggest that literate farmers are more likely to adopt mobile phone compared to those who are not. That shows the role of education in the mobile adoption. Otherwise, literate or higher educated farmers perceive better the usefulness of mobile phones in the production process beyond simple communication as having the mastery capacity of phone features and handling. The estimated marginal effect shows that the probability of a literate farmer to adopt mobile increases for 0.44 compared to a non-literate farmer.

Although its coefficient is not significant, he farmer's age plays negatively on its probability to adopt mobile phones even. This result is similar to that found by Falola and Adewumi, (2011) and Houghton (2009). This result is due to the fact that younger generations are more likely to familiarize and accept new technologies such as mobile phones though older farmers are more likely to get it. However, there are other studies in the literature, for example, Zahonogo (2011) who find a contrary result. Zahonogo (2011) estimated that, as income is correlated with age, more the age increase, people are likely to adopt new technology. However, in his analysis, he has ignored the potential of young people to work more than the old which may justify that young people have a higher income.

The production area also plays an important role in the adoption of mobile phones by farmers. Indeed, a producer who operates in the Bar land zone or in the fisheries zone has a low probability to adopt mobile compared to those operating in Benin cotton zone.

### 4.2. Effect of mobile telephony ownership on agricultural productivity in Benin

This subsection is devoted to estimate the effect of mobile phones on agricultural productivity. We introduced in the production equation out of production variables, the residual of the first step equation. This residual allows to measure the effect of mobile telephony adoption on agricultural productivity. The estimation results are presented in Table 2. Column (1) shows the results obtained by the OLS. To analyze the sensitivity of our results in terms of estimation method, a Poisson model is also estimated and the findings are presented in column (2).

**Table 2: Estimation of the effect of mobile phones ownership on agricultural productivity**

| VARIABLES | (1) OLS | (2) Poisson model |
|---|---|---|
| Residual | 0.2589*** | 0.0612*** |
| | (0.073) | (0.017) |
| Fertilizer NPK | 0.2082** | 0.0350* |
| | (0.103) | (0.020) |
| Seeds | 0.0611 | 0.0201 |
| | (0.065) | (0.013) |
| Urea | 0.0843* | 0.0164* |
| | (0.046) | (0.009) |
| Herbicide | -0.0245 | 0.0048 |
| | (0.051) | (0.010) |
| Labor | -0.0040 | -0.0007 |
| | (0.009) | (0.002) |
| Farm size | 0.0044 | 0.0027 |
| | (0.041) | (0.009) |
| Formal credit amount | 0.0245** | 0.0042** |
| | (0.010) | (0.002) |
| Informal credit amount | 0.0492*** | 0.0100*** |
| | (0.015) | (0.003) |
| Access to the farm | -0.3679* | -0.0857** |
| | (0.195) | (0.042) |
| Climate | 0.0048*** | 0.0013*** |
| | (0.000) | (0.000) |
| Maize selling price | 0.0049** | 0.0018*** |
| | (0.002) | (0.001) |
| Benin cotton zone | 0.9274*** | 0.2049*** |
| | (0.229) | (0.045) |
| Bar land zone | 0.1973 | -0.0644 |
| | (0.247) | (0.052) |
| Depression zone | 0.3198 | -0.0064 |
| | (0.279) | (0.057) |
| Fisheries zone | | |
| Observations | 209 | 209 |
| R-squared | 0.791 | - |
| F(15,194) | 2644.76 | - |
| Prob> F | 0.0000 | - |
| Wald chi2 (15) | - | 74029.14 |
| Prob> chi2 | - | 0.0000 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

A careful observation of the probability associated with both Fisher and Chi2 statistics shows that the model is overall significant at 1%. In other words, the variables included in the model significantly contribute to the explanation of agricultural productivity. The results show that the residual has a positive and significant effect on agricultural productivity in our two models. This indicates that the mobile phone adoption is an important determinant of agricultural productivity. Specifically, the findings show that the mobile phones adoption enhances the production of 0.26 and 0.06 respectively in the two models. This means that the mobile ownership is beneficial for agricultural productivity.

This result is consistent with those reported in the literature where mobile phone use is identified as source of improving productivity (Chavula, 2014; Aker and Fafchamps, 2010; Aker and Mbiti, 2010; Muto and Yamano, 2009; Houghton, 2009). For these authors, through phones, extension agents without moving can inform farmers about farming techniques. A close look at the results of the two models reveals that others important determinants of agricultural productivity are the NPK fertilizer, the urea, credit (formal as informal), climate (rainfall), the maize selling price and the production area. The results show that credit has a positive and significant effect on agricultural productivity. Indeed, a 1% increase of formal credit leads to an agricultural production increase of 0.02% and 0.004% respectively in both models. Furthermore, a 1% increase of informal credit leads to an agricultural production increase of 0.05% and 0.01% respectively in both models.

This result may be explained by the fact that the availability of credit (particularly informal which is more accessible to farmers in Benin) shifts liquidity constraint and allows farmers to purchase inputs on time given that they cannot otherwise afford it from their own resources and improves agricultural inputs use that leads to greater productivity. This result is consistent with that found by Asefa (2011). The maize selling price positively affects production. This is consistent with the theory of supply according to which farmers are sensitive to selling price of their products. Better, through the phone, the farmers can be informed and sell at a good price her product. This underscores the important role played by the policies aimed at stabilizing the selling price of this cereal. Benin cotton zone farmers have higher agricultural production compared to farmers in other areas. This result could be explained by the quality of soil that is found in each agro-ecological zone. This shows that the policy of improving agricultural productivity must take into account the specificity of each area to have more impact by defining the qualities and type of inputs that correspond to each agro-ecological zone.

**5. Conclusion and Policy Implications**

This study analyzes the effect of mobile phones on Agricultural Productivity in Benin using inputs and output data of 209 maize farmers from six Benin departments namely: Collines, Couffo, Mono, Ouémé, Plateau and Zou. First, the results show that variables such as income, literacy status, non-farm income, gender, farmer's age and the production area play a crucial role in the adoption of mobile phones by farmers in Benin. Secondly, in line with the literature, mobile phone is improving the agricultural productivity of maize farmers in Benin. Finally, other factors such as NPK fertilizer, seed, urea, credit (formal as informal), climate (rainfall), and production area have a positive role in the achievement of high agricultural production.

In terms of policy implications, our results point out the finger of real productive benefits of the prevalence of mobile phones in Benin. Such findings imply that national leaders should seek to promote telecommunications through ICT platforms so that more citizens can benefit from better services that improve their productivity and that of the country. For example, ICTs can be used to improve the extension service by enabling extension service agents to be in closer contact with farmers and provide the information they need in real time.

Other actions aiming at improving agricultural productivity should be continued. For example, the creation of incentives at the institutional level to increase the credit offer to set up a fund for agricultural credits allowing farmers to have access to agricultural credit at preferential rates and in a timely manner. Stabilization policies of maize selling price should also be pursued to guarantee farmers some assurance of the selling price of their production. Adaptation policies to climate change must be strengthened through for example the practice of irrigation, the use of improved seeds.

## Appendix

**Table A1. Definition of the variables of the models**

| Variable | *Definition* |
|---|---|
| **Mobile** | 1 if the farmer has a mobile phone; 0 otherwise |
| **Farmer's sex** | 1 if the farmer is male; 0 otherwise. |
| **Farmer's age** | The farmer's age in years |
| **Age squared** | The square of the farmer's age |
| **Climate** | Measured by yearly rainfall |
| **Literacy** | 1 if the farmer is literate ; 0 otherwise |
| **Formal credit** | Formal Credit amount obtained for the crop year |
| **Informal credit** | Informal Credit amount obtained for the crop year |
| **Farm area** | Farm size in hectares (ha) |
| **maize prices** | Maize Selling Price |
| **Membership of a farmers' grouping** | 1 if the farmer is a member of a farmers' group ; 0 otherwise |
| **Use of improved seeds** | 1 if the farmer uses improved seeds ; 0 otherwise |
| **Contact extension agent** | 1 if the farmer uses the services of an extension agent, 0 otherwise |
| **Contact with NGOs** | 1 if the farmer is in contact with an NGO operating in the agricultural sector, 0 otherwise |
| **Access to the farm** | 1 if the farmer has access to his/her farm in every season of the year, 0 otherwise |
| **Benin cotton producing zone** | 1 if the farmer is in the center Benin cotton producing zone ; 0 otherwise |
| **Bar land zone** | 1 if the farmer is in the bar land zone; 0 otherwise. |
| **Depression zone** | 1 if the farmer is in the depression zone ; 0 otherwise |
| **Fisheries zone** | 1 if the farmer is in the fisheries zone; 0 otherwise. |
| **Product** | Quantity of maize produced in kg/ha |
| **Herbicide** | Quantity of herbicide used in L/ha |
| **NPK** | Quantity of NPK fertilizer used in kg/ha |
| **Urea** | Quantity of urea used in kg/ha |
| **Seed** | Quantity of seeds used in kg/ha |
| **Labor** | Quantity of labor used in man-day/ha |

**Table A2. Descriptive statistics of the variables**

| **Sex** | **Frequency** | **Percentage (%)** | **Contact with NGOs** | **Frequency** | **Percentage (%)** |
|---|---|---|---|---|---|
| Male | 183 | 87,56 | Yes | 16 | 7,66 |
| Female | 26 | 12,44 | No | 193 | 92,34 |
| **Membership of a group** | **Frequency** | **Percentage (%)** | **Mobile** | **Frequency** | **Percentage (%)** |
| Yes | 20 | 9,57 | Yes | 85 | 40,67 |
| No | 189 | 90,43 | **No** | 124 | 59,33 |
| **Farm access** | **Frequency** | **Percentage (%)** | **Contact with extension agent** | **Frequency** | **Percentage (%)** |
| Yes | 157 | 75,12 | **Yes** | 49 | 23,44 |
| No | 52 | 24,88 | **No** | 160 | 76,56 |
| **Variable** | **Mean** | | **Standard Deviation** | **Minimum** | **Maximum** |
| **Farmer's age** | | | 14,023 | 17 | 89 |
| **Age squared** | 45,407 | | 1373,25 | 289 | 7921 |
| **climate** | 2257,483 | | 107,681 | 963,7 | 1288,9 |
| **Farm area** | 1112,289 | | 1,011 | 0,03 | 5,5 |
| **maize prices** | 0,913 | | 29,346 | 115 | 220 |
| **Product** | 173,828 | | 679,946 | 338 | 3250 |
| **Herbicide** | 1410,838 | | 19,870 | 1 | 65,518 |
| **NPK** | 52,806 | | 2,128 | 0,3333 | 18 |
| **Urea** | 3,614 | | 45,288 | 2,718 | 275 |
| **Seed** | 18,561 | | 33,457 | 0,1667 | 137,5 |
| **formal credit** | 31,231 | | 110946,7 | 0 | 950000 |
| **informal credit** | 20669,86 | | 11073,66 | 0 | 80000 |
| | 2488,048 | | | | |

Number of observations: 209

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