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Adoption of improved crop varieties by involving farmers in the e-wallet program in Nigeria[†]

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Adoption of improved crop varieties by involving farmers in the e-wallet program in Nigeria

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Abstract

The amount of improved seed used in Nigeria is extremely low. Overall, only 5 to 10 percent of cultivated land is planted with improved seeds, and about 10 percent of rural farmers use improved varieties. The objective of this investigation was to identify determinants of adoption of improved seed by farmers not participating in and those participating in the federal government's e-wallet program in Nigeria. We determined the impact of the e-wallet program on adoption of improved seed in rural areas. One thousand, two hundred (1200) rural farmers were sampled across six geopolitical zones of Nigeria. Results from the use of a bivariate probit model indicated that the e-wallet program continued to become increasingly popular among rural farmers; and that farmers' literacy, ownership of a mobile phone, value output, mobile network coverage, power for charging phone batteries and contact with extension agents were the positive determinants of farmer participation in thee-wallet program. Cultural obstacles to married women, growers' age, and increased distance to registration and input collection centers reduced farmers' tendency to participate in the e-wallet program. The results also showed that rural farmers depended on the e-wallet program for increased use and adoption of improved seed in Nigeria, to boost food security in sub-Saharan Africa. The results suggested the need for an improved e-wallet model by lessening constraints mostly associated with rural information and communication infrastructure, and distance to the registration and input collection centers.

Keywords: Agricultural transformation agenda; bivariate probit model; federal government of Nigeria; growth enhancement support scheme; mobile phone-based technologies; sub-Saharan Africa.

JEL Classification: J43; O40; O55; Q10

1. Introduction

Sustainable improvement of crop productivity in sub-Saharan Africa depends on improved varieties that are adapted to diverse environments (Keyser *et al.,* 2015). This is an area that the National Agricultural Seed Council (NASC) of Nigeria invested in to improve food security and enhance incomes of rural farmers in Nigeria (Awotide *et al.,* 2013). About 5 to 10 percent of the national seed requirement in Nigeria comes from certified seed, whereas the rest of the seed represents locally produced seed or seed saved by farmers from their own crop ('own-saved seed')(FMARD, 2010). With a few exceptions, most crop varieties being planted now in the country are improved, but often farmers plant such seeds for a long time without replacement (World Bank, 2014). Inadequate quantity of seed and high cost of seed of improved varieties have hampered their acceptance by farmers in Nigeria (World Bank, 2014). For decades, the government of Nigeria has sought to promote its agricultural sector by purchasing agricultural inputs and distributing them to the farmers. In 2012, the federal government of Nigeria began to distribute improved seed, fertilizers and other agricultural inputs through mobile phones, as the executive council awarded ₦1.327 billion (about US$ 8million) for the implementation of e-wallet system meant for small-scale farmers. In the e-wallet program, farmers receive information on the allocation of agricultural inputs via short message service (SMS) on mobile phone, thus by passing the middleman and avoiding corruption (Adesina, 2012). The federal ministry of agriculture has a database of about 3.5 million farmers; 75 percent of them being mobile phone users (Akinboro, 2014). The farmer that receives the allocation alert for seeds and fertilizers gets a subsidy of 50 percent. The farmer pays the remainder 50 percent and collects seeds and fertilizers from the agro-dealers in their communities; the monetary transaction is concluded without the involvement of the middleman (Adesina, 2012).

As a model, e-wallet distribution system has faced heavy criticism, and there has been serious debate over its utility and pragmatic application. While its advocates see it as a medium for potentially strengthening government–farmer relationship, critics view it as grounds for new tasks to be required of old institutions. This discrepancy in perception sets the basis for the e-wallet debate, pitting those for the elimination of the traditional middleman in the system through the use of mobile phone against those in favor of keeping the middleman. For example, Fadairo *et al.* (2015) argued that participation in the e-wallet program did not enhance input delivery to crop farmers in Oke-Ogun Area of Oyo State, Nigeria. In addition, Nwalieji *et al.* (2015) argued that the program had failed to make input delivery to rice (*Oryza*

sativa) farmers in Anambra State, Nigeria. Trini *et al.* (2014) had earlier affirmed that the program was not far-reaching or not deeply entrenched in rural areas. On the other hand, Grossman and Tarazi (2014) suggested that the e-wallet program had actually served smallholder farmers better than the prior paper voucher scheme (PVC). Olomola (2015) suggested that the realization of the e-wallet program was on a trajectory of progress, as input subsidy delivery had yielded much of the expected results. Recently, Adenegan *et al.* (2018) suggested that the e-wallet program contributed towards raising the income of farming households in Oyo State, Nigeria. Uduji and Okolo-Obasi (2018) introduced gender perspective to the debate, suggesting that the participation of young rural women would intensify the use of modern agricultural inputs in Nigeria. However, in Nigeria today, the debate on e-wallet system is not on whether this special agricultural scheme of the federal government is making available subsidized farm inputs to farmers and helping them shift from subsistence to profitable farming; rather, the debate is focused on how the e-wallet system can be applied to benefit the smallholder farmers in the rural areas of the country (Adebo, 2014; Uduji and Okolo-Obasi, 2017).

The use of improved seed in Nigeria is extremely low (Awotide *et al.,* 2013). In 2011, only about 5 to 10 percent of the cultivated land was planted with improved seeds and about 10 percent of rural farmers used improved varieties (Keyser *et al.,* 2015). In 2012, 7.2% of maize (*Zea mays*), 4.8 % of rice, 2 % of cowpea (*Vigna unguiculate*), 1.8 % of wheat (*Triticum aestivum*), and 1.7 % of sorghum (*Sorghum bicolor*) cultivated in Nigeria were planted with improved varieties (World Bank, 2014). Nevertheless, the foregoing debate has not delved into the issue of e-wallet program's role in the adoption of improved seed in rural Nigeria, especially as the use of improved varieties is exceedingly low. As a result, rural farmers have continued to face the challenge of availability of inadequate quantity of improved varieties on small farms. Against this background, the aims of this investigation, which were in line with government's agricultural transformation agenda (ATA) relative to agricultural and rural development, were to:

i. Analyze the extent to which rural farmers participate in the federal government's e-wallet program in Nigeria.
ii. Examine the level of adoption of improved varieties by rural farmers as a result of participation in the e-wallet program in Nigeria.
iii. Determine the consequences of adoption of improved varieties in rural Nigeria.

2. Materials and methods

In this study, we adopted a quantitative method, given the scarcity of quantitative data on the intricacies of production, allocation and extensive use of improved seed in the region (Uduji and Okolo-Obasi, 2018). This study made use of a survey research technique targeted at obtaining information from a representative sample of farmers. It is essentially cross-sectional and describes and interprets what exists at present.

2.1Study area

Nigeria comprises six geopolitically zones, with three zones, each making up the north and south, as shown in Figure 1. The study was carried out in six purposely selected states in Nigeria (see Table 1).

2.2. Sample size

The sample size (n) in this study was determined for finite population according to Taro Yamane (1964), using Equation 1 shown below:

$$n = \frac{N}{(1+N)\times(e\times e)} \qquad \text{Equation 1}$$

Where N = total or finite population of the study area, e = level of significance (limit of tolerable error), and 1 = unity (constant).

The estimated total population of farmers in the study area is shown in Table 2; hence N = 18,204,578. The 5% level of significance was used in this study, i.e., 95 percent confidence level; thus,

e = 0.05.

Thus: $n = \frac{18{,}204{,}578}{(1+18{,}204{,}578)\times(0.05\times 0.05)}$

$$= \frac{18{,}204{,}578}{18{,}204{,}579 \times 0.0025}$$

$$= \frac{18{,}204{,}578}{45{,}511.45}$$

$$= 399.99998$$

$$= 400$$

This was multiplied by 3 because of the three decisions involved in the specified model. This ensured that an adequate sample was selected for the study and probability of sampling error

was reduced. Hence, the total sample size = 1,200, as shown in the population of selected states in Table 1.

2.3. Sampling procedure

Multi-stage probability involving both cluster and simple random samplings were used to select the respondent households for the study. In the first stage, to ensure that the farmers' population was adequately represented, the states were clustered according to the six geopolitical zones: North-East, North-Central, North-West, South-East, South-South and South-West. In stage two, a purposive sampling was used to select one state from each of the six clusters (geopolitical zones). The purpose was based on the intensity of agricultural practices in the states. The selected states were: Benue State (North-Central), Adamawa State (North-East), Kano State (North-West), Ebonyi State (South-East), Cross Rivers State (South-South), and Ekiti State (South-West). In stage three, all the local government areas (LGAs) in each of the selected states were listed, and using purposive sampling, two LGAs were purposively selected from each state. The purpose was based on the intensity of agricultural practices in the LGAs. Thus, a total of 12 LGAs was selected for the study. In the fourth stage, to ensure proper representation, the main communities in the selected LGAs were listed and three communities were randomly selected from each LGA, giving a total of 36 rural farming communities for the study. In the last stage, out of the 36 communities selected, with the help of community leaders, 804 e-wallet-registered farmers and 396 non-e-wallet registered farmers were selected, giving a total of 1,200 randomly selected respondents (see Table 5).

2.4 Data Collection

Data for this study were collected mainly from the sampled farmers, who were the primary source of information. Participatory rural appraisal (PRA) technique, viz., semi-structured interview (SSI) questionnaire, was used for the primary data collection. The use of participatory research technique in collecting e-wallet impact data, especially as it concerns rural farmers, is based on the fact that it involves the people being studied, and their views on all the issues are important. The SSI questionnaire used was divided into three sections. Section one of the instrument elicited information on the socio-economic characteristics of respondents, and the other two sections elicited information based on the three research questions mentioned previously. The SSI questionnaire was the major tool we used in this study to conduct the household survey. It was directly administered by the researchers with

the help of a few local research assistants, who helped researchers communicate withlocal farmers who spoke languages and dialects different than those the researchers spoke.

2.5. Analysis technique

Data collected from respondents in the field were subjected to a series of treatments. Both descriptive and inferential statistics were used to analyze the data to achieve the objectives of the study. In modeling the impact of e-wallet on rural farmers, we used the bivariate probit model to test the hypothesis of the study, i.e., there is no significant correlation between the random terms of participating in the e-wallet model and adoption of improved seed in rural Nigeria. In this case, we were looking for the relationship between the random terms (the stochastic error terms (μ)), which determines farmer participation in e-wallet and adoption of improved varieties by farmers.

In modeling the impact of e-wallet and adoption of improved seed, so many statistical models, e.g., logit, probit and tobit models, could be applied. As good as these specifications may be, we noted that two major, interdependent decisions, i.e., to participate in the e-wallet program and to adopt improved varieties, were involved. According to Kefyalew *et al.* (2016) and Tura *et al.* (2010), using such single independent model specifications, e.g., logit, tobit or probit, might result in ineffective parameter estimation, as a single independent model may fail to capture the correlations between the two major decisions. Greene (2012) suggested that modeling two interdependent decisions, as in this case, required a model like the bivariate probit model. The bivariate probit model is a natural extension of the probit model, which appears in the decision to register and participate in the government's e-wallet model, and also in the decision to use the model to access improved seeds. Therefore, we adapted, with modification, the bivariate models used by Kefyalew *et al.* (2016) and Tura *et al.* (2010) for our data analysis. We used both econometric – view (E-view) and STATA software to analyze the data. After comparing the results of these statistical software, the results generated by the E-view were adopted. This is because it is particularly suitable to deal with the probit case in E-view, which has a built-in cumulative bivariate Normal Function that we explored and used to carry out the necessary tests.

2.6. Model specification

In specifying the model, we noted that the latent Y* from the decision to register and participate in the e-wallet program depends on a vector of explanatory variables 'x' so that the

binary outcome Y= 1 arises when the latent variable Y*> 0. Another observation about the interdependency of the decision to participate in the e-wallet and access improved seed is Y2, which is that using the e-wallet model to access and adopt the improved seeds is only observed if Y1 (participation in the e-wallet model) =1. The outcome of the decision represented by the first probit equation is fully observed. However, there is a censored sample in the second equation representing use of the model to access improved seeds because it is an off-shoot of the original response of the rural farmer. According to Tura *et al.* (2010), this censoring of observations implies the importance of taking into account self-selection at the registration and participation-decision-making stage to ensure proper estimation of model parameters. Hence, there are two latent variables (Y1*and Y2*) and in modeling two independent decisions, the assumption is that each observed variable takes on the value of 1 if and only if its underlying continuous latent variable takes on a positive value. The bivariate model can therefore be stated as follows:

$$Y1=\begin{cases}1, \text{if } Y1 *> 0\\ 0, \text{otherwise}\end{cases} \quad \text{Equation 2}$$

$$Y2=\begin{cases}1, \text{if } Y2 *> 0\\ 0, \text{otherwise}\end{cases} \quad \text{Equation 3}$$

with

$$\begin{cases}\gamma 1 *, X1\beta 1 + \varepsilon 1\\ \gamma 2 *, X2\beta 2 + \varepsilon 2\end{cases} \quad \text{Equation 4}$$

and

$$\binom{\varepsilon 1}{\varepsilon 2} \backslash X \sim \mu\binom{0}{0}, \binom{1P}{P1} \quad \text{Equation 5}$$

Note:

Y1*and **Y2*** are underlying latent variables

Y1 = 1, if sampled rural farmer registers and participates in the e-wallet model, 0 otherwise. (Not registered and not participating in the government's e-wallet program at the time of survey).

Y2= 1, if sampled rural farmer uses the e-wallet system to access improved seeds, 0 otherwise.

$\boldsymbol{\beta 1}$and $\boldsymbol{\beta 2}$ are vectors of estimation parameters to be computed.

X1and **X2** are explanatory variables entered into the estimation model.

$\boldsymbol{\varepsilon 1}$and $\boldsymbol{\varepsilon 2}$ are normally distributed error terms.

ρ= the likelihood ratio (LR) test function.

From the above, we estimated the values of $\beta 1$ and ρ to properly fit the model and maximize the likelihood of the bivariate model as follows:

L($\beta 1$, $\beta 2$) = (π**ρ**(Y1=1, Y2=1/ $\beta 1$, $\beta 2$)Y1Y2 **ρ**(Y1=0, Y2=1/ $\beta 1$, $\beta 2$)(1-Y1)Y2 **ρ**(Y1=1, Y2=0/ $\beta 1$, $\beta 2$)Y1(1-Y2) **ρ**(Y1=0, Y2=0/ $\beta 1$, $\beta 2$)(1-Y1)(1-Y2)

Equation 6

After substituting the latent variables Y1*and Y2*in the probability functions and taking log, we have the following:

$\sum Y1Y2\ln\rho(\varepsilon 1>-X1\beta 1,\varepsilon 2>-X2\beta 2)+(1-Y1)Y2ln\rho(\varepsilon 1<-X1\beta 1,\varepsilon 2)>-X2\beta 2)+(1-Y1)(1-Y2)ln\rho($
$\varepsilon 1<-X1\beta 1,\varepsilon 2<-X2\beta 2)$ Equation 7

The above equation is simplified by rewriting so that the log-likelihood function appears; thus, we have:

$\sum Y1Y2\ln\Phi\ (X1\beta 1,X2\beta 2,\rho)+(1-Y1)Y2ln\Phi(-X1\beta 1,-\rho)+(1-Y1)(1-Y2)ln\Phi(-X1\beta 1,-X2\beta 2,\rho)$

Equation 8

In equation 8, Φ is the cumulative distribution function of the bivariate normal distribution. Similarly, Y1and Y2 in the log-likelihood function above are observed variables, being equal to one or zero, depending on the farmer's decision regarding participation in the e-wallet program and using it to access improved seed. From the above, there are three possible observations obtainable from each respondent farmer, which are stated below:

$Y2 = 0 : prob(\ Y2 = 0) = 1 - \Phi(X2\beta 2)$ Equation 9

$Y1 = 0, Y2 = 1: prob(\ Y1 = 0, Y2 = 1) = \Phi_2(-X1\beta 1x, X2\beta 2, -\rho)$ Equation 10

$Y1 = 1, Y2 = 1: prob(\ Y1 = 1, Y2 = 1) = \Phi_2(-X1\beta 1x, X2\beta 2, \rho)$ Equation 11

2.7. Explanatory variables

In modeling the bivariate probit of participation in the e-wallet program and adoption of improved seed, some important covariates were included to maintain a reasonable number of degrees of freedom in the estimates (Deaton, 1997; Poirer, 1980; Men and Schmidt, 1985). Previous studies have suggested that adoption of new technology by farmers is an important determinant of the prosperity or otherwise of the farmers (Onyenweaku *et al.,* 2010; Imoru and Ayamga, 2015). The variables that determine the process of decision-making overlap. Such overlapping variables, which maybe household characteristics, farm and institutional

characteristics used to estimate the bivariate probit model, are as follows: Human capital endowments - family size and composition, and education are main factors that influence adoption decisions of households (Tura *et al.* 2010). The family size and its composition influence the decision from both the demand and supply sides of labor. Education, which includes skills and training, affect the profitability from the adoption of modern technology. This is because such human capital assets reflect unobservable productive characteristics of the decision maker (Carletto *et al.*, 1999). Education increases the ability of farmers to obtain, process, and use information relevant to the technologies (Wozniak, 1997). Also included as a covariate is off-farm income of the respondent specified as total income less farm income and expressed in Nigeria Naira(₦); income from the farming activities was excluded from the measure of income of the respondent and included as a separate covariate. Another important covariate included was value of farm output of farmers measured in₦. The difference in the value of e-wallet user's farm output and the farm output of non-e-wallet user determines adoption and usage of the e-wallet model by farmers. Farmers, who are yet to register and adopt the e-wallet program, examine the difference in output between them and the e-wallet users.

Also access to farm credit by farmers was included as a separate covariate, which is, either a farmer accessed credit or did not access credit. Also, of high importance was age bracket of the respondent, which was included, as it plays a major role in accepting or rejecting changes in technologies and methods. A gender dummy variable was used to account for the differential effects of gender of the respondent on resource availability and decision making. Though women are known to be more concerned about household welfare and development, they are often disadvantaged because of their social status and limited economic opportunities. Marital status of respondents was included to strengthen the issue of household decision making. Another variable used was farm size, measured in hectares, as researchers have argued that the larger the farm size, the greater the chance that farmer would adopt and use improved seed. Also, a dummy was used to account for the effect of type of farming on the decision of the respondent to participate in the e-wallet model and adopt improved seed. The experience of the farmer, measured as total number of years spent in active farming, definitely plays a role in adopting the e-wallet model. Other variables included were: land ownership type and contact with extension agent measured as number of times, which is very important as the complexity of the model may require constant communication from the change agents. A distance dummy used to account for the impact of distance to seed

certification and seed-selling point on the decision to use or not to use improved seed was also included.

The variables fitted into the model from X_1-------X_n are shown below:

X_1 = Age of farmer (years)
X_2 = Highest level of educational qualification (years)
X_3 = Marital status of respondent framer
X_4 = Household size of farmer (number)
X_5 = Access to farm credit by farmers (1=accessed and 0 otherwise)
X_6 = Size of farm cultivated by farmers (hectares)
X_7 = Ownership of mobile phones (1= owned, 0 = otherwise)
X_8 = Sources of seeds (1= e-wallet and 0= otherwise)
X_9 = Farming experience (years)
X_{10} = Off-farm income
X_{11} = Value of farm output of farmers in ₦
X_{12} = Mobile network coverage (1= covered and 0 = otherwise)
X_{13} = Land ownership type (1= inheritance, 0 otherwise)
X_{14} = Contact with extension agent (number of times)
X_{15} = Distance to improved seed-selling point (1 = far, 0 = otherwise)
X_{16} = Membership in cooperative organizations (1= Yes and 0 =No)
μ = Stochastic error term.

3. Results and discussion

To estimate the factors affecting the rural farmers' decisions to register and participate in the e-wallet scheme and the adoption of improved seed, a bivariate probit model was applied. This model was tested against other interdependent models like normal probit, logit and tobit. The results showed that the bivariate model was valid and fit for this estimation. Also, multicollinearity was measured using the variance inflation factor (VIF). The VIF assesses how much the variance of the estimated regression coefficient increases if the predictors are correlated. We noted that the VIF values of the independent variables were always <3. Hence, the bivariate probit regression coefficients were properly estimated.

3.1. Econometric estimation results

The bivariate probit used in the study was found to be valid. The likelihood ratio test (LR ratio test) carried out using independent equations showed that random terms in equations for registration and participation in the e-wallet model and adoption of improved seeds were strongly correlated, with LR of 1224.31. The significance of the LRtest (ρ=0) is an indication

that the decisions to register as a participant farmer and to adopt improved seeds are affected by almost the same set of unobservable heterogeneities. It is obvious that to estimate a univariate equation will result in inefficient parameterization. The results of the analysis showed that educational level of the farmer, access to credit, mobile phone ownership, off-farm income, value of output, mobile network coverage, land ownership, and extension contact significantly affected both decisions positively. On the other hand, age, marital status, farming experience and distance to registration and collection centers negatively affected both the decisions. This shows that the probability of participating in the e-wallet program and adopting improved varieties was greater than 0.5, as the set of hurdles to pass in both are the same.

3.2 Participation in the e-wallet program

Participation in the e-wallet starts with registration of farmers (Adesina, 2012). However, our findings (Table 2) indicate that only about 24% of the farmers in the study were registered. This implied that additional efforts would need to be made to ensure that the farmers actually take the first step of registering in the program. The reasons for not registering in the e-wallet program are shown in Figure 2. The econometric estimation shows that at the 1% significance level, ownership of mobile phone, access to power source for charging phones, land ownership type and contact with extension agents were significant (Table 3). This shows that farmers with access to mobile phone, which is the major source of communicating the e-wallet information, were more likely to register for and participate in the program. Access to power to charge the mobile phone is as important as owning a mobile phone. These two factors, i.e., access to mobile phone and access to power source to charge phones, combined with adequate land ownership and access to extension agents, should definitely promote farmer participation in the e-wallet program. On the other hand, marital status, surprisingly, negatively affected farmers' registration and participation in the e-wallet program. This was as a result of the fact that rural women rarely participate in the development intervention, as they majorly face cultural obstacles.

Educational level, value of participants' output and mobile network coverage were significant at the 5% probability level, showing that an increase in any of these factors would positively influence participation in the e-wallet model. Increased level of education increases the capacity to read and write, which is required in the e-wallet text messaging; whereas access to

power source and mobile network coverage ensure that phones are active and massages sent are received and acted upon. Increase in the output of e-wallet users is a natural motivation for non-users. Also, at the same probability level (5%), age of the farmer and their farming experience were significant and negatively related to adoption of the e-wallet program. This implied that as the age of the farmer increased with the experience in farming, the tendency to participate in e-wallet model decreased. At 10% significance level, access to credit and off-farm income were positively significant, showing that increased access to credit and off-farm income provided funds to be able to redeem the inputs.

We noted (Figure 2) that in line with the factors identified to be significant in the decision making of the famers, about 38% of the respondents did not register for the e-wallet program because of total absence of information. Also, another 10% farmers who did not register for the e-wallet program did not register because of incomplete information about the e-wallet process. Hence, 48% of the non-registered farmers did not register for reasons related to information. On the other hand, distance to the registration and collection centers explained why about17% of the non-registered farmers did not register; religious reasons accounted for 13%, political affiliations accounted for 16% and unpredictability of government policies accounted for 6%. This implies that there is a need for a grassroots campaign in rural areas to ensure that farmers take the first step of registering in the e-wallet program.

3.3. Adoption of improved varieties

We noted four factors that negatively influenced the decision to adopt improved seeds (Table 4). While the marital status of the farmer, distance to input redemption centers and farming experience were negatively significant at 1% probability level, age of the respondent was significant at 5% level. The marital status can be explained by the cultural challenges faced by most of the rural women farmers, who seldom make decisions independent of their husbands. The adoption of any kind of input by women is relatively restricted, which agreed with Uduji and Okolo-Obasi (2017) in that it is always a function of availability of land, and culturally, many married women have no land of their own but can only have access to land either through their husbands or adult sons. In this case, young women's marriage negatively influenced their adoption decision, as all decisions must be made with the consent of their husbands. Also, as the age of the young rural women increases and it is expected that access to land can be guaranteed through their children, they have become so used to the tradition that adoption of innovation does not appeal to them. This finding agreed with Uduji and

Okolo-Obasi (2018) in that, in a typical Nigerian village, where farmers must travel 20-30 kilometers to buy a handful of improved seed, one cannot expect poor rural farmers to register in the e-wallet program. Sources of getting improved seed, access to credit, off-farm income, household size and educational level of the respondent were significant at 5%, whereas membership in a cooperative body was positively significant at the 10% probability level. Household size was positive because through the provision of household labor, it influenced the decision to adopt even when it might be more labor-intensive not to adopt. Education, as noted in Wozniak (1997), helped the farmers with supply of adequate information and at the right time. In summary, increases in these factors should definitely increase the tendency to adopt improved seeds.

3.4. Implications of findings

Overall, the analysis indicates that the federal e-wallet program is increasingly becoming popular among rural farmers in Nigeria. The rural farmers want to participate if they have the means. Analysis (Figure 3) showed that the federal e-wallet program had enhanced the timeliness of getting improved seed in rural Nigeria. Most importantly, analysis (Figure 4) revealed that the e-wallet program was making some progress in access to improved varieties for agricultural production in rural Nigeria. This information is supported also by World Bank (2014), which posited that farmers who used improved varieties of rice obtained an average yield of 5.4 tons per hectare, whereas those who did not use improved varieties obtained an average of 2.9tons per hectare.

Of the 1200 farmers that were sampled, men constituted 59% of the registered farmers, 44% of non-registered farmers; whereas women made up 41% of the registered farmers and 56% of non-registered farmers. This gap in registration tends to corroborate findings of Uduji and Okolo-Obasi (2018) in that the cultural constraints forced women to farm under their husbands. Further analysis showed that 75% of the registered women farmers were either widowed, separated or divorced, indicating that they were not working under any man.

The average age of registered farmers was28 years, with an average of 11.5 years of experience in farming (Table 5).The average age of the non-registered farmers was 41 years, with 21 years of farming experience. The registered farmers were more educated, with only 8% illiteracy level, whereas the literacy level among the non-registered farmers was low, with about 40% not able to read or write. About 63% of the registered farmers had their own

mobile phone, whereas 34% used the phones of their neighbors' children or relatives; and only 3% had no access to mobile phone use. Among the registered farmers, 46% had network coverage and only 13% had no network coverage in their communities. On the contrary, only 17% of non-registered farmers had access to mobile phones, whereas 83% did not. This is a big issue as far as the e-wallet program is concerned because the main mechanism driving the adoption of e-wallet program is having a mobile phone and being able to use mobile phone-based technologies. Generally, among the registered and non-registered farmers, access to credit was low, as only 18% of the registered farmers had access to credit, whereas only 5% of non-registered farmers had access to credit. The study also showed that 51% of the registered farmers had inherited land, whereas 32% purchased their farmland. On the contrary, about 52% of non-registered farmers leased their farm land. This showed that the registered farmers were more disposed to the availability of land than non-registered farmers. About 85% of the farmers registered because they made contact with the extension agent, whereas95% of the farmers did not register, as they did not have any contact with the extension agents. Also, 85% of the non-registered farmers did not register because the registration center was far from their communities. Results also showed that about 44% of the registered and 89% of non-registered farmers still earned between 0 and N100,000(0 and 278 USD) per annum.

The introduction of e-wallet program increased the availability and affordability of improved seed to the farmers who participated in the e-wallet program (Table 6). About 61% of the registered farmers had access to improved seed at a moderate price of N12, 000 (per 50kg bag); whereas only 8% of the registered farmers still lacked information on how to access improved seed via e-wallet program. On the other hand, only 17% of the non-registered farmers had access to improved seed at an affordable price of N15, 000 (per 50kg bag); whereas about 37% had no access to information on how to access improved seed via the e-wallet program. This finding supports Aker (2011) in that if agricultural information using mobile communication is complemented with physical contact with extension agents in rural areas, the usage of improved seed could reach farmers faster in developing countries.

The e-wallet usage by registered farmers improved the timeliness of getting access to the improved seed by 30%. Also, the registered farmers that had access to improved seed moderately early increased by 15% (Figure 3). This suggested that the e-wallet program reduced untimely receipt of improved seed in rural Nigeria by 33%, and reduced the number

of farmers who never accessed improved seed by 12%. About 28% of non-registered farmers had no access to any kind of improved seed (Figure 4), whereas only 4% of the registered farmers did not have access to improved seed. The findings also revealed that farmers' personal reserve of seed accounted for 18% of the improved seed used by non-registered farmers; whereas open market and cooperative societies accounted for 18% and 16%, respectively; and e-wallet accounted for none. Among the registered farmers, personal reserve accounted for 13% of the improved seed, open market and cooperative societies accounted for 3% and 9%, respectively, and e-wallet accounted for 60%. This showed that there was much improvement in the adoption and usage of improved seed compared with the findings of Mariano *et al.*(2012) in the Philippines. However, because the personal reserve and open market still control a significant part of the seed market, there is a need to further explore the campaign communication theories (Bandura, 1986), especially the social cognitive model to persuade the poor rural farmers to adopt improved varieties to enhance their income and improve food security in the country.

On the whole, our findings demonstrated that e-wallet program improved smallholder farmers' access to improved varieties in rural Nigeria. However, the results also showed that insufficient dissemination of information about the e-wallet program has been among the major challenges in rural areas. The poor rural electrification service and Global System for Mobile (GSM) Communications network were the major hindrances to effective implementation of the e-wallet program in rural communities of Nigeria. The findings support campaign communication theories (Bandura, 1986) in that generating specific outcomes in a relatively large number of individuals, within a specified time, requires a targeted, organized set of communication activities, implying that rural farmers learn from observation and that the reinforcement or punishment of the behavior impact their participation in the e-wallet program and adoption of the improved varieties. Therefore, if the federal government of Nigeria is to work towards an ideal e-wallet program for effective adoption of improved seed by rural farmers in the country, constraints mostly associated with rural information and communication infrastructures, and distance to the registration and collection centers be reduced. It is our contention that the federal ministry of agriculture and rural development holds the key to adoption of improved seed in rural Nigeria. Hence, embracing effective information and communication technology, and accessible centers, should form the foundation of the agricultural transformation agenda; which in turn would create sufficient

dissemination of information for increased participation of rural farmers, increased knowledge and adoption of improved varieties; and widespread food security in sub-Saharan Africa.

4. Conclusions and policy

We investigated the impact of involvement of rural farmers in the e-wallet program in Nigeria on improved varietal seed adoption. Results from the use of a bivariate probit model indicated that the e-wallet program continued to become increasingly popular among rural farmers; and that farmers' literacy, ownership of mobile phone, value of output, mobile network coverage, power for charging phone batteries and contact with extension agents were positive determinants for participating in the e-wallet program. Cultural obstacles to married women, grower's age, and increased distance to registration and collection centers reduced farmers' tendency to participate. The results also showed that rural farmers depended on the e-wallet program for increased use and adoption of improved seed in Nigeria, to boost food security in sub-Saharan Africa. The results suggested the need for an improved e-wallet model by lessening constraints mostly associated with rural information and communication infrastructure, and distance to the registration and collection centers.

This investigation adds to the literature on agriculture and rural development in five notable ways. Firstly, we identified the factors that hamper or enhance effective execution of the e-wallet program. Secondly, the research provides insights into the usefulness of mobile phone in adoption of improved seeds in rural areas. Thirdly, unlike former studies, this study makes use of a quantitative methodology, keeping in mind that quantitative works on seed information and distribution in the region are lacking. Fourthly, the investigation seeks to explore the nature of campaign communication theories in a rural African farmer context. Fifthly, we put forward policy suggestions that would aid sub-Saharan African nations to successfully tackle the challenge of low adoption rates of improved seeds in the region. To our knowledge, this is the first study that surveys the relevance of mobile phone in adoption of improved seeds by rural farmers in sub-Saharan Africa.

Disclosure statement

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Table 1. Sample distribution table

States (Geopolitical zones)	Male	Female	Total population	Farmers' population	Samples per state	Samples per community	
						Regd.	Non-Regd.
Adamawa(North-East)	1,607,270	1,571,680	3,178,950	2,384,213	156	17	9
Benue(North-Central)	2,114,043	2,109,598	4,223,641	3,167,731	210	23	11
Cross River(South-South)	1,471,967	1,421,021	2,892,988	2,169,741	138	16	8
Ebonyi(South-East)	1,064,156	1,112,791	2,176,947	1,632,710	114	12	6
Ekiti(South-West)	1,215,487	1,183,470	2,398,957	1,799,218	120	14	6
Kano(North-West)	4,947,952	4,453,336	9,401,288	7,050,966	465	52	26
Total	**12,420,875**	**11,851,896**	**24,272,771**	**18,204,578**	**1200**	**134**	**66**

Source: FMARD, 2010/authors' computation

Table 2. Estimation of rate of farmer participation in the e-wallet program

States (Geopolitical zones)	Estimated farming population	No. of registered farmers	Percentage
Adamawa (North-East)	2,384,213	476,843	20
Benue (North-Central)	3,167,731	823,610	26
Cross River (South-South)	2,169,741	455,646	21
Ebonyi (South-East)	1,632,710	310,215	19
Ekiti (South-West)	1,799,218	449,805	25
Kano (North-West)	7,050,966	2,326,819	33
Total	**18,204,578**	**4,369,099**	**24**

Source: FMARD, 2010/authors' computation

Table 3. Econometric estimates of bivariate probit models for farmer participation in the e-wallet program in Nigeria.

Variables	Coefficients	Standard error	|P| z > z|
Constant	-.2531	.3020	.9251
Age (years)	- 154	.128	0.342*
Education (years)	0.032	953	0.145*
Marital status	-0.266	1.139	1.217**
Household size	- 0.231	1.21	1.218
Access to credit	0.6251	0.042	0.175!
Size of farm	1.302	0.857	1.431
Mobile phone	2. 823	0.034	0.085**
Farming experience (years)	-3.136	0.027	2.213*
Off-farm income	0.128	0.009	0.001!
Value of output (₦)	2.91	0.034	1.078*
Mobile network coverage	3.125	0.021	0.0319*
Land ownership type	1.08	0.41	1.125**
Extension contact	0.596	0.018	0.302**
Access to power supply	0.925	0.407	0.123**
Distance	-.021	0.07	0.824*
Number of observations	1200	1200	1200
(Likelihood Ratio) LR test (ρ =0)	χ 2 (1) =1224.31*		
Pseudo R^2	0.26		

!, *, ** Significant at 10%, 5%, and 1% probability level, respectively.

Source: Computed from the field data by authors.

Table 4. Econometric estimates of bivariate probit models for adoption of improved seeds by rural farmers in Nigeria

Variables	**Coefficient**	**Std. error**	**|P| z > z|**
Constant	32.342	11.9117	7.9125
Age of a farmer (years)	- 0.1421	0.379	0.214*
Highest level of educational qualification (years)	1.521	.175	0.123*
Marital status of respondent Farmer	0.2181	0.312	2.172**
Household size of farmer	- 1.0134	0.1321	1.83
Access to farm credit by farmers	0.218	0.523	0.175*
Size of farm cultivated by farmers (hectare)	4.725	2.712	1.81
Ownership of mobile Phone	1.687	1.769	0.032*
Farming experience (years)	-0.121	0.1443	4.93**
Membership of cooperative body	0.5612	0.2205	0.031!
Sources of improved seed	2.102	0.239	0.578*
Off-farm income	2.017	1.215	0.029*
Value of farm output of farmers in ₦	2.0241	1.0513	1.032**
Mobile network coverage	0.142	0.275	.102!
Land ownership type	0.371	0.251	0.312**
Access to power source	0.126	0.142	1.482
Contact with extension agent	2.864	1.086	0.492**
Distance to improved seed/selling point	-0.037	0.094	0.097**
n = 1200			
LR test (ρ =0)	χ 2 (1) =175.24*		
Pseudo R^2	0.34		

!, *, ** Significant at 10%, 5%, and 1% probability level, respectively.

Source: Computed from the field data by authors

Table 5. Socio – economic characteristics of the respondents

	Registered farmers			Non-registered farmers		
Variables	**Freq**	**%**	**Total**	**Freq**	**%**	**Total**
Males	476	59	59	173	44	44
Females	328	41	100	223	56	100
	804	**100**		**396**	**100**	
Years of experience						
0- 10 years	489	61	61	99	25	25
11- 20 years	231	29	90	125	32	57
21 – 30 years	56	7	97	111	28	85
31 - 40 years	21	3	99	35	9	93
Above 40 years	7	1	100	26	7	100
	804	**100**		**396**	**100**	
Age of respondents						
Less than 20 years	138	17	17	54	14	39
21-35 years	456	57	74	197	50	89
36-50 years	186	23	97	126	32	95
51 years and above	24	3	100	19	5	100
	804	**100**		**396**	**100**	
Land ownership type						
Inherited	410	51	51	65	16	16
Purchased	260	32	83	126	32	48
Leased	134	17	100	205	52	100
	804	**100**		**396**	**100**	
Contact with extension agent						
Yes	687	85	85	378	95	95
No	117	15	100	18	5	100
	804	**100**		**396**	**100**	
Ownership of mobile phone						
Have a set	510	63	63	45	11	11
Uses a neighbor's set	272	34	97	24	6	17
Have no set	22	3	100	327	83	100
	804	**100**		**396**	**100**	
Mobile Network coverage						
Network is good	370	46	46	119	30	30
Poor	122	15	61	85	21	52
Very poor	210	26	87	64	16	68
No network at all	102	13	100	128	32	100
	804	**100**		**396**	**100**	
Access to Credit						
Yes	144	18	18	18	5	5
No	660	82	100	378	95	100

	804	**100**		**396**	**100**	

(Continued)

Table 5. Continued

	Registered farmers			**Non-registered farmers**		
Variables	**Freq**	**%**	**Total**	**Freq**	**%**	**Total**
Level of Education						
None	64	8	8	157	40	40
FSLC[‡]	405	50	58	142	36	76
WAEC/WASSC[§]	216	27	85	65	16	92
B.Sc. and Equivalent	48	6	91	11	3	95
Post Graduate Degrees	26	3	94	6	2	96
Others	45	6	100	15	4	100
	804	**100**		**396**	**100**	
Close	467	58	58	311	79	79
Far	337	42	100	85	21	100
	804	**100**		**396**	**100**	
Monthly income level						
₦0 - ₦50,000	34	4	4	76	19	19
₦51,000 - ₦100,000	73	9	13	114	29	48
₦101,000 - ₦ 150,000	82	10	24	126	32	80
₦ 151,000 - ₦200,000	130	21	44	36	9	89
₦ 201,000 - ₦ 250,000	168	16	61	20	5	94
₦ 251,000 - ₦ 300,000	112	14	75	11	3	97
₦ 301,000 - ₦ 350,000	92	11	86	7	2	98
₦351,000 - ₦ 400,000	65	8	94	4	1	99
Above ₦[**] 400,0000	48	6	100	2	1	100
	804	**100**		**396**	**100**	

Source: Computed from the field data by authors

[‡]First school leaving certificate

[§] West Africa Examination Council / West Africa Secondary School Certificate

[**]Nigeria Naira (₦) [Three Hundred and Eighty Nigeria Naira (₦380) = One US dollar ($1)]

Table 6. Distribution of respondents by constraints faced in accessing improved seeds

	Registered farmers			Non-registered farmers		
Actual cost of improved seed	**Freq**	**%**	**Total**	**Freq**	**%**	**Total**
Available and affordable (low price)	279	35	35	24	6	6
Available and affordable (moderate price)	212	26	61	42	11	17
Available and unaffordable (high price)	165	21	82	78	20	36
Unavailable and unaffordable (high price)	83	10	92	105	27	63
Total lack of information	65	8	100	147	37	100
	804	100		396	100	

Source: Computed from the field data by authors

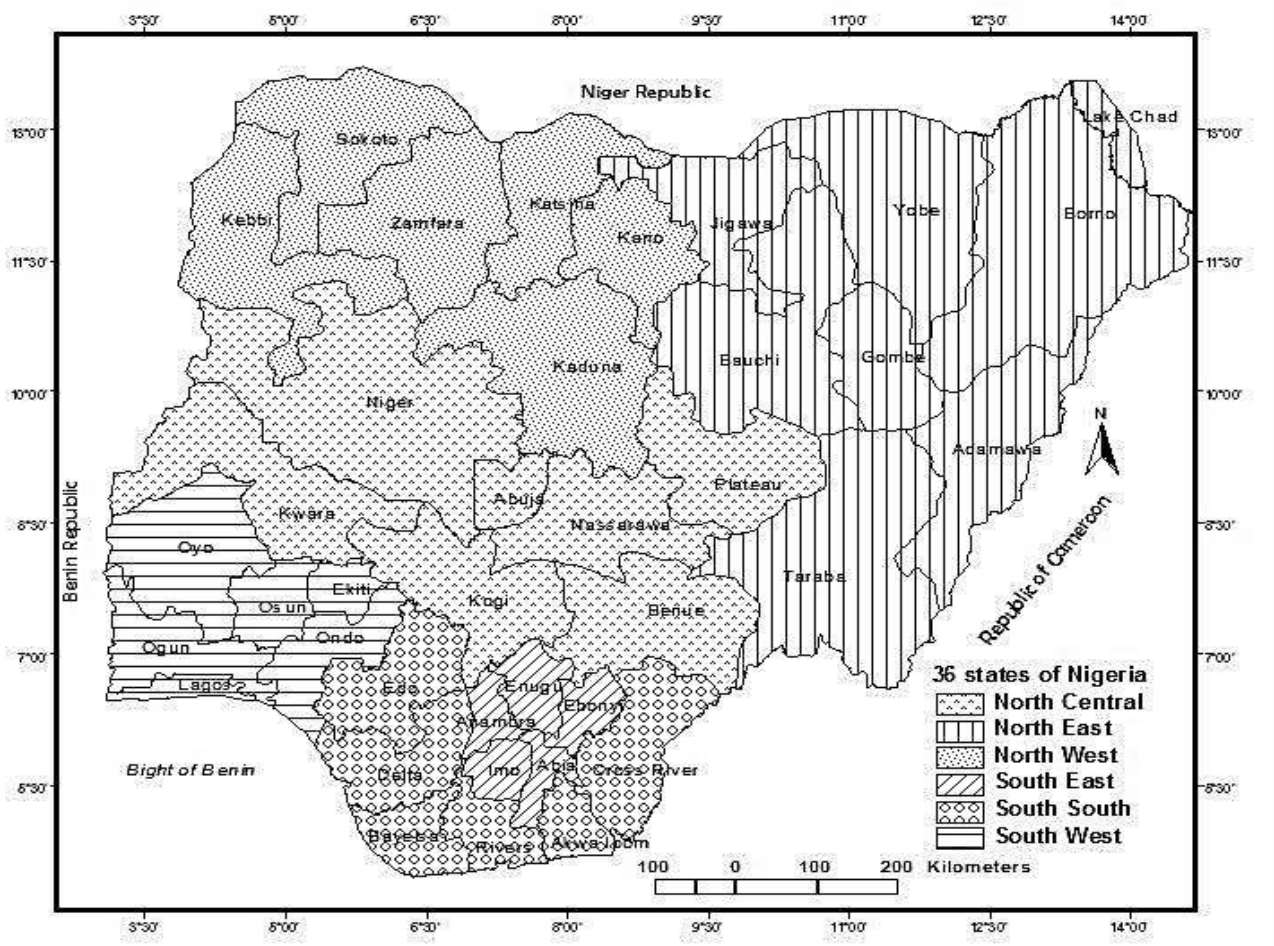

Figure 1. Constituent states of the geo-political zones in Nigeria

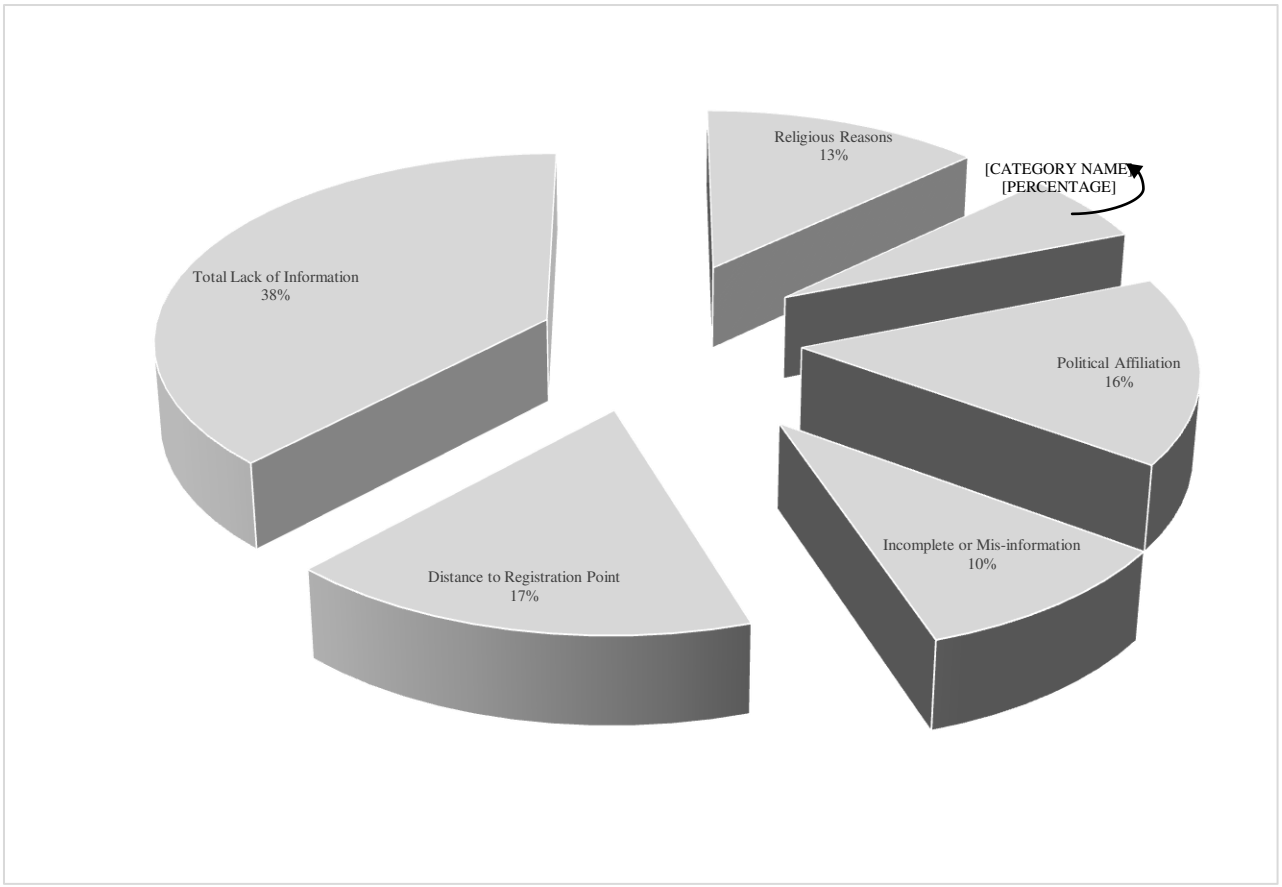

Figure 2. Distribution of non-registered farmers by main reason for not registering in the e-wallet program

Source: Computed from the field data by authors.

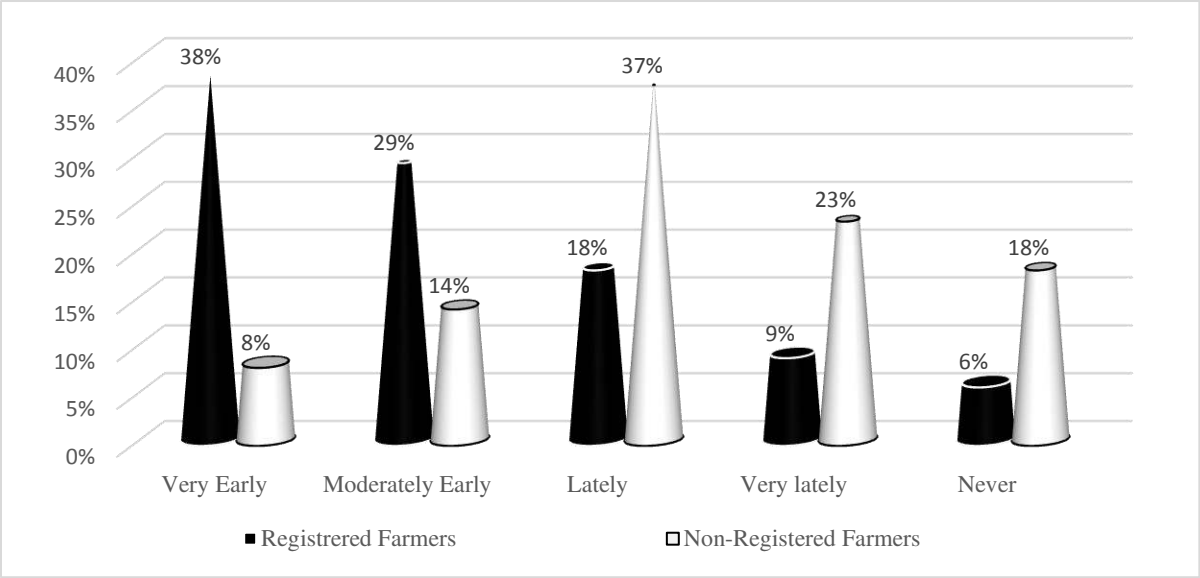

Figure 3. Distribution of respondents by timeliness of getting the improved seed

Source: Computed from the field data by authors

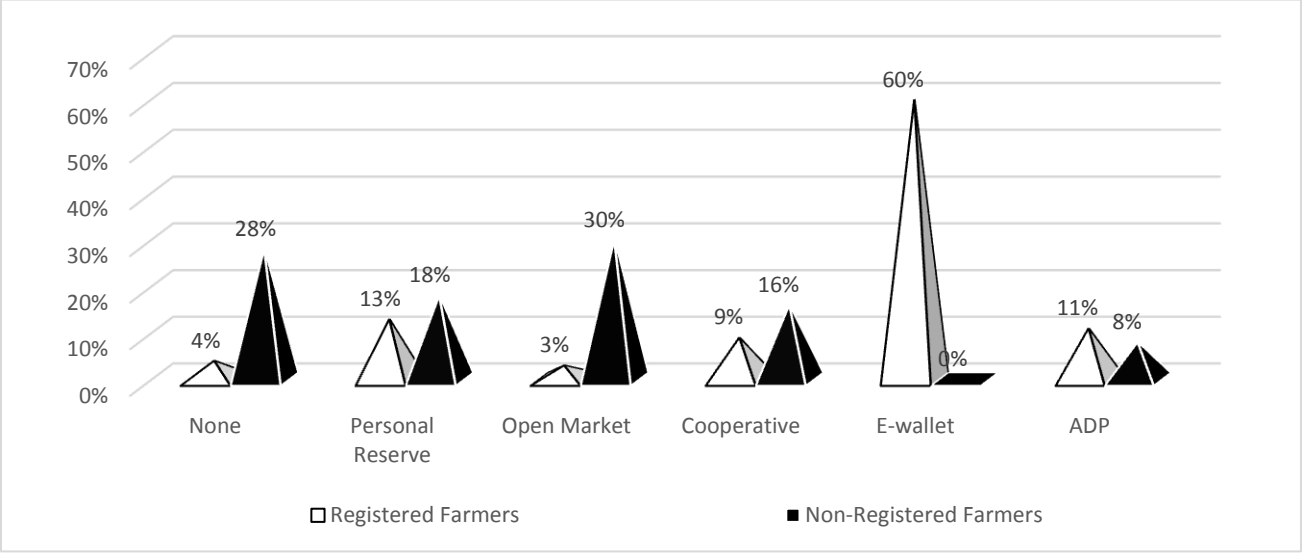

Figure 4. Distribution of respondents by source of improved seeds

Source: Computed from the field data by authors