WOAS IJFAEMA JOURNAL

International Journal of Financial Accountability, Economics, Management, and Auditing
ISSN (2788-7189)
Int. J. Fin. Acc. Eco. Man. Aud. 3, No.5 (October-2021)
https://doi.org/10.52502/ijfaema.v3i5.150

Impact of Mobile-Based Extension Service on Wheat yield among Rural Farmers of Settat Province, Morocco

Ayabei Karen[1], El Azhari Mohamed[2*], Laamari Abdelali[3], Jemo Martin[4], Hattab Samia[5], Zoumana Bomba[6], Tahirou Abdoulaye[7]

[1] Mohammed VI Polytechnic University (UM6P), Bengurir, Morocco.
[2] FEG, Hassan 1 st University, Settat, Morocco.
[3] National Institute of Agricultural Research (INRA), Settat, Morocco.
[4] Mohammed VI Polytechnic University (UM6P), Settat, Morocco.
[5] FEG, Hassan 1 st University, Settat, Morocco.
[6] International Institute of Tropical Agriculture (IITA), Nigeria.
[7] International Institute of Tropical Agriculture (IITA), Nigeria.

Abstract: Despite the undeniable advantages of innovative agricultural production technology, their adoption rate in Morocco is relatively low. In addition to research institutes and private institutions, agricultural information is provided by extension agents who are limited in terms of financial and logistical resources. In this study, we examine, on the one hand, the factors influencing the adoption of mobile phones to access extension services. On the other, we measure the impact of this adoption on wheat production and farmers' income in the province of Settat (Morocco). In this study we use data collected through a survey of 130 farmers from the province of Settat (Morocco). As analysis methods, we use stratified sampling, descriptive statistics, and the propensity score matching model. The results revealed that farmers who use their mobile phones for extension purposes have slightly higher wheat production than those who do not. The developed model showed that the adoption of mobile phone-based extension services is influenced by farmer's age, educational level, primary source of income, the use of inorganic fertilizers, access to credit and the availability of road infrastructure**.** The study is a contribution to the efforts of various national stakeholders who have launched a national strategy focused on the digitalisation of extension services.

Keywords: Adoption**,** Extension services, wheat production, Propensity score matching, Mobile phones.

Résumé : Malgré les avantages indéniables des nouvelles technologies agricoles, leur taux d'adoption au Maroc est relativement faible. En plus des instituts de recherche et des institutions privées, l'information agricole est fournie par des agents de vulgarisation qui sont limités en termes de ressources financières et logistiques. Dans cette étude, nous examinons, d'une part, les facteurs influençant l'adoption des téléphones mobiles pour accéder aux services de vulgarisation. D'autre part, nous mesurons l'impact de cette adoption sur la production de blé et les revenus des agriculteurs dans la province de Settat (Maroc). Dans cette étude, nous utilisons les données recueillies lors d'une enquête auprès de 130 agriculteurs de la province de Settat (Maroc). Comme méthodes d'analyse, nous utilisons un échantillonnage stratifié, des statistiques descriptives et le modèle d'appariement par score de propension. Les résultats ont révélé que les agriculteurs qui utilisent le téléphone mobile à des fins de vulgarisation ont une production de blé légèrement plus élevée que ceux qui ne l'utilisent pas. Le modèle développé a montré que l'adoption de services de vulgarisation par téléphone mobile est influencée par l'âge des agriculteurs, leur niveau d'éducation, leur principale source de revenus, l'utilisation d'engrais inorganiques, l'accès au crédit et la disponibilité des infrastructures routières. Les données utilisées dans cette étude ont été collectées dans une zone agro-écologique pluviale. L'étude est une contribution aux efforts de divers acteurs nationaux qui ont lancé une stratégie nationale axée sur la numérisation des services de vulgarisation.

Mots-clés : Adoption, Services de vulgarisation, production de blé, Appariement des scores de propension, Téléphones mobiles.

1. Introduction

Since the independence, Morocco has increased its efforts to rehabilitate the agricultural sector. The socio-economic importance of agriculture is evident and reflected through strategies and agricultural policies of Morocco. According to statistics, this sector contributes about 17% to the GDP and offering labor opportunities for a large working population (Harbouze et al., 2019). Indeed, several strategies have been implemented ranging from tillage program to the Green Morocco Plan (Toumi, 2008). The latter's objective was to introduce innovative practices into the production system and consider social issues for human development.

However, these innovations can only be conveyed through the transmission of new technologies by researchers from various research institutes, agricultural advisers, and extension agents, who are among the key channels of dissemination. Nevertheless, the diagnosis of the current situation indicates that the agricultural advisory and extension sector is constrained by several problems. The inefficiency in the agricultural extension program, which covers only 5% of the rural population, and the limited human and financial resources are the main constraints (El Amrani, 2017).

On the other hand, the use of new information and communication technology, especially the mobile phone, is expanding rapidly in Morocco. Researches state that the totality of Moroccans living in rural areas use at least one mobile phone (ANRT, 2016).

This observation makes us wonder if mobile phones could be used to access extension services in particular, as well as agricultural information in general. In this study we discuss the factors that drive farmers to adopt this innovative practice. Also, we assess the impact of this adoption on agricultural productivity among farmers in the province of Settat, which is considered as of one of Morocco's major cereal production regions.

The article is structured in a way to answer our research problem; first a review of the existing literature on the factors behind the adoption of new information and communication technologies by farmers, second an empirical study was conducted, and finally we used propensity score matching methods, to test our research hypotheses. A sample of 130 farmers from the province of Settat was interviewed.

2. Context

In Morocco, the majority of the rural population depends directly or indirectly on agriculture for their livelihood and are likely to be three times poorer than those living in urban areas (Ghanem, 2016). Morocco has employed various interventions to increase agricultural productivity and improve the livelihood of rural poor in general, investing in the *Plan Maroc Vert* (PMV) strategy is one of them (Ghanem, 2016). This strategy aims to improve the livelihood of more than 950,000 smallholder farmers in rural areas (Diouri and Saidi, 2017; Faysse et al., 2015). One of the objectives of this plan is the introduction of new practices into the agricultural production system. However, these practices can only reach a large farming community if they are disseminated by researchers and agricultural extension services.

Extension services are the optimal channel through which information can be relayed to the farmers (FAO, 2019). Since the start of structural adjustment initiatives in developing countries, funding for agricultural extension has been substantially decreased. This situation along with the increased number of smallholder farmers and marginal lands has had an adverse effect on extension work in Africa. Hence, messages are reaching only few smallholder farmers.

Morocco's extension services are mostly delivered by extension agents who are pulled from a variety of underfunded state organizations. (El Bilali et al., 2013). With only one extension agent covering an average of 24,000 hectares of cropped area and reaching out to 1930 farmers, the extension agents are limited (El Bilali et al., 2013). This shows that extension agents are constrained in their ability to serve farmers, necessitating the adoption of technological innovation in extension work, such as digital platforms (mobile-based extension services, radio, television or print media).

Over the last decade, mobile phone use in the agricultural structure has tremendously increased across the world (Talaviya et al., 2020). The proliferation of mobile phones has simplified access to information and reduced transactional costs in rural areas of developing countries, mostly faced with poor infrastructural development (Jenny C. Aker and Ksoll, 2015; Vidal-González and Nahhass, 2018). Many researchers have documented the nexus between agriculture and mobile phone use in the rural areas, where the use of mobile phones in agricultural sector has increased productivity and subsequently impacting positively the livelihoods of the rural poor (Al-Hassan, 2013); (Fu and Akter, 2016a); (Beuermann et al., 2012).

The Utilization of installed or pre-installed applications facilitates near-real-time access to market information, input prices, weather updates, and financial access through mobile-based credit services (Duncombe, 2016; Katengeza et al., 2011; Tata and McNamara, 2016). Timely access to markets, key inputs, and financial support positively influences crop yield and translate to increased household income.

The research documented by Nakasone & Torrero (2016), shows that the adoption of mobile phones in the extension work allows farmers in rural areas to improve their productivity without necessarily interacting physically with extensions agents. Furthermore, researchers such as Evans (2018) argued that the source of information for farmers is essential as it largely contributes to the level of impact (Evans, 2018; Fu and Akter, 2016b; L. P. Sousa et al., 2016). Therefore, increasing agricultural income through use of mobile phones provides a good opportunity to lure young generation (youth) especially in the rural areas into farming, as documented in other parts of developing nations in Africa (Kirui et al., 2013; Nzié and Temple, 2018; Vidal-González and Nahhass, 2018).

in Morocco, According to the national agency for the legalization of communication, the number of mobile phone subscribers was estimated to be 49.47 million by the end of mars 2021 (ANRT, 2021). In rural areas, 99.9% of people own mobile phones, and 90.7% of this population are aged between 12 to 65 years (ANRT, 2019).

3. Factors influencing the adoption of new communication technologies in the agricultural sector: a literature review

Several factors that influence the use of mobile phones as a tool to access extension services have been identified through studies conducted in recent years:

For Fambeu (2017), the use of mobile phones by farmers is a form of the digital transformation of the agricultural sector (smart agriculture). This transformation can only be achieved if certain conditions are met. The first one is directly linked to connectivity infrastructures such as network coverage, internet and electricity network access; the second one is the level of farmers' literacy and particularly their technological literacy.

The study conducted by Pasquati (2010), states that the appropriate use of information and communication technologies promotes the optimization of obtaining, exchanging and processing information, as well as the acquisition and renewal of specific knowledge relevant to the agricultural activity and its implementation. The author postulates that the introduction of these technologies have a direct and positive effect on the control of production factors. He considers that the effective participation of local actors and the integration of small-scale farmers into local groups is a key factor favoring the use of mobile phones for agricultural purposes.

The results of the survey conducted by Dondeyne (2010), revealed that farmers' educational level and the size of the farm influences the adoption of mobile phone as an essential digital tool for agricultural activity. The same study also revealed that owning the land have an impact on the adoption of these technologies.

On his part, Florez (2018), argues that age, educational level, size of the farm, availability of roads and connectivity infrastructure, the existence of a farmer-extension agent relationship, farmer's involvement in cooperatives and his awareness of the existence of these tools are primary factors in the adoption of mobile phones in agricultural activity.

Access to credit is considered as one of the major constraints for adopting new technologies. The research carried out by Janvery et al, (2015) indicate that most smallholder farmers do not have access to credit and are not qualified for loans offered by commercial banks. Helping them overcome this barrier could therefore promote their adoption of costly technologies. Access to credit helps provide the resources needed to acquire technological tools. In addition, farmers who have accessed agricultural credit aim to achieve higher yields, which may allow them to repay their loans, access better inputs, and access better markets for their products. The work of Fu and Akter (2016) states that 21% of farmers with access to mobile technology-based extension services in India were more likely to access credit.

On the other hand, the impact of using mobile phones, as a tool to access agricultural information, on small scale farmers' income was investigated by various studies. Ilahiane (2007) revealed in his research that, in Morocco, farmers who used mobile phones were able to increase their income by about 21%. A similar study in Kenya by Suri & Jack (2016) found out that the use of mobile phone increased the income of female-headed households by 22%, this can be explained by the fact that mobile phone enables timely access to information at a lower cost compared to traditional extension services (Aker, 2011).

4. Variables

We adopt the following variables to confirm or reject the hypotheses we have just formulated. The following table summarizes the variables that will be introduced into our model.

Table 1: Variables

Variable in the model	Description of the variable	Nature of the variable
Endogenous variable	Decision to use mobile phone to access extension services	Boolean (0: No; 1: Yes)
Outcome variable	Annual wheat revenue in DH per Hectare (Ha)	Quantitative
Outcome variable	Average annual wheat production in Quintals/ Ha	Quantitative
Explanatory variable	Age of the farmer in years	Quantitative
	Number of years of education	Quantitative
	Number of persons in household	Quantitative
	Ownership of the land	Boolean (0 : No ; 1 : Yes)
	Farm size	Quantitative
	Agriculture as the main source of income	Boolean (0 : No ; 1 : Yes)
	Mobile phone price in Dirham (DH)	Quantitative
	Use of inorganic fertilizer	Boolean (0 : No ; 1 : Yes)
	Ownership of a radio	Boolean (0 : No ; 1 : Yes)
	Accessibility to the road network: type of road available	Boolean (0 : No ; 1 : Yes)
	Quality of the network strength (low)	Boolean (0 : No ; 1 : Yes)
	Accessibility of extension agents' services	Boolean (0 : No ; 1 : Yes)
	Access to financing	Boolean (0 : No ; 1 : Yes)
	Relationship with agents of agricultural cooperatives	Boolean (0 : No ; 1 : Yes)
	Membership in an agricultural or social group	Boolean (0 : No ; 1 : Yes)

5. Methodology & data

This study used data collected in Settat province of north-west Morocco. Settat produces about 50% of the total wheat production in the country, and this criteria was used to justify our choice to conduct this study in this area. Wheat grown in the region is mainly rainfed. The area is classified as a semi-arid region (Selmani, 1990). Therefore, information on weather forecast is important to farmers. The lack of this information and the wrong timing of wheat cultivation severely affects the productivity and in turn, threatens food security.

Semi-structured questionnaires were used to collect the data. To obtain data from the targeted respondents, a multi-stage random sampling technique was used. The first stage entailed selecting five communes, namely: Laghnimiyine, Gdana, Sidi El Aidi, Ouled Said, and Ouled Bouziri. In the second one, 130 farmers were selected and questioned using a simple random sampling approach.

6. Model selection

The decision to use a mobile phone to access agricultural information is a binary outcome, a smallholder wheat farmer can either decide to use or not use a mobile phone to access extension and marketing information. A single smallholder wheat farmer decision to use mobile phone to access agricultural information is based on the utility function (Smale et al., 1994). This decision ensues when the expected utility of users (M_i^1) is greater than that of non-users (M_i^0) as illustrated in equation 1 below.

$$M_i^1 > M_i^0 \qquad (1)$$

The difference between users and non-users of mobile phone, as an extension tool, may be denoted by a latent variable R_i^* as presented in equation 2:

$$R_i^* = M_i^1 - M_i^0 > 0 \qquad (2)$$

The decision to use or not use a mobile phone-based extension service is dependent on the farmer's socioeconomic, technical and institutional characteristics.

Productivity is a linear function which is explained by a number of variables (X_i) and (M_i) as shown in equation 3.

$$Y_i = \beta X_i + \alpha M_i + \varepsilon_i \qquad (3)$$

Where Y_i represents, in a first stage the outcome variable which is wheat productivity measured in quintals per hectare and in a second stage the household income in Dirhams. X_i represents farmers' socio-economic characteristics and M_i representing the use of mobile phones to access agricultural information which is a dummy where M_i is 1 if a farmer uses the mobile phone and 0 otherwise. ε_i is the stochastic term representing unobserved characteristics affecting the outcome variable. Imposing a linear function implies that the coefficients of the control variable for both users and non-users of mobile phones are the same.

However, the use of a mobile phone in accessing agricultural information, is a non-random assignment, meaning the farmer chooses to use or not use a mobile phone as an extension tool. Subsequently, two groups are formed, the first is composed of users (treated group), the second is composed of non-users (control group) and each group differs from the other by different characteristics. Therefore, calculating the treatment difference between the two groups will result in biased and inconsistent estimations.

Several approaches have been utilised in non-experimental research to estimate the effects of several programs on agricultural productivity (Issahaku et al., 2018a; Marty et al., 2019; Nakasone and Torero, 2016). In this study we used propensity score matching (PSM) to estimate the effect of using mobile phones on wheat productivity and household income. The advantage of PSM when it comes to the evaluation of non-experimental research over other models, such as Heckman two-step approach, double difference method and instrumental variable, is its ability to provide unbiased estimation of treatment effects hence drawing causal effect inferences. This method is also used when the sample size is relatively small (Caruana, 2017).

The PSM addresses the challenge of selection bias by assuming conditional independence where non-users of mobile phone with similar observable characteristics with users are matched. PSM involves two steps; the first step is the computation of propensity scores of mobile phones as an extension service which is a binary response, which was estimated by using a Probit model to estimate the propensity to use mobile phone by farmers represented in equation 4.

$$p(u_i) = prob(Mi = 1|u_i) \qquad (4)$$

Where the propensity $p(u_i)$ is estimated by a Probit model, which regress mobile phone users on observed characteristics (farmer demographics, institutional and farm).

Second step is to select a matching estimator. Several methods have been proposed for matching users with non-users having similar characteristics such as nearest-neighbour matching (NNM), the radius matching (RM) and kernel-based matching (KBM) (Caliendo and Bonn, 2008). The NNM method looking treated and control individuals with closest propensity scores and match them together. The KBM matches everyone with weighted average of all the controls. The weights employed are inversely proportionate to the difference between user and non-user propensity scores. In RM approach an individual within the non-user category is chosen as a matching partner for an individual belonging to a specified radius of propensity scores.

The final step is the estimation of the average treatment effects on the treated (ATT) which it the mean difference between wheat yield and income of users, (Y_i^1) and non-users (Y_i^0) of mobile phones (Lecocq et al., 2014; Quantin, 2018), which is given in equation 5.

$$ATT_{ij} = E[E\{Y_{ij}^1|M_{ij} =, p(X_{ij})\} - E(Y_{ij}^0|M_{ij} = 0, p(X_{ij})\}] \quad (5)$$

Where Y_{ij}^1 and Y_{ij}^0 denotes the productivity and the income of the i^{th}farmer that use or not use mobile phones to access agricultural information, respectively.

7. Results and Discussions

In order to provide a better estimate of the impact of cell phone use on wheat production and household annual income, STATA is used. Our choice is justified by the fact that its performance, over other software in propensity score matching, is better as it provides a detailed estimate using all of the above-mentioned methods (Morelle et al., 2018).

7.1. Descriptive statistics

Table 2 represents the descriptive statistics of the surveyed farmers according to their use of a mobile phone to access agricultural information. The study revealed that out of the 130 farmers, half use mobile phones to access agricultural information (users), these users were entirely men. In this sense, it is noted that there were no women in the sample surveyed. This is not surprising, as the respondents were all heads of households, and at the national level, the rate of women considered as heads of household in rural areas does not exceed 4%, moreover, these women take on this responsibility in the majority of cases following the death of the husband (Moisseron et al., 2019).

As for the wheat production, phone users achieve an average wheat production of 35 quintals per hectare that is 8 quintals more than what non-users produce. This difference is statistically significant at 1% level. Users' annual income from wheat is on average 1000 Dirhams higher than non-users in a single hectare (about USD 100/Ha).

The average age of mobile phone users is 37.41 years compared to 46.23 years for non-users. The former are better educated with an average of 8.21 years of schooling compared to an average of 4.66 years of schooling for non-users, this difference, as is the case for age, is significant at 1% level.

Our results show that about 84.62% of users' primary income come from agricultural activity, which is not much different from the national figure of 80% of the population in rural areas (Abis, 2019).

Furthermore, 90% of adopters use a smartphone. This is a very significant figure since access to agricultural extension information depends on access to applications that are only compatible with smartphones. We will not retain this variable in the model because its presence bias the estimations due to the multi-collinearity.

Our calculations show that 81.54% of adopters use chemical fertilizers. This rate of use is lower among non-adopters of mobile phones since it does not exceed 64%, this gap is significant at 5% level. In fact, the use of this type of fertilizers is proportional to rainfall. Moreover, in Morocco, the use of chemical fertilizers for rainfed grain crops is still low. As for food legumes, there is a crucial lack of fertilizers use (Naili, 2019). Access to road network is one of the results that stood out. In fact, 70.77% of users have access to a paved road, compared to 50.77% of non-users. Our study revealed that this difference is significant at 5% level. In this sense, we observe that these percentages are lower than the one provided by the World Bank stating that currently, nearly 80% of rural inhabitants benefit from a road network in good condition (World Bank 2018).

Involvement in social groups is relatively high among users with 61.54%, compared to only 40% among non-users, a difference that is significant at the 5% level.

As for the quality of telephone network coverage, in our study area, 21.54% of mobile phone users rated the network signal strength as poor, compared to 35.38% of non-users, difference significant at 1% level.

Table 2: Descriptive statistics

Outcome variable	**Mobile Phone Users**		**Mobile phone non-users**		**T/ Chi-2 test**
	Mean	**Percentage**	**Mean**	**Percentage**	
Demographic characteristics					
Farmer's age in years	37.41		46.23		5.40***
Farmer's years of schooling	8.21		4.66		-4.6***
Number of persons in household	2.7		2.8		0.81
Main source of income (1=agriculture)		84.62		60.00	9.83***
Type of phone (1= Smartphone)		93.85		7.69	96.51***
Own a radio (1=yes)		67.69		58.46	1.18
Own a Tv (1=yes)		56.92		44.62	1.96
Farm characteristics					
Farm size (Ha)	13.03		11.31		1.01
Wheat yield (quintals per ha)	35.01		27.23		-5.22***
Annual wheat income (MAD per ha)	6663.69		5642.53		-1.15
Use of inorganic fertilizers (1=yes)		81.54		64.62	4.73**
Institutional characteristics					
Access to credit (1= yes)		16.92		26.15	1.63
Type of road (1= paved road)		70.77		50.77	5.45**
Member of a social group (1=yes)		61.54		40.00	6.03**
Poor mobile network signal (1= yes)		21.54		35.38	3.06*
Access to government extension service agents/officer(s) (1=yes)		26.15		23.08	0.16

*Note: * Significant at 10%. ** Significant at 5%. *** Significant at 1%.*

7.2. Determinants of mobile phone use and estimation of propensity scores

Table 3 presents the output of our final retained model taking into account all statistical and econometric considerations. The results obtained show that most of the variables used in the model had the expected signs. The model has high explanatory power, as indicated by the Pseudo R-squared, where the covariates explain 34% of the variation in the dependent variable.

We will start with the demographic factors; farmer age has a negative and significant impact, at 5% level, on the probability of using mobile phones to access extension services. As a farmer's age increases, the probability of using a cell phone as an extension tool decreases. This means that young farmers tend to use new information and communication technologies to support agricultural activity. The results of this study are consistent with Irungu, Mbugua, and Muia (2015) that young people are technologically receptive compared to older people.

Table 3: Probit estimates on propensity to use of mobile phone-based extension services

Endogenous variable	Use of mobile phone to access agricultural extension services	
Demographic characteristics		
Farmer's age in years	-0.040**	(0.016)
Number of persons in household	0.250	(0.199)
Main source of income (1=agriculture)	1.034***	(0.322)
Farmer's years of schooling	0.095***	(0.033)
Own a radio (1=yes)	0.362	(0.294)
Farm characteristics		
Farm size (Ha)	-0.021	(0.015)
Use of inorganic fertilizers (1=yes)	0.736**	(0.336)
Institutional characteristics		
Access to government extension service agents (1= yes)	0.301	(0.346)
Poor mobile network signal (1= yes)	-0.294	(0.312)
Access to credit (1= yes)	-0.656*	(0.363)
Type of road (1= paved road)	0.630**	(0.296)
Member of a social group (1=yes)	0.343	(0.290)
Constant	-1.326	(1.055)
Observations	130 Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1	
Log likelihood = -59.764444		LR chi2(12) = 60,69
		Prob > chi2 = 0,0000
		Pseudo R2 = 0,3368

The education levels of a farmer positively and significantly, at 1% level, influences his decision to use a mobile phone as an extension tool. This can be explained by the fact that using mobile phones, especially smartphones, need a higher level of literacy. Farmers with higher educational level are able to retrieve information relevant to their productivity compared to less educated farmers. The results show that literacy is an important human capital that influences technological adoption especially among rural farmers (Donkor et al. 2019; Gupta, Ponticelli, et Tesei 2020; Pan et al. 2017)

Interestingly, in contrast to the results of Amir et al (2016), Chowdhury and Wolf (2003), the primary source of income for farmers positively and significantly influences the use of a mobile phone by farmers at 1% level. In our case, respondents whose main activity is farming are more likely to use mobile phones as an extension tool. This is because most farmers in the area consider wheat farming to be their main socio-economic activity, and therefore its development and promotion require special attention on their part.

As for the results of farm factors, farm size does not have a significant impact on the decisions of adoption. However, farmers who used inorganic fertilizers were more likely to use mobile-based extension services; this is due to the need to access a better fertilizer market. The presence of programs like fertilizer promotion caravans in the region, which promotes the use of a mobile phone to authenticate genuine fertilizers in the market, has possibly promoted the use of mobile phones for other extension related programs (Alene et al., 2008). The usage of a mobile phone has been credited as being effective in the control of counterfeit products in the market, and technology has been used to battle fraudulent agro-inputs products along the supply chain.

Regarding to the institutional factors, access to a government extension agent has a positive but non-significant influence on the likelihood of using a mobile phone. This result indicates that the deployment of mobile phones in the extension service constitute an alternative to the physical contact between the farmers and extension agents. The latter are normally stretched thin due to minimal budget allocation and the vast area covered. Our results are consistent with those of Etwire et al (2017), where they state that farmers who had close contact with extension agents were more likely to use their mobile phones to access market and weather information.

Belonging to a social group positively influences the ability to access and use mobile-based extension services. Social interactions and farmer-farmer learning motivates them to use mobile-based extension services. However, another study conducted by Amir, Peter and Muluken, (2016) in Ethiopia, affirm the opposite, they state that belonging to a social group insignificantly and negatively influences the role of mobile phone in accessing agriculture information among the smallholder farmers (Sinyolo and Mudhara, 2018).

As for credit access, we found out that farmers who do not have access to credit are the ones who tend, significantly at 1% threshold, to use mobile phones to access agricultural information. This can be justified by religious considerations on the one hand, and by the fact that those who have access to credit already have the financial resources to develop their agricultural activity, access good quality inputs, equip their farms with high-performance machines, and seek the expertise of private researchers to improve their productivity, on the other. Additionally, farmers who do not have access to credit opt for the use of mobile phones as an alternative to access these services because they are relatively less expensive, save time and offer a variety of choices.

Our results have also shown that the availability of road infrastructure has a positive and significant influence, at 5% level, on the adoption of the technology in question. In this sense, the road network acts as a catalyst for the diffusion of new technologies. Indeed, Torre and Rallet (2005) indicate that the perspective on the geography of innovation is interesting for it shows the influence of proximity on the diffusion of knowledge, which means that proximity could influence both innovation and the diffusion of innovations, i.e., the diffusion of new technologies (Bocquet and Brossard, 2008). Our results disagree with those obtained by Fu and Akter (2016) who consider that it is the lack of a good quality road network that influences technology adoption and forces farmers to access agricultural and weather information through a mobile phone. This, according to the authors, allows for planning and avoids making losses or losing time to access markets on bad weather days (Fu and Akter, 2016b; Ogutu et al., 2014).

7.3. Impact of mobile phone use on wheat yield and household income

Table 4 presents the result of the impact of mobile phone use on wheat production and annual income. The impacts were estimated using the propensity score matching. To improve the robustness of the results, different matching techniques were used, which include nearest neighbour, kernel matching and radius calliper. The key objective of the propensity score estimate is to balance the distribution of important factors between the adopters and non-adopters, rather than produce a precise prediction of selection into treatment.

Table 5 shows the outcomes of covariate balancing tests pre and post matching. The propensity score's normalized mean difference for overall variables is reduced to about 14%-25% after matching using the nearest neighbour method. Thus, indicating a substantial reduction in total bias. The p-values of the likelihood ratio tests show that the combined significance of independent variables was always rejected after matching but never before. The pseudo-R^2 also decreased considerably, from 13.4% before matching to around 1-6% after matching. The other indicators (see Table 5) suggest that the proposed propensity score specification is reasonably successful in terms of balancing the distribution of covariates between adopters and non-adopters of mobile-based extension services.

Table 4: Impact of mobile phone use on household yield and income from wheat

	Wheat yield in (quintal/Ha)		**Annual wheat income in (Dirham/year**	
	Adoption effect	**Standard D**	**Adoption effect**	**Standard D**
nearest neighbor	6.723***	1.994	2,469.692**	1,015.431
Radius	6.949***	2.636	617.965	1,367.137
Kernel	6.532**	2.996	1,831.759	1,469.030

*Note: * significant at 10%. ** significant at 5%. *** Significant at 1%.*

In addition, the common support graph (Figure 1) gives a clear visual inspection that shows treated (users) group get a better match from the control (non-users) group. The group further demonstrate that the density distributions of the predicted propensity scores for both groups suggest that the common support criterion is met after PSM matching for the various approaches employed. The results reveal a significant similarity in the distribution of propensity scores among adopters and non-adopters.

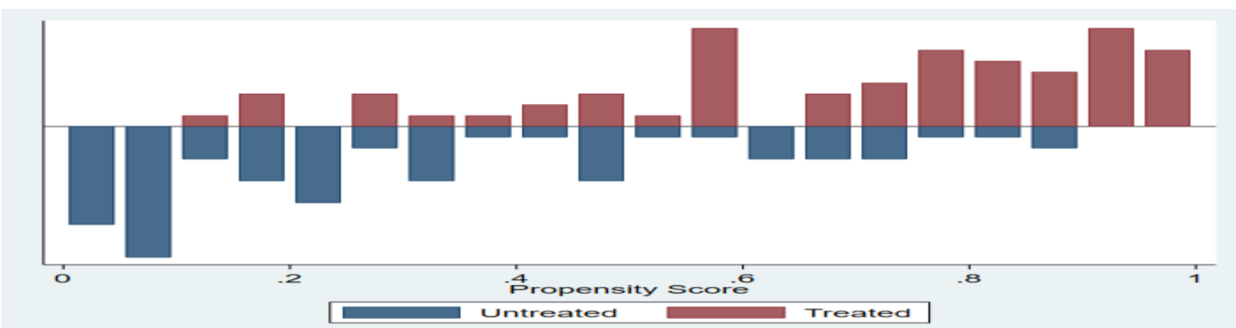

Figure 1: Comparison of Propensity score distribution between treated and control group

Table 5: Matching quality indicators before and after matching

Matching Algorithm	**Pseudo R^2 before matching**	**Pseudo R^2 after matching**	**LR Khi^2 (p-value) before matching**	**LR Khi^2 (p-value) after matching**	**S.D before matching**	**S.D after matching**
Wheat yield in (quintal/Ha)						
NNM (nd)	0.134	0.064	24.20 (p=0.019)	8.33 (p= 0.759)	2.625	1.994
RBM	0.134	0.016	24.20 (p=0.019)	2.05 (p= 0.999)	1.754	2.636
KBM	0.134	0.032	24.20 (p=0.019)	4.15 (p= 0.981)	NS	2.996
Annual wheat income in (Dirham/year)						
NNM (nd)	0.336	0.064	60.69 (p=0.000)	8.33 (p=0.759)	1649.123	1015.431
RBM	0.336	0.016	60.69 (p=0.000)	2.05(p=0.999)	1074.559	1,367.137
KBM	0.336	0.032		4.15(p=0.981)	NS	1469.03

Results show that mobile phone use has a positive and significant effect on wheat yield according to the five matching methods, and a positive and significant effect on household income only according to the nearest neighbour and stratification methods. They also indicate that the use of mobile base extension services increased wheat yield per hectare by 23% to 25, 5%. While the net income increases by 10% to 43 % per annum (see Table 4). The findings concur what Yamano and Muto (2009) state. They found out that farmers who owned a mobile phone, in Uganda, were able to increase the probability of their banana sale by 20%. In addition, the study conducted by Issahaku et al (2018) in Ghana revealed that farmers who owned and use mobile phone increase the productivity of maize yield by 261kg/ha.

The increase in yields per hectare can be attributed to better inputs (fertilizer and agricultural advice received through mobile phones). While higher income can be attributed to better market value; farmers receiving market related information through their mobile phone are able to compare prices offered in different markets and reduce the transaction cost by selling via mobile phone. Fu and Aker (2016) observed that the use of information communication technology in extension services has a greater impact on farmer's access and general knowledge on agriculture. Having prior information on the market prices and sourcing for markets in advance enable farmers to make an informed decision to transport their wheat to the market on a convenient time. Also, they are more likely to reduce the cost of production due to the use of better farming skills.

8. Conclusions and Policy Implications

The purpose of this study was to investigate the impact of using mobile phones as an extension tool on wheat production and household income of rural farmers. The study was conducted in Morocco, using survey data. Understanding of socio-economic characteristics of farmers in the rural area is crucial since it leads to the adoption of agricultural technologies aimed at increasing productivity. One of the technologies being encouraged to improve rural life is the use of mobile phones to disseminate agricultural information. As a result, such technologies must be evaluated to establish their true impact.

The study has shown that the use of mobile phone significantly increases wheat productivity and household income which in turn improve the livelihoods of the rural farming community. The study's findings suggest that, in view of the current COVID-19 epidemic, which has limited physical interactions, there is an urgent need to implement comprehensive programs encouraging the use of mobile phones as an extension tool. This will allow for the smooth flow of critical agricultural information required to boost productivity and improve farmers' livelihoods.

Furthermore, our findings indicate that despite the fact that women play a critical role, when it comes to manual work in the farm; the role of head household is still monopolized by men. This is due to the nature of the community. This is due to the community's nature. As a result, using a mobile phone as an extension tool will empower women by providing them with access to the information they need to advance to a sustainable position in farming.

The increased yields associated with mobile phone use will serve as an incentive for young people to engage in agricultural activities. Young individuals are more versatile, energetic, and more technologically savvy. High yields and income generated by the usage of a mobile phone would encourage them to expand their farming operations, reducing rural-urban migration. It's clear that improvement of ICT in transferring knowledge well help improving farmer's performances and contributes to food security in Morocco.

Despite all the glamour of the importance of mobile phone use as an extension tool, the sustainability of initiatives aimed at using mobile phones as an extension tool remains a concern. The major concern is whether farmers are willing to pay for customized agricultural information or not. As a result Therefore, future studies should focus more on how much farmers can invest in terms of resources to use technology to access agricultural information.

REFERENCES

[1] Abis, S. "Maroc : l'agriculture comme levier de développement national et international". IRIS. 2019.https://www.iris-france.org/130463-maroc-lagriculture-comme-levier-de-developpement-national-et-international/ (accessed 5.4.21)

[2] Aker, J.C. "Dial 'A' for agriculture: a review of information and communication technologies for agricultural extension in developing countries". Agricultural Economics 42, 631–647. 2011.https://doi.org/10.1111/j.1574-0862.2011.00545.

[3] Aker, Jenny C, Ksoll, C. "Can mobile phones improve agricultural outcomes? Evidence from a randomized experiment in Niger". Journal of food policy. 2015.https://doi.org/10.1016/j.foodpol.2015.03.006

[4] Aker, Jenny C., Ksoll, C. "Call Me Educated: Evidence from a Mobile Monitoring Experiment in Niger". SSRN Scholarly Paper No. ID 2623143. Social Science Research Network, Rochester, NY. 2015. https://doi.org/10.2139/ssrn.2623143

[5] Alene, A.D., Manyong, V.M., Omanya, G., Mignouna, H.D., Bokanga, M., Odhiambo, G. "Smallholder market participation under transactions costs: Maize supply and fertilizer demand in Kenya". Food Policy 33, 318–328. 2008.

[6] Al-Hassan, M. "Farm household level impacts of information communication technology (ICT)-based agricultural market information in Ghana". Journal of Development and Agricultural. Economics 5, 161–167. 2013. https://doi.org/10.5897/jdae12.143

[7] Amir, Peter, Muluken. "The role of mobile phones in accessing agricultural information by smallholder farmers in Ethiopia". (ISSN 1607-9345) No. 14 (1): 395-402. 2016. http://repository.ruforum.org

[8] Beuermann, D.W., McKelvey, C., Vakis, R. "Mobile Phones and Economic Development in Rural Peru". Journal of Development Studies 48, 1617–1628. 2012. https://doi.org/10.1080/00220388.2012.709615

[9] Bhattacharjee, S. "Mobile Phone Applications for Agricultural Extension in India. Mobile Phones for Agricultural Extension: Worldwide mAgri Innovations and Promise for Future". New India Publishing Agency, New Delhi. 2014.

[10] Bishaw, Z., Yigezu, Y.A., Niane, A., Telleria, R.J., Najjar, D. "Political Economy of the Wheat Sector in Morocco: Seed Systems, Varietal Adoption, and Impacts". International Center for Agricultural Research in the Dry Areas, Beirut, Lebanon. 2019.

[11]Bocquet, R., Brossard, O. "Adoption des TIC, proximité et diffusion localisée des connaissances". Revue dEconomie Regionale Urbaine octobre, 411–446. 2008.

[12]Caliendo, M., Bonn, I. "Funding Ontario Hospitals in the Year 2000: Implications for the JPPC Hospital Funding Committee". Journal of Economic Surveys 22, 31–72. 2008.https://doi.org/10.1111/j.1467-6419.2007.00527.x

[13]Caruana, E. "Développement d'une nouvelle mesure d'équilibre pour l'aide à la sélection des variables dans un modèle de score de propension". Médecine humaine et pathologie. Université Sorbonne Paris Cité. Français. NNT : 2017USPCC134ff. Tel-02036721ff . 2017.

[14]Chowdhury, S.K., Wolf, S. "Use of ICTs and the economic performance of SMEs in East Africa". WIDER Discussion Paper, No. 2003/06, ISBN 9291903930, The United Nations University World Institute for Development Economics Research (UNU-WIDER), Helsinki. 2003. http://hdl.handle.net/10419/52781

[15]Diouri, M., Saidi. "Food self-sufficiency under the Green-Morocco Plan". JEBAS 5, 33–40. 2017. https://doi.org/10.18006/2017.5(Spl-1-SAFSAW).S33.S40

[16]Dondeyne, C. "Les technologies numériques de l'information et de la communication au service d'une agriculture durable ?". Terminal. Technologie de l'information, culture & société. 2010. https://doi.org/10.4000/terminal.1816

[17]Donkor, E., Onakuse, S., Bogue, J., Rios-carmenado, I.D.L. "Land Use Policy Fertiliser adoption and sustainable rural livelihood improvement in Nigeria". Land Use Policy 88, 104193. 2019. https://doi.org/10.1016/j.landusepol.2019.104193

[18]Duncombe, R. "Mobile Phones for Agricultural and Rural Development: A Literature Review and Suggestions for Future Research". The European Journal of Development Research 28, 213–235. 2016.

[19]El Bilali, H., Driouech, N., Berjan, S., Capone, R., Abouabdillah, A., Ahouate, L., Azim, K., Najid, A. "Agricultural extension system in Morocco: problems, resources, governance and reform". 2013.

[20]Etwire, P.M., Buah, S., Ouédraogo, M., Zougmoré, R., Partey, S.T., Martey, E., Dayamba, S.D., Bayala, J. "An assessment of mobile phone-based dissemination of weather and market information in the Upper West Region of Ghana". Agriculture & Food Security 6, 8. 2017. https://doi.org/10.1186/s40066-016-0088-y

[21]Evans, O. "Digital Agriculture: Mobile Phones, Internet & Agricultural Development in Africa". 2018. https://mpra.ub.uni-muenchen.de/90359/ (accessed 5.17.21).

[22]Fàbregas, N., Lozano-Elena, F., Blasco-Escámez, D., Tohge, T., Martínez-Andújar, C., Albacete, A., Osorio, S., Bustamante, M., Riechmann, J.L., Nomura, T., Yokota, T., Conesa, A., Alfocea, F.P., Fernie, A.R., Caño-Delgado, A.I. "Overexpression of the vascular brassinosteroid receptor BRL3 confers drought resistance without penalizing plant growth". Nature Communications 9, 4680. 2018. https://doi.org/10.1038/s41467-018-06861-3

[23]Fambeu, A.H. "L'adoption des TIC dans un pays en développement". Revue d'économie industrielle. 61–101. 2017. https://doi.org/10.4000/rei.6518

[24]Faysse, N., Mkadmi, S.E., Errahj, M. (2015). "Capacités d'action des agriculteurs dans les projets locaux de développement agricole au Maroc". Revue Tiers Monde N° 224, 143–162. 2015.

[25]Fu, X., Akter, S. "The Impact of Mobile Phone Technology on Agricultural Extension Services Delivery: Evidence from India". Journal of Development Studies 52, 1561–1576. 2016. https://doi.org/10.1080/00220388.2016.1146700

[26]Ghanem, H. "Agriculture and rural development for inclusive growth and food security in Morocco". The Arab Spring Five Years Later: Vol 2: Case Studies 371–394. 2016.

[27]Gupta, A., Ponticelli, J., Tesei, A. "Information, technology adoption and productivity: The role of mobile phones in agriculture". NBER Working Paper No. 27192. 2020.

[28]Harbouze, R., Pellissier, Rolland, Khechimi. "Rapport de synthèse sur l'agriculture au Maroc", CIHEAM-IAMM. 2019.

[29]Issahaku, H., Abu, B.M., Nkegbe, P.K. "Does the Use of Mobile Phones by Smallholder Maize Farmers Affect Productivity in Ghana? ". Journal of African Business 19, 302–322. 2018. https://doi.org/10.1080/15228916.2017.1416215

[30]Katengeza, S.P., Okello, J.J., Jambo, N., Katengeza, S.P., Okello, J.J., Jambo, N. "Use of Mobile Phone Technology in Agricultural Marketing: The Case of Smallholder Farmers in Malawi".2011. https://services.igiglobal.com/resolvedoi/resolve.aspx?doi=10.4018/978-1-4666-3607-1.ch008 . https://www.igi-global.com/gateway/chapter/75589 (accessed 5.17.21).

[31]Kirui, K.B., Kairo, J.G., Bosire, J., Viergever, K.M., Rudra, S., Huxham, M., Briers, R.A. "Mapping of mangrove forestland cover change along the Kenya coastline using Landsat imagery". Ocean & Coastal Management 83, 19–24. 2013. https://doi.org/10.1016/j.ocecoaman.2011.12.004

[32]Lecocq, A., Ammi, M., Bellarbre, É. "Le score de propension : un guide méthodologique pour les recherches expérimentales et quasi expérimentales en éducation". mee 37, 69–100. 2014. https://doi.org/10.7202/1035914ar

[33]Marty, C., Lévesque, J.-A., Bradley, R.L., Lafond, J., Paré, M.C. "Lowbush blueberry fruit yield and growth response to inorganic and organic N-fertilization when competing with two common weed species". PLoS One 14. 2019. https://doi.org/10.1371/journal.pone.0226619

[34]Moisseron, J.-Y., Ahmar, M.B.E., Romagny, B., Alary, V., Aderghal, M., Tebbaa, O. “Financements et activités des femmes en milieu rural au Maroc”. Maghreb - Machrek N° 240, 53–76. 2019.

[35]Morelle, M., Plantier, M., Dervaux, B., Pagès, A., Deniès, F., Havet, N., Perrier, L. “Méthodes d’analyse et de traitement des données de coût : approches par « micro-costing » et « gross-costing »”. Revue d’Épidémiologie et de Santé Publique 66, S101–S118.2018. https://doi.org/10.1016/j.respe.2018.02.003

[36]Mwalupaso, G.E., Tian, X., Matafwali, E., Mwamba, M.C., Alavo, E.J.-P., Ethetie, A.M., Korotoumou, M., Waseem, F. “Understanding The Purpose and Potential Popularity of Mobile Phone Use in Zambia’s Maize Production”. Journal of Agricultural Science 11, 32. 2019. https://doi.org/10.5539/jas.v11n6p32

[37]Naili. “Productivité agricole : La consommation d’engrais toujours faible”. Medias24. 2019. https://www.medias24.com/2019/04/15/productivite-agricole-la-consommation-dengrais-toujours-faible/ (accessed 5.4.21).

[38]Nakasone, E., Torero, M. “Agricultural Extension through Information Technologies in Schools: Do the Cobbler’s Parents go Barefoot? ”. Annual Meeting, July 31-August 2, Boston, Massachusetts No. 236114). Agricultural and Applied Economics Association. 2016.

[39]Nzié, J.R.M., Temple, L. “L’offre de recherche converge-t-elle vers les besoins du secteur agroalimentaire au Cameroun ? Une analyse par la bibliographie”. Cah. Agric. 27, 25008. 2018. https://doi.org/10.1051/cagri/2018016

[40]Ogutu, S.O., Okello, J.J., Otieno, D.J. “Impact of Information and Communication Technology-Based Market Information Services on Smallholder Farm Input Use and Productivity: The Case of Kenya”. World Development 64, 311–321. 2014. https://doi.org/10.1016/j.worlddev.2014.06.011

[41]Pan, D., Kong, F., Zhang, N., Ying, R. “Knowledge training and the change of fertilizer use intensity: Evidence from wheat farmers in China”. Journal of Environnemental Management 197, 130–139. 2017. https://doi.org/10.1016/j.jenvman.2017.03.069

[42]Pasquati, É. “Aspects socioculturels des usages des TIC dans le développement rural en Afrique”. Communication langages N° 163, 107–119. 2010.

[43]Quandt, A., Salerno, J.D., Neff, J.C., Baird, T.D., Herrick, J.E., McCabe, J.T., Xu, E., Hartter, J. “Mobile phone use is associated with higher smallholder agricultural productivity in Tanzania, East Africa”. PloS one 15, e0237337. 2020. https://doi.org/10.1371/journal.pone.0237337

[44]Quantin, S. “Méthodologie statistique : Estimation avec le score de propension sous R”. 2018.

[45]Simonet, V., Terracol, A. “Formation sur Stata11 : Notes des cours”. 2015

[46]Sinyolo S, Mudhara M. “Farmer groups and inorganic fertilizer use among smallholders in rural South Africa”. S Afr J Sci.114(5/6), Art. 2017-0083, 9 pages. 2018. http://dx.doi.org/10.17159/ sajs.2018/20170083

[47]Sinyolo, S., Mudhara, M. “Collective action and rural poverty reduction: Empirical evidence from KwaZulu-Natal, South Africa”. Agrekon 57, 78–90. 2018. https://doi.org/10.1080/03031853.2018.1451349

[48]Smale, M., Just, R.E., Leathers, H.D. “Land Allocation in HYV Adoption Models: An Investigation of Alternative Explanations”. American Journal of Agricultural Economics 76, 535–546.1994. https://doi.org/10.2307/1243664

[49]Sousa, Sousa, A.I., Alves, F.L., Lillebø, A.I. “Ecosystem services provided by a complex coastal region: challenges of classification and mapping”. Sci Rep 6, 22782. 2016. https://doi.org/10.1038/srep22782

[50]Talaviya, T., Shah, D., Patel, N., Yagnik, H., Shah, M. “Implementation of artificial intelligence in agriculture for optimisation of irrigation and application of pesticides and herbicides”. Artificial Intelligence in Agriculture 4, 58–73. 2020. https://doi.org/10.1016/j.aiia.2020.04.002

[51]Tata, J.S., McNamara, P.E. “Social Factors That Influence Use of ICT in Agricultural Extension in Southern Africa”. Agriculture 6, 1–10. 2016.

[52]Vidal-González, P., Nahhass, B. “The use of mobile phones as a survival strategy amongst nomadic populations in the Oriental region (Morocco) ”. GeoJournal 83, 1079–1090. 2018. https://doi.org/10.1007/s10708-017-9823-6.

[53]Yamano, T., Muto, M. “The Impact of Mobile Phone Coverage Expansion on Market Participation: Panel Data Evidence from Uganda”. World Development 37, 1887–1896. 2009. https://doi.org/10.1016/j.worlddev.2009.05.004.