Vol. 17(7), pp. 953-960, July, 2021
DOI: 10.5897/AJAR2020.15197
Article Number: 009F19467195
ISSN: 1991-637X

http://www.academicjournals.org/AJAR

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African Journal of Agricultural Research

Full Length Research Paper

Determinants of farmers' adoption decision of improved crop varieties in Ethiopia: Systematic review

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Received 10 September, 2020; Accepted 5 January, 2021.

Determinants of adoption decision have been studied by many researchers for a long time. This systematic review applied weight analysis method to summarize and synthesize the most common factors from twenty-one studies that determine the farmers' adoption decision of improved crop varieties in a regular pattern in Ethiopia. Hence, the result revealed that factors like Access to credit, Participation in social organization, hired labour, Participation in field day, farm income, farm size and extension contact were marked as best determinants. While training, oxen, fertilizer and access to input market were identified as promising determinants. This review recommends that adoption studies are still in need of fully conceptualization of the studies and methodological improvements.

Key words: Determinants, adoption, crop-varieties, weight- analysis, Ethiopia.

INTRODUCTION

Agriculture is the back bone of Ethiopian economy. It is also indispensable for the comprehensive growth through ensuring food security and assuring economic wealth for many of the third developed countries. Agriculture in Ethiopia is characterized by its subsistence traditional farming and low level of technology adoption. The adoption of improved agricultural technology is considered as a fundamental strategy to transform the agricultural sector from subsistence farming to commercialized and industrialized agriculture so as to enhance productivity and efficiency of the sector. Many empirical literatures reveal that improved technology adoption for agricultural transformation and poverty reduction is a central issue of modern agriculture (Minten and Barrett, 2008).

The country's capacity to efficiently exploit its agricultural resources mainly depends on its ability to innovate and adopt new agricultural technology (Akudugu et al., 2012). Adoption is a mental process through which the actor's ability is developed from hearing technology to its adoptions that follows awareness, interest, evaluation and trial (Rogers, 1962). The capability of farmers to adopt new technology is also conditional on the availability of technology. According to (Macauley and Ramadjita, 2015) and Bihon (2014), absence of suitable and affordable new agricultural technologies, inaccessibility to agricultural technology and low adoption rate toward new agricultural technologies are among the main obstacles of agricultural sector.

To overcome these obstacles the Ethiopian Government has been allocating substantial resources to research and extension in view of inspiring small-scale farmers to increase their productivity (Bayyisa, 2010). The national agricultural research system has generated a number of improved agricultural technologies and recommendations such as crop variety, agronomic practices, crop protection measures as well as other

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technical advices and practices (Negash, 2007: 20).

However, the farmers′ adoption of these improved agricultural technologies is influenced by socio-economic, institutional, attitude and perceived technology attributes (Bihon, 2015; Yu et al., 2011).

In Ethiopia many empirical studies have been conducted to analyze factors that affect the decision adoption of improved technologies. For example, Feder et al. (1985) summarized the tremendous amount of empirical literature on adoption and said that the determinants adoption of a new technology may arise from many sources, such as lack of credit, inadequate farm size, unstable supply of complementary inputs, limited access to information, uncertainty and so on. However, some review has reported the absence of two studies which used identical set of explanatory variables and also revealed inconsistence effect or result of a single variable, that is, particular variables do have different influences in different cases (Wauters and Matthijs, 2014). Therefore, this systematic review aimed at:

(i) Summarizing the result of many research articles that has been conducted on the determinants or factors that influence the adoption decision of improved crop varieties (technology) in the past ten years in Ethiopia.
(ii) Synthesizing these incongruent results and sorting factors that influence the adoption decision of improved crop varieties as best determinants, promising determinants and worst determinants
(iii) Assessing the existence of (possibly) universally acceptable effect of explanatory variables across the studies.

LITERATURE REVIEW

In order to get related literature, we followed three steps i) identifying source of the literature, ii) setting a time frame for the literatures to be selected, and iii) selection of the articles to be reviewed. Hence, the available literature was reviewed by selecting the pertinent adoption literature through a keyword search in abundant electronics databases like Science Direct, CORE, Scopus, Taylor and Francis and JSTOR. Furthermore, all available topic- related literatures were searched using Google Scholar and Scopus search engines so as confirm the inclusion of concerned literatures as much as possible.

These sources were systematically searched for determinants of adoption decision and related words, such as searched through using the following key-words and phrases: adoption, agricultural technology, determinant of adoption, adoption factors, improved varieties and crop technology. In addition to this related articles were searched from the reference list of the downloaded articles.

Inclusion criteria

Among the various types of agricultural technology, this systematic review selected only the articles published in the past ten years regarding determinants of adoption decision of improved crop varieties in Ethiopia only. Each of the articles included in this review followed quantitative method and quantifies the effect of each explanatory variable on the adoption decision of the individuals. Depending on these criteria, twenty-one studies were selected.

GENERAL OVER VIEW OF THE ADOPTION STUDIES

In the past two decades, many scholars began to publish empirical technology adoption studies with the intention to create better understanding regarding the behavioural components of adoption. These emanated from diverse bodies of accumulated theoretical works like theories that typically investigate an individual's behavioural intention to adopt new technology or actual adoption behaviour. For example, Theory of Reasoned Action explains an individual's behavioural intention to adopt (Ajzen and Fishbein, 1975). Different theories propose different types of explanatory variables, such as Gender (Venkatesh et al., 2003), experience (Igbaria, 1993), attitudes (Taylor and Todd, 1995), age (Venkatesh et al., 2003), education (Igbaria, 1993), and motivation (Davis and Stretton, 1989).

The number of explanatory variables stated in the studies can be mainly categorized based on numerical value they can take into discrete, categorical and continuous variables. Continuous variables can take any numerical value and can be measured. Discrete variables can only take some numerical and are counted. While categorical variables are finite number of categories and may not have a logical order. For example, Wondale et al. (2016) categorized independent variables as continuous and discrete dummy explanatory variables.

Under continuous explanatory variables they listed variables like age of farmer, farm size, house hold size, total livestock, farming experience, distance to development centre, distance to market centre, off-farm income, farm income and distance to road. While under category of Discrete dummy variables they stated variables such as sex of the household, access to credit, extension contact, research contact, hired labour, attending field day, knowledge of improved crop varieties, participation in social organization, ownership of radio, access to input supply and education level. Contrary to Wondale et al. (2016)), Knowler and Bradshaw (2007) conducted analytical review on factors influencing farmers' adoption of conservation of agriculture and they classified an explanatory variable that affected adoption as farmers and farm household characteristics such as

age, education, gender etc; farm biophysical characteristics like farm size, farm fragmentation; farm financial/management characteristics like family labour, hired labour, income and exogenous factors such as input price, output price, membership in organization etc.

Finally, the scholars who had breakthrough in the adoption studies addressed that the determinants of farmers' adoption decision are not limited only to the factors related to farm and its management but also incorporate exogenous institutional and social factors which go far beyond the farm finance and farm households' characteristics (Prager and Posthumous, 2010). Additionally, Llewellyn et al. (2005) also reported the influence of expected economic value from adoption practices, cultural and characteristics of the innovation itself on the adoption decision. Therefore, it became semi-compulsory in adoption studies to identify these factors, that is, Technical or Environmental, Personal, cultural, Economic and Institutional factors. This helps in paving way for the researchers to distinguish the separate and joint effect of these factors on the farmers' decision, the magnitude of their interconnection in between them and their relative importance (Prager and Posthumous, 2010).

As noted earlier, the decisive factors of adoption across studies point to contradicting result from one case to another. In this part of the review, an attempt is made to synthesize the result obtained from selected studies and distinguish those explanatory variables that uniformly explain adoption. To start with the characteristics of farmers, after the work of Ryan and Gross (1943) that exposed irregular adoption of agricultural innovation from farmer to farmer, the researcher explored the reason behind this unevenness adoption of agricultural technology. Several researchers have analyzed the influence of age on the adoption and revealed anomalous result.

Studies conducted by Tefari et al. (2015) identified old aged farmers were more likely to adopt new technology and influence adoption positively. The reason behind this was that old aged farmers were expected to be more experienced than young farmers. Hossain and Croach (1992) also repeated similar result and discovered the likelihood of adoption increases as the age of farmers increases. In contrast to the study of Tefari et al. (2015), Beshir and Wegary (2014) found the adopters of hybrid maize were younger than non- adopters. In support of Beshir and Wegary (2014), Aman and Tewodros (2016) observed the negative effect of age on the adoption and intensity of improving barely; they claimed as the farmers got old their trust toward new technologies dropped since the adoption required additional expense. Ayana (1985) found similar result connected with conservative or risk aversion behaviour of aged farmers. Freud et al. (1996) found no significant relation between age of farmers and adoption of coca varieties.

With respect to education, most studies (Afework and Lemma, 2015; Beshir and Wegary, 2014; Tefari et al., 2015; Keba et al. 2019) identified significant and positive impact on adoption decision. Whereas, few studies (Fufa and Hassan, 2006) discovered there was no meaningful relation between formal years of education and adoption decision. Another variable that affected adoption decision was farm size.

It has been anticipated that increase in farm size encourages adoption. However, the collective results obtained from the studies were incongruent. Gecho et al. (2011), Yenealem Kassa et al. (2013), Dibaba and Degye (2019), Teferi et al. (2015) and Beshir and Wegary (2014) among many others revealed positive correlation, Fufa and Hassan (2006), Gemadea et al. (2001) and Degu et al. (2000) showed no considerable correlation; whereas, Mengistu (2016) observed negative correlation between farm size and adoption of potato package. According to his analysis, the adoption of this production technology needs intensive production management that could be better handled in smaller farms. Extension service and frequency of extension contact has been long considered as a key influential factor that accelerates the rate of adoption.

Most studies reviewed Solomon et al., 2014; Tefari et al., 2015; Yenealem Kassa et al., 2013; Tura et al., 2010; Yemane, 2014) showed high positive correlation between extension contact and adoption. The extension service enables the farmers in getting valuable knowledge, training and information that help in not only increasing awareness to the benefit of technology but also in reducing uncertainty, transaction cost of accessing information, and risk associated with the adoption of improved crop varieties (Nigatu et al., 2018). However, Beshir and Wegary (2014) proved negative correlation but with no significant association. The possible justification they mentioned was that extension workers do not offer advice on hybrid maize as the study area is expected to be not suitable for hybrid maize production. Such inconsistency of various studies toward a particular variable creates ambiguity and leads to an inconclusive argument.

It is worth noting that the impact of the number of livestock unit owned by farmer on the adoption of crop technology has been widely assessed and reported anomalous result. Dibaba and Degye (2019) observed positive, Yemane (2014), no significant difference between adopter and non-adopter, whereas Wondale et al. (2016) identified negative impact of livestock unit on adoption of improved bread wheat varieties. The apparent reason behind was as the livestock size increases, the attention toward fattening sheep and bulls providing for the nearest market increases.

Membership to farmer organization has been regularly hypothesized by many researchers as farmers who joined the organization are more likely to adopt crop

technology than the farmers who refute to join the farmer local organization. It has been assumed that participating in farmers' organization exposes individuals to chance of accessing agricultural input and on time information from government officials and change agents (Bayissa, 2010; Dawit, 2020). Surprisingly, Dibaba and Degye (2019) reported negative impact of joining local organizations on the adoption of improved varieties and claimed that organizations in the study area were poorly engaged in cultivating high yielding wheat varieties and failed to provide credit for members so as to purchase high yielding wheat seed.

Lastly, another determinant of adoption expected to have positive influence was oxen ownership of the household. Studies by Tefari et al. (2015) and Gecho et al. (2011) revealed positive influence. Contrary to the work of Tefari et al. (2015) and Gecho et al. (2011) Beshir and Wegary (2014) showed no significant difference between adopters and non- adopters and connected the cause of the result with the availability of pair oxen to show the possible meaningful difference.

The overall analysis of the review revealed that the impacts of most of independent variables on adoption of improved crop varieties were confusing and difficult to conclude. However, there were some variables which showed mostly identical result across all studies (Table 1). Factors like access to credit, access to input and output market, off-farm income have been far recognized mostly by their positive influence across many studies. Similarly, the negative impact of factors like distance from the nearest market, distance from all-weather road and the like was also addressed by few researchers.

Researchers have investigated the sources of incongruency and perplexity seen in the adoption studies. Knowler and Bradshaw (2007) said that the absence of universally accepted significant factors affecting adoption leads to uneven result across the study. In support of this view, Wauters and Mathijs (2014) point out an absence of standard definition of variables among adoption studies. This leads to confusion and misinterpretation of the results. For example, the absence of clear-cut boundary between farming experience and age of farmer created ambiguity among researchers and begged the question: if farming experience is expressed in years as in the study of Aman and Tewodros (2016), does it mean old aged mean more experienced? If yes, why old aged respondent is less adopter and more experienced farmer is more adopter in most studies?

The difference in sample size is also another cause of result variation in adoption studies. As the result from Table 1 depicts, the average sample size of the studies was 137. The difference between highest and lowest sample size was 180 which can create a great variation in the result of the studies particularly in the test of significance. This difference in return disturbs sample representativeness of target area. Type of econometric model applied by researchers was also mentioned as the source of unevenness in the result. Feder et al. (1985) declared that Logit and Probit models better suit than OLS. For analyzing the result some studies use regression, while others use correlation coefficient which does not reveal causal relations between variables. Moreover, difference in the type of technology adopted, statistical outcome, number of explanatory variables used in the model, location of the studies and omitted variable bias were assumed as the sources of ambiguity identified by Knowler and Bradshaw (2007) and Wauters and Mathijs (2014) in the adoption studies.

Weight analysis

Given the number of adoption studies and articles published in the last years has been showing an increasing trend, nearly all studies conducted proposed identical research objectives to be achieved: What factors determine or influence the adoption of improved varieties? The early stated evidence on the inappropriateness and inconsistency even regarding a particular explanatory variable evidently revealed the existence of paradoxes, gaps, and irregularities in the relevant literature of adoption studies in Ethiopia. This situation may actually enforce researchers toward shifting their direction of research from repeating similar studies to reflecting light on the existing accrued body of literatures.

Accordingly, this paper attempts to review twenty-one empirical studies carried out on determinants of adoption decision of improved crop varieties in Ethiopia. Apart from this, the paper also tried to classify the most/least frequently used explanatory variables of adoption as the best, promising and worst determinants of adoption decision using weight analysis method (Jeyaraj et al., 2006).

Weight analysis is a method used to scrutinize the strength of a determinant, in our case the explanatory variables, in a given relationship (Jeyaraj et al., 2006). It indicates the degree of influence a given independent variable has on dependent variable. To conduct weight analysis, I few steps were set to be followed i) sorting the list of predictor variables included in the empirical studies (Table 1) ii) merging variables that have similar meaning or can be used interchangeably. For example, household size or family size, sex of the house hold or gender. iii) identifying how many times the variable is selected as predictor and found to be significant at 10%; lastly calculating the weight (Tables 2 and 3) for each explanatory variable through dividing the number of times the variable found to be significant to the number of times the variable selected as a predictor.

Based on frequency of use and the magnitude of weight, variables can be classified as best predictor (if the variable examined at least five times and has weight

Table 1. Summary of 21 selected studies.

Study	Sample size	Type of crop Under adoption	Econometric model	Number of explanatory variables	Location of study
Teferi et al. (2015)	300	Maize	logit	14	Oromia
Afework and Lemma (2015)	151	Rice	Probit	14	Amhara
Keba (2019) Alemayehu et al (2020)	189	Maize	Double-hurdle	14	Oromia
Aman and Tewodros (2016)	129	Barely	Tobit	14	Sidama
Demissie et.al (2018)	140	Wheat	Tobit	20	Oromia
Beshir and Wegari (2014)	277	Maize	logit	12	Oromia
Dawit (2020)	144	Teff	Tobit	15	Oromia
Gedefaw (2018)	150	Maize	Double-hurdle	16	Amhara
Wondale et al., (2016)	120	Wheat	logit	21	Amhara
Mengistu (2016)	214	Potato	Tobit	18	Oromia
Tura et.al (2010)	120	Maize	Probit	22	Oromia
Dibaba and Degye (2019)	174	Wheat	probit	13	Benishangul
Samuel (2018)	174	Wheat	Probit	14	Benishangul-Gumuz
Susie and Bosena (2020)	150	Teff	Double -hurdle	16	Amhara
Tura et al., (2010)	120	Maize	Probit	11	Oromia
Solomon et al. (2014)	150	Wheat	Double-hurdle	21	Oromia
Walelgn et.al (2020)	150	Sorghum	logit	15	Amhara
Yemane (2014)	120	Rice	logit	15	Amhara
Yenealem et al. (2013)	148	Maize	logit	9	Oromia
Gecho et al. (2011)	150	Maize	logit	14	Wolaita
Abebe and Debebe (2019)	204	Wheat	Double-hurdle	18	Amhara

≥ 0.6), worst predictor (if the variable used at least five times and has weight<0.5) and promising predictors (if the variable used less than five times and has weight ≥ 0.6).

MATERIALS AND METHODS

This paper used weight analysis to review, synthesize and further analyze the factors that affect decision of the farmers to adopt new improved agricultural technology (improved crop varieties).

RESULTS AND DISCUSSION

As a result of reviewing the selected articles conducted on the determinants of adoption decision of improved crop varieties, forty-eight independent variables were identified. This happened after merging some variables that have similar meaning or synonyms and can be used interchangeably. For instance, farm size and land, gender, education |literacy |schooling were merged since these variables nearly give the same meaning. Of the total forty-eight determinants, only the results of variables that were examined three times and above were presented.

Most frequently (≥10) used determinants of adoption were Distance from market, Extension contact, Education level, Sex of household, Farm size, Size of livestock, Participation on social organization, Family size, Farming experience, farm income and access to credit. It is worth noting that being tested most frequently does not mark the variable as a best determinant as we will see in details. Explanatory variables that tested at least five times (≥5) with the weight ≥0.6 were labelled as best determinants.

Best determinants are factors that can highly influence the dependent variable. These are Access to credit, Participation on social organization, Hired labour, Participation on field day, farm income, farm size and extension contact. This implies that access to credit has power of enhancing and promoting adoption technology. Participation of the farmers on the field day is one of the techniques through which teaching and learning of improved technology is executed (Tesfaye et al., 2014). It is expected to enable the farmer get a variety of information as they are closer to sources of information, thereby significantly increases the likelihood of adoption of improved varieties.

Table 2. List of independent variables used.

1. Age	14. Access to credit	26. District dummy	40. Participation on demonstration
2. Farm size	15. Use of improves seed	27. Fertilizer	
3. Family size	16. Extension contact	28. Fragmentation	41. Training
4. Hired labour	17. Research contact	29. Access to weather	42. House
5. Livestock	18. Attend field day	30. Own radio	43. Oxen
6. Farming experience	19. Past knowledge of seed	31. Education	44. Input price
7. Distance to road	20. Participation on social organization	32. Access to output market	45. Drought
8. Distance to market		33. Access to input market	46. Altitude
9. Off farm income	21. Active family force	34. Marital status	47. Cultivated land%
10. Gender	22. Farmer association	35. Cultivated land size	48. Distance to gov. office
11. Soil fertility	23. Farmers' perception	36. Row planting	
12. Rent machinery	24. Seed availability	37. DAP use	49. Saving
13. Urea use	25. Motivation	38. Social participation	

Table 3. Weight of explanatory variables.

Explanatory variable	Frequency	Significant	Insignificant	Weight
Access to credit	13	8	5	0.61
Participation on social organization	10	8	2	0.80
Hired labour	8	7	1	0.87
Participation on field day	6	5	1	0.83
Access to input supply	3	3	-	1
Farm income	12	8	4	0.67
Family size	11	3	8	0.27
Farming experience	10	3	7	0.3
Farm size	15	10	5	0.65
Size of livestock	15	8	7	0.53
Age of household	11	6	5	0.54
Education level	17	6	11	0.35
Sex of household	12	5	7	0.41
Distance from market	15	8	7	0.53
Extension contact	16	10	6	0.62
Radio	5	2	3	0.40
Training	4	3	1	0.75
Fertilizer	3	2	1	0.67
Oxen	4	3	1	0.75

The conceivable reasoning for the extension contact is that regular contacts are expected to create awareness and build the necessary knowledge for using the innovation and enhancing the exposure of farmers on the adoption practice of improved technologies (Susie and Bosena, 2017). Having high level of income and huge size of the land highly influence the chance of adoption positively.

Among the most frequently used determinants, there are least effective explanatory variables that were examined at least five times (≥5) and found to be insignificant most of the time. These factors are: Education level, Sex of household, farming experience, family size and distance to market. Lastly, weight analysis revealed few variables that have been examined less than five times with their weight ≥0.6 classified as promising explanatory variables: training, oxen, fertilizer and access to input market. Such variables require conducting further research to confidently classify them under the best determinants.

Conclusion

This paper reviewed twenty-one studies conducted on factors affecting adoption decision of improved crop varieties in Ethiopia. The studies identified several explanatory variables that range from 8 to 22 which affect the adoption decision of improved crop varieties. For further analysis various studies categorized these independent variables based on the numerical value they can take and how they can be measured as discrete and continuous variables. Others classified as technical, personnel, social, cultural and institutional factors.

With respect to the combined results of these explanatory variables, systematic review observed mixed and contradictory results from selected studies. For a particular variable, some studies found positive and significant influence on adoption, others revealed negative influence and the remainder reported no significant association between variable and adoption decision at all.

Variation in sample size, type of econometric model used, type and characteristics of technology to be adopted, number of explanatory variables used in the model, location of the studies, incongruence and non-standard definition of variables and absence of universally accepted that impact explanatory variables are considered as the sources of inconsistence and inconclusive results across the studies.

However, to synthesize findings from the accumulated body of literature and present the summary of current status of knowledge, the author used weight analysis method following Jeyaraj and his colleagues. Based on the weight analysis method the author classified independent variables like Access to credit, Participation on social organization, hired labour, farm size and extension contact as best determinants of adoption. On the other side, variables like training, oxen, fertilizer and access to input market were classified as promising explanatory variables. Finally, to get consistency across the studies, obtain collective results at aggregate levels and draw policy implication from the results, future researchers should give due emphasis to the fully conceptualization of adoption studies and methodological improvements.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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