AIMS Agriculture and Food, 4(4): 833–853.
DOI: 10.3934/agrfood.2019.4.833
Received: 07 April 2019
Accepted: 30 July 2019
Published: 24 September 2019

http://www.aimspress.com/journal/agriculture

Research article

Farmers' attitude towards the use of genetically modified crop technology in Southern Ghana: The mediating role of risk perception

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Abstract: Food and agricultural policy research is often challenged with the issue of commercializing the application of transgenic technology in food production. There is a need for an enhanced understanding of how risk and benefit information influence the general attitudes of farmers towards genetically modified (GM) technology. This paper contributes to existing literature by studying the various adoption factors that influence Ghanaian farmers' attitudes toward GM crop technology by using risk perception as a mediating tool. An empirical choice of methodology which is structural equation analysis was incorporated in this study. We report that, after conducting a survey among 325 respondents, Ghanaian farmers' negative attitudes toward GM technology is as a result of the influence of risk perception on the attributes of the innovative technology (relative advantage, trialability, mass media, and interpersonal relations). We employ a conceptual framework that incorporates Innovation Diffusion Theory (IDT) and Risk analysis to assess the relationships between the attributes and attitudes towards GM technology. It was revealed in the structural equation modeling (SEM) analysis that, risk perception exerts a significant influence on the effects of the attributes of GM technology adoption thus reflecting a negative attitude towards the adoption of the related technology. We further discussed the implications for emphasizing the need for a positive attitude toward the acceptance and adoption of GM technology in Ghana.

Keywords: genetically modified food; risk perception; structural equation analysis; Innovation Diffusion Theory (IDT)

1. Introduction

Genetically Modified (GM) crop technologies have raised and continue to raise unending debates about its adoption in Africa in an attempt to tackle poverty and food security problems in the area. These debates are primarily centered on the benefits and safety of crops and foods made from this modern biotechnology. In view of the growing number of populations in the world and Africa to be precise, the potential of genetic engineering (GE) agriculture is necessary to be given consideration and would, therefore, bring about the significant transformative change needed [1].

In recent times, interest in the new green revolution in Africa has sparked debates about the interference of policymakers in agricultural markets and biotechnology. Recently, initiatives and policies have been made to make the three northern regions (Upper West, Upper East, and Northern Regions) of Ghana the hub of the country's agricultural producing area in an attempt to expand the Ghanaian economy [2]. Hence, technical and scientific innovation, as well as appropriate technology, must be developed and used effectively in order to attain substantial productivity and tangible viability in the agricultural industry [3].

According to Bailey et al. biotechnology has broadly been defined as any process that uses living things or substances from those organisms, to create or transform an invention, to increase plants, animals or microbes for precise usages [4]. Genetically engineered foods and crops have over the past two decades been the topic of discussion across the globe on public policy usually focusing on the commercialization of GE crops within the ecosystems. The major user of this novel technology is agriculture. It is used ideally to alleviate various problems of production and promote effective production. It goes further to enhance the nutritional value of food.

In as much as the impacts of biotechnology in the advancement of agriculture are made known, the contribution of this technology to increase agricultural yields has not been given the sufficient acclaim it deserves [5]. Considering the previous study on agricultural biotechnology, it can be observed that increased crop production, increased production of pest and disease resistant crops, increased production of drought-resistant crops and improved food and crop dispensation emerged as the key developments of agricultural biotechnology [6]. However, the importance of expediting the adoption of this technology in Ghana and Africa as a whole has not been emphasized. This can be attributed to the manner in which technology is generally viewed and accepted in the agricultural sectors. More often than not, there is no education or no awareness creation in this direction. Many countries that have adopted and commercialized the use of GE agriculture have experienced substantial economic growths [7]. Developing countries like Argentina, Brazil, China, and India, for instance, have made inroads in this regard by producing a number of valuable crops and foods. However, in Africa, few countries such as Burkina Faso, Egypt and South Africa have commercialized the use of GMO whereas Ghana, Kenya, Uganda, Nigeria, Malawi, and others have it under confined testing [8]. Rogers et al. underscore the pertinence of a feasibility study relative to adoption and acceptance of innovation before its introduction [9]. The study objective, therefore, is to investigate the factors that influence the attitude of general farmers towards the adoption of GMOs in developing countries specifically Ghana. On this score, given the relevance of GMO, especially in

a world of an ever-growing population, face-to-face climate-related uncertainties that are likely to affect food production, there is the need to investigate factors likely to influence GMO adoption. The current study intends to highlight the role of risk perception in explaining both the negative and positive effects contributing to poor adoption of GMO in Ghana.

2. Theoretical background

2.1. Innovation Diffusion Theory (IDT)

Regarding technology adoption research, a series of studies have focused on acceptance, adoption, and implementation of various inventions and technologies [3,10–12]. Innovation adoption generally has sociological aspects and implications. A specific example is one built on the theory of diffusion and innovation [13]. Among other things, the theory postulates that innovation transfer across the social sphere and strata are done via certain definite networks over a particular stretch of time. It further stresses that innovation and adoption ought to undergo various processes and stages including understanding, decision, persuasion, implementation, and confirmation. Closely connected to the innovation adoption process are gender, age, and education related factors. A series of seminal studies have used these variables to develop logical frameworks and evaluate sociodemographic and economic factors that affect adoption behavior. Feloor et al. in a piloted study stressed on the role of social variables (like social media) and other innovation measures in the adoption of integrated pest management application [14]. Peshin et al. also conducted extensive research on how the theory of innovation diffusion could assist in investigating the adoption behavior of integrated pest management technology [15]. In the views of Robertson et al., innovation attributes such as relative advantage (the ratio of the expected benefits of the innovation against the idea that is to be replaced), Compatibility (the rate to which an innovation is consistent with past experiences, existing values, and needs of farmers), Trialability (the ability to observe and test the innovation on limited basis), Complexity (the extent or degree to which a precise invention is tough to comprehend and use) and Observability (the degree of how visible the innovation or the results of the innovation are visible to others) impels the rate of adoption and helps in decreasing doubt about the technology [16].

2.2. Risk perception

According to Hirunyawipada et al., risk perception is an interplay of unanticipated results of adoption and the consequence that is derived from expectations [17]. When it comes to the issue of risk perception and consumers or farmers, researchers have offered a number of speculations, but they are usually based on the ground that consumers are often sensitive to both the likelihood and degree of probable loss that comes with a purchase and usage of a new product [18]. More often than not, farmers face a risk decision because whenever they attempt to adopt new products, they are challenged with the dilemma between necessary and unnecessary consequences of the adoption. Some researchers claim the attributes of innovation may influence risk perception [12], however, perceived risk could also influence an individual's perception of characteristics of an innovation [19].

Kim discovered that when a particular innovation does not give an individual a new functionality in the technical markets, they tend to doubt such innovation [20]. Even though there exist a number of dimensions of perceived risks [21], not all risk perceptions have effects on

innovative products. In this paper, most of the farmers have never used or tried GM technology and are not familiar with GM crop technology. It is, therefore, necessary to have in mind psychological and time loss risk since these dimensions of risk perception would go a long way to help us measure the actual risk perception that stems from the attributes of innovation. Psychological risk usually refers to the dissatisfaction or concern that post-purchase results cause [22]. On the other hand, time loss risk occurs when one develops anxiety in loss of money or time spent to buy a particular good. One may say that, in most developing countries, farmers would not spend so much time on learning how to use any new technology since they're accustomed to the primitive way of doing things. The uncertainty of GM crop technology among farmers would prevent them from viewing the benefits of this new agricultural technology. Hence, we posit that perceived risk will negatively influence farmers' attitudes towards the attributes of GM crop technology.

3. Model development

3.1. Relative advantage

As stated earlier, a relative advantage is how the innovation is seen well than the idea it replaces. Elements of relative advantage include low initial cost, economic profitability, decrease production cost and effort. Peshin in the adoption of integrated pest management (IPM) research posit that there exists a positive relationship between relative advantage and adoption [15]. Moreover, the results of studies of Miller & Meek revealed that farmers' decision and choices are influenced by certain benefits of IPM such as economic profitability, decreasing production cost and efforts [23]. Results from prior studies show that relative advantage positively influence farmers' attitudes towards the adoption of GM technology [24]. However, in many developing countries or in Africa, the relative advantage of GM technology doesn't necessarily influence a positive attitude towards adoption. The level of uncertainty existing among farmers rather deters them from trying out new things; therefore, the effects of relative advantage on attitude will decrease as a result of perceived risks. From the foregoing discussion, we propose that:

H1: Relative advantage is negatively related to risk perception.

3.2. Trialability

Trialability basically refers to the extent to which any innovation stands the chance of being tested and experimented on a limited basis [9]. Rogers opined that latent adopters would feel more comfortable to accept new inventions if invited and allowed to experiment the said innovation for trials. Trialability to some extent provides farmers the opportunity to evaluate and assess the benefits arising from the use of innovation [25]. Trialability helps to reduce fears of the unknown when farmers are given the chance to try to test the innovation. In as much trialability has the effects of reducing uncertainty among farmers in trying out new technology, the various dimensions of risk perception will induce negative effects of trialability on attitudes of farmers towards the related technology. For example, time loss risk might induce negative effects of trialability on farmers' attitude towards GM technology if they develop anxiety in loss of money or time invested in the

technology in question. These concerns or negative attitudes will be mitigated by farmers risk perception in a highly technological domain. On this basis, the research proposes that:

H2: Trialability is negatively related to risk perception.

3.3. Mass media

According to Mannan et al., there cannot be any proper adoption of innovation without detailed and extensive communication [11]. In lieu of the adoption process suggested by Rogers & Quinlan, the conduit of communication is of cardinal significance in information assimilation and perception development [9]. Ronteltap et al. accentuate that, individuals tend to utilize these means to help alleviate doubts whiles gathering innovation information [26]. In as much as studies conducted by various researchers like Gaskell et al. emphasize the role of communication channels in the adoption of innovation, it doesn't suffice any distinction between the various means of communication and the extent to which they influence the adoption processes [27]. Talebian & Mishra further confirm the strong influence of the mass media on the adoption process [28]. Mass media channels such as television, radio, social media websites, newspapers, etc. could be used effectively to sensitize create awareness and further effect behavioral changes among farmers towards this new agricultural biotechnology. Lagnaoui et al. suggests that it is important to organize labor intensive communication strategies such as workshops and demonstrations to forge a deeper understanding of the prospects of GMO to influence the implementation and adoption of GMO [29]. Bardin et al. also stresses on microelectronic mass media networks such as television and radio as germane for persuading decision to adopt innovation [30]. Swarts & Strand asserted in a study that, after media reports were made on a keepone contamination, there was a negative impact on demand for oysters in certain US markets [31]. Another study by Barcellos et al. and Verbeke et al. in Belgium found that the expenditure on beef consumption reduced by 2% after media coverage of the Bovine Spongiphorm Ecephaopatsy (BSE) crisis [32,33]. It is therefore necessary to state that, the magnitude of influence the media has on the attitude of farmers is huge since it often emphasizes the possible risks of using GM technology. In most African countries, there is a quick acceptance of social networks and popular press and these media houses usually respond to an exaggeration of the possible risks associated with GM crop technology instead of scientific evidence. For example, a local news agency called Modern Ghana in September 2013 argued in an article that the fact that there haven't been any studies of the effects of GMOs doesn't necessarily mean there isn't any existing [34]. Fake news and poor quality coverage of the importance of GM crop technology in agriculture instigate a negative attitude of farmers towards the adoption of GM technology since perceived risks and uncertainties would be on the increase [35].

H3: Mass media is negatively related to risk perception.

3.4. Interpersonal relation

Interpersonal communication is equally important in influencing innovation adoption. It is important to note that mass media is too general and broad to strengthen trust in innovation. Intragroup information dissemination about GMO, among members sharing similar or the same

characteristic, is more likely to be facilitated and enabled by interpersonal communication. This would, in turn, help farmers to properly handle the changes required by new technologies [36]. Dibden et al. reiterates the need to educate farmers on present and sophisticated agricultural information [37]. Scott also revealed face-to-face communication via personal contact as a major communication channel used to get information in Uganda [38]. Gupta et al. opined that communicating risk uncertainty amongst individuals would increase their level of distrust in GMOs [19]. In Ghana, farmers usually rely on judgments of colleague farmers rather than certainty. Hence, when farmers are confident in the information provided by friends and family concerning GMFs, it becomes crucial for farmers' willingness to accept GM technology. In the situation where uncertainty or doubts are conveyed, it spikes up perceived risks thereby resulting in a negative influence of such interpersonal relations on attitude. An increase in perceived risks reduces the influence of interpersonal relations on attitudes of farmers towards GM technology adoption. We, therefore, propose the following hypothesis.

H4: Interpersonal relation is negatively related to risk perception.

3.5. Risk perception

There always exist benefits and risks of innovation to the end-user. Before deciding to adopt technology, farmers and consumers are likely to undertake the risk-benefits analysis. GM technology is not void of this phenomenon. However, what makes it cynical is the individual's perception of risk and benefits and not necessarily the actual risks and benefits [39] Perceived risk has been defined by Featherman & Pavlou as the combination of doubt and gravity of results [40]. The level of perceived risk is inversely related to the perceived benefit such that, the larger the perception of risk, the more likely the tendency to reduce the perceived benefit of technology [41]. Risk perception has been the focal point of many studies, but they show that the measure of risk perception is not peculiar to the individual and rather view it on a general level [42,43]. This broad perception is in line with the subjective assessment of information that people receive from their environment through established interpersonal relationship [30]. Though risk perception predicts perceived threat to some extent, this risk perception could differ from the perceived threat they actually feel for themselves. In this regard, we suggest that:

H5: Risk perception is negatively related to attitude towards GM technology adoption.

Attitude is very important when it comes to predicting farmers' behavior towards adoption and acceptance of a particular innovation or technology. Attitude can help determine and understand why people accept or reject GM technology and its use. This research assumes that farmers' attitude toward GM agriculture is as a result of certain elements of adoption and attitudinal models. It was asserted by Vänninen et al. that attitude is useful in any context of innovation acceptance [44].

The theory of Planned Behavior [45] suggests perceived behavioral control (where the individual thinks they can execute the behavior) as a determinant of behavior intention, together with social norm (where individuals are likely to support the use of an innovation to others or influence their choice on the use of the innovation) and attitude (level to which an individual is optimistic or pessimistic about engaging in the behavior under deliberation) [46]. Attitudinal models have aided

generally in explaining the diffusion of information systems and consumer adoption [26]. The current study adopts a construct (attitude) from TBP to determine the behavior of farmers towards GM technology. Burke et al. in a study, adopted models provided in the related literature, to investigate individuals' attitude towards the adoption of biotechnology [47].

There has been extensive research on the diffusion of innovation and consumer adoption in technology-based food innovations. This study aims to make people gain deeper understanding of GM technology and later, adopt and provide suitable solutions to agricultural issues arising. GM technology acceptance and adoption by farmers would, in the long run, increase agricultural productivity [48]. Adoption of technology is the comparative capability with which an innovation is accepted by members of a society [9]. Sjakir et al. indicate innovation adoption as an important and necessary feature in agricultural development activities [24]. It is, therefore, necessary to state that; the attitude of farmers is a prerequisite in so far as the adoption of new technology in agriculture is concerned. It is, therefore valid to conclude that, the adoption of any better technology is anticipated to be highly profitable and would encourage the transition from primitive and traditional agriculture to modern agriculture [11].

4. Research model

In this study, we tend to analyze and ponder over the appropriate variables regarding the determinants GE technology adoption in Ghana using and comparing Everett M Rogers & Quinlan, (2004) innovation adoption model and the construct attitude from the attitudinal models of [45]. Precisely, this study seeks to analyze and reflect on the appropriate determinants of the adoption of gene technology in Ghana. It was assumed that the attitude towards the adoption of GM technology is related to concepts previously mentioned that is, relative advantage, trialability, and Interpersonal relationship, the influence of mass media and risk perception. Based on related literature, a theoretical working model was constructed in Figure 1.

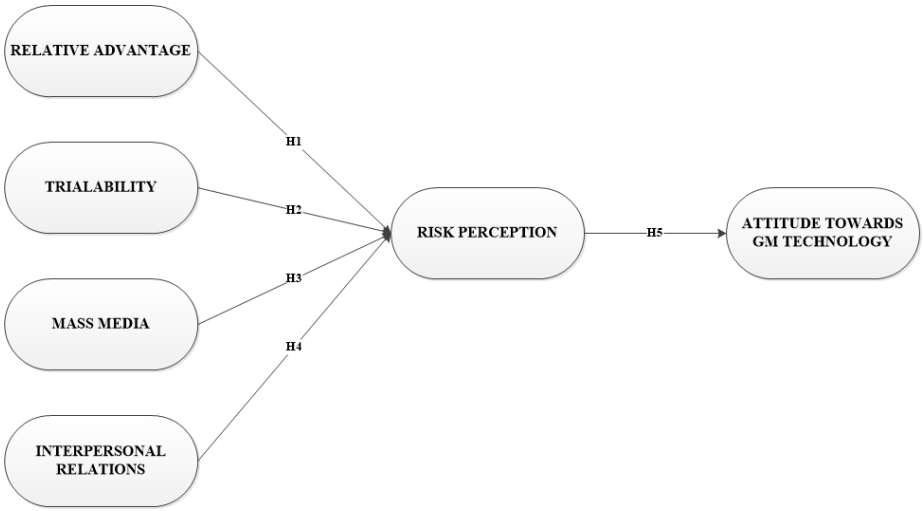


Figure 1. Research model of the study.

In this conceptual model, the selected independent variables are the characteristics of innovation (Relative advantage and Trialability) and means of communication (interpersonal relations and mass media). The mediating variable is risk perception and the dependent variable is the attitude towards GM food.

4.1. Sample and data collection

This study employs a structural equation modeling approach to develop and confirm the research model and to show the relationship between six constructs (Figure 1). Generally, the larger population of Ghanaian farmers and advocates in the agricultural sector reside in the south. As such, the statistical populations for this research were farmers from the southern part of Ghana. For the purpose of increasing sincerity and credibility, purposeful random sampling technique was used to select respondents in order to ensure effect representativeness. The research used a questionnaire survey to collect data from four main farming municipalities in Greater Accra Region. In an attempt to enhance the external validity of the questionnaire, two Ph.D. academic researchers with skills in survey methodology and who have knowledge in the innovation adoption area of the study reviewed the questionnaire and made the necessary changes and recommendations. The study also adapted existing measures that had previously been used in prior studies. Before distributing the questionnaire, the purpose of the study was explained to the respondents briefly. Respondents were assured of their utmost confidentiality and incentives were given to them to avoid possible biases. They were further not requested to give out any names or contact details as data collected for this research was solely for academic purposes. Between December 2018 and January 2019, a total of 338 completed and submitted questionnaires were received after distributing 370 questionnaires across the study regions. After removing incomplete and invalid questionnaires, only 325 functioning questionnaires were retrieved. This indicates a response rate of about 87% which is acceptable in studies adopting survey method [10,49]. The demographic information of the respondents, such as gender, age, and academic background are exhibited in Table 1.

Table 1. Demographic information.

Variable	Category	Frequency	Percentage
Age	$18 < x \leq 24$	94	28.9
	$25 < x \leq 3$	149	45.8
	$35 < x \leq 44$	63	19.4
	$x > 45$	19	5.8
Gender	Male	197	60.6
	Female	128	39.4
Academic qualification	Diploma/HND	39	12.0
	Bachelor	72	22.2
	Master's	156	48.0
	PhD	58	17.8

4.2. Measurement model

The survey conducted involved 26 items dispersed over chosen constructs adapted from previously validated instruments. In order to reflect the measurements of the various constructs used, few changes were made in the language of the questions. The items for Relative Advantage and Trialability were adapted from preceding studies, who have already recognized their reliability and validity [3,9,11]. Examples of measurement items for RA and TT are 'The use of GM technology brings about increased efficiency and economic benefits if there are no risks involved' 'Testing GM technology gives farmers the opportunity to evaluate the benefits and risks of GM crop technology'. In the same vein, items for Interpersonal Relations and Mass Media were adapted from Rogers et al., Mannan et al. & Peshin et al. [9,11,15]. Examples of the questions asked are 'Information provision of risk uncertainty by the media increase public distrust in GMOs' 'Information from friends and family about GM technology are reliable' whereas items for Risk Perception were adapted from Sarcheshmeh et al., Peshin et al., Bearth et al. & Aerni [3,15,43,50]. For example 'Fears over the use of bt maize are unfounded and exorbitant'. The items for Attitude towards the adoption of GM technology were adapted and modified from Sarcheshmeh et al., Mannan et al. & Pardo et al. [3,11,52]. For instance, 'If the benefits of genetic engineering agriculture outweigh the risks, I will use GM crop technology'. Latent variables for the research were measured using a five-point Likert scales ranging from strongly agree to strongly disagree and specific alterations were made in the sentence structure of questions according to the current investigation.

4.3. Data analysis and results

Smart Partial Least Square (PLS) structural equation modeling was employed for creating the model and data analysis based on the aforementioned theoretical framework and hypothesis. The software packages used in this study were Smart-PLS 3.0 and SPSS 21. The basic principle behind employing structural equation analysis or modeling entails the use of certain observed variables to measure one unobserved variable. This measurement tool has been used in various fields such as marketing, management, education, public administration, and many other social science fields [53]. SEM possesses certain advantages that are suitable for scientific research which includes covariance matrix construction, simulation estimates, modeling of latent variables, measurement error correction just to mention a few [54]. The data was analyzed using a two-step approach; the initial step involved the verification of the measurement model to confirm the validity and reliability of constructs. The next was to assess the structural model by employing hypothesis testing. In the current study, we checked the possible CMB by employing Harman's one-factor test and the results indicated that the test classified the items that measured the latent variables of the model into six constructs with eigenvalues greater than 1. The first construct represents 24.4% of the total variance which less than the benchmark of 30%. Therefore, there isn't any issue regarding CMB in the collected data in this study.

Moreover, we employed a one-way ANOVA to test the probable differences between the means of constructs of the data retrieved from participants in different geographical settings. The results indicated that at a 1% significance level, there is no substantial difference between the means of constructs and this proves that, the location has no impact on the results.

4.3.1. Step one: Model analysis

An exploratory factor analysis was achieved using SPSS to deal with dimension reduction of items. This was to examine the values of factor loadings higher than 0.6 to enable the identification of structural relations between predictor and result variables. The principal component analysis through a rotation method of Promax with Kaiser Normalization approach was the means used for extracting the factors at a significant level of 0.000 for Bartlett's Test of Sphericity, KMO of 0.779 and Chi-square value of 3683.274 with degrees of freedom(df) = 325 [53]. The results of the factor loadings show values between 0.626 and 0.874 which is an indication that indices are in accordance with benchmark values which validate the proposed model. Items were repressed at thresholds of 0.6 which resulted in items "RelativeA1" and "Media3" being removed. The remaining items were employed in advance factor validation purposes. Table 2 shows the results of the factor loadings. To test the internal consistency of the items in each construct, construct reliability was used. This is done by assessing the values of both Cronbach's Alpha and Composite Reliability. Internal consistency basically means how closely related the items in a construct are as a group. Cronbach's Alpha measures this consistency. The Composite Reliability, on the other hand, refers to what a sequence of indicators can show the latent construct [54]. In Table 2, all construct values for the Cronbach's alpha were above 0.7. The composite reliability values are all above 0.7 which exhibit a good construct validity and reliability. Just like the construct validity, convergent validity and discriminant validity were also used. It is the level at which two or more items of a construct are theoretically related to each other [55]. Hence it is necessary to extract average variance extracted (AVE) to measure the degree of variance that is absorbed by the constructs with regards to the amount of variance. In the current study, the AVE scores are all above 0.5 which show a good convergent validity.

Table 2. Reliability and convergent validity test.

Constructs	Indicators	Factor Loadings	Cronbach's alpha	Average Variance Extracted(AVE)	Composite Reliability (CR)
Interpersonal Relations	Inter1	0.752	0.797	0.618	0.866
	Inter2	0.811			
	Interr3	0.792			
	Inter4	0.788			
Relative Advantage	RelativeA1 (deleted)		0.805	0.508	0.859
	RelativeA2	0.692			
	RelativeA3	0.723			
	RelativeA4	0.817			
	RelativeA5	0.785			
	RelativeA6	0.715			
Trialability	Trial1	0.853	0.812	0.642	0.877
	Trial2	0.789			
	Trial3	0.874			
	Trial4	0.675			

Continued on next page

Constructs	Indicators	Factor Loadings	Cronbach's alpha	Average Variance Extracted(AVE)	Composite Reliability (CR)
Attitude towards adoption	Attitude1	0.725	0.780	0.604	0.859
	Attitude2	0.829			
	Attitude3	0.801			
	Attitude4	0.749			
Mass Media	Media1	0.743	0.701	0.527	0.815
	Media2	0.766			
	Media3 (deleted)				
	Media4	0.788			
Risk Perception	Risk1	0.723	0.742	0.558	0.833
	Risk2	0.626			
	Risk3	0.793			
	Risk4	0.830			

According to Bagozzi et al. and Arts et al., a composite reliability value greater than 0.7 demonstrates good validity [56,58]. The composite reliability shows the point to which a group of dormant construct parameters shares their scope of a construct. The correlations among constructs and the square roots of AVEs can also be used to test the discriminant validity. In actual sense, the square roots of AVEs ought to be greater than the correlations among constructs just as it is illustrated in Table 3. Values exhibited in Table 2 prove that the measurement model has adequate reliability and validity hence the measurement model was suitable for the data. In this regard, all the values of composite reliability in Table 2 are above 0.8 and this shows a valid convergent validity.

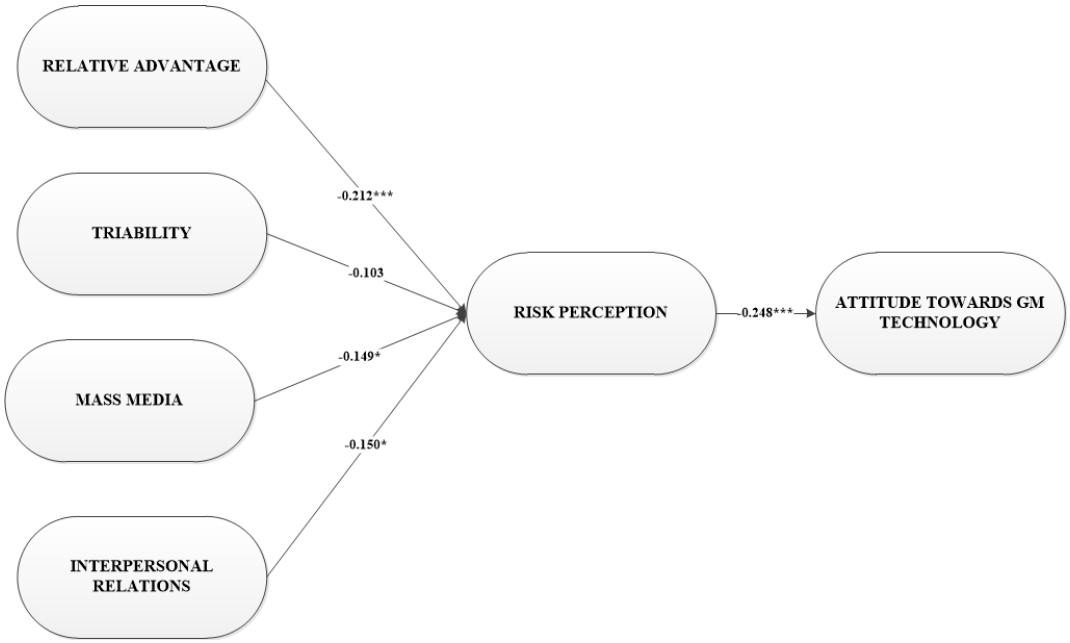
Table 3. Mean, standard deviation and correlation.

Constructs	Mean	SD	A	IR	MM	RP	RA	T
Attitude (A)	6.348	2.210	0.777					
Interpersonal Relations(IR)	5.886	2.060	0.239	0.786				
Mass Media (MM)	5.945	1.815	0.364	0.286	0.726			
Risk Perception (RP)	4.421	0.530	−0.401	−0.259	−0.238	0.747		
Relative Advantage (RA)	9.548	3.120	0.388	0.259	0.316	−0.281	0.713	
Trialability (T)	7.095	2.830	0.241	0.226	0.166	−0.175	0.200	0.802

4.3.2. Step two: Measurement and structural model evaluation

In this research, we used path analysis with Smart-PLS 3.0 to estimate the path coefficients in the model in order to get a satisfactory measurement model. Table 4 illustrates results of the structural model and it can be observed that, Relative advantage ($\beta = -0.212$, $p < 0.001$), Trialability ($\beta = -0.103$, $p < 0.097$), Interpersonal Relations ($\beta = -0.150$, $p < 0.022$) and Mass Media ($\beta = -0.149$, $p < 0.044$) all have negative influences on attitude to GM technology adoption as a result of risk perception. Risk perception ($\beta = -0.248$, $p < 0.000$) negatively influence attitudes towards the adoption of GM technology. However, risk perception shows no significant influence on the effects of trialability on attitudes of farmers' towards GM technology. Therefore, these findings support of

H1, H3, H4, and H5 respectively and further indicates that these hypotheses proposed in the study were supported. The results from the study reveal that farmers negative attitude towards GM technology is as a result of the influence of risk perception on the attributes of innovation. Trialability, however, will not induce any uncertainty since farmers get to test the new technology before actually adopting it. From Table 5, it is worth noting that the change in R signifies the strength of the significant levels. Model 1 and 2 represent respectively, the variance of the explanatory variables on risk perception and subsequently, risk perception on attitudes towards GM technology. The complex nature of the farmers' attitude in southern Ghana contributes to the low values of the R-square. Generally, most farmers in Ghana obtain information through mass media (radio, newspaper and television), friends and family as well as the network they belong (farmer unions, trade unions, etc.). Most of the information from these sources project the negative effects of GM technology and highlights the risk involved in adopting such technology. This results in the low magnitudes of some estimates.



Note: *p < 0.05; **p < 0.01; ***p < 0.001.

Figure 2. Path diagram for the study.

Table 4. Path coefficient of the structural model.

Path	Path weight (β)	P values	Hypothesis	Results
RA→RP	−0.212	0.001***	H1	Supported
T→RP	−0.103	0.097	H2	Not Supported
MM→RP	−0.149	0.044*	H3	Supported
IR→RP	−0.150	0.022*	H4	Supported
RP→A	−0.248	0.000***	H5	Supported

Note: RA = Relative Advantage, T = Trialability, IR = Interpersonal Relation, MM = Mass Media, RP = Risk Perception, A = Attitude towards GM; *p < 0.05; **p < 0.01; ***p < 0.001.

Table 5. Results of R, R Square and Adjusted R Square.

Model	R	R Square	Adjusted R Square
1	0.489a	0.239	0.229
2	0.547b	0.299	0.288

4.4. Test of mediating effects

The results of analysis excite interests in varying dimensions of this field of study. Many studies have confirmed and affirmed that perceived risks significantly influence negative attitudes towards the acceptance of GM foods [3,58,59]. However, these results are not different from the current study. The study revealed that risk perception significantly influences negative attitudes toward adoption and acceptance of GM foods. Vilella and Gyau et al. argued that perceived risk indirectly influences consumers attitude towards GM food through perceived benefits [42,60]. Direct relationships may not exist in some variables whereas other indirect effects may be found through mediating effects.

According to Zhao et al. in testing the mediation, the first thing to note is whether the direct effect is significant or not [59]. This indicates the type of mediation or nonmediation. Thus: if the indirect effect is significant but the direct effect is not, indirect mediation is only obtained (synonymous to full mediation). If the indirect effect is not significant but the direct effect is, direct only nonmeditation is obtained (no mediation). Also, if both the indirect and direct effect is not significant, no effect nonmeditation (no mediation) is recorded. In instances where both the direct and indirect effects are significant, we have either complementary or competitive mediation (partial mediation). It is complimentary if the product of the direct and indirect effect points to the same direction (positive), otherwise, we have a competitive mediation. Zhao et al. contend that to create mediation, all which is important is the significance of the indirect effect [59].

Therefore, the results of the mediation effect in Table 6 indicate that Risk Perception fully mediates the effects of all independent variables on attitude towards GM technology with the exception of Relative advantage. The results indicate that trialability, mass media and interpersonal relationship have significant indirect effect on farmers' attitude towards the adoption of GM technology through risk perception. Thus, an increase in farmers' ability to try and test GM technology, the mass media as a source of information regarding GM technology usage and the interpersonal relations that exist between farmers and the network they belong (family, friends, neighbors etc.) might increase farmers' attitude towards GM technology, but the presence of risk perception will decrease such effects. In fact, a decrease in farmers' positive attitude towards GM technology may depend on the effects of perceived risk associated with GM technology. Hence, the higher the perceived risk, farmers' attitude towards GM technology will decrease and vice versa. The case of no mediation is indication that relative advantage has neither direct nor indirect effect on farmers' attitude towards GM technology.

Table 6. Mediation effects analysis.

IV	M	DV	Direct Effect IV→DV	Indirect Effect IV→M→DV	Mediating
Relative Advantage (RA)	RP	A	0.279	0.053	No
Trialability (T)	RP	A	0.091	0.026*	Partial
Mass Media (MM)	RP	A	0.064	0.037*	Partial
Interpersonal Relations (IR)	RP	A	0.246	0.037*	No

Note: *$p < 0.05$; **$p < 0.01$.

One of the purposes of a relative advantage as an attribute of Innovation is to promote the socio-economic advantage of any new technology. It is interesting that a number of respondents interviewed were influenced that cultivating GM seeds will upsurge income levels and were therefore ready to grow GM crops on their farms. This revelation, however, contradicts research by Gyau et al. on farm managers in Western Germany [60]. In the study, it was observed that if the majority of farmers were convinced that GM seeds will improve their level of income then, they will adopt the technology. Nonetheless, farmers in Ghana expressed concerns that they weren't convinced the public would accept their farm products. Here, farmers are more concerned about public acceptance rather than the necessary risks associated with using GM technology. Risk perception also plays no mediating role on the effects of interpersonal relations on the attitudes of farmers.

5. Policy implications and limitations

The issue of acceptance of genetically modified foods in Ghana has been an interesting topic of discussion over the years. We tested our assertion that Ghanaian farmers' attitude towards GM technology is as a result of the influence of risk perception on the elements of innovation diffusion model; trialability, relative advantage, mass media alongside interpersonal relations. The current study contributes to the existing literature by incorporating the IDT model and part of Benefits and Risk Analysis to understand and determine farmers' attitude towards GM crop technology. The survey was conducted in the four farming municipalities southern Ghana. The traditional models do not allow for both exogeneity and endogeneity. It only allows exogeneity and that is not substantial enough. To get rid of this methodological problem, we employed structural equation analysis to analyze and test the data and research model respectively and this permits us to test for endogeneity. Smart PLS designed a suitable and adequate theoretical model and framework that allows for an in-depth comprehension of attitude development. The results revealed empirically that, perceived risk has no significant impact on farmers' attitudes resulting from the effects of trialability. This means that irrespective of risk perception, farmers attitudes are likely to change due to the characteristics of trialability. Nonetheless, risk perception significantly serves as a mediator between Relative advantage, Interpersonal relations, and Mass media on one hand, and farmers' attitudes towards GM technology adoption. Moreover, risk perception has a significant negative influence on farmers' attitude towards GM crop technology just as hypothesized. Comparing this current study to previous studies [3,58,60], the inclusion of risk perception as a mediator in this research augmented the described variance by 6% ($\Delta R2 = 6\%$, $p < 0.001$) more than anticipated aggregate. Just as opined by Chen et al. perceived risks are very important constructs that reinforce attitudes towards GM food [62], the current study is consistent with prior studies [60,63]. The concept of agricultural biotechnology

and GM food is new in Ghana and many lack adequate knowledge and credible information on the dynamics and nuances of this technology, hence the prevailing factor explaining the attitudes towards GM technology is the general risk perception of farmers. This is in accordance with evidence from many EU states such as Greek, Germany, and Finland [26,64].

This study further reveals that the typical model of food consumption and acceptance behavior research is an integration of Perceived risks (Benefits and Risks Analysis) and IDT frameworks. The analysis of the results concludes that Ghanaian farmers' risk perception of GM technology reduces the positive attitude towards the related technology, thereby reducing its purchase intention. However, Mass media and interpersonal relations with friends, colleagues, and family directly influence the attitudes of planters due to perceived risk. In Ghana, the general means of information dissemination is through media and by word of mouth. The general view many farmers and consumers have about GM crops and foods is the risks associated with consuming GMOs. Many farmers also believe that, though the economic and social benefits of GMOs and the general agricultural biotechnology outweighs that of the traditional means of food cultivation, anything made through artificial processes may impose adverse future effects to the society. As a result of this, media and interpersonal relations have a negative influence on attitudes as a result of risk perception. The findings validate the dimensions of prior researches conducted by Sarcheshmeh et al., Mannan et al., Peshin et al., Zhang et al., Nelson, Martinez-Poveda [3,11,15,58,65,66].

The negative attitude of Ghanaian farmers shows that should there be both non-gm seeds and gm seeds on the market, most people of this category would go for the non-GM labeled seeds. This attitude would go a long way to affect the commercial and marketing nature of GMOs as well as determine the future and development of agricultural biotechnology. In policymaking especially in agriculture, it is crucial to understand the factors that influence farmers' concerns on GM crop technology. Incorporating these matters into policy-making processes are equally important. The government of Ghana has made attempts to commercialize GM foods and crops in the country but a number of civil groups have risen against the efforts. To promote agricultural biotechnology and GMOs in the country, it is necessary to give adequate attention to the arts and science of biotechnology and promote efficient transgenic knowledge. The dissemination of information about science and technology can improve the public objective understanding of the nature and history of GM technology, benefits, and risks associated with GM technology in a comprehensive way. This will, in the long run, promote public awareness of the safety and benefits of this technology and get rid of any perceived risks and myths of the past as well. It would also positively influence attitudes towards GM food and lead to the acceptance or adoption of GM technology and eventually regulate the commercial viability of GMOs in the future [59,67].

A number of studies have emphasized that relative advantage is very important in the development of any form of biotechnology in the field of agriculture [3,11,12,15]. If farmers and plant breeders can attest that the advantages of transgenic technology outweigh that of the traditional means, then indeed GM crops could gain a certain degree of acceptance. Results from our study imply that, if farmers' exhibit low risk perception then, the effects of the relative advantage of GM foods and crops could improve their perceived benefit with regards to their attitudes. It is therefore pragmatic to say that, relative advantage plays a crucial role in influencing farmer's attitudes towards GMFs. Nonetheless, the presence of risk perception exerts a degree of uncertainty in the attitudes of farmers that eventually deters from adopting GM crop technology. This is crucial for policymakers because knowledge about GMFs and its related developments must be effectively communicated to

the public by not only researchers in this field, but also the government.

Even though there has been significant progress in the usage and application of GM technology in the agriculture and food industry worldwide [67], Ghanaians and many other African countries show a negative attitude towards GM food [1]. Having a clear understanding and knowledge of farmers' preference for GM seeds or crops can offer the food and agriculture industry ideas and insights into developing marketing strategies in line with the altering demands of farmers [68]. The research, therefore, suggests that, before the commercialization of any GM application, stakeholders of the ministry of agriculture and food industry should evaluate the safety and risks of GMOs and its application to measure its public acceptance. This study may also reveal some information to policymakers pertaining to what is realistic and suitable. Policymakers ought to identify the sources of uncertainty among farmers and find implement means to alleviating such fears. This would ultimately lead to a positive attitude of farmers towards GM technology adoption and ultimately result in actual adoption of the related technology. There are few studies that provide systematic, empirical evidence and theoretical explanations of the attitude toward GM food [30,60]. The current study adds up to existing literature by merging empirical evidence and theoretical framework on the procedures that may influence farmers' attitudes towards GM crop technology. This study endeavored to give an ample understanding of the determinants of attitude towards this new agricultural biotechnology in Ghana under both integrated and independent frameworks. Other authors in this field of study can employ the conceptual frameworks proposed in this paper to examine the risk perception and attitude toward GM crops and food.

This study has a number of caveats. First, this study emphasized on farmers' attitude towards adoption of GE agriculture rather than actual adoption behavior. Even though attitude is an immediate determinant of actual adoption intention and whenever an appropriate measure of attitude is achieved, it will provide the most accurate prediction of adoption intention [46]. However, there exists a gap between attitude and adoption intention. A farmer's actual adoption intention may not necessarily be equivalent to attitude towards that adoption. Hence, to deepen the conclusion, future researches should further explore these respondents' actual adoption intention and behavior by using interview and sampling methods in the related research area. Secondly, this study only focused on a particular type of group (farmers) but obviously different people have varying risk perceptions and preferences which might one way or the other influence their attitudes towards the acceptance of GM technology. Thirdly, the study only tackled risk perception which is one part of the general benefits-risks analysis. Many studies reveal that the traditional risks and benefits analysis go hand in hand and have confirmed that, farmers' benefit perception is a crucial predictor of attitude toward GM crops and nutritional uses of GM technology [59,60,70]. Finally, other elements of the theory of planned behavior such as subjective norm, perceived behavioral control and consumer purchase intention were not included in the theoretical framework that used to examine the behavior and attitude of consumers. Hence such issues should be discussed in future research.

6. Conclusions

Agricultural development in Ghana and Africa at large is one of the key areas of African Union (AU) 20-year biotech strategy plan. However, little has been done to realize this agenda. Currently, the risk perception of GM technology in Ghana outweighs perceived benefits and this highly affects farmers' attitude towards GM technology adoption. Issues of agricultural productivity

facing Ghana requires a practical response and careful evaluation of biotechnology and its related tools. This is therefore consistent with our arguments that, policymakers and stakeholders ought to evaluate whether and how GM technology can contribute to sustainable agricultural developments and outline measures to assuage risk perceptions of farmers.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

This work is supported by National Natural Science Foundation of China (NSFC project number is 71573241) as well as the Chinese Scholarship Council (CSC) Research Program.

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