A STUDY OF FACTORS AFFECTING ADOPTION OF PIVOT SPRINKLER IRRIGATION TECHNOLOGY FOR WHEAT CROP PRODUCERS

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Abstract

This research was aimed to investigate a model of confirmatory structural validity for indicators of adopting axial sprinkler irrigation technology for wheat producers in Ain Al-Tamr district as the Karbala governorate during the agricultural season (2020-2021) through a number of hypotheses to measure and estimate the latent variables based on the five-point Likert scale to show the behaviors and psychological preferences for a set of phrases the samples targeting of farmers to the most important factor affecting the adoption of pivot sprinkler irrigation technology. The sample consisted of (100) farmers and based on the method confirmatory factor analysis and using the AMOS program. The most important influencing factors were obtained after exceeding the quality of conformity model, as the study proved that technology is of great importance in solving production problems, and social media has a significant impact on the availability of concepts and information about technology and great importance in the dissemination of that technology, and the decrease in water levels in the rivers (Tigris and Euphrates). Climatic changes led to directing the behavior and preferences of producers towards adopting pivot sprinkler irrigation to compensate for the shortage in irrigation water sources. Academic achievement and government support have a significant impact on the producer's behavior in using modern irrigation methods.

Key words: structural equation modeling, confirmatory factor analysis, likert scale, responsible consumption.

***Part of Ph.D. dissertation of the 1st author**

دراسة للعوامل المؤثرة في تبني تقانة الري بالرش المحوري لمنتجي محصول القمح

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المستخلص

هدف البحث الى الحصول على انموذج للصدق البنائي التوكيدي لمؤشرات تبني تقانة الري بالرش المحوري لمنتجي القمح في قضاء عين التمر التابعة لمحافظة كربلاء للموسم الزراعي (2020–2021) من خلال عدد من الفرضيات لقياس وتقدير المتغيرات الكامنة بالاعتماد على مقياس ليكرت الخماسي لبيان السلوكيات والتفضيلات النفسية بمجموعة من العبارات البسيطة المستهدفة للمزارعين لاهم العوامل المؤثرة على تبني تقنية الري بالرش المحوري. وتكونت العينة من (100) مزارع وبالاعتماد على اسلوب التحليل العاملي التوكيدي وبأستخدام برنامج AMOS. تم الحصول على اهم العوامل المؤثرة بعد تجاوز الانموذج جودة المطابقة، اذ اثبت البحث ان للتقنية اهمية كبيرة في حل مشكلات الانتاج كما ان وسائل التواصل الاجتماعي له اثر كبير في توفر المفاهيم والمعلومات عن التقنية وله اهمية كبيرة في نشر تلك التقنية، ان انخفاض مناسيب المياه في نهري (دجلة والفرات) والتغيرات المناخية ادت الى توجيه سلوك وتفضيلات المنتجين نحو تبني الري بالرش المحوري للتعويض عن النقص الحاصل في مصادر مياه الري. كما ان للتحصيل العلمي والدعم الحكومي تأثير كبير على سلوك المنتج في استخدام الطرق الحديثة في الري.

الكلمات المفتاحية: نمذجة المعادلة البنائية ، التحليل العاملي التوكيدي ، مقياس ليكرت، الاستهلاك المسؤولز

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INTRODUCTION

Agricultural expansion with its horizontal and vertical wings is the mainstay for achieving agricultural development in light of the limited and scarcity of available land and water resources. The importance of using bio-technology to develop agricultural production has emerged. The use of technology is one of the most important means that affect wheat productivity, achieve profits and increase agricultural production. Iraq's annual need of wheat is approximately 5 million tons where the growing population needs are met by imports. Where the imports of wheat in 2018 amounted to 1552 thousand tons, according to the report on commodity balances in 2018 by the Ministry of Planning. Therefore, Iraq launched national projects to develop wheat cultivation through programs implemented by the Ministry of Agriculture and its affiliated directorates to reduce this gap by increasing agricultural production of grain crops in general and wheat in particular, either by horizontally expansion by increasing the cultivated area or by vertical expansion through the development of new strains and varieties with high productivity and seeds that are resistant to salinity and drought and resistant to diseases, which leads to a high rate of self-sufficiency from them. In light of the limitations of both land and water resources, it is necessary to rely on modern biotechnology, which contributed about 60% of the increase in productivity achieved worldwide in the last quarter of the twentieth century. The decline in the cultivated areas of the wheat crop in the country due to the scarcity of water and the lack of rainy seasons during the past two years and the low water levels in the Tigris and Euphrates rivers (2), all of these led to a reduction in production and a decline in wheat stocks, as farmers tend to waste irrigation water as a result of their misconceptions about the amount of water needed by crops, in addition to their expect-ations about rain, as well as the lack of mandatory legislation and laws to manage water resources, all this had a negative impact on the wheat yield and the efficiency of irrigation water use as well (3). Improving the efficiency of irrigation water use is a key factor in improving wheat production in Iraq, which suffers from a large food gap (9). One of the ways to raise the efficiency of irrigation water use in light of the limited irrigation water is to rationalize the available water and follow modern irrigation systems, including pivotal sprinkler irrigation. The research area is located in the district of Ain al-Tamr (Shathatha) in the southwest of the holy governorate of Karbala and is 67 km away from the center of the governorate. The area of the district of Ain al-Tamr is (2558) km2. The water resources in the study area consist of three sources: surface water and groundwater, As for rain, it is not an important source of water in the study area, as it is considered one of the desert areas and needs large amounts of water to compensate for the shortage in irrigation water due to the open nature of the surface, the type of porous sandy soil and the prevailing climate in this area, which increases the water need of agricultural crops, so the problem in investing these desert lands lies in providing water for sustainable agriculture. The aim of this research is to obtain a model of confirmatory structural validity for indicators of adopting axial sprinkler irrigation technology for wheat producers in the district of Ain Al-Tamr of the Karbala governorate for the agricultural season 2020-2021, through a number of hypotheses to measure and estimate the latent variables based on the five-point Likert scale to show the behaviors and psych-ological preferences of a group of simple statements targeted to farmers. The problem of water shortage is one of the modern problems in Iraq, which requires efforts to exploit this resource efficiently in order to expand the agricultural area to increase production and reduce water waste. Despite the work of gover-nment institutions and research centers to find solutions to them by introducing modern tech-nologies in the cultivation of the wheat crop through the application of center pivot sprinkler irrigation technology, many farmers are still reluctant to adopt this technology, which leads to a huge waste in investing limited water resources. By studying the factors affecting changing behaviors and psychological prefere-nces for the decision to adopt pivot sprinkler irrigation technology for wheat crop producers in Ain Al-Tamr district through the biometric data of the sample of the research community and

using the confirmatory factor analysis (CFA) method to determine the structural equa-tion model (SEM). Assuming that there are a number of factors (personal and social factors, soil and water properties, farm tenure, irrigation water sources, indicative and regulatory factors, ease of use, maintenance, expected benefits, environmental factors, social communication, personal desire, government support) affect the latent variable (adopting center pivot irrigation technology). A number of researchers studied the adoption of agricultural technology using (SEM) such as (1, 4, 7, 8, 13, 16, 19, 20).

MATERIALS AND METHODS

For the purpose of identifying the development of the preparation of axial sprinkler irrigation systems for the study area, whether it was within the preparations equipped by the state within (the project of using modern irrigation technologies) which covers about three million acres of agricultural areas in Iraq. The types of systems and their supported sizes varied and distributed to the farmers. The total number of sprinklers that were equipped by the Holy Karbala Agriculture Directorate reached 236, including 229 sprinklers in Ain Al-Tamr district, that is by 97% of the total number of equipped sprinklers. There was use of remote sensing technology by Geographical Information Systems (GIS) and using satellite images of the European Space Agency Sentinel-2 with an accuracy of 10 meters through the US Geological Survey website (USGS) (22). The great importance of remote sensing is reflected in the process of monitoring the growth stages of the wheat crop, which is a strong indicator of both the quantity of production, the date of maturity and the harvest during the growing season, which contributes to the development and management of economic plans accurately and at a comprehensive level (12). the time evolution of the spread of pivot irrigation systems was calculated, as shown in table (1). It is obvious that there is a great development in the preparation of pivot sprinkler irrigation systems from 2010 to 2020, where the growth rate of the number of pivot sprinklers in the district reached (66.3%) of the total number of sprinklers, and the largest percentage change in the number of sprinklers was in 2020 about 34.62% of the total sprinklers, which amounted to 395.

Table 1. Number of sprinklers for Ain al-Tamr district that were calculated from USGS satellite images.

Year	Total number of sprinklers	Annual change of sprinklers	Relative change of sprinklers
2010	1	1	0.09%
2011	3	2	0.18%
2012	12	9	0.79%
2013	48	36	3.16%
2014	57	9	0.79%
2015	173	116	10.17%
2016	205	32	2.80%
2017	285	80	7.01%
2018	449	164	14.37%
2019	746	297	26.03%
2020	1141	395	34.62%
growth rate	66.3%	1141	100%

Source: Prepared by the researcher and based on digital satellite images from (USGS) website

For the purpose of achieving the objectives of this research to find the factors affecting the decision to adopt pivot sprinkler irrigation techniques for wheat crop producers in the district of Ain Al-Tamr in the holy governorate of Karbala, several hypotheses have been deve-loped to measure and estimate the latent variables based on the five-year Likert Scale to show the behaviors and psychological preferences of a set of simple phrases targeted at farmers, and it is in front of each paragraph or phrase to determine the degree of approval by choosing (Fully Disagree, Disagree, Neutral, Agree, Fully Agree). For the most important factors influencing the adoption of axial sprinkler irrigation technology, with the help of previous economic studies, each worker was asked number of paragraphs (questions) for 100 farmers drawn from a random sample of 571 farmers from the actual producers within the agricultural plan of Ain Al-Tamr district for the agricultural season (2020-2021) who have adopted this technique. The main theory about adoption that has gained wide recognition is: Rogers theory of adoption and diffusion. Therefore, this theory becomes important in studying the social, economic and institutional factors underlying the adoption and non-adoption of agricultural technologies,

although they differ, the concepts of adoption and diffusion are sometimes used interchangeably when discussing issues of technology transfer and innovations. Figure 1 shows the steps or processes that an individual, farmer, company or group takes in making the adoption decision (18).

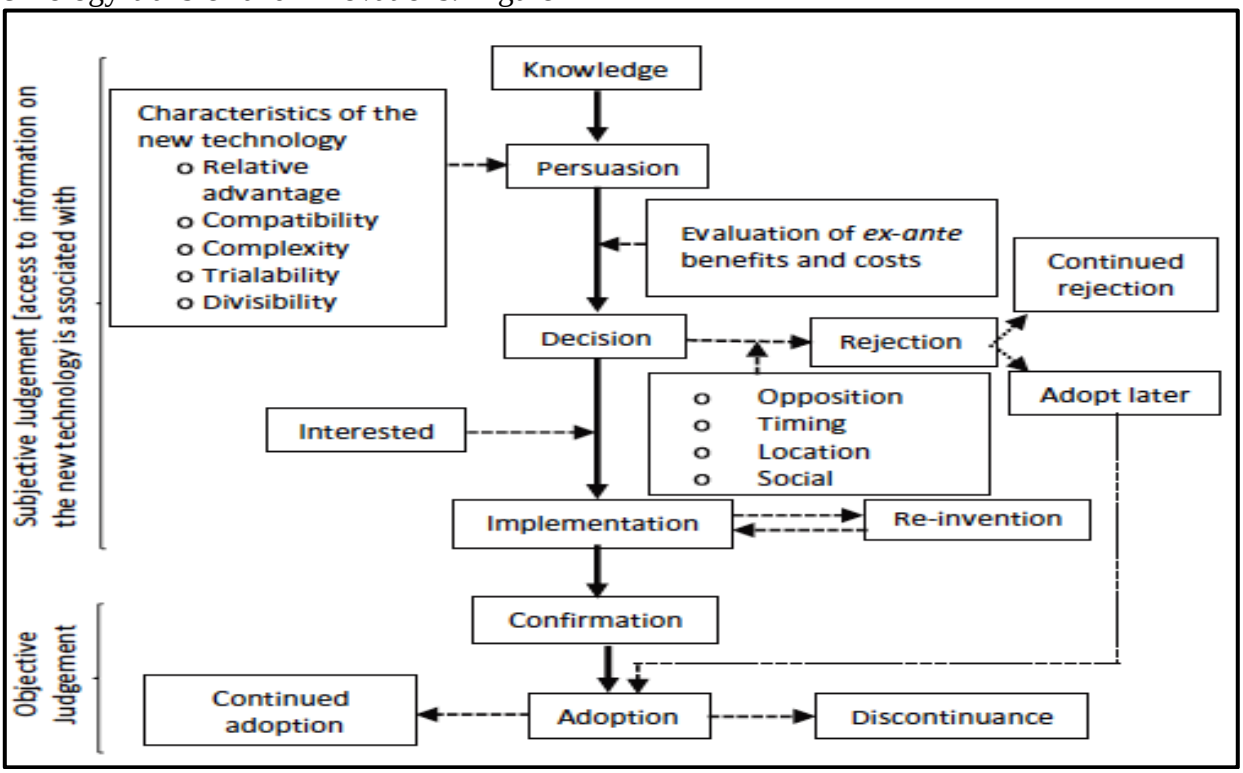

Figure 1. Model of the technology adoption decision-making process

Source: Rogers, 2003.

The adoption process begins with obtaining information about new technology, whether through media advertisements, mentorship agents, or social networks. This is followed by a careful review of the expected features of the technology and the potential benefits and costs of acquiring the technology, after examining the characteristics and balancing the benefits, costs, and trade-offs associated with the new technology, a decision is made to either adopt or reject the technology, which is the most important stage (15). These different steps can be summarized as:

1- Knowledge: about innovation.

2- Persuasion: Shaping and changing attitudes.

3- Decision: Adoption or non-adoption.

4- Implementation: Applying technology to reality.

5- Confirmation: Continuing or discontinuing implementation.

Many studies have clearly indicated the occurrence of the first and third steps, as for the other steps, they are hypothetical, and the evidence for their occurrence is less clear, as persuasion may not occur until after the adoption process, which may sometimes happen in a hurry and without delay. Likewise, implementation may take place before the decision-making stage. The implementation phase often indicates that the innovator responds to the needs of the farmer who adopted, it comes after the stage of adopting the innovator to collect additional information to make sure of the correctness of their decision. Although most of the adoption literature focuses on the adoption of individual technology (such as fertilizers, improved varieties or hybrids, modern irrigation techniques, and many other technologies), studies look at the adoption of a group of technologies such as improved varieties and fertilizers, and some literature indicates that the adoption of technologies may in fact be enhanced due to the complementarities that exist between the technologies, so integrations occur at two levels: at the worker and at the technology. About factor complementarities occur from the way groups of factors work together to influence adoption. Also, factor complementarities occur where all the inputs considered together have a significant impact on adoption but when the influence of one

remains constant the correlation between the other remaining inputs and technology adoption is greatly reduced, where inputs of critical importance to adoption are scarce (17). For example, the water supply which is critical to the adoption of irrigation technology, the lack of irrigation water may lead to the adoption of irrigation techniques, that is, critical inputs must be readily available in order to encourage adoption, At the technology level complemen-tarities occur because one technology enhances the positive effects of the other. For example, in some cases, a high seed yield cannot be achieved unless fertilizers are used, meaning there is a complementary relationship between them (10). The site specificity of agricultural practices leads some authors to assert that adoption studies in every region experiencing technological change are warranted. There are also many differences in the factors and characteristics of farmers between regions, and the study of technology adoption in a geographical area does not mean that the study is similar to the same technology in another geographical place. Also within the same geographical environment, different regions have patterns of adopting different technologies for the same type of technology (24). Structural Equation Modeling (SEM) represents a group of advanced statistical methods or strategies in data analysis in order to test the validity of the network of relationships between variables (theoretical models) that the researcher assumes in one sentence without the need to break the assumed relationships into parts, and testing the validity of each part of the relationships separately. Modeling with structural equations has been used in various cognitive and applied fields, including psychology, education, sociology, administrative and organizational sciences, economics, life sciences, medicine, nursing sciences, and others (23). It is the closest concept to mathematical modeling, specifically statistical, that enables testing measurement models and tools that include a set of quantitatively measured indicators through a set of advanced statistical methods based on confirmatory factor analysis (CFA) to test the structural validity of the measurement tools included in the theoretical models, where each phenomenon (variable) has an independent model to measure it, and the process of determining the influence relationships between the multiple variables takes place, leading to an interpretation that simulates the reality of the phenomenon or problem under study. Structural Equation Modeling (SEM) is a general analytical framework for types of models such as path models, multi regression models, and Conformity Factorial Models, which represents parts and stages of modeling with structural equations and thus an extension of the general linear model that allows analyzing a set of regression equations simultaneously and integrated where the relationships between variables are determined in a more comprehensive and clear through testing the hypotheses set to explain the relationships between the latent (unobserved) and measured (observed) variables. Among the most recent and reliable statistical programs used in structural equation modeling are (Amos, Lisrel, in addition to SPSS) (5).

Factory analysis: It is one of the highly efficient statistical methods in revealing the relationships and the degree of affiliation of the dimensions to their axes to which they belong, It is a method that analyzes the data represented by a set of multiple variables and determines whether it is possible to segment and classify those variables into aggregates, as it measures certain axes or dimensions, it is also possible through factor analysis to reduce the number of variables to a smaller number by deleting the ineffective variables. The Confirmatory Factor Analysis (CFA) model is one of the applications of structural equation modeling, it is concerned with studying the relationships between measured variables or indicators (vocabulary or test scores) and latent variables or factors. The basic principle of CFA is based on the verification of hypotheses (a structure whose dimensions or factors are known in advance) in contrast to the exploratory factor analysis (EFA) based on discovering the nature of the factorial structure (identifying the factors that saturate the vocabulary on it), That is, the analysis of (CFA) is carried out in the light of a preconception of the nature of the building with the number of its supposed factors and its

saturations (6). There are some important concepts that will be used in the results of the analysis:

Eigenvalue: The latent root measures the size of the variance in all the variables that are calculated on one factor, and the factor in which the root value is greater than one is accepted. **Communalities:** When the factor matrix is extracted, the degree of contribution of each variable to each of the factors is known, and the sum of the squares of these contributions is the value of the social.

Kaiser-Meyer-Olkin (KMO) measure: For the purpose of measuring the adequacy of the number of the sample members to achieve the conditions for conducting the factor analysis, which should not be less than 0.5.

Bartlett's Test: It is an indicator of the relationship between the variables, as the level of significance for this relationship must be less than 0.05 (14). Psychometricians have identi-fied a number of psychometric properties, they are statistical evidence and indicators of the quality of the scale and its paragraphs and the extent of their internal consistency, to verify these characteristics:

First stage: Verification of the validity of the paragraphs of the form is carried out by presenting it to a number of experts to judge its validity in the measurement and its enjoyment of an appropriate degree of apparent truthfulness of its statements, ease and clarity. The paragraphs according to the influencing factors (axes) are:

First: Personal and Social Factors.

1- Farmers are interested in center pivot irrigation because it does not require high knowledge and skill to use.

2- The technology is consistent with the long experience in the field of agriculture (for more than 10 years).

3- Academic achievement in the field of agriculture has an impact on adopting center pivot irrigation technology.

4- The prices of pivot sprinkler irrigation systems are commensurate with the economic capabilities of all farmers.

Second: Soil and Water Properties.

5- Farmers are interested in axial sprinkler irrigation because it is suitable for desert soils.

6- Axial sprinkler irrigation is suitable for all types of soil.

7- Pivot sprinkler irrigation is restricted to soils and water with low saline levels.

8- The use of sprinkler irrigation prevents high salinity in the soil.

Third: farm holding.

9- Axial sprinkler irrigation saves areas of used land (used as an irrigation channel).

10- Its use is limited to specific areas and is not suitable for the diversity of holdings.

Fourth: Irrigation water sources.

11- The use of axial sprinkler irrigation, as there are no irrigation channels nearby.

12- Pivot sprinkler irrigation can be used with all water sources (ground and surface).

13- Because of the low water quota, center pivot irrigation is used.

Fifth: Indicative and organizational factors.

14- The availability of information through agricultural extension and agricultural directorates in the governorate has a significant impact on the use of sprinkler irrigation technology.

15- Ease of obtaining axial sprinkler irrigation systems through governmental or commercial marketing channels.

16- There is still a weakness in the services and guidance programs for the use of the systems.

Sixth: Ease of use.

17- Center pivot irrigation systems are characterized by equal water distribution in the field.

18- Tourist irrigation requires a lot of expensive labor, speed and skill, unlike what is characterized by axial sprinkler irrigation, which reduces the cost of irrigation.

19- Axial sprinkler irrigation does not require much time in distributing irrigation water in the field.

20- The pivot sprinkler irrigation facilitates the addition of fertilizers and pesticides, which reduces the use of drawers and reduces the loss of the crop.

Seventh: Maintenance.

21- Center pivot irrigation systems require complex and expensive periodic maintenance, which limits their spread.

22- Lack of spare materials for the systems.

Eighth: Expected benefits.

23- Pivot sprinkler irrigation achieves an increase in production and raises the level of profits.

24- Pivot sprinkler technology reduces production costs when adopted.

Ninth: Environmental factors.

25- The use of center pivot irrigation is not harmful to the environment from (soil, water plants, animals, air).

26- Axial sprinkler irrigation reduces the amount of water needed for irrigation, which reduces water wastage.

Tenth: Social Media.

27- Social media via the Internet has an impact on the availability of information about technology.

28- Connecting with farmer friends is the reason why technology is so important.

Eleventh: personal desire.

29- Farmers' dissatisfaction with center pivot irrigation systems.

30- Farmers' fear of using center pivot irrigation systems.

31- The technology does not suit the many needs and problems of farmers.

Twelfth: Government support.

32- With government support, farmers can adopt the technology to cover its high costs.

33- The more affordable the loans, the higher the percentage of farmers who will adopt the technology.

34- There is still weakness in the government support needed to expand the use of pivot sprinkler irrigation systems.

35- Weak support for crop prices and agricultural production requirements prevented the rapid expansion of technology spread.

Second stage: The validity of the study tools is verified through reliability coefficient and The validity of the internal consistency of the paragraphs of the questionnaire. After the farmers' answers were entered and classified using the SPSS ver.26 and the reliability is measured. Reliability means that the answers are stable around certain values and do not differ much from one experiment to another or one sample to another. As for the internal consistency, it is the degree of consistency of the answers within each question, within each axis, or within the questionnaire as a whole. Reliability can be measured in three ways: The first method: testing and re-testing, and the second method: measuring reliability by splitting the half by calculating the correlation coefficient between the scores of individual questions and the scores of even questions, then correcting the correlation coefficient by Pearson-Brown's equation (11). As for the third method: which will be used to measure the stability of the resolution items by measuring the stability coefficient of Cronbach's alpha, and it ranges between (0-1). This value shows the extent of the correlation between the answers to the sample paragraphs. When the value of the Cronbach alpha coefficient is zero, this indicates that there is no absolute correlation between the answers to the sample paragraphs, and therefore the resolution is not stable at all. But if the value of Cronbach's alpha coefficient is one correct, this indicates that there is a complete correlation between the answers to the sample questions. However, the correct one is not considered an acceptable result, and the resolution is invalid. It is known that the smallest acceptable value of Cronbach's alpha coefficient is 0.6 but not less than 0.5, and the best value ranges between (0.7 - 0.9), and the higher its value is 0.9, the better it is not to reach the correct one (21). The statistical value of the total stability coefficient was 0.62 for 35 items, and this is considered acceptable.

RESULTS AND DISCUSSION

Exploratory factor analysis (EFA) was carried out using the statistical analysis program SPSS ver26 to find out the validity of the content by calculating the correlation coefficients between each paragraph of the dimensions of the questionnaire and the total score. The results of the descriptive analysis of the data were started, and they included the arithmetic means and standard deviations using the five-point Likert scale, where we note that most of the values of the arithmetic circles have exceeded the basic rate of (3) according to the five-point Likert scale used in the study, except for questions (1, 4, 15, 22, 24, 29, 31), which came with values less than the basic average. As for KMO test which is one of the tests that indicate the sufficiency of the sample and its suitability, where its value reached 0.839 which is higher than 0.50 meaning that the value close to the correct one gives an indication that the factorial analysis is an appropriate analysis of the data under study. But if it is less than 0.50 this indicates that the factor analysis is not appropriate. The

Bartlett's Test which tests the hypothesis that the matrix of association between variables is the identity matrix, in other words, it indicates that the variables are not related to each other, and therefore the factor analysis is not appropriate for the analysis, as shown in table 2.

Table 2. The results of the KMO test and Bartlett's test in the EFA analysis.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**.839**
Bartlett's Test of Sphericity	**Approx. Chi-Square**	**5900.052**
	df	**595**
	Sig.	**.000**

Source: Calculated using SPSS, using the data of the Five-point Likert scale.

The significance value of Bartlett's test, which is less than (0.01), confirms the rejection of the null hypothesis that the matrix of correlations between variables was identity matrix, that is, there are significant correlations that indicate that the factor analysis is appropriate to analyze that data. In Table 3 the values of the quantities of Communalities.

Table 3. The results of Communalities in EFA.

Item	Extraction	Item	Extraction	Item	Extraction
q1	**0.839**	**q13**	**0.893**	**q25**	**0.949**
q2	**0.570**	**q14**	**0.689**	**q26**	**0.866**
q3	**0.814**	**q15**	**0.876**	**q27**	**0.927**
q4	**0.595**	**q16**	**0.904**	**q28**	**0.710**
q5	**0.797**	**q17**	**0.719**	**q29**	**0.813**
q6	**0.913**	**q18**	**0.957**	**q30**	**0.845**
q7	**0.661**	**q19**	**0.969**	**q31**	**0.978**
q8	**0.844**	**q20**	**0.674**	**q32**	**0.687**
q9	**0.868**	**q21**	**0.921**	**q33**	**0.760**
q10	**0.480**	**q22**	**0.764**	**q34**	**0.921**
q11	**0.866**	**q23**	**0.932**	**q35**	**0.924**
q12	**0.923**	**q24**	**0.940**		

Source: Calculated using SPSS, with the data of the Five-point Likert scale.

Communalities are the amount of variance that the paragraph shares with the rest of the paragraphs in the interpretation of the factor dimension or axis. Very small values indicate that this paragraph does not share a sufficient amount to explain the variance in the studied axis and vice versa. We also note that the values of the quantities of commonness that were obtained after the analysis are not small values, and this gives evidence that all paragraphs have participated in the interpretation of the variance. After the structural validity was measured using exploratory factor analysis EFA, one of the applications of the structural equation SEM, which is the confirmatory factor analysis CFA method, is used for the purpose of determining the structural model that consists of latent variables which represent the assumed axes of the measurement. As for the second type of variables, they are the measured or endogenous variables that represent the paragraphs (questions) related to each of the axes. These statements are linked to the axes through arrows that move from the latent variables to the internal variables, using the AMOS ver26. We build the confirmatory form and check the appropriate form using the data of the questionnaire form to answer the hypothetical questions on a five-point Likert scale of the factors affecting the adoption of center pivot irrigation techniques for wheat producers in the Ain Al-Tamr district for the agricultural season 2020-2021 by excluding the variables (paragraphs) with the least factor score weights of influence of the confirming factor and the least explanatory power (R^2) for the indicators of adoption, to get the best indicators for matching the model with the real data. As shown in Figure 2, which represents a model of the confirmatory structural validity of adoption indicators, a first-class or first-rank model using the AMOS 26.

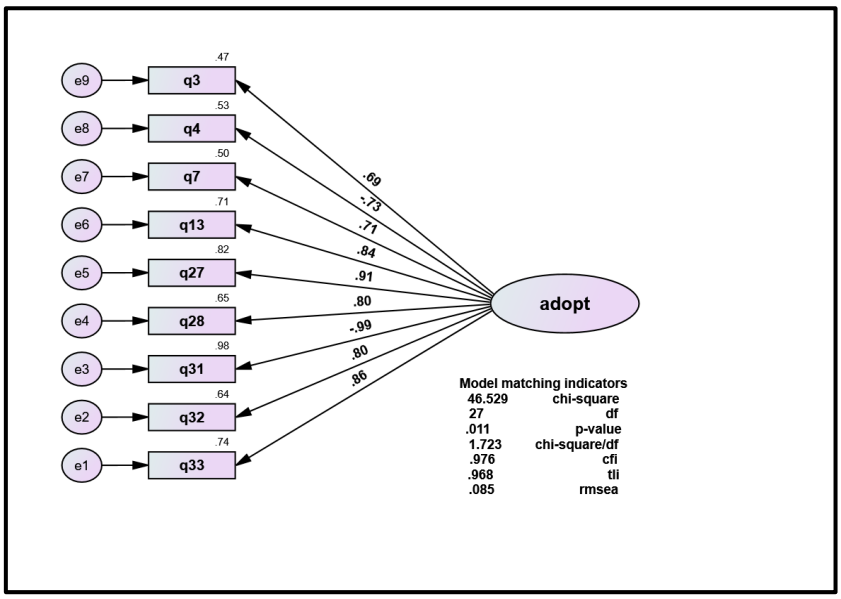

Figure 2. The confirmatory structural validity model CFA of the factors affecting adoption.

Source: The model was built using AMOS 26 and based on the data of the questionnaire.

Conformity indicators were obtained, as shown in Table 4, where the calculated indicators fall within the assumptions of accepting the confirmatory constructivist model for the adoption indicators (5, 23).

Table 4. Conformity indicators of the quality of assertive construct validity CFA.

Indicator	The value	Acceptable value for a match	researcher's decision
Chi-square	**46.529**	**If the chi-square value is lower, it indicates a better match**	**Acceptance**
df	**27**		
χ^2/df	**1.723**	**Less than 5 accept and match**	**Acceptance**
P-Value	**0.011**	**less than 0.05**	**Acceptance**
CFI	**0.976**	**0.90 or greater**	**Acceptance**
TLI	**0.968**	**0.90 or greater**	**Acceptance**
GFI	**0.911**	**0.90 or greater**	**Acceptance**
AGFI	**0.852**	**0.90 and above is good, less than 0.50 is acceptable**	**Acceptance**
RMR	**0.020**	**Between zero and 0.01, less than 0.05 indicates a good fit**	**Acceptance**
RMSEA	**0.085**	**Between zero and 0.01, less than 0.05 indicates a good fit**	**Acceptance**

Source: Results of CFA analysis using AMOS 26.

We note in the confirmatory factor analysis method for the estimated values of standardized regression weights, shown in table 5 on the curved arrows between the latent variable (adoption) and the explanatory variables (paragraphs, phrases), it was estimated accor-ding to the Maximum Likelihood Estimates (MLE).

Table 5. values of standardized regression weights according to MLE.

Observed		Latent	Estimate
q33	**<---**	**Adopt**	**0.862**
q32	**<---**	**Adopt**	**0.802**
q31	**<---**	**Adopt**	**-0.989**
q28	**<---**	**Adopt**	**0.803**
q27	**<---**	**Adopt**	**0.908**
q13	**<---**	**Adopt**	**0.843**
q7	**<---**	**Adopt**	**0.708**
q4	**<---**	**Adopt**	**-0.726**
q3	**<---**	**Adopt**	**0.688**

Source: CFA analysis using AMOS 26.

We note that the estimates and the degree of influence vary between positive acceptance of assumptions and negative ones that show rejection of the hypothesis stated in the statements of the questionnaire. All estimators appeared with a high level of significance, as shown in Table 6 for the regression weights.

Table 6. values of regression weights according to MLE.

Observed		Latent	Estimate	S.E.	C.R.	P
q33	**<--**	**Adopt**	**1.00**			
q32	**<--**	**Adopt**	**0.95**	**.09**	**10.4**	*******
q31	**<--**	**Adopt**	**-1.09**	**.06**	**-16.1**	*******
q28	**<--**	**Adopt**	**0.91**	**.08**	**10.4**	*******
q27	**<--**	**Adopt**	**1.39**	**.10**	**13.2**	*******
q13	**<--**	**Adopt**	**1.35**	**.11**	**11.3**	*******
q7	**<--**	**Adopt**	**0.86**	**.10**	**8.5**	*******
q4	**<--**	**Adopt**	**-0.90**	**.10**	**-8.8**	*******
q3	**<--**	**Adopt**	**2.19**	**.26**	**8.1**	*******

Source: CFA analysis using AMOS 26.

We also note the multiple determination coefficient (R^2), which is a statistical measure that determines the efficiency of the estimated model, came with relatively different values ranging from weak 47.3% to relatively high 97.9%. The value of R^2 explains that the percentage of variance in the dependent variable (adoption) can be predicted through the explanatory variables (paragraphs), as shown in Table 7.

Table 7. values of the multiple determination coefficient according to MLE.

Item	Estimate
q3	0.473
q4	0.527
q7	0.502
q13	0.710
q27	0.825
q28	0.645
q31	0.979
q32	0.644
q33	0.744

Source: CFA analysis using AMOS 26.

Also, the factor score weights in the latent variable showed the highest factor weight, which is paragraph (q31), the highest weight, which reached (65.9%), with a negative sign, it means rejecting the hypothesis contained in the questionnaire paragraph. As for the last factor score weights in the latent variable it is paragraph (q3), where the value of the coefficient of determination is very weak, and this gives the importance of each paragraph according to its weight, as shown in Table 8.

Table 8. factor score weights in adoption.

Item	Adopt
q3	0.006
q4	-0.019
q7	0.018
q13	0.028
q27	0.053
q28	0.031
q31	-0.659
q32	0.029
q33	0.045

Source: CFA analysis using AMOS 26.

After exceeding the quality of conformity model through statistical indicators to indicate the quality of conformity, we can show the most important factors affecting changing the behavior and preferences of wheat producers in the decision to adopt axial sprinkler irrigation technology in the district of Ain Al-Tamr of the holy governorate of Karbala for the agricultural season 2020-2021. We note that the most satisfying variable for the adoption decision is q31 (the technology does not suit the many needs and problems of farmers), which is one of the factors of personal desire, where the standardized regression weight was 98.9% with a negative sign, that is, the hypothesis of the paragraph was rejected by the sample members, meaning that technology is of great importance in solving production problems. Also, the factor score weights appeared with a higher estimate than all transactions, as it reached 65.9%. As for the ways of spreading information about this technology, the saturation of the adoption decision variable q27 (social media via the Internet has an impact on the availability of information about technology). It is one of the factors of social communication and its importance in the dissemination of this technology, so it appeared at a standard degree 90.8% and with a positive sign, that is, the sample members agreed that social media services at the present time are of great importance in conveying concepts and information about axial spray technology, which facilitates the use of the technology in the best scientific way. It also appeared with a factor effect weight 5.3%. Also, the adoption decision variable q28 (communication with farmer friends is the reason for knowing the importance of technology). Appears with a standard degree 80.3% and with a positive sign, it is also one of the methods working in the spread of technology, which led to directing the behavior and the desire of producers to adopt the technology of pivotal sprinkler irrigation, it appeared with a factor effect weight 3.1%. The government support factor is also of great importance in the dissemination and adoption of this technology, Where the variable q33 is satisfied (the more affordable the loans, the higher the percentage of farmers who adopt the technology). It appeared at a standard degree 86.2% and with a positive sign, that is, the sample members agree that the easier the loans are, the more it helps a lot in adopting technology, it was also shown with a factor effect weight 4.5%. This confirmed the saturation of the variable q32 (with government support, farmers can adopt

the technology to cover its high costs). It appeared with a standard degree 80.2% and a positive sign, which indi-cates the approval of the sample members that government support has a significant impact on improving farmers ability to cover the costs of pivot irrigation systems, which helps raise producers preferences and direct their decisions towards adopting pivot sprinkler irrigation technology, It appeared with a factor effect weight 2.9%. Because of the low water levels in the rivers (Tigris and Euphrates) and climatic changes which led to a decrease in the water shares of the cultivated areas in general, the factor of irrigation water sources was important in the opinions of the selected sample, as the saturation of the variable q13 appeared (due to the low water shares, pivot sprinkler irrigation is used). It appeared with a standard degree 84.3% and a positive sign, which refers to directing the behavior and preferences of producers towards adopting pivot irrigation to compensate for the shortage in irrigation water sources and because it is one of the important resources in the production process, It appeared with a factor effect weight 2.8%. As for the conditions that must be met for adopting the spraying technique, they are the properties of soil and water. The salinity ratio in water and soil must not exceed the required range (provided that it does not exceed 7dsm^{-1}), that is, it is one of the important factors in changing the behavior and preferences of producers in adopting the technology, as the saturation of the variable q7 appeared (the use of pivot sprinkler irrigation is limited to soils and water with low salt levels), It appeared at a standard degree (70.8%) and with a positive sign, that is, the opinions of the sample are consistent with the hypothesis of the phrase (the paragraph) and have a factor effect of 1.8%. Also, personal factors had an impact on a change in the attitudes and behavior of the adopters of the technology, as the variable q3 was satisfied (the educational attainment in the field of agriculture has an impact on the adoption of the pivot sprinkler irrigation technique). with a standard degree 68.8% and with a positive sign, that is, educational attainment has an impact on the behavior of the producer in using modern methods of irrigation because of their importance in improving the quality of production and the best ways to conserve the quantities of water consumed, but it appeared with non-significant variation, and this is due to a difference in the scientific levels of the selected sample of producers, It appeared with a factor effect 0.6%. As for the other factor of personal factors q4 (prices of pivot sprinkler irrigation systems are commensurate with the economic capabilities of all farmers). appears with a standard degree (72.6%) and with a negative sign, that is, the sample members rejected this hypothesis due to the high prices of the systems, which do not fit the economic capabilities of the sample members, where it appeared with a factor effect 1.9%, which should provide the necessary government support to provide these technologies at low and subsidized prices, which reduces their high cost that does not fit with the possibility of wheat producers in the study area. The research concluded that the most influential factor on the decision to adopt axial sprinkler irrigation technology for wheat producers in Ain Al-Tamr district is the personal desire factor, and the social communication factor has a significant impact on the spread of this technology among the members of the study community, and the government support factor is important in providing the soft loans and the money needed for wheat producers to adopt the pivot sprinkler irrigation technology because of its great importance at the present time due to the scarcity of the irrigation water resource due to the low levels of irrigation water with the low annual rate of rain in Iraq. Accordingly, the study recommends that wheat producers adopt axial sprinkler irrigation technology to compensate for the shortage in irrigation water sources, and because the water resource is an important resource in the production process. Government support for production require-ments must also be provided to reduce production costs and help producers to adopt new technologies in the production of the wheat crop, including the technology of pivotal sprinkler irrigation. The necessary government support must be provided to provide these technologies at low and subsidized prices, which will reduce their high costs, which are not commensurate with the potential of wheat producers in the study

area. The level and number of extension activities must also be raised to demonstrate the economic benefit of adopting this technology, as well as activating social media channels in conveying concepts and information about axial spray technology to facilitate the use of the technology in the best scientific way.

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