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FARMERS AS A CONSUMERS: UTAUT WITH DUAL MODERATED MEDIATION MODEL

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Abstract

The purpose of the study is to determine the factors that affect the adoption and implementation of clean and energy efficient practices by farmers. For this reason, in line with the model developed within the scope of UTAUT, it was investigated whether two moderator variables (environmental concern, financial benefits) make a difference for clean and energy practices. Data were collected from 400 participants for clean production and 400 participants for energy-efficient production. The data obtained were analyzed with Process Macro model 4 and model 21 developed by Hayes. As a result, it was seen that the UTAUT variables had a significant effect on farmers' adoption intention in both data. In addition, the moderating effect of adoption intention on the relationship between UTAUT variables and usage behavior was proven. Furthermore, the effect of both moderator variables in the study was revealed. While environmental concern has a moderating effect between performance expectancy, effort expectancy and facilitating conditions and adoption behavior in the clean production. Financial benefits has a significant moderating effect between adoption intention and usage behavior for all four of the UTAUT variables in the energy efficient production.

Keywords: *UTAUT, Adoption Behavior, Dual Moderated Mediation, Cleaner Production, Energy Efficient Production*
JEL Classification: *M31, M11, Q13*

TÜKETİCİ OLARAK ÇİFTÇİLER: İKİLİ MODERATÖRLÜ ARABULUCULUK MODELİYLE UTAUT

Öz

Çalışmanın amacı, çiftçiler tarafından temiz ve enerji verimli uygulamaların benimsenmesini ve uygulanmasını etkileyen faktörlerin belirlenmesidir. Bu nedenle UTAUT kapsamında geliştirilen model doğrultusunda iki moderatör değişkenin (çevresel kaygı, finansal fayda) temiz üretim ve enerji verimli üretim uygulamaları için fark yaratıp yaratmadığı araştırılmıştır. Temiz üretim için 400, enerji verimli üretim için ise 400 katılımcıdan veri toplandı. Elde edilen veriler Hayes'in geliştirdiği Process Macro model 4 ve model 21 ile analiz edilmiştir. Sonuç olarak her iki veride de UTAUT değişkenlerinin çiftçilerin benimseme niyeti üzerinde anlamlı etkiye sahip olduğu görülmüştür. Ayrıca UTAUT değişkenleri ile kullanım davranışı arasındaki ilişkide benimseme niyetinin düzenleyici etkisi kanıtlanmıştır. Ayrıca araştırmada her iki moderatör değişkenin etkisi ortaya konmuştur. Çevresel kaygı, temiz üretimde performans beklentisi, çaba beklentisi ve kolaylaştırıcı koşullar ile benimseme davranışı arasında düzenleyici bir etkiye sahiptir. Finansal faydalar, enerji verimli üretimde UTAUT değişkenlerinin dördü için de benimseme niyeti ve kullanım davranışı arasında önemli bir düzenleyici etkiye sahiptir.

Anahtar Kelimeler: *UTAUT, Benimseme Davranışı, İkili Moderatörlü Aracılık, Temiz Üretim, Enerji Verimli Üretim*
JEL Sınıflandırması: *M31, M11, Q13*

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1. Introduction

The concern for sustainability is becoming increasingly widespread today and needs to be taken seriously together with climate change (Michels et al., 2024). Climate change, especially triggered by greenhouse gases, has serious ecological impacts on our world and it is aimed to reduce this urgently. In this direction, steps have started to be taken in line with the sustainable development goals set by the United Nations (Nguyen & Drakou, 2021). Reducing these damages in technological, environmental, economic and social terms will contribute to sustainable development. Therefore, it should be ensured that governments, companies, and individuals take steps in this direction. Economic growth and rapid growth in global markets have increased the demand for energy, which in turn has increased the use of fossil fuels. This has directly affected global warming (Giua et al., 2022). Therefore, with the Paris Climate Change Agreement signed in December 2015, it was decided to take necessary measures to reduce the use of fossil fuels. Accordingly, the renewable energy industry is expected to grow from USD 1,000 billion in 2023 to USD 2,000 billion in 2030 (Fernandez, 2023). It is important that energy-efficient technologies are developed accordingly and that these technologies can reduce negative impacts on the environment. However, in order to maximize the benefits of new technologies, they need to be used correctly and effectively (Han et al., 2022). Agriculture is one of the areas where energy efficient technologies have not been used effectively enough (Novak, 2021; Gabriel & Gandorfer, 2023). It is stated that many factors are effective in the emergence of this situation. Among them are farmers' insufficient knowledge, low technology utilization skills, low levels of innovation and low support (De Canio et al., 2021; Barbosa Junior et al., 2022). All of these factors make it difficult for farmers to adopt relevant technologies. Therefore, these factors need to be reduced to achieve sustainability goals in agriculture.

Improving clean food production as part of food safety is another important component to be addressed in sustainability efforts (Da Silva et al., 2021). New environmentally friendly technologies are increasing the number of ecologically conscious consumers. However, it is still not enough (Nowak, 2021; Zhao et al., 2023). Therefore, efforts to increase farmers' awareness need to be intensified (Ricart et al. 2023). If awareness and utilization rates can be increased, significant progress can be made towards sustainable development goals. Therefore, green and smart agricultural systems need to be implemented more widely (Zameer et al., 2020; Veltheim et al., 2021). Green agriculture is defined as an environmentally friendly production method that minimizes erosion, soil salinization and the effects of other diseases and pests without polluting the air, water and soil. (Cachero-Martinez, 2020). Smart agriculture is the practices of modern technologies, tools and devices to increase the quality and quantity of agricultural products (Molina-Maturano et al., 2021). The economic and ecological sustainability of agriculture depends on the dissemination of green and smart agricultural practices. However, even today, these systems have limited diffusion in agricultural practices, and farmers lack knowledge about the main behavioral drivers of adoption (Rizzo et al., 2024; Thompson et al., 2024). This study aims to bridge this gap in two ways. Clean production to support ecological sustainability and energy efficient practices to ensure economic sustainability will be discussed. The adoption behaviors of farmers will be investigated through these practices.

The purpose of the research is to determine the factors that affect the adoption and implementation of clean and energy efficient practices by farmers. For this purpose, a model will be developed with the combined UTAUT and the behavior of farmers towards clean and energy efficient practices will be investigated. It is predicted that environmental concerns of farmers may be prominent in clean practices, while financial benefits may have a moderating effect in energy efficient practices. To this end, two moderator variables are added to the combined UTAUT model. Thus, the factors underlying farmers' behavior towards environmental and energy-oriented practices can be revealed. The study makes two important contributions to the literature. First, it will reveal farmers' preference between clean and energy efficient production. Thus, motivations that will direct farmers to clean and energy efficient practices can be determined and strategies can be developed on these. The second important contribution is to reveal the underlying UTAUT factors (performance expectancy, effort expectancy, social influence and facilitating conditions) that affect farmers towards clean and energy efficient practices. Thus, positive factors that may lead farmers towards environmentally friendly products/practices can be increased. In addition, the effects of the moderation variables environmental concern and financial benefits on farmers' intention-behavior will also be revealed. Thus, the question of whether farmers' financial concerns or the importance they give to the environment are more prominent among the factors that direct farmers to clean and energy efficient production practices will also be answered.

2. Literature review

Agriculture is vital for ensuring food security, increasing food production and quality, and achieving sustainable development goals (Thompson et al., 2024). Developing technologies can help individuals working in agriculture in this direction. However, while adaptation to emerging technologies is high in other fields, it is lower in agriculture (Gabriel & Gandorfer, 2023). Therefore, it is important that new technologies are adopted by farmers. Even more than adoption, it will require continued use and diffusion of use among a wider community (Rizzo et al., 2024). Thus, the rate of adoption and the speed of diffusion will determine the ultimate impact of the technology produced (Barbosa Junior et al., 2022). Many scholars have developed different theories and models explaining the behavioral change process related to adoption. Among these, the most well-known model is the Technology Acceptance Model (TAM). The technology acceptance model was first proposed by Davis in 1986 (Davis, 1986). The model was developed to describe an individual's behavior towards information technologies. Davis (1989) modified this model and identified the variables that are important for the adaptation of computer technologies. This model also explains the user's behavior towards different computer systems and different users. The final version of the technology acceptance model was created by Venkatesh and Davis (2000). In 2003, it was modified and the Unified Theory of Acceptance and Use of Technology (UTAUT) model was introduced. The UTAUT model has become a preferred model by many researchers (Jain et al., 2022; Sewandono et al., 2023) in the literature (Venkatesh et al., 2003). In recent years, the Unified UTAUT model has come to the forefront in studies on adoption in agriculture (Xie et al., 2022; Shi et al., 2022; Triandini et al., 2023). In this model, there are four basic variables to determine the user's adoption intention. These variables are explained below.

2.1. Performance Expectancy

Performance expectancy is specifically the expectation that a technology can help an individual perform a routine task and assesses the impact of perceived simplicity on doing work (Sewandono et al., 2023). In the agricultural sector, performance expectation is defined as the degree to which it helps farmers monitor daily data analysis (Rübcke von Veltheim et al., 2021). The user's expectancy regarding the performance of the technology affects the intention to adopt the technology. This effect has been confirmed in many studies in the literature, especially in the field of financial technology (Jadil et al., 2021), healtcare technolgy (Utomo et al., 2021) and digital education (Sewandono et al., 2023). In studies in the field of agriculture, there are studies (Molina-Maturano et al., 2021; Shi et al., 2022) that show that performance expectancy affects the intention to adopt technology, as well as studies (Foroughi et al., 2023) that argue that it does not. For this reason, the study will investigate performance expectancy on farmers' adoption intention for clean production and energy efficient production. The hypothesis prepared in this direction is as follows;

H1: Performance expectancy is significantly and positively related to farmers’ adoption intention

2.2. Effort Expectancy

Effort expectancy explains how easy a particular technology is perceived to be to use (Giua et al., 2022). In other words, it reveals with how much effort we can become able to use that technology. Therefore, it is an important factor in technology adoption. Although farmers' ability to use technology is low, their adoption intentions increase when they evaluate these technologies as good and useful (Shi et al., 2022). Especially innovative technologies that can be learned with minimal effort can make a difference in the agricultural sector in this direction. Many studies in the literature (Veltheim et al., 2021; Foroughi et al., 2023) have proven the effect of effort expectancy on individuals' behavioral intentions. However, Molina-Maturano et al. (2021) and Triandini et al. (2023) stated that effort expectancy does not affect farmers' adoption intention. Therefore, in this study, the hypothesis was prepared as follows to address the bidirectional debate on this issue.

H2: Effort expectancy is significantly and positively related to farmers' adoption intention

2.3. Social Influence

Social influence is the importance an individual attaches to the position of other individuals using a new technology or system. In this influence, the influence of the opinion of others and the influence of peers come to the fore (Puriwat & Tripopsakul, 2021). That is, individuals are influenced by the people around them and their usage habits are formed accordingly. Therefore, individuals are constantly under social influence. In the literature, this effect has been confirmed by many researchers in different fields such as mobile applications (Michels et al., 2024, payment systems (Manrai & Gupta, 2020), mobile banking (Jadil et al., 2021). In agriculture, farmers are more likely to adopt agricultural technologies when they receive a suggestion from other farmers, experts, and individuals they follow (Giua et al., 2022). However, Molina-Maturano et al. (2021) and Foroughi et al. (2023) reported that social influence does not affect farmers' adoption intention as it does effort expectancy. Therefore, the next hypothesis is prepared accordingly.

H3: Social influence is significantly and positively related to farmers' adoption intention

2.4. Facilitating Conditions

Facilitating influences describe how well a person believes that his or her organization is helping change towards the adoption of new technology (Abbad, 2021). An individual is more likely to adopt a new technology when the usefulness and ease of use of the technology is evident, the technology is available, and the technology support from opinion leaders is acceptable. Therefore, these effects directly influence behavioral intention (Han et al., 2022). In fact, in the modified UTAUT model, it is also stated that facilitating conditions directly affect usage behavior (Abbad, 2021; Puriwat and Tripopsakul, 2021). Farmers need technological and organizational assistance to use the relevant equipment. Studies in this direction in the literature (Molina-Maturano et al., 2021; Giua et al., 2022) have revealed that facilitating conditions have a strong impact on farmers' adoption intention. There are also studies indicating that facilitating conditions show moderation effect in the agricultural sector (Shi et al., 2022). However, Triandini et al. (2023) stated that facilitating conditions do not affect farmers' use behavior. Therefore, in line with the general studies in the literature, the hypothesis is formulated as follows.

H4: Facilitating condition is significantly and positively related to farmers' adoption intention

2.5. Mediating Role of Adoption Intention

Adoption intention is defined as consumers' acceptance of a product, service, innovation or technology based on their evaluations (Jain et al., 2022). As an occupational group that is not open to innovation, farmers are among the groups that are skeptical about adopting innovations (Nowak, 2021). However, it is also known that if farmers adopt a new technology, they use it for a long time (Ricart et al., 2023). Therefore, it can be stated that increasing adoption intentions has a significant impact on their use. There are also many studies in the literature (Nguyen & Drakou, 2021; Xie et al., 2022; Michels et al., 2024) showing that adoption intention is effective on actual use. In addition to these, there are many studies from different sectors (Jadil et al., 2021; Nguyen & Tran, 2022) where it has an effect as a mediator. For this reason, the study will investigate the usage status of farmers in line with their adoption intentions towards the tools used in clean and energy efficient production. Accordingly, the hypothesis is formulated as follows.

H5: Adoption intention is significantly and positively related to farmers' actual use

H6: Adoption intention mediate the association between UTAUT dimensions relating to a) performance expectancy, b) effort expectancy, c) social influence, d) facilitating conditions and actual use.

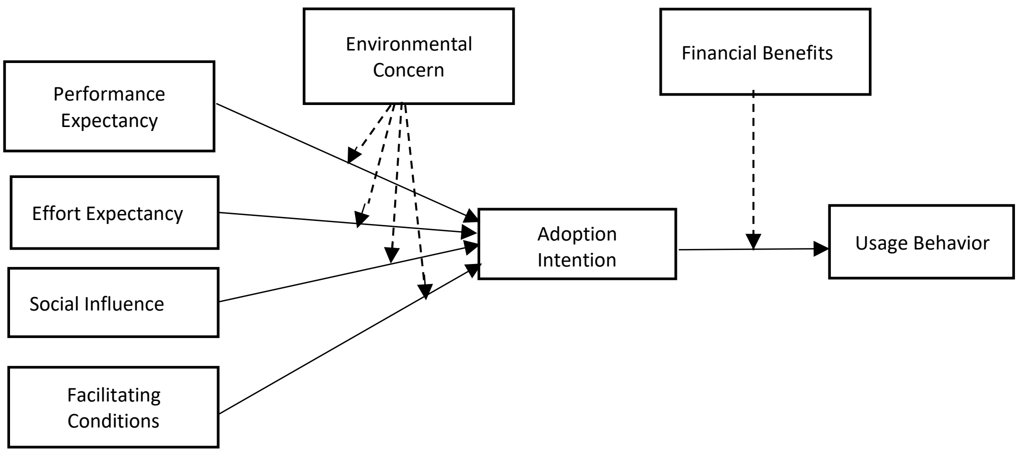
2.6. Moderating Role of Environmental Concern and Financial Benefits

Two moderator variables were added to the Unified UTAUT model in the study. These are environmental concerns and financial benefits. In the studies in the literature (Cachero-Martínez, 2020; De Canio et al., 2021), the moderating role was investigated only on the basis of facilitating effects. In this study, the moderating role of environmental concerns in the effect of all four independent variables on adoption intention will be investigated. In other words, it is predicted that farmers with high environmental concerns will increase adoption behavior. It is stated that this effect may be higher especially in clean farming practices than in energy efficient farming practices (Zhang et al., 2020). Financial benefits are thought to have a regulatory role in the relationship between adoption intention and usage behavior. In the literature, the moderating role of financial benefits between intention and behavior has been revealed in different sectors (Manrai & Gupta, 2020; Twum et al., 2022). However, this effect has not been revealed in terms of farmers' behavior in agriculture. Therefore, this study will investigate whether financial benefits have a moderating role. It is predicted that this moderating effect may be higher in energy-efficient agricultural practices than in clean agricultural practices. It is thought that the reason why farmers prefer energy-efficient practices is generally due to their costs, while the cost of clean production is secondary. Therefore, this research will investigate the accuracy of the predicted relationships (Figure 1). The hypotheses determined in this direction are as follows.

H7: Environmental concern moderates the mediation effects of adoption intention on the relationship between UTAUT dimensions relating to a) performance expectancy, b) effort expectancy, c) social influence, d) facilitating conditions and actual use.

H8: Financial benefits moderate the relationship between adoption intention and actual use.

Figure 1: **Research Model**



3. Method

3.1. Procedures and Measures

The study investigates farmers' behavior towards clean and energy efficient production, so purposeful sampling is used (Thomas, 2022). Before the study, all participants are asked whether they are farmers and people who are not farmers are not included in the study. The sample size for the study is 800 which is adequate according to the recommended ratio of 15:1 (Hair et al. 2006). Data was collected in four cities in the north of Türkiye in the first three months of 2024.

In the research, the extent to which farmers currently benefit from these elements was measured through ecological agricultural products and smart agricultural practices. Green agriculture techniques for clean production and smart agriculture techniques for energy efficient production were explained to the farmers and data was collected by survey method. Three students took part in the data collection and it was completed in 4 months through face-to-face interviews. $0.25 was paid as incentive for each participation. The sample collected included 400 farmers, of whom 21% were female and 79% male. Their ages ranged from 19 to 78 years (M=47.5). Only 7.6 percent of farmers have higher education graduates.

Two separate forms are created for the survey. In the first form, farmers' opinions on clean production were determined, and in the second form, farmers' opinions on energy efficient production were determined. A total of 35 items were used. Xie et al. (2022) UTAUT variables were used. Jain et al. (2022) environmental concern and adoption intention were utilized for mediating and moderating variables. Chaveesuk et al. (2023) financial benefits items and Abbad (2021) usage behavior items were utilized to measure last variables. Seven-point Likert scale ranging from strongly disagree (1) to strongly agree (7) was used in the study.

3.2. Data Screening

Preliminary analyses were conducted before testing the measurement model. First, descriptive statistics were used to check for missing data. There is no missing data in the data. Afterwards, the normality distribution in the data was examined. Skewness and kurtosis values for all variables in the data are in the range of +1/-1. Therefore, it can be stated that the data is normally distributed (Hair et al., 2021).

Table1: **Means, Standart Deviations and Correlations**

Variables*	**Means ****	**S.D**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
PE	5,75/5,96	,56/,57	,74/,76							
EE	5,57/5,37	,57/,54	,17/,03	,70/,70						
SI	5.86/5,97	,67/,55	,18/,36	,09/,06	,77/,73					
FC	5.89/5,97	,65/,51	,29/,39	,03/,02	,31/,22	,73/,71				
EC	6.27/5,72	,58/,58	,30/,14	,20/,22	,23/,13	,15/,12	,74/,75			
FB	4.53/6,10	,49/,51	,05/35	,07/,01	,01/,39	,04/,50	,09/,05	,68/,71		
AI	5.78/5,97	,53/,50	,41/,36	,31/,04	,40/,34	,34/,42	,64/,14	,07/,37	,75/,73	
UB	5.90/6,07	,48/,47	,33/,37	,22/,01	,35/32	,35/,46	,47/,08	,04/,48	,68/,40	,71/,71

Note: *1-Performance expectancy 2-Effort expectancy, 3-Social influence, 4- Facilitating conditions, 5-Environmental concern, 6-Financial benefits, 7-Adoption intention, 8-Usage behavior

** The first values are calculated for clean production, the second values for energy efficient production.

*** Bold values shows squared root of AVE scores of each variables.

Table 1 shows the means, standard errors and correlations calculated for all variables. The fact that the correlation coefficients are not higher than 0.80 is an important indicator that there is no hetorodasticity and multicollinearity problem. In addition, the VIF coefficient was examined to determine whether there is a multicollinearity problem among the variables. According to the Rule of Thump, a VIF coefficient above 10 may indicate a multicollinearity problem among variables. For all variables in the study, the VIF coefficient is below 1.5 in both data.

Table 2 shows the Cronbach Alpha (C.A), composite reliability (C.R.), average variance extracted (AVE) values obtained for reliability and validity. Cronbach alpha and composite reliability values are expected to be above 0.70. These values were achieved for all variables. AVE values should be above 0.50 (Hayes, 2022). In the study, it is below the expected value for facilitating conditions only in the clean production data. However, since there is not a big difference and it is higher in energy efficient production data, the study was continued with the existing data. In their study, Henseler et al. (2015) stated that cross-loading and Fornell-Larcker criterion are insufficient for discriminant validity and proposed HTMT criterion. For this reason, the discriminant validity was evaluated by performing HTMT (Heterotrait Monotrait Ratio) analysis. The HTMT value should be below 0.90 (Hair et al., 2021). This criterion was met for all variables in the study.

Table2: **Reliability and Validity**

Variables	Avr. Factor Loading	C.A.	C.R.	AVE
PE	0,74/0,76	0,82/0,84	0,83/0,84	0,55/0,58
EE	0,71/0,71	0,86/0,86	0,86/0,86	0,50/0,50
SI	0,77/0,73	0,86/0,82	0,86/0,82	0,60/0,53
FC	0,73/0,71	0,88/0,86	0,88/0,86	0,54/0,51
EC	0,74/0,75	0,78/0,79	0,79/0,79	0,55/0,56
FB	0,68/0,72	0,81/0,84	0,81/0,84	0,46/0,51
AI	0,75/0,73	0,79/0,77	0,79/0,77	0,56/0,53
UB	0,71/0,71	0,80/0,80	0,80/0,80	0,50/0,51

Note: * The first values are calculated for clean production, the second values for energy efficient production.

In addition, as can be seen in Table 3, confirmatory factor analysis was performed with AMOS 24 to reveal the factor structure and loadings. Recommended goodness of fit values were obtained for both data obtained for clean production and energy efficient production (Yaslıoglu & Yaslıoglu, 2020). Thus, convergent validity was achieved in the study.

Table3: **Confirmatory Factor Analysis**

CFA Model	CMIN/DF	CFA	GFI	TLI	RMSEA
Clean Production	1,358	0,97	0,91	0,96	0,03
Energy Efficient Production	1,316	0,97	0,91	0,97	0,03
Recommended Values	<3	>0.95	>0,90	>0,90	<0,08

In addition to these, the study tried to control common method bias with a three-stage test. First, a procedural controller (survey design, temporal separation) was used to prevent source bias (Kock et al., 2021). In the survey design, it was clearly stated in which subject the respondents' opinions were asked, and two separate forms were filled out for clean production and energy efficient production. Farmers were informed about the products used for clean production and energy efficient production. Thus, they were enabled to concretize clean production and energy efficient production in their minds. Complex and double-barreled questions were avoided to increase the comprehensibility of the questionnaire (MacKenzie & Podsakoff, 2012). For temporal separation, clean production and energy efficient production data were collected from the same farmers one month apart. In the second stage, common method variance was tested with Harman's one-factor test. The cumulative variance value was calculated as 18.24% for clean production and 21.27% for energy efficient production. Since this value was below 50% for both data, no common method bias was observed. In the third stage, the common method effect was tested with ULMC (unmeasured latent method factor construct). There should not be a difference of more than 0.2 between the factor loadings in the model tested with the common latent factor and the model tested in confirmatory factor analysis. No such difference was observed for both data used in the study (Table 4). Therefore, common method bias is not at a level that would affect the analysis.

Table 4: **ULMC test for Common Method Bias**

	Factor Loadings	Unmeasured Latent Factor Loadings	Differances
PE1	0,819/0,852	0,742/0,813	0,077/0,039
PE2	0,727/0,773	0,641/0,714	0,086/0,059
PE3	0,780/0,585	0,704/0,511	0,076/0,074
PE4	0,629/0,818	0,560/0,764	0,069/0,054
EE1	0,761/0,731	0,687/0,671	0,074/0,060
EE2	0,771/0,738	0,705/0,690	0,066/0,048
EE3	0,741/0,689	0,669/0,636	0,072/0,053
EE4	0,728/0,683	0,653/0,620	0,075/0,063
EE5	0,669/0,695	0,603/0,654	0,066/0,041
EE6	0,633/0,755	0,571/0,691	0,062/0,064
SI1	0,731/0,744	0,668/0,705	0,063/0,039
SI2	0,847/0,782	0,804/0,723	0,043/0,059
SI3	0,771/0,655	0,716/0,594	0,055/0,061
SI4	0,782/0,731	0,725/0,655	0,057/0,076
FC1	0,715/0,766	0,662/0,728	0,053/0,038
FC2	0,797/0,779	0,750/0,712	0,047/0,067
FC3	0,720/0,692	0,668/0,612	0,052/0,080
FC4	0,713/0,682	0,659/0,607	0,054/0,075
FC5	0,694/0,679	0,643/0,611	0,051/0,068
FC6	0,774/0,691	0,717/0,620	0,057/0,071
EC1	0,715/0,713	0,632/0,652	0,083/0,061
EC2	0,755/0,840	0,661/0,805	0,094/0,035
EC3	0,760/0,684	0,695/0,621	0,065/0,063
FB1	0,700/0,783	0,568/0,735	0,132/0,048
FB2	0,673/0,755	0,574/0,694	0,099/0,061
FB3	0,665/0,702	0,551/0,615	0,114/0,087
FB4	0,681/0,628	0,565/0,556	0,116/0,072
FB5	0,676/0,713	0,597/0,657	0,079/0,056
AI1	0,775/0,807	0,699/0,753	0,076/0,054
AI2	0,725/0,675	0,608/0,568	0,117/0,107
AI3	0,740/0,699	0,644/0,635	0,096/0,064
UB1	0,726/0,766	0,632/0,706	0,094/0,060
UB2	0,650/0,686	0,539/0,595	0,111/0,091
UB3	0,710/0,693	0,563/0,620	0,147/0,073
UB4	0,746/0,701	0,695/0,612	0,051/0,089

Note: * The first values are calculated for clean production, the second values for energy efficient production.

4. Results

To test the measurement model developed in this study, a two-level moderated-mediation model was utilized with eight latent variables. In the first stage, analysis was carried out with Process Macro model 4 developed by Hayes (2022) to measure mediation effects. In the next stage, model 21 was used to reveal moderated mediation effects.

4.1. Mediation Effect of Adoption Intention

To investigate the mediating role of adoption intention between performance expectancy, effort expectancy, social influence and facilitating conditions and usage behavior, separate bias-corrected bootstrap models were constructed with 5,000 bootstrap samples taken from the available data as suggested by Hayes (2022). Thus, the mediating role of adoption intention in the measurement model was investigated at 95% confidence interval. Table 5 illustrates the regression weights of mediation effects for cleaner production and energy efficient production. In the direct effects, other relationships are significant except for the effect of effort expectancy on adoption intention for energy efficient production. In indirect effects, it is seen that adoption intention has a significant mediator effect in the relationship between performance expectancy ($R2=0.30$, $p<0.01$), effort expectancy ($R2=0.29$, $p<0.01$), social influence ($R2=0.31$, $p<0.01$), facilitating conditions ($R2=0.31$, $p<0.01$) and usage behavior in cleaner production data. In energy efficient production data, adoption intention has a significant mediator effect for performance expectancy ($R2=0.21$, $p<0.01$), social influence ($R2=0.19$, $p<0.01$), facilitating conditions ($R2=0.25$, $p<0.01$). Only the effect of effort expectancy on usage behavior through adoption intention was not confirmed ($p>0.05$).

Table 5: **Direct and Indirect Effects of Mediation Model**

Direct effects	**b**	**SE**	**t**	**p**
1-PE→AI	0,33/0,31	0,05/0,04	7,2/7,4	0,00/0,00
1-AI→UB	0,48/0,28	0,04/0,04	11,5/6,2	0,00/0,00
2-EE→AI	0,23/-0,06	0,05/0,05	5,2/-1,2	0,00/0,21
2-AI→UB	0,50/0,36	0,04/0,04	12,2/8,3	0,00/0,00
3-SI→AI	0,27/0,30	0,03/0,04	7,3/7,1	0,00/0,00
3-AI→UB	0,46/0,29	0,04/0,04	11,2/6,6	0,00/0,00
4-FC→AI	0,23/0,40	0,04/0,05	6,0/8,9	0,00/0,00
4-AI→UB	0,47/0,23	0,04/0,04	11,6/5,2	0,00/0,00
Bootstrap results for indirect effects	**β**	**SE**	**Boot LLCI**	**Boot ULCI**
1-PE→AI→UB	0,16/0,09	0,03/0,01	0,11/0,06	0,21/0,12
2-EE→AI→UB	0,12/-0,02	0,02/0,01	0,07/-0,05	0,17/0,01
3-SI→AI→UB	0,13/0,09	0,02/0,02	0,09/0,06	0,16/0,12
4-FC→AI→UB	0,11/0,09	0,02/0,02	0,07/0,06	0,16/0,13

Note: * β=standardized regression estimate, b=unstandardized regression estimate, SE=standard error of unstandardized estimate, CI (lower)=confidence interval lower bound, CI (higher)=confidence interval higher bound
** The first values are calculated for clean production, the second values for energy efficient production.

4.2. Dual Model of Moderated Mediation

We used the PROCESS macro for SPSS Model 21 with individual bias-corrected bootstrap models created using 5,000 bootstrap samples. Thus, conditional effects were tested with two-stage moderated mediation. We examined the conditional effect of performance expectancy, effort expectancy, social influence and facilitating conditions on adoption behavior through adoption intention. A two-stage moderation effect was also tested. We tested the effects of environmental concerns in the first stage and financial benefits in the second stage on cleaner production and energy efficient production (Table 6 and 7).

When we evaluate the results for cleaner production, the independent variables performance expectancy, effort expectancy, social influence and facilitating conditions were considered together with environmental concern for the first stage moderation effect. When their effects on adoption intention are examined, it is seen that the moderated effect of performance expectancy on adoption intention with environmental concerns is CI (0.01/0.25), $p<0.05$. The effect of effort expectancy on adoption intention moderated by environmental concerns was also significant with CI (0.05/0.30), $p<0.01$. Social infleunce, on the other hand, did not have a significant effect on adoption intention moderated by environmental concern, CI (-0.09/0.10), $p>0.05$. Facilitating conditions also produced a significant effect on farmers' adoption intention with the moderating effect of envrionmental concern, CI (0.10/0.32), $p<0.01$. In addition, when conditional indirect effects were evaluated, partially significant results were obtained for dual moderated mediation for ±1 SD. Bootstrap confidence intervals were not significant at low level for conditional indirect effects (-1SD). However, significant results were obtained at both levels for mean (M) and higher level (+1SD). For the moderation effect in the second stage, the effect of adoption intention together with financial benefits on farmers' usage behavior was investigated. However, no significant moderated mediation effect was found in the cleaner production data.

Table 6: **Direct and Indirect Effects of Dual Moderated Mediation Model (Clean Production)**

Predictors*	β	t	SE	95% CI
Adoption Intention (Level 1)				
PE	-0,61	-1,50	0,40	-1,41 / 0,19
PE x EC	0,12	1,93	0,06	0,01 / 0,25
EE	-0,99	-2,46	0,40	-1,79 / -0,20
EE x EC	0,17	2,79	0,06	0,05 / 0,30
SI	0,12	0,38	0,31	-0,50 / 0,74
SI x EC	0,01	0,16	0,05	-0,09 / 0,10
FC	-1,15	-3,36	0,34	-1,83 / -0,48
FC x EC	0,21	3,87	0,05	0,10 / 0,32
Usage Behavior (Level 2)				
PE	0,08	2,09	0,04	0,01 / 0,16
AI x FB	-0,05	-0,60	0,08	-0,22 / 0,11
EE	0,04	1,11	0,04	-0,03 / 0,11
AI x FB	-0,05	-0,55	0,08	-0,21 / 0,12
SI	0,10	3,09	0,03	0,04 / 0,17
AI x FB	-0,05	-0,55	0,08	-0,21 / 0,12
FC	0,10	3,12	0,03	0,04 / 0,17
AI x FB	-0,08	0,08	-0,92	-0,25 / 0,09
Bootstrap results for indirect effects (Adoption Intention)**	**Indirect Effect**	**Boot SE**	**Boot LLCI**	**Boot ULCI**
−1 SD	0,09/0,02/0,06	0,06/0,05/0,04	-0,02/-0,08/-0,01	0,20/0,12/0,15
M	0,16/0,12/0,19	0,04/0,04/0,03	0,09/0,05/0,13	0,24/0,19/0,25
+1 SD	0,23/0,22/0,32	0,05/0,05/0,05	0,13/0,12/0,22	0,33/0,32/0,41

Note: * X: PE, EE, SI, FC; M: AI; W:EC; Z: FB; Y: UB
** First values are calculated for PE*EC, second values for EE*EC, third values for FC*EC

Table 7: **Direct and Indirect Effects of Dual Moderated Mediation Model (Energy Efficient Production)**

Predictors*	β	t	SE	95% CI
Adoption Intention (Level 1)				
PE	0,26	0,64	0,40	-0,53 / 1,06
PE*EC	0,01	0,08	0,07	-0,13 / 0,14
EE	-0,50	-1,13	0,44	-1,37 / 0,37
EE*EC	0,07	0,93	0,08	-0,08 / 0,22
SI	0,45	1,11	0,40	-0,34 / 1,24
SI*EC	-0,03	-0,40	0,07	-0,17 / 0,11
FC	0,63	1,35	0,46	-0,28 / 1,53
FC*EC	-0,04	-0,51	0,08	-0,20 / 0,11
Usage Behavior (Level 2)				
PE	0,15	3,86	0,04	0,07 / 0,22
AI*FB	-0,23	-2,38	0,10	-0,42 / -0,04
EE	-0,03	-0,72	0,04	-0,10 / 0,05
AI*FB	-0,25	-2,53	0,10	-0,44 / -0,05
SI	0,11	2,76	0,04	0,03 / 0,19
AI*FB	-0,24	-2,47	0,10	-0,43 / -0,05
FC	0,23	4,88	0,05	0,14 / 0,32
AI*FB	-0,20	-2,08	0,09	-0,39 / -0,01

Table 7 (Countinued): **Direct and Indirect Effects of Dual Moderated Mediation Model (Energy Efficient Production)**

Predictors*	β	t	SE	95% CI
Bootstrap results for indirect effects (Usage Behavior)	**Indirect Effect**	**Boot SE**	**Boot LLCI**	**Boot ULCI**
−1 SD	0,33/0,38/0,35/0,29	0,07/0,07/0,07/0,07	0,20/0,25/0,22/0,16	0,46/0,51/0,48/0,43
M	0,21/0,25/0,22/0,19	0,04/0,04/0,04/0,04	0,12/0,17/0,14/0,10	0,30/0,34/0,31/0,28
+1 SD	0,09/0,12/0,10/0,09	0,07/0,07/0,07/0,07	-0,04/-0,01/-0,03/-0,04	0,22/0,26/0,23/0,22

Note: *X: PE, EE, SI, FC; M: AI; W:EC; Z: FB; Y: UB

For energy efficient production, in the first stage, the effect of environmental concern and performance expectation, effort expectation, social impact and facilitating condition on farmers' adoption intention was investigated for the moderation effect. However, no significant effect was found in the first stage. For the moderation effect in the second stage, adoption intention was considered together with financial benefits and its effect on usage behaviors was investigated. In the performance expectancy path, a significant moderation effect CI (-0.42/-0.04), p<0.01 was found for financial benefits together with adoption intention. Similarly, in the Effort expectancy path, a significant moderation effect for financial benefits together with adoption intention was found with CI (-0.44/-0.05), p<0.01. In the social influence path, the moderation effect for financial benefits was again significant CI (-0.43/-0.05), p<0.01. Finally, in the facilitating conditions path, a significant moderation effect for financial benefits in the second stage was found CI (-0.39/-0.01), p<0.05. In addition, when conditional indirect effects were evaluated, partially significant results were obtained for dual moderated mediation for ±1 SD. Bootstrap confidence intervals were significant at low level for conditional indirect effects (-1SD) and mean (M). However, no significant results were obtained for the higher level (+1SD).

5. Conclusion

The main objective of the study is to determine the factors affecting the adoption and implementation of clean and energy efficient practices by farmers. The reason for choosing farmers as a sample is that they have difficulty in adoption behavior and when they adopt, they use those applications for a long time. The model including two moderators and one mediator created in this direction was analyzed with Process Macro. As a result of the study, it was proved that adoption intention has a significant mediator effect between UTAUT variables (PE, EE, SI, FC) and usage behavior for cleaner production practices. For energy efficient practices, adoption intention has no significant effect only on the relationship between effort expectancy and usage behavior. However, the mediating effect of adoption intention was confirmed for the other three independent variables (PE, SI, FC). Therefore, H6 is partially accepted (H6a, H6c, H6d).

The interesting findings of the study emerged in the moderation effects. In the analysis for the first level, the moderation effect of environmental concern on the relationship between UTAUT variables and adoption intention was investigated. Here, there were differences in farmers' evaluations for cleaner production and energy efficient production. For cleaner production, environmental concerns had a moderating effect on three independent variables (PE, EE, FC), while for energy efficient production, environmental concerns had no moderating effect. This shows that farmers act with more environmental concerns while practicing cleaner production. As a result, H7 is partially accepted for cleaner production data (H7a, H7b, H7d). In the second level, financial benefits moderation effect on the relationship between adoption intention and usage behavior was investigated. Here, in contrast to environmental concern, a moderation effect emerged in energy efficient production, while no significant effect was found in cleaner production. Financial benefits proved to have a moderating effect between adoption intention and usage behavior for all four UTAUT variables (PE, EE, SI, FC). This shows that H8 is supported for the energy efficient production data. Hence, it appears that farmers who engage in energy efficient production do so with financial considerations.

As a result, shifting farmers with environmental concerns to clean production and farmers with financial concerns to energy efficient production will create a more effective production strategy. Moreover, bringing agricultural technologies to a common denominator to address financial and environmental concerns will enable farmers in both groups to use these technologies. For example, drip irrigation, which is an energy-efficient practice, also provides clean production. Increasing practices in this direction will facilitate the adaptation of farmers to these technologies. Applications developed with artificial intelligence applications and interconnected with IOT technologies, agrivoltaic agriculture, photovoltaic agriculture, hydroponic farming, and climate-smart agriculture techniques stand out as applications that farmers should adapt in the coming years. In this direction, emphasizing the environmental concerns of these practices for clean production and financial benefits for energy efficient practices can be effective in their adoption and use by farmers.

This study adheres to the premises of the UTAUT model and provides current literature in the following aspects. First, previous studies (Molina-Maturano et al., 2021; Barbosa Junior et al., 2022; Foroughi et al., 2023) provide in-depth knowledge of UTAUT in terms of farmers' adoption of digital applications in general. This study makes an important contribution to the application of UTAUT in agriculture by presenting clean and energy efficient production in a comparable way. Secondly, the study proved the impact of UTAUT variables (performance expectancy, effort expectancy, social inflence, facilitating conditions) on adoption intention. This result is in line with most of the recent studies in the literature (Han et al., 2022; Shi et al., 2022; Xie et al., 2022; Michels et al., 2024). Third, the mediator effect of adoption intention between UTAUT variables and usage behavior is proven. This relationship has been confirmed in different sectors in the literature (Jadil et al., 2021; Nguyen & Tran 2022). The findings in this study also support the findings in other sectors with significant results in the agricultural sector. Unlike previous studies, no significant mediating effect of adoption intention in energy efficient production was found only for effort expectancy.

Fourth, the moderating role of environmental concerns between UTAUT variables and adoption intention is revealed. Jain et al. (2022) obtained significant results in his research on the adoption of electric vehicles. However, there is no study in this direction in the field of agriculture. In the study, the moderation effect of environmental concerns on the relationship between the three variables of UTAUT (PE, EE, FC) and adoption intention in cleaner production data was revealed. Therefore, it provides an important information contribution in terms of cleaner production. Finally, the moderating effect of financial benefits on the relationship between adoption intention and usage behavior is revealed. In the literature, there are studies indicating that perceived benefits have a significant effect on this relationship (Manrai and Gupta, 2020; Twum et al., 2022). However, there is no study that shows a moderation effect on financial benefits. Therefore, it can be stated that the moderation effect revealed in energy efficient production in this study makes an important contribution to the literature.

In agriculture, uncovering farmers' adoption behavior is an important issue as it affects their long-term use of farming practices (Ricart et al., 2023; Michels et al., 2024). The role of environmental concerns is more prominent in clean production, while the role of financial benefits is more prominent in energy efficient production. Therefore, environmental concerns of farmers need to be increased in order to enable them to engage in cleaner production (Nguyen & Drakau, 2021). Since the education level of farmers is lower than other occupational groups, it would make sense to explain to them with more concrete examples to increase their environmental concerns. For example, a training on the hazards of chemicals in agriculture can be organized. Thus, the damages of fertilizers, seeds or other pesticides used in the laboratory environment can be explained.

For the adoption of cleaner production practices, it would be beneficial to increase PE, EE, SI, FC as well as environmental concerns. To increase PE, the long-term benefits of cleaner practices to soil, crops and human health need to be explained to farmers (Zhang et al., 2019). To increase the EE, the level of knowledge about clean practices needs to be increased (Utomo et al., 2021). For example, for agrivoltaic agriculture, it may be sufficient to simply purchase solar panels and place them on the field at regular intervals. To increase SI, communication between farmers needs to be increased. For example, agricultural cooperatives can increase this impact by connecting farmers who grow crops with hydroponic practices with other farmers (Xie et al., 2022). FC can be increased by government support in the purchase of solar panels for farmers practicing photovolatic agriculture.

UTAUT variables (PE, EE, SI, FC) are effective in the adoption of energy efficient practices. In order to increase PE, the impact of energy efficient practices on crops can be explained to farmers. For example, the impact of the use of artificial intelligence on field yields can be explained to farmers. To increase the EE, farmers need to be told how energy efficient practices require less effort than their current farming practices and make their work easier (Shi et al., 2022). For example, systems interconnected with IoT technologies can provide weather information for greenhouses, monitor soil health through sensors, and use drones for seed sowing (Xie et al., 2022). To increase SI, farmers using smart agricultural products can be encouraged to share their knowledge. To increase FC, subsidies can be provided to farmers for the purchase of smart farming systems (Giua et al., 2022). In addition, once energy efficient production is adopted by farmers, the financial impacts of these practices increase their use.

This study, like other studies, has some limitations due to time and cost considerations. The first limitation concerns the UTAUT model. This model was tested in Turkey in terms of farmers' adoption of clean and energy-efficient practices in agriculture. This study could be replicated to further validate the generalization of the model in other countries. The second limitation concerns the data collection. The data were collected cross-sectionally rather than longitudinally. Therefore, causal relationships were not investigated. Future studies could conduct exploratory research in this direction to reveal the causal relationships between the independent and dependent variables.

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