

Estimating the Model of Investigating Attitude and Intention in the Usage of Variable Rate Irrigation Technology

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Authors' contributions

This work was carried out in collaboration between all authors. SS designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. AA and KRM were supervisor and DH was advisor in study. FK helped in the literature searches. All authors read and approved the final manuscript.

Research Article

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ABSTRACT

Aims: This study investigated the attitude and intention of experts in Agriculture Organization of Fars and Khuzestan Provinces towards the usage of variable rate irrigation technology.

Study Design: Cross-sectional study.

Place and Duration of Study: In Agricultural Organization of Fars and Khuzestan Provinces, between July 2006 and September 2006.

Methodology: According to multiple stratified random sampling, We included 249 experts (135 Fars experts, 114 Khuzestan experts, 193 men, 56 women; age range 23-68 years) in both provinces. Davis's Technology Acceptance Model (TAM) and Rogers's Innovation Diffusion Theory (IDT) was theoretical framework. Data analyzed by Structural Equation Modeling Technique (SEM) base on LISREL software.

Results: Findings suggest that experts have intention towards application of this

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technology. Observability, perceived ease of use, attitude to use and perceived usefulness variables have a direct effect on experts' intention to use for the application of VRT-I; and experts' attitudes to use of technology directly affects variables of observability and perceived usefulness.

Conclusion: this study was successful adding some variables in Davis's TAM and made it more complete. Some applicable recommendations have been presented at the end of article according to the research conclusion.

Keywords: Variable rate irrigation technology; technology acceptance model; attitude; intention; Iran.

1. INTRODUCTION

Water plays very essential role in the development of human civilization. Primitive humans settled down near rivers and natural water resources for farming and irrigation. Farming can be considered the first human activity in environment basically dependent on water, helping in land irrigation via rivers and springs. Although, Earth comprises 97 percent of salty water but a limited amount is in direct use for man. In addition, slightly more than 1.75 percent of the Earth's water sources are blocked as Ice Rivers or crystals while rest is saved deep inside Earth clusters (Dashti, 1995).

Although Iran is located 30 degrees north, a large part of land is dry with semiarid climate due to which. Water is the top limiting factor in agricultural development (Mahjoub, 2004). Iran's average annual precipitation is about 250 mm ranking third of the world's average. Even rainfall in Iran also has disproportionate distribution for agricultural seasons, and local variances. Yet, high evaporation rates mean is more than 2000 mm which adds to water challenges.

One percent of world population lives in Iran, but the land encompasses 0.36 percent of freshwater and renewable resources (Shayan-far, 2004). Studies have indicated that in Iran of about 88.5 billion cubic meters of renewable water, 93 percent is used in agricultural sector, 5 percent for drinking purpose and rest is consumed in the industrial sector (Sadat-Miri and Farashi, 2004). Thus, water is the most important and limiting input of agricultural production.

Resources extinction and water pollution have been witnessed 51 among all recent investments of water, in Iran. A number of reasons can be said responsible for it viz., over-acquisition, industrial growth, urbanization, drought phenomenon, increasing water acquisition cost, carelessness about water sources' conservation and inappropriateness change of underground water resources. Therefore, water supply became insufficient to fulfill its increasing demand. This situation addresses water to become a competitive good for different consumptions. As agricultural sector has been consuming more than 90 percent of water volume in Iran, it makes planners not only to think of managing water supply, but also to think of managing water demand in order to conserve national water sources (Azizi, 2001). Determining effective factors on the amount of agrarian water loss, Azizi (2001) conducted a research among 40-60 years old wheat farmers of *Sarvestan* County in Fars Province where results revealed that farmers lacking crop insurance had no ownership over

their water resources and were under pressure of their neighbor consumer behaviors. His study represented that agrarian water enhancement price failed to establish farmers' sustainable reactions towards water usages.

Keeping all these problems into consideration sustainable water consumption seems utterly crucial. Therefore, policy makers are obsessed by application of water saving technologies and encouragement of farmers so that proper utilization of water resources can be done.

The general direction of development in world is symbolized by the shift from the remedial strategy involving end-of-pipe technology to preventive strategies involving clean-up technologies based on precautionary principle and interests are due to application of new agricultural sciences that increase productivity with better environmental performance (Rezaei-moghaddam et al., 2006). Nowadays, Information Technology (IT) is utilizing jobs to be done more quickly and accurately. From 1990s, IT is used in agriculture too, and is called Precision Agriculture (PA).

Precision agriculture is a specific managing system based on information and knowledge of producing inputs. The aims are increasing profits, decreasing costs and decreasing of environmental effects of utilization of agricultural inputs (Sasao and Shibusawa, 2000). Precision agriculture is a comprehensive approach to farm management and has the following goals and outcomes: Increased profitability and sustainability, improved product quality, effective and efficient pest management, energy, water and soil conservation, and surface and ground water protection (Griso et al., 2002). It is the third scenario of application and development of agricultural technologies aiming to "optimize input-output" (Shibusawa, 1998) and more than 60 micro technologies that are being used from pre-planting to post-harvesting in the farm. This technique typically requires a significant investment in human capital (McBride and Daberkow, 2003). Since 1990 Precision Agriculture (PA) has emerged in agricultural field to cover both economical and ecological goals.

Variable Rate Technologies (VRT) comes under precision agriculture (PA) technologies that vary the rate of agricultural inputs in response to changing local conditions. VRT allow farmers to vary inputs, such as water, fertilizers, pesticides and seeding rates throughout fields based on management zones (Adrian et al., 2005).

Variable Rate Technologies-Irrigation (VRT-Irrigation) is type of VRT. It does variable irrigation in a field based on plant water requirements, soil condition (texture, structure, water holding capacity and water infiltration/drainage rates ...), non-uniform cropping patterns due to terraces, differing rates to wet areas and wastewater from feed yards to cropland for the nutrients in the wastewater. VRI technology allows farmers to easily apply varying rates of irrigation water based on the individual management zones within a field.

Fars and Khuzestan provinces, with regard to their climate, are two important agricultural producers in Iran. As noted before whereas, more than 90 percent of national freshwater is used in agricultural sector and Iran has confronted with draught stresses, using variable rate irrigation technologies is very important and justifiable, such technologies can enhance farms water use efficiency. Moreover, whereas, there is no evidence toward widespread use of such technologies, understanding agricultural experts' attitudes, as transformers of new technologies among farmers, toward these technologies applicability is necessary.

The aim of our study was to evaluate the attitude and intention experts Agriculture Organization of Khuzestan and Fars provinces to use intelligent technologies where water is applied with changing rate at the farms.

2. THE STUDY OF THEORETICAL FRAMEWORK

Based on different studies, several variables cast their effect on people's attitude while dealing with new technologies. Among all models describing or predicting motivational factors on the adoption of information technologies by users, "Technology Acceptance Model" (TAM) (Fig. 1) by Davis are widely applied (Yi et al., 2006). TAM presented by Fishbin and Ajzen (1975) is one of the most influential one about Theory of Reasoned Action (TRA). Accepting TRA as a basic theoretical framework, Davis (1989) expressed "TAM" in order to describe the behavior of the use of information technologies. The Structural Equation Model (SEM) explains simultaneous effects of perceived ease of use and perceived usefulness on information systems users in both the attitude and intention to accept the use of technology, and the actual use of technology (Adrian *et al*, 2005). Davis (1989) stated other external variables affecting on perceived ease of use and Perceived usefulness of attitude and intention that finally influences accepting behavior of information technologies use (Fig. 1). Therefore, several studies have been implemented to examine the attitude and intention to use information technology (IT) by putting this model in to consideration like the Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB) and Innovation Diffusion Theory (IDT).

To predict behavior or attitude to the use of information technology, researchers have conducted various studies by using TAM model with some external variables such as technical support, normative subjective thought causality, entertaining, attitude of confidence, adaptability, triability and observability.

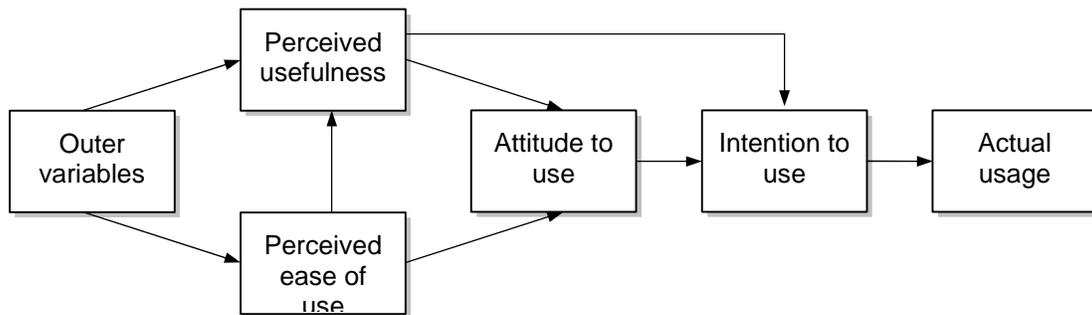


Fig. 1. Technology acceptance model (Davis, 1989)

Lee et al.'s (2007) and Wu et al.'s (2007) investigations on understanding the relationship between perceived usefulness, perceived ease of use, attitude to use and intention to use of information technology (IT) are widely used. Chen and Tan (2004) added the compatibility variable to the model and found out there is a positive and significant relationship not only between TAM variables, but also between the compatibility with perceived usefulness and attitude to the use of technology. The following model (Fig. 2) was taken into consideration in this study in order to investigate agricultural experts' attitude and intention towards the usage of variable rate irrigation technology.

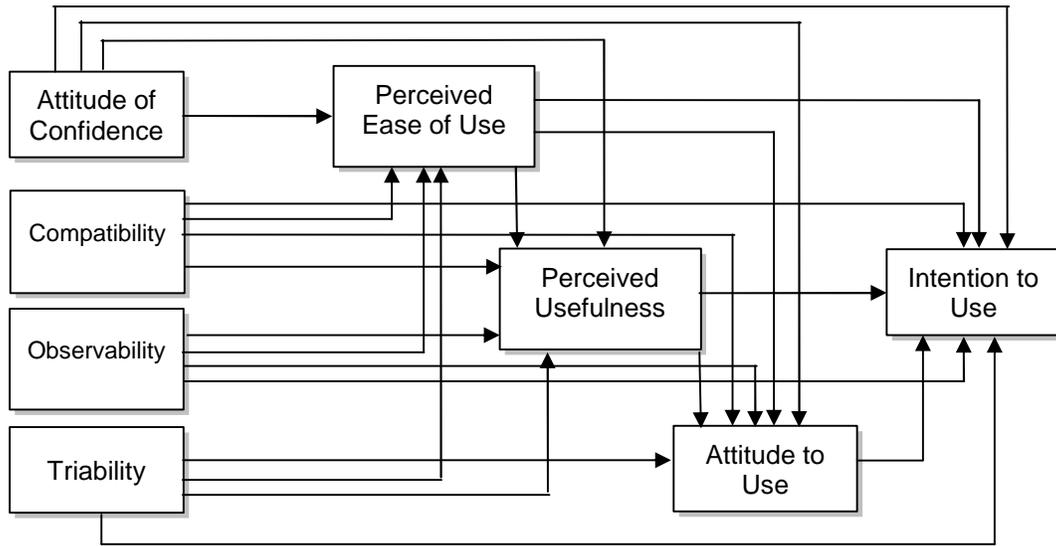


Fig. 2. The study theoretical framework

3. METHODOLOGY

Cross sectional survey was adopted as research method. Statistical population of 705 agricultural experts who were official employees of Iran Agricultural Ministry in Fars and Khuzestan provinces were assessed. Sample population consisted of randomly selected 249 individuals. Based on experts' opinions about agricultural status in both provinces, a three-stratum division with favorable agricultural conditions, moderate and weak was formulated. Sample group were selected in each stratum, separately and randomly. Experts working in Central Agricultural Office in each province were also classified, separately.

Those agricultural experts who employed in governmental agricultural organization (705 experts) were the research statistical population. Based on Krejcie and Morgan (1970) sampling determination table, 249 experts were considered as sample group by using two stages stratified random sampling method. Therefore, according to each province expert's proportion, 135 and 114 agricultural experts selected from Fars and Khuzestan provinces as sample group, respectively. Each province area was classified in three strata regarding its agricultural condition (appropriate, mediate and weak). Then proportional samples were selected in each stratum.

A questionnaire was used to collect required data when the reviews of literatures were carried out. Based on the theoretical framework the questionnaire comprised individual characteristics, experts and hidden variables with two to four questions or items – observability (OBS) (2 items), variables of attitude of confidence (AOC) and attitude (ATT) testable (3 items) and intention to use (INT), perceived usefulness (PU), perceived ease of use (PEOU), and compatibility (COM) (4 items). People commented on the study variables in the Likert spectrum with 5 scales from completely disagree (1) to completely agree (5). Table 1 shows conceptual definition of research variables.

Table 1. Conceptual definition of the research variables

Variable	Conceptual definition	Reference
Intention to use (INT)	The likelihood a person will employ a technology	Fishbin & Ajzen, 1975
Perceived usefulness (PU)	The degree to which a person believes that using a particular system would enhance his or her job performance	Davis, 1986
Perceived ease of use (PEOU)	The degree to which a person believes that using a particular system would be free from effort	Davis, 1986
Attitude to use (ATT)	The user's evaluation of the desirability of employing a technology	Fishbin & Ajzen, 1975
Triability (TRI)	The degree to which an innovation may be experimented with before adoption	Moore & Benbasat, 1991
Observability (OBS)	The degree to which the results of an innovation are observable to others	Moore & Benbasat, 1991
Attitude of confidence (AOC)	The attitude of having the ability to learn and use technology.	Adrian et al., 2005

To check validity and reliability, the pre-test questionnaire was filled in by a sample of 30 experts from outside of the main sample selection, in the shape of a pilot study. Reliability is the extent to which an experiment, test, or any measuring procedure yields the same result on repeated trials. Validity refers to the degree to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure. Ideas were collected to determine Cronbach's Alpha coefficient for determining the reliability of the questionnaire and theoretical framework variables. Cronbach's Alpha coefficient for the Variable Rate Irrigation Technology (VRIT) equals 0.66 and other information is expressed in Table 2. Necessary changes over the questionnaire were done and data was analyzed by SPSS software and LISREL.

Table 2. Validity and reliability of the research indicators

Variable / Indicator	Number of items	Reliability
NT	4	0.66
ATT	3	0.85
PU	4	0.66
PEOU	4	0.77
COM	4	0.77
TRI	3	0.63
OBS	2	0.77
AOC	3	0.86
Total	27	0.66

4. RESULTS AND DISCUSSION

4.1 Demographical Characteristics of Sample Experts

Sample experts were evaluated by a series of demographical characteristics such as: age, gender, experience, educational level, occupational category, field of study, and the city where they were working. The findings illustrated that the average age and experience of experts were 37.65 and 13.19 years, respectively. The range between the minimum and maximum age and experience was 45 and 36 years. About 15 percent of sample was post graduate experts, more than a third of sample's academic field was Plant Production, Agronomy or Plant Breeding, and the least were of Agricultural Extension and Education background. Experts working Central Agricultural Office comprised one third of sample individuals, while the highest number of experts were working those provinces were best condition in relation to agricultural production was prevailing.

Descriptive statistics related to the experts on each of these variables used in this study are listed in Table 3. The findings pointed out that all experts not only agree or completely agree with the use of these technologies (mean>3, according to Likert's 5 scale), but also they had high intention of use but their attitude of confidence (AOC) turns to moderate level of agreement which is minimum in comparison with other variables. Altogether, experts' opinions were in agreement for all of the research variables.

Table 3. Descriptive analysis of research model variables

	N	Minimum	Maximum	Mean	Std. Deviation
Attitude to use (ATT)	244	2.67	5.00	4.56	0.51
Perceived ease of use (PEOU)	240	2.00	5.00	3.35	0.70
Intention to use (INT)	240	3.00	5.00	4.29	0.45
Perceived usefulness (PU)	241	2.25	4.75	3.66	0.40
Compatibility (COM)	240	1.00	5.00	3.66	0.65
Triability (TRI)	242	1.00	5.00	3.58	0.69
Observability (OBS)	243	1.50	5.00	4.20	0.63
Attitude of confidence (AOC)	240	2.00	5.00	3.24	0.51

*: mean according to Likert's 5 scales (1-5 spectrums)

4.2 Estimating the Model of Investigating Attitude and Intention in the Usage of Variable Rate Irrigation Technology

A research model tests a kind of usage of structural equation models (SEM). SEM measuring model and structural model present the model variables. To measure the model, correlation between variables and the fitted model have been taken into account.

4.2.1 Measuring model

4.2.1.1. Correlation between variables

According to Table 4, there is a positive and significant correlation between intention to use, attitude to use, perceived usefulness and perceived ease of use. There is a significant causal correlation between attitude to use with intention to use ($p < 0.01$, $r = 0.46$). Also, the

relationship between perceived usefulness and perceived ease of use with the tendency to use found equal, approximately in 0.01 level of significance (respectively, 0.36 and 0.35). Findings were same for these two variables with attitude to use at 0.01 level of significance ($r_{PU}=0.22$ and $r_{EOU}=0.20$), while correlation coefficient between two variables of perceived ease of use and perceived usefulness was significant 0.05 level ($r=0.19$).

The significant correlation coefficient was achieved between results triability ($r=0.24$), observability ($r=0.43$) and attitude of confidence ($r=0.23$) with INT at 0.01 level. Additionally, the relationship between observability with attitude to use was significant ($p<0.01$, $r=0.25$). Also, the relationship between observability ($r=0.32$) and attitude of confidence ($r=0.24$) with PU was significant at 0.01 level, while correlation coefficient between triability and perceived usefulness was significant at 0.05 ($r=0.15$). Results represented a significant and positive relationship between triability ($r=0.41$), observability ($r=0.20$) and attitude of confidence ($r=0.29$) with PEOU at $p<0.01$ level.

In addition, Pearson correlation coefficient towards the usage of Variable Rate Technology-Irrigation (VRT-I) showed that the relationship between triability ($r=0.20$, $p<0.01$) and observability ($r=0.28$, $p<0.01$) with attitude of confidence was positive and significant (Table 4).

Meaningful correlation coefficient of moderator variables (PEOU, PU and ATT) with dependent variable (Intention to use) can be attributed to enhancing experts' awareness toward sustainable agriculture and variable rate irrigation technologies with regarding to spreading climate changes and drought in the country. Also, meaningful relationship of observability and triability with intention to use and perceived usefulness of VRT-I can be attributed to pragmatic and experimental characteristics of the agricultural experts.

Positive meaningful relationship between attitude of confidence (AOC) and perceived usefulness (PU) could be related to experts' good experience that lead to they have convinced they can use VRT-I actually. Besides, positive attitude of experts toward VRT-I reveals their tendency for applying such technologies to better and efficient use of water resources.

4.2.1.2 Fitted model

Estimation of measuring models, including test results of the model is listed in Table 5. Model fit indices that arbitration results are based, including Chi-square statistic (χ^2) with degrees of freedom (df), goodness-of-fit (GFI) and adjust goodness-of-fit (AGFi), normed fit index (NFI) and non-normed fit index (NNFI), comparative fit index (CFI), root mean square residual (RMR), root mean square error of approximation (RMSEA) and multiple correlation coefficient square explaining that the index value for each minimum are necessary in this step (Jöreskog and Sörbom, 1983; Gefen et al., 2000; Markland, 2006).

The results showed that division of Pearson Chi-square over degrees of freedom (χ^2/df), the usage of VRT-I was 0.78 a numerical value and probability (p -value) was 0.85, higher than 0.05 which should be. Root mean square error of approximation (RMSEA) and root mean squared residual (RMR) also are measured less than 0.10 and 0.05. Considering Table 5, it can be concluded that perceived ease of use, perceived usefulness, attitude and intention to use, additional to four variables of compatibility, triability, observability and attitude of confidence may be well combined in a model for explaining attitude and intention to use of experts toward VRT-I in two provinces.

Table 4. Correlation coefficients between research model variables in relation to variable rate irrigation technology

	Intention to use	Attitude to use	Perceived usefulness	Perceived ease of use	Compatibility	Triability	Observability	Attitude of confidence
Intention to use	1.00							
Attitude to use	.463**	1.00						
Perceived usefulness	.361**	.222**	1.00					
Perceived ease of use	.352**	.200**	.192**	1.00				
Compatibility	-0.10	0.07	-0.04	-.200**	1.00			
Triability	.244**	0.12	.147*	.410**	-.152*	1.00		
Observability	.430**	.254**	.316**	.198**	0.07	.200**	1.00	
Attitude of confidence	.225**	0.04	.226**	.285**	-.132*	.281**	0.09	1.00

* Significant in 0.05, **Significant in 0.01

According to measurement model and suggested indices in Table 5, can conclude that variables which used in the research model could introduce an appropriate model toward VRT-I based on experts' viewpoint in the research area. Overall, the goodness-of-fit measures indicated an adequate fit.

Table 5. Fitted indices for variable rate technology-irrigation

Fit indices	Index*	Results in this survey
t^2/df	≤ 3	0.78
<i>p-value</i>	≥ 0.05	0.85
NFI	≥ 0.90	0.98
NNFI	≥ 0.90	1.00
CFI	≥ 0.90	1.00
GFI	≥ 0.90	0.99
AGFI	≥ 0.90	0.97
RMR	≤ 0.05	0.019
RMSEA	≤ 0.10	0.000

*Jöreskog and Sörbom, 1983; Geffen et al., 2000; Markland, 2006

4.2.2 Structural model

The analysis of experts' opinions in Fars and Khuzestan expressed relations between the variable rate technology-irrigation with compatibility, triability, attitude of confidence (at 0.01 level of significance) and observability (at 0.05 level of significance) which had a direct effect on experts' perception toward ease of use. Triability was found to be most effective variable on PEOU ($p < 0.01$, $\beta = 0.28$). The second effective variable was attitude of confidence had a direct effect on PEOU towards the usage of VRT-I ($p < 0.01$, $\beta = 0.18$). Observability also affected experts' perceived ease of use towards the usage of VRT-I in two provinces, and the path coefficient for the variables mentioned above could predict 21% of variability in perceived ease of use ($SMC = 0.21$). The same findings were also reported by Adrian et al. (2005).

Moreover, the causal relationship between observability and attitude of confidence –two independent variables of this study– with perceived usefulness as a dependant variable, have predicted 16% of experts' perceived usefulness for the usage of VRT-I ($SMC = 0.16$). Observability with path coefficient of 0.25 has a most direct effect on perceived usefulness and was significant at 0.01 level ($p < 0.01$, $\beta = 0.25$). Also, path coefficient of attitude of confidence and perceived usefulness was significant at 0.05 level ($p < 0.05$, $\beta = 0.16$).

Analysis about the path coefficient between independent variables of compatibility, triability, attitude of confidence and observability and moderate variables of perceived ease of use and perceived usefulness with VRT-I indicated observability had the most significant direct effect on VRT-I ($p < 0.01$, $\beta = 0.26$). Indeed, not only perceived usefulness had less direct effect than observability, but also it was significant at 0.05 level ($p < 0.05$, $\beta = 0.14$). Observability, perceived ease of use and perceived usefulness predicted 9% of VRT-I variations ($SMC = 0.09$). The results regarding the positive and significant casual relations between perceived usefulness and attitude to use were in quick agreement with the findings of Hung et al. (2006), Chang (2004) and Karahanna et al. (1999).

Based on casual relations between independent or external variables of compatibility, triability, observability, attitude of confidence and moderate variables of perceived ease of use, attitude to use, perceived usefulness with the dependent variable intention to use of VRT-I a positive relationship was obtained. Attitude to use was found as the most influential variable for experts' intention to use of VRT-I in both provinces ($p < 0.01$, $\beta = 0.33$). The next influential variable was perceived ease of use which was significant at 0.01 level ($p < 0.01$, $\beta = 0.20$). Perceived usefulness directly affected on tendency to use of this technology and its relation to attitude to use was significant at 0.05 level ($p < 0.05$, $\beta = 0.15$). From independent or exogenous variables observability had significant direct effect on intention to use ($p < 0.01$, $\beta = 0.24$). All together, these four variables predict 40% variances of experts' intention to use (SMC= 0.40) (Fig. 3).

Considering study findings, there are two remarkable points toward experts' intention to use of VRT-I. The strong significant correlation between attitude to use and intention to use is the first one and second is significant casual relation between exogenous variable of observability and intention to use. According to Fig. 3, observability is a variable directly affecting PEOU, PU, ATT and intention to use towards VRT-I. It also has the significant and positive path coefficient. The importance of observability on technology acceptance has already been mentioned by Rogers (2003) and Karahanna et al. (1999). The positive significant casual relation between perceived ease of use and perceived usefulness is mentioned by Mahadeo (2009), Shroff et al. (2011) and Aggorowati et al. (2012). The finding Shroff et al. (2011) and Al-Hujran et al. (2011) support current research that demonstrates the positive significant causal relationship among perceived ease of use and attitude to use. Indeed, the positive significant casual relation between perceived usefulness and perceived ease of use with intention to use deduced from this study has also been reported of Schepers and Wetzels (2007), Wangpipatwong et al. (2008), Miler and Khera (2010), Azim and Bee (2010) and Optize et al. (2012). Also, a positive significant casual relation between attitudes of use with intention to use confirmed previous findings of Schepers and Wetzels (2007), Karahanna et al. (1999), Mahadeo (2009) and Al-Hujran et al. (2011).

With regarding to structural model results, the variable of attitude to use is the most effective variable on experts' intention. The exogenous variable of observability has the most direct effect on attitude to use and perceived usefulness. Meanwhile, the variable of observability has the most direct effect on intention to use of VRT-I after the variable of attitude to use.

The variable of triability (TRI), in compare to other exogenous variables, has the most direct effect on experts' perceived ease of use (PEOU) and it also has indirect effect on intention to use (INT) as dependent variable, in this way. Attitude of confidence (AOC) and observability (OBS) variables by effecting on perceived usefulness (PU), indirectly effect on attitude and intention to using VRT-I.

The variables of observability (OBS) and perceived usefulness (PU) by direct affecting on attitude to use (ATT), indirectly effect on experts' intention to use (INT). In other word, the results show that perceived usefulness (PU) and observability (OBS) all indirectly influence the behavioral intention to use (INT) through attitude to use.

Altogether, the explained variances (R^2) of attitude to use, perceived usefulness and perceived ease of use of VRT-I have low impressionability. But, impressionability of intention to use is acceptable in the model.

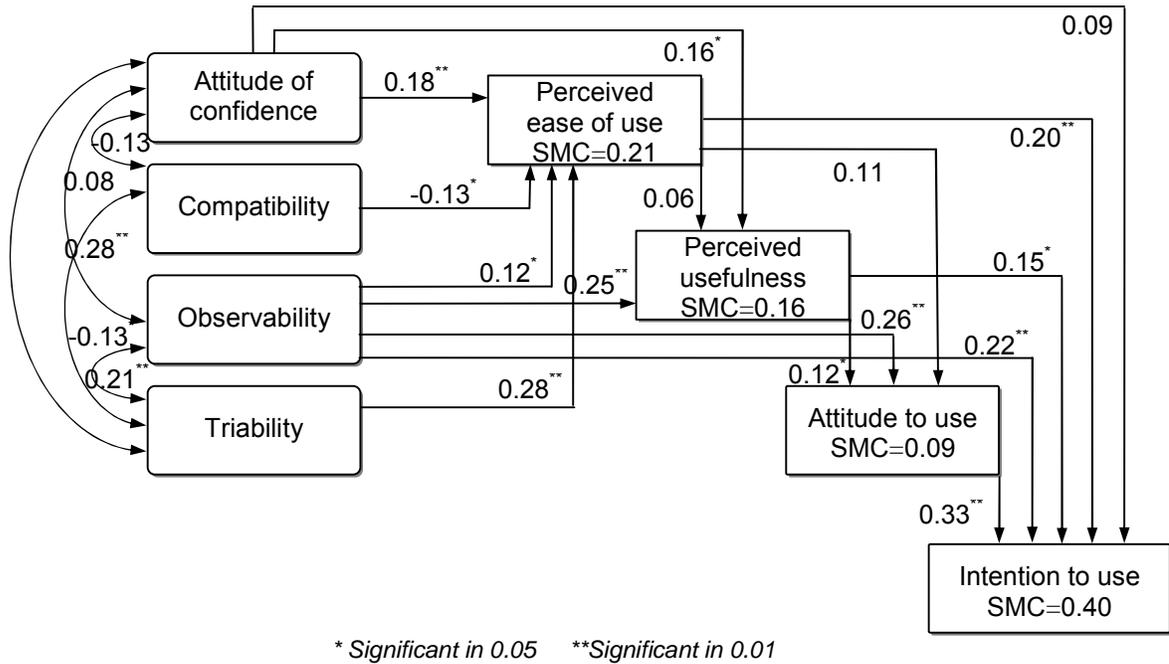


Fig. 3. SEM analysis of research model

5. CONCLUSION

This study was successful adding some variables in Davis's TAM and made it more complete. Iranian Experts' attitude to use and observability have the most effect on experts' intention to use VRT-I, and observability has most causal relationship with attitude to use and perceived usefulness in compare to other variables. It shows indirect effect of that on intention to use of VRT-I. According to findings, attitude to use, perceived usefulness and perceived ease of use receive a little impact from model's variables and the explained variances of intention to use has acceptable in model.

These findings can help change agents, (such as Extension Agents and Subject Irrigation Special Matter and Experts) to provide appropriate training and services to improve intention toward utilizing variable rate irrigation technology.

The recommendation is to assess the attitude of farm managers and productive cooperative chairmen toward VRT-I, and to put priorities for planning these educational packages must be focused on: demonstrating these technologies practically, conducting workshops in a way addressing to technologies application, comparing the actual result of these technologies usage with current irrigating systems such as droplet irrigation, and executing periodical training courses based on farming system research approach.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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