Effects of Manufacturing and Non-Manufacturing Occupations on Smart Manufacturing Technology Acceptance – UTAUT2 Model Perspective

Sung-Yoon Chei, Yen-yooYou, Keo Young Song, Ji Sung Kim, Mun-Seok Cho

Abstract: ***The model theory of TAM and UTAUT1, UTAUT2 identified performance acceptance, effort expectancy, facilitating conditions, social influence and price value, hedonic motivation and habit factor as factors of technology acceptance.***

Methods/Statistical analysis: In order to measure the influence of the technology acceptance factor of smart manufacturing technology emerging from the 4th industrial revolution, we constructed four measurement items and created a total of 50 questionnaires. Survey subjects were SME workers, managers, managers and Smart Convergence Researchers across Korea.

Findings: The results of the study show that the expectation, facilitation requirements, hedonic motivation, price value accept the technology through hedonic motivation and price value. Also, there was no difference in accepting technology according to manufacturing or non-manufacturing occupation group. For smart manufacturing technology, hedonic motivation and cost saving were effective and there was no difference according to occupation group.

Improvements/Applications: This study categorizes technology acceptance factors of smart manufacturing technology related to the 4th Industrial Revolution and interprets it as helpful to identify effective factors to accommodate more advanced technology in the future.

Keywords: Technology acceptance factors, TAM, UTAUT, Fourth Industrial Revolution, Smart Manufacturing Technology, Moderate effect

I. INTRODUCTION

Through TAM and UTAUT model theory, it was confirmed that there are eight factors of technology acceptance factors by Bagozzi and Venkatesh et al.: effort expectation, performance expectation, facilitating condition, social influence, experience, gender, age, voluntariness of use[1,2,3]. However, there are differences in technology acceptance factors depending on the nature of the technology. Research on technology acceptance factors of smartphone, internet, IT technology and various advanced new technologies has been studied. Among them, studies on technology acceptance factors of smart manufacturing technology, which is a technology related to the fourth revolution, are important in the times. This study is also important for the education and policy direction of smart manufacturing technology.

TAM (Technology Acceptance Model), this mode was first introduced in 1987 by Davis and Bagozzi to explain and predict usage behavior for users who use a variety of information technologies. TAM model is shown below as Figure 1. Efforts to understand why people accept or reject new information technologies are among the most important areas of research into new technologies[4]. Davis, Bagozzi's proposed technology acceptance model was largely based on Fishbein and Ajzen[5]. Ajzen's theory of reasoned action based on social psychology of TRA and Ajzen Theory of Planned Behavior (TPB) is based on three theories, and many studies that predict future consumer behavior on technology acceptance are based on these three theories[6]. In particular, since Davis and Bagozzi (1989) have shown that perceived usage easiness and perceived usefulness are factors that influence usage intention and usage behavior, many studies have shown that perceived easiness and perceived usefulness influence the acceptance of technology Proved to be a factor.

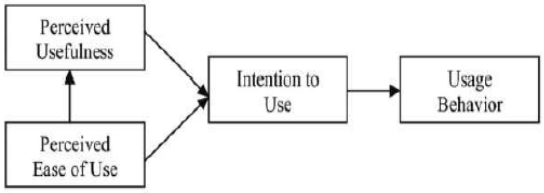

Figure 1.Technology Acceptance Model, TAM Model

UTAUT, Unified Theory of Acceptance and Use of Technology is technology acceptance model and first introduced in 1987 as TAM based on TAM2, TAM3, TRA (Theory of Reasoned Action, Reasoned Behavior) through research that subdivides the influence relationship of technology acceptance factors according to characteristics of industry,

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(Theory of Planned Behavior), MPCU as Model of Personal Computer Utilization, Roger's innovation diffusion model, Ram's Model of Innovation Resistance, MM (C-TAM-TPB) (combining the technology acceptance model and the planned behavioral theory), Venkatesh, Davis's UTAUT for Unified Theory of Acceptance and use of technology[7]. The UTAUT model presented by Venkatesh in 2003 showed that technology acceptance factors of IT and information technology are related to performance expectation, And the control factors of age, gender, experience and voluntary use. Especially, the model of UTAUT is more active in information technology and IT related technology than TAM. As smart manufacturing technology is a convergence of general manufacturing technology and advanced IT technology, it seems that UTAUT model can analyze technology acceptance factor better than TAM model. UTAUT model is below for Figure 2.

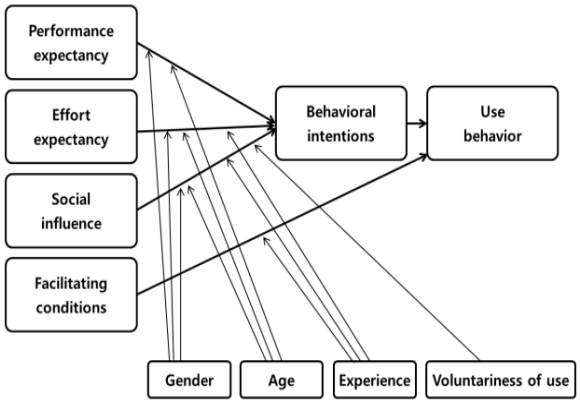


Figure 2.Unified Theory of Acceptance and Use of Technology, UTAUT Model

UTAUT 2 (Extending UTAUT) explained that Information technology usage and technology acceptance factors were one of the most important researches in the early information system research[8]. The UTAUT and TAM models have been used to identify eight factors of technology using. UTAUT has largely identified key factors in predicting the intent and behavior of technology using in the organizational societies. Since then, much research has been done to prove this. In 2012, VENKATESH revised it to develop the EXTENDING UTAUT model. The changes in the existing UTAUT technology acceptance factors are as follows. First, it is confirmed that EFFORT and PERFORMANCE EXPECTANCY which are utility factors, consistently appear as the most powerful elements. Motivation is also a key variable in many consumer behavior research and consumer technology use environment studies. Therefore, it was confirmed whether it is a factor of accepting technology by adding hedonistic motivation factor[3]. Second, in terms of effort expectations and usefulness, the members are trying to measure and evaluate the time and effort for using technology. Therefore, the price and cost of using technology should be regarded as an important factor[3]. UTAUT 2 is the addition of price value and hedonic motivation factors to the existing UTAUT model. UTAUT2(Extending UTAUT)model is below as Figure 3.

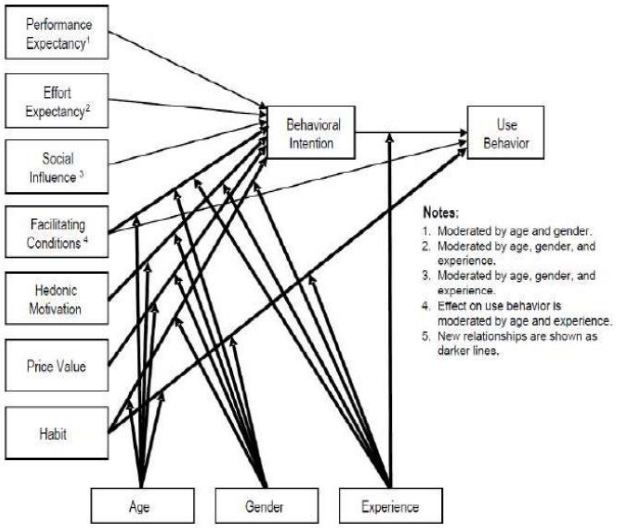


Figure 3.EXTENDINGUTAUT (UTAUT 2) Model

To summarize the above, Technology Acceptance Factors is explained as follows; The UTAUT and UTAUT2 model accepts seven factors with Table 1: effort expectancy, performance expectancy, facilitating conditions, social influence and price value, hedonic motivation, habit. Among these, factors introduced as perceived ease of use in the TAM model have been renamed to effort expectations and perceived usefulness to performance expectations. For these factors, prior studies have further verified each factor under various circumstances[9,10]. And out of the seven elements of UTAUT 1,2 models proposed by Venkatesh, we were selected as technology acceptance factors, effort expectancy, hedonic motivation, facilitating conditions, and price value. Based on the above argument for technology acceptance, we examined the differences between the manufacturing industry and other types of industries by examining the differences in factors that affect the acceptance factor of smart manufacturing technology.

Table 1. Modified UTAUT model Variables Definition for Smart Manufacturing Technologies

Variables	Operational definition	References
Effort Expectancy	easiness degree associated with the system's usage	Venkatesh, 2003
Facilitating Conditions	the degree to which individuals think there is a technical and systematic infrastructure to support the use of the system	Venkatesh, 2003
Hedonic Motivation	Pleasure or fun with technology use	Brown and Venkatesh, 2005
Price Value	Cost Advantage or Relative Advantage. Cost savings expected when adopting the technology / The degree to which innovation is perceived as better than its predecessor	Smyth, P.,2009/ Moore and Benbasat , 1991

Behavioral Intention	Significant positive influence on technology usage	Venkatesh, 2003
Use Behavior (Perceived Behavioral Control)	Subjective control over the performance of the behavior itself	Ajzen, I., 2002

II. MATERIALS AND METHODS

To collect questionnaires to measure the influence of technology acceptance factors, we recruited workers, managers, managers and smart convergence researchers working or living in SMEs throughout South Korea by convenience extraction method. Questionnaires were collected online and distributed to this group. We modified all of the previously validated measures to accommodate smart manufacturing technology acceptance factors. A total of 7 questionnaires were distributed to 50 items by constructing four measurement items according to Effort Expectance, Hedonic Motivation, Price Value, Facilitating Conditions, Behavioral Intention and Use Behavior, variables from UTAUT and UTAUT2. After distributing questionnaires to the study group, 231 copies were finally collected.

III. RESULTS AND DISCUSSION

Exploratory factor analysis and Confirmatory Factor Analysis was conducted on variables related to technology acceptance factors as Table 2 and Table 3. All measured variables used principle component analysis to extract constructive factors. In order to simplify the factorial placement, the ortho rotation method (varimax) was adopted. The parameter selection was based on the Eigen value of 1.0 or more and the factoriality of 0.4 or more. The total variance explained was 79.2%, which is the same as the previous study. The Cronbach 's α for each variable ranged from .915 to .921, indicating that the reliability was very high (Cronbach α> 0.8).

Table 2. Exploratory factor analysis

Variables		Measurement question	1	2	3	4	5	6
Independent variable	Hedonic Motivation	inno 3	.887					
		inno 2	.858					
		inno 4	.828					
		inno 1	.812					
	Effort Expectance	effort 3		.921				
		effort 2		.911				
		effort 4		.836				
		effort 1		.784				
	Price Value	cost 4			.913			
		cost 3			.839			
		cost 2			.828			
		cost 1			.723			
	Facilitating Conditions	facil 2				.896		
		facil 1				.868		
		facil 3				.784		
		facil 4				.760		
Dependent variable	Use Behavior	behav 3					.787	
		behav 2					.741	
		behav 4					.680	
	Behavioral Intention	intention 3						.680
		intention 4						.674
		intention 1						.614
Cronbach α coefficient			.918	.918	.915	.917	.919	.919

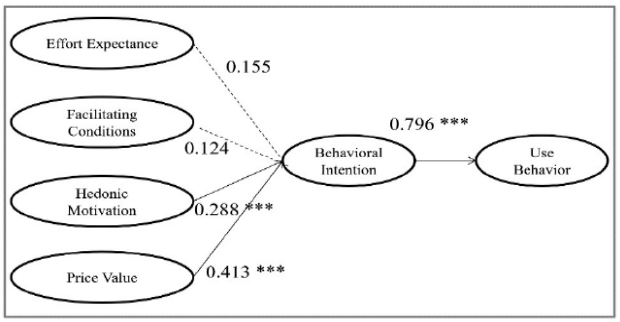
Table 3. Confirmatory Factor Analysis

Variables		Standardization Coefficient	Standard error	t-value	p	AVE	C.R.
Effort Expectance	effort 2	0.984	0.023	15.796	***	0.84721772	0.98
	Effort 3	0.909	0.135	-	-	0.82737075	0.977
Facilitating Conditions	Facil 3	0.936	0.149	12.187	***	0.82190792	0.976
	facil4	0.898	0.21	-	-	0.81537936	0.975
Hedonic Motivation	inno1	0.908	0.125	21.449	***	0.81227568	0.975
	inno2	0.866	0.215	19.187	***	0.79707127	0.972
	inno3	0.927	0.099	22.532	***	0.79938076	0.973
	inno4	0.897	0.165	-	-	0.78584016	0.967
Price Value	cost 2	0.849	0.22	16.873	***	0.77863283	0.961
	cost 3	0.877	0.192	17.922	***	0.7809912	0.955
	cost 4	0.901	0.19	-	-	0.77638551	0.945
Behavioral Intention	intention 1	0.746	0.147	-	-	0.76509926	0.929
	intention 3	0.819	0.211	10.69	***	0.75719783	0.903
Use Behavior	behav 2	0.709	0.202	8.269	***	0.75503268	0.86
	behav 4	0.759	0.148	-	-	0.79560298	0.796

The model was analyzed using AMOS 20.0 and Maximum Likelihood Estimation (MLE) was used. As a result of analyzing the fit of the model as Table 4 and Figure 4, the p-value for x^2 is 0.000, which is statistically significant. In the field where continuous research is conducted in general, the index of CFI, GFI, NNFI, However, in the case of the field where research is not active, most of the fitness values are between 0.8 and 0.9, which is a satisfactory model.

Table 4. Fitness test

Fit index	χ^2(p)	df	CMIN/DF	GFI	AGFI	CFI	NFI	IFI	TLI	RMR	RMSEA
Measure	237.084	79	3.001	.887	.829	.941	.914	.941	.921	.034	.080
standard	Over .05	-	Below 3	more than .8	more than .8	more than .9	more than .9	more than .9	more than .9	Below .05	Below .08
Estimation	-	-	Good	Fitness	conformation	conformation	conformation	conformation	conformation	conformation	conformation



The solid line represents the significant path
* P<.05 ** P<.01 *** P<.001

Figure 4. Path coefficient

Among the four variables, Effort Expectance and Facilitating Conditions requirements are insignificant in the degree of influence on Behavioral Intention, and Price Value, Hedonic Motivation have a significant effect on Behavioral Intention, and also Behavioral Intention has a positive effect on Behavioral Intention. The result was shown by Table 5.

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Intention -> Use Behavior				

Table 5. Research hypothesis test result

Variables	Standardization Coefficient	S.E.	C.R.	p
Effort Expectance-> Behavioral Intention	0.155	0.036	2.278	0.023
Facilitating Conditions-> Behavioral Intention	0.124	0.032	1.787	0.074
Hedonic Motivation -> Behavioral Intention	0.288	0.042	3.561	***
Price Value -> Behavioral Intention	0.413	0.035	5.601	***
Behavioral	0.796	0.100	8.315	***

It is also important to consider whether the acceptance factors and the degree of influence vary depending on the group of companies involved in the results of the study. The degree of acceptance and application of technologies may vary depending on the manufacturing, production and management sectors. Therefore, in this study, we divided the group into the manufacturing industry and the non - manufacturing industry based on the respondent 's engaged business group in order to verify the moderating effect in the potential human relations by the group of enterprises. In the split group, the constraint model with the same path constraint of the two groups and the non-constraint model with the free path of each group were analyzed together to confirm their respective control effects. The constraint model with the same path coefficients of the manufacturing group (n = 102) and the non - manufacturing group (n = 129) was established and compared with the non - constrained model. It's shown by Table 6 below.

Table 6.Verification of control effect between groups

	Standardization factor		S.E.		C.R.		p	
	Manufacturing Group	Non-Manufacturing Industry Group	Manufacturing Group	Non-Manufacturing Industry Group	Manufacturing Group	Non-Manufacturing Industry Group	Manufacturing Group	Non-Manufacturing Industry Group
Effort Expectance-> Behavioral Intention	0.172	0.114	0.042	0.053	1.787	1.234	0.074	0.217
Facilitating Conditions-> Behavioral Intention	0.104	0.086	0.043	0.042	0.947	0.936	0.344	0.349
Hedonic Motivation->Behavioral Intention	0.798	0.257	0.079	0.058	4.164	2.558	***	0.011
Price Value->Behavioral Intention	-0.144	0.493	0.053	0.05	-1.151	4.939	0.25	***
Behavioral Intention ->Use Behavior	0.843	0.91	0.182	0.132	5.666	6.902	***	***

The significance level for the constraint model was .044, which is p <.05. Therefore, there was no measurement equality between manufacturing and non - manufacturing group. This result implies that there is no difference in the degree of influence on the intention to use according to the technology acceptance factor between manufacturing and non - manufacturing group.

IV. CONCLUSION

Among the various technologies of the Fourth Industrial Revolution, it was found that price value and hedonic motivation among the expectations of expectation, promotion requirements, price value and hedonic motivation influenced the adoption of smart manufacturing technology. The degree of ease of operation and social and systemic facilitation requirements appear to be less influential. When smart manufacturing technology saves money and feels fun and entertainment in technology use, it appears to be more aggressive in accepting technology. There is also a need to study more about how changes can be made when it comes to improving the productivity or convenience of your direct business productivity.

There seems to be no difference in the degree of acceptance of technology according to the manufacturing industry and non - manufacturing industry. This is a manufacturing-related technology, so it is necessary to check whether it differs

from the use of household appliances or personal digital devices. These findings suggest that education and policy directions to accelerate the acceptance of the fourth revolutionary technology and smart manufacturing technology may be considered.

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