A META-ANALYSIS OF ADVANCED UTAUT VARIABLES IN THE ICT INDUSTRY: AN ANALYSIS OF PUBLISHED PAPERS IN KOREAN JOURNALS

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Abstract. *The unified theory of acceptance and use of technology (UTAUT) has improved the technology acceptance model (TAM), and it is a model that has been presented and used recently in various fields of research to accept new technologies and new products. In this study, the results of main and additional variables are presented and analyzed through a meta-analysis of variables used in UTAUT research. The meta-analysis showed that hedonic motivation, attitude, and perceived enjoyment showed a high effect as additional variables. Security was also shown to be highly utilized but the effect size was small, which means that careful attention needs to be paid to the choice of variables. We analyzed the Korean information and communication technology (ICT) industry and presented the results of key variables in the ICT industry. Our results showed that the ICT service industry has a high effect size with attitude, security, and innovativeness.*
Keywords: UTAUT, Meta-analysis, ICT industry, Hedonic motivation, Attitude

1. **Introduction.** The rapidly changing industrial environment and the development of information and communication technology (ICT) have had a great impact on individuals and corporations. Therefore, many researchers are making efforts to identify and understand the factors that influence the behavioral intention and behavior of companies and individuals. The most commonly used research model is the technology acceptance model (TAM) [1]. However, there was no clear presentation of external variables. Thus, criticisms of excessive deformation and expansion of models also occur [2]. Additionally, the recent emergence of a fourth industrial revolution, smart factory, and related technologies required a research model with higher explanatory power. In addition, UTAUT has higher explanatory power than TAM, and studies are being conducted in various fields related to adoption and acceptance of new technology [3-5]. Therefore, it is necessary to study UTAUT, which is most recently presented and has a higher explanatory power, regarding the adoption and diffusion of new technology and new products [3]. Instead of using the original theory, there are many studies that utilize a fusion model with addition of variables suitable for research subjects and models of other research. However, a meta-analysis or systematic review of UTAUT's original theory based on citation studies, empirical studies, and contradictory results are not enough. Korea also has the position as the global ICT leader and it has ranked in the first place six times since 2010, according to the ICT development index (IDI) announced by International Telecommunication Union (ITU). Therefore, it is necessary to confirm the main variables and the UTAUT variables via a meta-analysis of the UTAUT research conducted in Korea.

There are three purposes of this research. Firstly, a UTAUT meta-analysis was performed to identify variables that have a significant influence on acceptance intention and acceptance of services using new technologies such as smart factory-related technology, AR (augmented reality), VR (virtual reality), SNS (social network service), and mobile apps, and new products such as a smart device, wearable device, and smart TV. Secondly, we identified the main and additional variables using the ICT industry classification, and compared the effect sizes of these variables. Thirdly, we examined the difference through comparing the previous studies applying original theory and meta-analysis. This research is structured as follows. In Section 2, we examine previous studies on UTAUT and meta-analysis; Section 3 provides an overview of the research methodology; Section 4 presents the analysis results; Section 5 shows the explanations of the conclusions, limitations, and future research direction.

2. Theoretical Background.

2.1. **Previous research on UTAUT meta-analysis.** UTAUT has been actively researched in various fields, but UTAUT meta-analysis research is lacking. Dwivedi et al. reviewed 27 studies between 2007 and 2010 [6], and Taiwo and Downe analyzed 37 studies between 2003 and 2011 [7]. Overall, the size of the effect shown by Taiwo and Downe was larger. However, the effect of BI on UB was similar for both studies (see Table 1). The previous study only performed path analysis for UTAUT major variables. Therefore, there is a lack of analysis on additional variables and industrial classification. In this study, the additional variables used in UTAUT were analyzed, and the research subjects were classified by ICT industry. Table 1 shows a comparison of previous research on UTAUT meta-analysis.

TABLE 1. A comparison of the previous research on UTAUT meta-analysis

Researcher	Dwivedi et al. [6]			Taiwo and Downe [7]		
Number of papers	27			37		
Pathway	d	k	n	d	k	n
Performance Expectation → Behavioral Intention	.343*	8	4,170	.536***	37	11,057
Effort Expectation → Behavioral Intention	.140*	8	4,170	.436***	36	10,995
Social Influence → Behavioral Intention	.231*	10	4,453	.424***	31	9,304
Facilitating Condition → Use Behavior	.165*	6	1,846	.377***	13	3,048
Behavioral Intention → Use Behavior	.405*	3	1,990	.436***	13	3,048

* d: effect size, k: number of papers, n: sample size * *p < 0.05, **p < 0.01, ***p < 0.001
* Effect sizes classification is based on Cohen's [8], small (.1 < d ≤ .3), medium (.3 < d ≤ .5), large (.5 < d)

2.2. **UTAUT.** TAM presented by Davis et al. is a widely used research model for understanding adoption and diffusion of new technology [9]. However, there is a limit to the use of some variables or variants of the research model because there is no explicit external variable presented [2]. To solve this problem, Venkatesh et al. presented UTAUT by integrating eight existing theories [3]. The basic structure of UTAUT is the intention of the user's behavior using the external variable, which leads to use behavior. External variables that affect the behavioral intention (BI) are performance expectancy (PE), effort expectancy (EE), and social influence (SI). The variables that influence use behavior (UB) are the facilitating condition (FC) and BI, which measure and describe the effects of each.

TABLE 2. Definitions of variables

Variable		Definition
PE	Performance Expectancy	The degree to which we believe that we can help improve work performance by using new technologies, new products, and new services.
EE	Effort Expectancy	The degree to which users believe that they can easily use new technologies, new products, and new services.
SI	Social Influence	The degree to which people in important neighborhoods believe that they should use new technology, new products, new services, etc.
FC	Facilitating Condition	The degree to which we believe that our organizational and technical infrastructure is well-equipped to support the use of new technologies, new products, and new services.
BI	Behavioral Intention	The degree of intention or plan to use new technology, new products, new services, etc.
UB	Use Behavior	What appears as actual behavior or performance.

Additionally, BI is moderated by moderating variables such as gender, age, experience, and voluntariness of use. The definitions of the variables are shown in Table 2.

2.3. **Meta-analysis.** A meta-analysis is an attempt to identify the concept as a whole by synthesizing the results of individual studies, and to analyze a large number of results using statistical methods [10]. Hanford and Hattie described meta-analysis as a quantitative statistical method to represent multiple studies using the same measurements [11]. Zhao reanalyzed the data, examined each analysis method and process, and defined the comprehension of contents found through comparison and evaluation based on usefulness [12]. The purpose of a meta-analysis is to organize and integrate generalized knowledge on specific research models, research fields, and industrial categories. Additionally, it is a research method leading to an integrated conclusion through the process of statistical summarization, analysis and inference of the results of individual empirical studies. Characteristics of the meta-analysis are as follows: 1) summary statistics through data integration are used from a quantitative viewpoint; 2) when calculating the effect size, the results of research are converted, using different scales and methods into common units and compared in an integrated manner; 3) general conclusions can be derived [10].

3. **Research Methodology.**

3.1. **Research object.** This study is based on the main variables (PE, EE, SI, FC, BI, UB) of UTAUT. The variables affecting BI are independent variables (PE, EE, SI, FC), and the variables that affect UB (FC, BI) are used as parameters. The research objects are papers published from 2003 to April 2017.

3.2. **Data collection.** The research data were collected from academic journals and research papers registered in the Korean Journal Database. We also searched for papers that included "UTAUT" or "Unified Theory of Acceptance and Use of Technology" in the title or keywords of the paper. A total of 144 papers were identified through the search, and the final 69 papers were selected for the study based on the following criteria:
   1) Whether to use the UTAUT main variables;

2) Whether there is a value that can output the effect size correlation coefficient, t-value, or sample size.

As a result of the analysis, the UTAUT paper was first published in 2008, and the research has been actively proceeding since 2012 (see Table 4).

3.3. **Data coding.** To prevent coding errors in the collected papers, it is necessary to collect and organize information by applying consistent standards. In this case, using the coding table is a way to increase the reliability [13]. This study coded all of the main attributes (paper attributes, variable attributes) used in the meta-analysis to characterize individual studies. Paper attributes include the serial number of the paper, author, topic, journal, and publication year. Variable attributes include research variables, sample size, correlation coefficient, and t-value.

3.4. **Calculation of effects size.** In a meta-analysis, the values presented in the individual studies are different, so the effect size (d) converted to a standardized value is used. As a representative method, the correlation coefficient is represented by the effect size and standardized mean difference. A recent study [14-16] showed a method that conversion to Fisher's Z_i using correlation coefficients [17] is preferred. In this study, the effect size was calculated using the correlation coefficient. The calculation of effects size is as follows:

1) Calculate Fisher's Z_i (Equation (1)) using the correlation coefficient (r_i);
2) Obtain the weight W_i (Equation (2)) using the sample size (v_i);
3) Calculate the adjusted Fisher's Z_i' (Equation (3)) to obtain a unified value for individual research;
4) Calculate the average effect size (d_i, Equation (4)) for each variable, and Table 3 shows the definition of abbreviations.

$$Z_i = 0.5 \times \ln((1 + r_i)/(1 - r_i)), \text{ where } r_i \text{ is an individual correlation coefficient} \quad (1)$$

$$W_i = 1/(v_i - 3), \text{ where } v_i \text{ is an individual sample size} \quad (2)$$

$$Z_i' = Z_i \times W_i \quad (3)$$

$$d_i = \sum Z_i' \Big/ \sum W_i \quad (4)$$

TABLE 3. Definition of abbreviation

Abbreviation	Definition
Z_i	Fisher's Z of the ith individual papers
W_i	Weight of the ith individual papers
v_i	Sample size of the ith individual papers
r_i	Correlation coefficient of the ith individual papers
Z_i'	Adjusted Fisher's Z of the ith individual papers
d_i	Average effect size of the ith individual papers

3.5. **Verification of homogeneity and publication bias.** We verified the homogeneity (Q) to analyze whether the effect sizes of individual studies to be included are values extracted from the same population. In effect size testing, the fixed effect model is used when the null hypothesis that the subject is extracted from the same population, and the random effect model is used when the null hypothesis is rejected. However, the most important consideration was that the researchers should decide whether the research objects have heterogeneity [18]. In addition, we verified the publication bias to secure the reliability of the research results. Publishing bias is a statistical test, assuming that it is

published, because statistically insignificant studies tend not to be published [18]. Fail-safe N (N) which is used in publishing bias refers to the number of missing studies to make the significance of effect size insignificant. This study used the method of Rosenthal, and if N was larger than $5k + 10$ (k is the number of papers), it did not affect the overall effect size [19].

4. **Results of Analysis.**

4.1. **Basic statistics.** The papers utilized in the analysis of this research were first published in 2008 as shown in Table 4. In addition, it was confirmed that many researches were conducted since 2012. ICT service, ICT device, and ICT software (including the mobile app) are classified into three categories according to the classification system of the ICT industry in Korea [20]. Table 4 shows the annual publication status by ICT industry. ICT Software is the most active in research followed by ICT Service, and ICT Device.

TABLE 4. Annual publication status by ICT industry

Industrial Classification	'08	'10	'11	'12	'13	'14	'15	'16	'17	**Total**
ICT Service		2	2	4	3	4	5	2	1	**23**
ICT Device				2	1	1	3	4		**11**
ICT Software	1		1	4	6	4	5	9	2	**32**
Etc							2	1		**3**

A summary of the variables used in the research identified 57 variables except BI and UB which were used as mediating or dependent variables (see Table 5). The main variables (PE, EE, SI, FC) of UTAUT were used frequently, followed by security, innovativeness, trust, and self-efficacy.

TABLE 5. Number of papers in which each variable is represented

Variables	Number of papers	Variables	Number of papers
Performance Expectancy	66	Hedonic Motivation, Price Value	7
Effort Expectancy	64	Attitude, Perceived Enjoyment	6
Social Influence	63	Information Attributes, Service Expectancy, Satisfaction, Experience	5
Facilitating Condition	52	System Attribute (suitability), Product Feature (usability), Perceived ease-of-use	4
Security	19	Habit, Product Feature (aesthetic), Innovation Resistance	3
Innovativeness	13	Compatibility and 5 other variables	2
Trust, Self-efficacy	9	Mobility and 28 other variables	1

4.2. **Results of the meta-analysis.** The "meta" package of the R studio (Ver.1.0) was used in the analysis. The random effects model was used because of the characteristics of the research objects (such as the measurement method and the period) and the heterogeneity of the effects size. Table 6 is a table for analyzing the relationship between the variables that constitute UTAUT through meta-analysis and classifying the analysis of variables presented more than six times through meta-analysis in the previous study.

TABLE 6. Description of classifying the analysis of variables

Name	Description
Main	Metaanalysis based on variables of UTAUT original theory
Additional	Meta-analysis based on variable with high occurrence frequency through analysis of previous research (More than 6 times)

The results of the main variable analysis are shown in Table 7. PE, EE, SI, and FC which influence BI were more used. A relatively small number of studies have been conducted on FC and BI affecting UB. The effect of BI on UB and the influence of PE on BI showed a large effect size. The rest of them (the influence of EE on BI, SI on BI, FC on BI, FC on UB) showed medium effect size. Unlike original theory, we found many studies utilizing FC as a variable affecting BI, and thus, the effect size on BI (.440) was larger than the effect size on UB (.334). We also analyzed other variables. Hedonic motivation was the largest effective. Additionally, attitude and perceived enjoyment showed a large effect size. Security showed the most utilization, but the effect size (.288) was small, and it did not affect the acceptance of actual users. The publication bias (N) was verified to ensure the reliability of the effect size. The value of N in all variables is higher than $5k + 10$, so there was no influence of publication bias.

TABLE 7. Summary of meta-analysis on key variables

	Pathway	d	k	n	m	Z-value	95% low	95% high	Q	N
Main	PE → BI	.533***	66	17,096	259	19.6	0.489	0.574	1028.62***	143,609
	EE → BI	.457***	64	17,493	273	13.42	0.398	0.512	1435.48***	93,508
	SI → BI	.462***	63	16,913	268	14.34	0.406	0.514	1247.50***	93,826
	FC → BI	.440***	37	9,354	252	9.01	0.354	0.519	913.11***	28,256
	FC → UB	.334***	15	4,735	315	7.32	0.249	0.413	145.03***	2,994
	BI → UB	.641***	23	6,495	282	9.73	0.542	0.723	854.53***	29,771
Additional	SEC → BI	.288***	19	5,245	276	4.9	0.176	0.393	335.36***	2,859
	INNO → BI	.441***	13	3,210	246	7.57	0.338	0.535	146.87***	3,314
	TR → BI	.437***	9	2,294	254	8.59	0.346	0.519	53.22***	1,593
	SE → BI	.479***	9	2,397	266	6.18	0.341	0.596	133.06***	2,068
	PV → BI	.396***	7	1,944	277	7.57	0.301	0.483	34.62***	860
	HM → BI	**.595*****	7	2,481	354	5.24	0.404	0.736	245.34***	2,727
	PENJ → BI	**.502*****	6	1,947	324	9.13	0.408	0.585	30.58***	1,157
	ATT → BI	**.507****	6	1,505	250	3.16	0.209	0.719	227.89***	944

* d: effect size, k: number of papers, n: sample size, m: average of sample size,
Q: Q statistics, N: Fail-safe N
* d, Z-value, 95% low and high are based on random effects model
* **p < 0.01, ***p < 0.001
* SEC: security, INNO: innovativeness, TR: trust, SE: self-efficacy, PV: price value
HM: hedonic motivation, PENJ: perceived enjoyment, ATT: attitude

A meta-analysis of 14 key variables from the ICT industry sector is presented in Table 8. We compared the effect size of the main variables. In ICT devices, PE (.600) affecting BI, and FC (.514) affecting UB have the largest effect sizes. However, BI influencing UB showed a lower effect size (.460) than other ICT industries. The remaining variables overall showed a medium effect size. As an additional variable, security has a large effect size only in the ICT service field, and trust is not utilized in ICT devices. Hedonic motivation was not utilized in ICT service, but ICT device and ICT software showed a large effect size, and attitudes showed a large effect size only in ICT service.

TABLE 8. Results of a meta-analysis in ICT industry

	Pathway	ICT Service (23)			ICT Device (11)			Software (32)		
		d	k	Q	d	k	Q	d	k	Q
Main	PE → BI	.552**	22	293.02***	.600***	10	263.09***	.485***	31	461.52***
	EE → BI	.466***	23	625.36***	.432***	9	249.43***	.457***	29	437.33***
	SI → BI	.480***	20	312.80***	.408**	9	329.78****	.450***	31	419.73***
	FC → BI	.442***	13	91.08***	.491**	5	158.15***	.424***	16	564.78***
	FC → UB	.345***	7	46.25***	.514***	2	1.15	.251***	6	46.46***
	BI → UB	.619***	8	430.00***	.460***	3	10.50**	.692***	12	345.70***
Additional	SEC → BI	.528***	6	48.33***	.251	2	16.89***	.162***	10	63.28***
	INNO → BI	.430***	3	2.69	.376***	2	0.56	.458***	8	140.04***
	TR → BI	.385***	3	7.25*	—			.461***	6	42.23***
	SE → BI	.409***	3	59.13***	.466	1	0	.519***	5	68.89***
	PV → BI	.527***	1	0	.307**	3	17.12***	.427***	2	0.78
	HM → BI	—			.593**	3	76.22***	.600***	3	166.36***
	PENJ → BI	.667*	1	0	.465***	4	21.89***	.488***	1	0
	ATT → BI	.647***	3	55.12***	.199**	1	0	.400	2	62.57***

* d: effect size, k: number of papers, Q: Q statistics * *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$
* Effect Sizes classification is based on Cohen's [8], small (.1 < d ≤ .3), medium (.3 < d ≤ .5), large (.5 < d)

4.3. **Comparison with literature.** We compared the results of this study with those of Venkatesh et al. [3] who first presented UTAUT, and with UTAUT meta-analysis studies conducted by Dwivedi et al. [6] and Taiwo and Downe [7]. Venkatesh et al. and Taiwo and Downe showed that the effect size of the variable PE on BI is similar. EE and SI were similar to results reported by Taiwo and Downe, but we showed slightly larger effect sizes. We observed a slightly smaller effect size of FC on UB than Taiwo and Downe. In addition, FC that affects BI is a path without original theory, which is widely used in Korean studies, and was analyzable in this research. We showed a medium effect size at .440, and that FC has more influence on BI than UB. Finally, the effect size of BI on UB was the largest compared to the previous studies. These results are summarized in Table 9 and Figure 1.

As shown in Figure 1, BI showed the largest effect size to UB. In addition, the effect size of FC on BI is larger than the effect size of FC on UB. Therefore, it is necessary to consider the research model.

5. **Conclusions.** This study investigated the academic journals indexed in the Korean Journal Database and the UTAUT research paper published here in the last 10 years by using a meta-analysis. This study showed several results. Firstly, FC is used more as a variable that influences BI in the study of main variables, and the effect size was

TABLE 9. A comparison of the results of UTAUT effect sizes

Researcher	Venkatesh et al. [3]			Dwivedi et al. [6]			Taiwo and Downe [7]			The research result		
Number of papers	−			27			37			69		
Pathway	d	k	n	d	k	n	d	k	n	d	k	n
PE → BI	.53**	−	133	.343*	8	4,170	.536***	37	11,057	.533***	66	17,096
EE → BI	.25***	−	133	.140*	8	4,170	.436***	36	10,995	**.457***	**64**	**17,493**
SI → BI	.29***	−	133	.231*	10	4,453	.424***	31	9,304	**.462***	**63**	**16,913**
FC → BI	−			−			−			**.440***	**37**	**9,354**
FC → UB	.22***	−	133	.165*	6	1,846	.377***	13	3,048	.334***	19	4,735
BI → UB	.51***	−	133	.405*	3	1,990	.436***	13	3,048	**.641***	**23**	**6,495**

* d: effect size, k: number of papers, n: sample size * *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$
* Effect Sizes classification is based on Cohen's [8], small ($.1 < d \leq .3$), medium ($.3 < d \leq .5$), large ($.5 < d$)
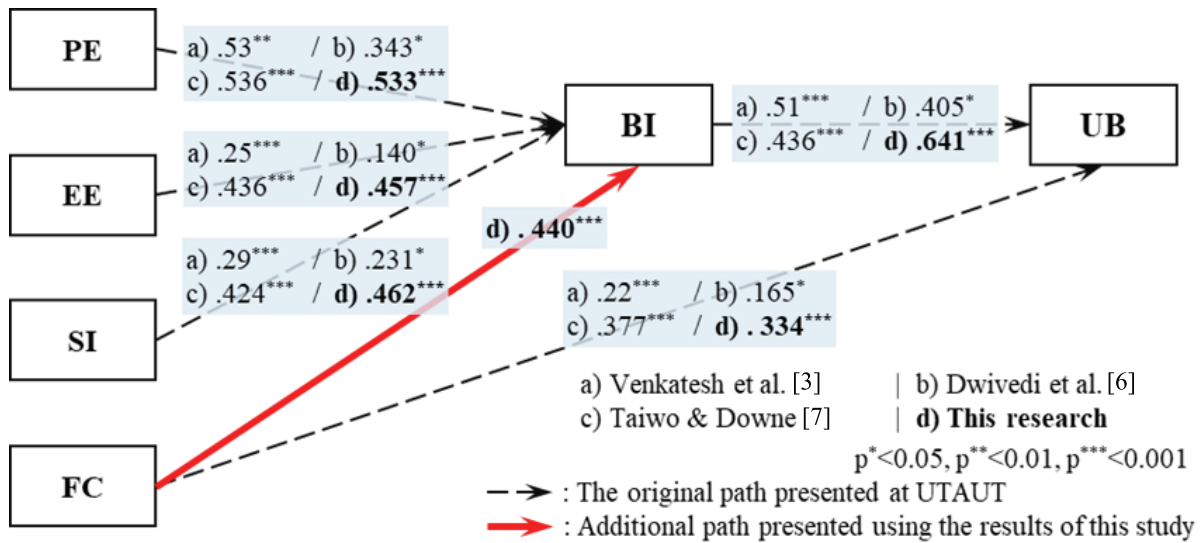

FIGURE 1. Comparison of the results of effect sizes

larger than the effect size on UB. Therefore, additional validation of the path is required. Secondly, hedonic motivation, attitude, and perceived enjoyment among the additional variables show large effect sizes, and security is the most utilized variable, but the effect size is small. Thirdly, analysis by ICT industry classification is as follows: the ICT service industry showed a large effect size with attitude, security and innovativeness; in the ICT device production and sales, hedonic motivation and perceived enjoyment are important variables; in the ICT software industry, hedonic motivation, self-efficacy, trust, and innovativeness were analyzed as key variables. There were several implications of this study. Firstly, we presented various variables through the analysis of main and additional UTAUT variables, which will form the basis for future research. Secondly, the influence of FC on BI was larger than that of UB. Therefore, we need a model that considers the relationship between FC and BI other than original theory. Thirdly, as a result of comparative analysis by ICT industry classification, it is necessary to properly adjust industry variables. Fourthly, it is important to induce the customer's intention to use the

new products or new technologies. Therefore, the company can identify which variables are important for consumers, and apply them to business practices.

There are some limitations of this study and suggestions for future research. Firstly, this study used the Korean Journal Database, and future research should derive additional suggestions by carrying out research including overseas research. Secondly, it is difficult to subdivide the industry classification because it is based on Korea's ICT industry classification. Thus, more data is needed in future studies. Finally, the results of a meta-analysis are dependent on the characteristics, quality, and sample of the research used in the analysis. Therefore, it is necessary to advance meta-research using various research sources.

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Appendix.

TABLE 10. Number of papers in which each variable is represented

Variables	Number of papers	Variables		Number of papers
Performance Expectancy	66	Hedonic Motivation,	Price Value	7
Effort Expectancy	64	Attitude,	Perceived Enjoyment	6
Social Influence	63	Information Attributes, Service Expectancy,	Satisfaction, Experience	5
Facilitating Condition	52	System Attribute (suitability), Product Feature (usability)	Perceived ease-of-use,	4
Security	19	Habit, Product Feature (aesthetic)	Innovation Resistance,	3
Innovativeness	13	Compatibility, Personal Characteristics, Information Quality,	Infra Availability, Product Feature (functional), Ubiquity	2
Trust, Self-efficacy	9	Mobility, Perceived usefulness, Expectation confirmation model, Efficiency expectancy, Education level, Income, Gender, Age, System concern, System quality, Social value, Legal endeavor, Policy recognition, System efficiency, Amount of contents,	Leadership, Information sharing, Service flexibility, System convergence, Switching cost, Profit, Service interface, relation support, extravert, Technology attributes, Social usability, Social visibility, Brand awareness, Contents quality	1