A Study on Diffusion of Innovation based on Mahajan's Model

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Abstract

It is important to understand the process of technology diffusion among end users for effectively implementing adoption and coping with frequent changes in the environment. Previous studies indicate that information and communication technology (ICT) adoption is affected by innovation influence such as usefulness, ease of use and self-efficacy. Most of these studies, however, bypassed imitation influence such as subjective norms, word-of-mouth, and advertising, specifically, interactive innovation having critical mass in technology acceptance research. Thus, this study investigates imitation influence in individual adoption of mobile communication technology, more specifically, mobile phones, using Mahajan's diffusion model in individual ICT adoption.

Keywords: Technology Acceptance Model (TAM), Mahajan's Model, Diffusion of Innovation Theory (DIT)

I. Introduction

This study seeks to derive the relationships among initial-acceptance constructs by mathematical model. Specifically, we investigate whether an imitation influence exists in individual ICT adoption. The test hypothesis to accomplish the purpose of this study is based on Bayer and Melone [1], Zmud [12, 13], Mahajan *et al.* [8], Brancheau and Wethebe [2], Gubaxani [3], Venkatraman *et al.* [11], and Rogers [10].

II. Research Hypothesis

According to Rogers [10], the time dimension should be involved in the diffusion of innovations. When the number of individuals adopting a new idea or practice is plotted on a cumulative frequency over time, the growth pattern of the number of adopters corresponding to a normal distribution is an S-curve.

Gurbaxani [3] applied Diffusion of Innovation Theory (DIT) to BITNET and strongly indicated that the adoption pattern is like an S-curve pattern over time, fitting the exponential model and Gompertz curve. To show the imitation-adoption power, such as word-of-mouth, subjective norm from the prior adopters to potential adopters, and mass advertising through TV or newspaper commercials in the ICT diffusion process, we set the hypothesis as follows.

Hypothesis: Potential adopters of mobile phones are affected by the imitation-adoption power.

III. Research Method

3.1 Data Collection

The survey questionnaire was originally designed in English and then translated into Korean. To avoid cultural bias and ensure validity, the Korean version was translated back into English in order to detect any significant misunderstanding due to translation.

For the pilot study, the questionnaires were distributed to 40 undergraduate and 20 graduate students, most with full time jobs, at the University of Nebraska-Lincoln. The pilot study was based on 55 returned questionnaires from 60 students.

On the basis of the pilot study, the questionnaire was revised three times, and they were redistributed to current mobile phone users and potential adopters in eight Korean universities from March 15, 2003 through April 12, 2003. The subjects voluntarily participated in the study.

The research hypothesis was tested using SAS 8.0, which is well known to be useful for analyzing time series data.

Table 1. Time-series Data of Mobile Phone Adoption

The Number of Mobile Phone Adopters					
Month-Year	X(t)	N(t)	Month-Year	X(t)	N(t)
Apr-96	2	2	Oct-99	14	339
May-96	3	5	Nov-99	16	355
Jun-96	3	8	Dec-99	15	370
Jul-96	4	12	Jan-00	15	385
Aug-96	2	13	Feb-00	14	399
Sep-96	3	14	Mar-00	15	414
Oct-96	3	17	Apr-00	12	426
Nov-96	2	19	May-00	7	433
Dec-96	2	21	Jun-00	7	440
Jan-97	3	24	Jul-00	5	445
Feb-97	3	30	Aug-00	4	449
Mar-97	2	32	Sep-00	5	454
Apr-97	2	34	Oct-00	3	457
May-97	6	40	Nov-00	5	462
Jun-97	4	44	Dec-00	5	467
Jul-97	4	48	Jan-01	6	473
Aug-97	3	51	Feb-01	7	480
Sep-97	2	53	Mar-01	8	488
Oct-97	3	56	Apr-01	5	493
Nov-97	4	60	May-01	3	496
Dec-97	6	66	Jun-01	4	500
Jan-98	7	73	Jul-01	5	505
Feb-98	9	82	Aug-01	3	508
Mar-98	11	93	Sep-01	3	511
Apr-98	11	104	Oct-01	4	515
May-98	12	116	Nov-01	3	518
Jun-98	11	127	Dec-01	4	522
Jul-98	11	138	Jan-02	3	525
Aug-98	14	152	Feb-02	3	528
Sep-98	14	166	Mar-02	2	530
Oct-98	14	180	Apr-02	5	535
Nov-98	14	194	May-02	3	538
Dec-98	11	205	Jun-02	2	540
Jan-99	15	220	Jul-02	2	542
Feb-99	9	229	Aug-02	4	546
Mar-99	12	241	Sep-02	4	550
Apr-99	12	253	Oct-02	3	553
May-99	17	270	Nov-02	2	555
Jun-99	16	286	Dec-02	3	558
Jul-99	12	298	Jan-03	3	561
Aug-99	15	313	Feb-03	5	566
Sep-99	12	325	Mar-03	3	569

x(t): the number of mobile phone adopters in Korea at time t
N(t): the cumulative number of mobile phone adopters in Korea at time t

3.2 Sample Description

Data were collected from 610 subjects. Among them, 569 turned out to be complete and usable for the analysis. The instruments were developed based on measures validated by prior research [5]. Measurement items were modified so as to confirm to the adoption context. A large volume of data was collected by the survey to increase the generality of the study.

From the descriptive analysis, an interesting fact was found that among mobile phone adopters, 512 respondents out of 569 have changed their mobile phones 2.4 times on average. The reasons for change are reported as follows: out of order (40%), old-fashioned design (38%), bad connections (13%), bulky size (12%), lost phone (9%), bad voice quality (6%), and other reasons (8%).

IV. Testing Hypothesis and Discussion

Using the time series data as shown in Table 1, the hypothesis was tested. The White-noise model is set as the null hypothesis, and the external influence model and the mixed influence model are set as alternative hypotheses using Mahajan's analysis process [6]. The parameters of the white-noise, external influence, and mixed influence

Table2. Models

Hypothesis	Model Type	Equation	Parameter	
			β_1	β_2
Null Hypothesis	White – noise Model	$x(t) = x(t-1) + \varepsilon(t)$	1	-
Alternative Hypothesis	External Influence Model	$x(t) = \beta_1 x(t-1) + \varepsilon(t)$	<1	-
	Mixed Influence Model	$x(t) = \beta_1 x(t-1) + \beta_2 N^*(t-1) + \varepsilon(t)$	>1	<0

Note: $x(t)$ = the number of adopter at time t
$N^*(t-1) = N^2(t-1) - N^2(t-2)$ where $N(\cdot)$: number of cumulative adopters
$\varepsilon(t)$: error term

models were tested by OLS (Ordinary Least Squares) as shown in Table 2 using the data in Table 1 of mobile phone adopters.

4.1 Analytical Formulations for Hypothesis

Since Rogers [9] introduced his DIT, a number of mathematical models have been proposed to represent adoption of an innovation over time [6, 7, 8, 11].

4.2 Discussion

The results from the hypothesis test concerning innovation and imitation influence in mobile phone adoption is as follows. Table 2 shows the model in this study.

As shown in Tables 2 and 3, the sign and value of each of the estimated parameters of the external influence model and the mixed influence model match with the signs and values of the expected parameters in Table 3. The t value of β□ of the external influence model was 0.91348 and it was significant at the level of 0.001. Also, the adjusted-R^2 of the external influence model was higher than that of the white-noise model. Under the OSL estimation, the white-noise model is rejected at the 0.0571 significance level in favor of the external influence model. The null hypothesis is also rejected in the case of the mixed influence model ($p<0.05$). Thus, the external influence model turns out to be better than the white-noise model when explaining the adoption behavior of mobile phones.

Consequently, as shown in Table 4, we can conclude that adoption of mobile phones is affected by imitative behavior. Another finding is that the mixed model is more effective in explaining the adoption behavior than the white-noise model is.

In sum, these results support the hypothesis involving innovation and imitation influences in adopting mobile phones. More specifically, the results imply that imitation influence is stronger than that of innovation. A plausible explanation for this implication is based on the fact that the time series data used in this study reflect the entire mobile phone life cycle (introduction, growth, maturity, and decline) in Korea. According to Lee [4], as the telecommunication market will soon reach the saturation point, the broadband Internet and mobile communication service areas in Korea are already facing with the challenge of creating new value for end users of mobile communication.

As aforementioned, Rogers' DIT [10] may also

Table 3. Estimated Parameter of Hypothesis Models

Hypothesis	Coefficients		
	β_1	β_2	Adj. R^2
White – noise Model	1	-	0.0326 (3.73)
External Influence Model	0.91348[a] (20.38)[b]	-	0.8385 (415.41)[c]
Mixed Influence Model	1.01726[a] (15.47)[b]	-0.00020591 (-2.11)[b]	0.8421 (214.40)[c]

Note: a: Alternative models whose value of the estimated parameter is contrary to the value of the expected parameter

b: Parameters' significant level of the t value

c: R^2 significant level of the F value

Table 4. Estimation of External and Internal Coefficients

Description	OLS Specification	
	Mixed Influence	External Influence
Parameter Estimation		
p (Coefficient of External)	0.08652	0.08652
q (Coefficient of Internal)	0.10378	N/A
m (Potential number of adopters)	504.0066	N/A
Model Fit		
MSE	3.5075	3.6188
F-Value	214.40 (0.000)	415.41 (0.000)
Adjusted R^2	0.8365 (0.000)	0.8421 (0.000)
Hypothesis Testing		
Null Values	$\beta_1=1; \beta_2=0$	$\beta_1=1$
Test Statistic	$F = 4.05$	$F = 3.73$

explain the results well in that mass media channels, such as TV commercials and newspaper advertising, are relatively more important at the beginning of the adoption stage while interpersonal channels such as word-of-mouth are relatively more important at the persuasion stage in the innovation-diffusion process.

V. Conclusion

Until now, even though the technology acceptance model (TAM) has been criticized, TAM dominates the adoption research area. This paper attempted to overcome the drawbacks of TAM by incorporating diffusion theory with imitation influence in the technology adoption area. The contribution of this study is that it shows an imitation influence actually exists in ICT adoption, using a mathematical approach. Until now, the results of the previous research regarding imitation influence were mixed and research-specific. This paper, however, clearly shows that an imitation influence exists in adopting mobile phones and its power is stronger that that of innovation in Korea.

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