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RESEARCH NOTE

A Meta-Analysis of the Role of Environment-Based Voluntariness in Information Technology Acceptance[1]

By: **Jiming Wu**
Department of Management
College of Business and Economics
California State University, East Bay
25800 Carlos Bee Boulevard
Hayward, CA 94542
U.S.A.
jiming.wu@csueastbay.edu

Albert Lederer
School of Management
Gatton College of Business and Economics
University of Kentucky
Lexington, KY 40506
U.S.A.
lederer@uky.edu

Appendix A

Procedures to Convert Test Statistics into Correlations[2]

1. If shared variance (r^2) is reported, correlation (r) is obtained by calculating the square root of shared variance.

2. If covariance (cov(x, y)) is reported, the correlation (r) is obtained by applying the formula

$$r = \frac{\text{cov}(x, y)}{\sigma_x \sigma_y}$$

where σ is the standard deviation.

[2] Procedure 5 and the second part of procedure 6 are described in Wolf (1986).

3. If β value, the standardized regression coefficient, is reported and there is only one independent variable, correlation (r) equals to β.

   If β (β_1 and β_2) values are reported and there are two independent variables (variable 1 and variable 2), the correlation (r_{y1}) between dependent variable and independent variable 1 is obtained by applying the formula

$$r_{y1} = \beta_1(1 - r_{12}^2) + r_{y2}r_{12}$$

   and the correlation (r_{y2}) between dependent variable and independent variable 2 is obtained by applying the formula[3]

$$r_{y2} = \beta_2(1 - r_{12}^2) + r_{y1}r_{12}$$

4. If regression coefficient (b) is reported, β value can be obtained by applying the formula

$$\beta = b \times \frac{\sigma_x}{\sigma_y}$$

   where σ is the standard deviation. Then proceed via 3 above.

5. If F-value, the ratio of the Regression Mean Square to the Error Mean Square, is reported and there is only one independent variable, correlation (r) is obtained by applying the formula

$$r = \sqrt{\frac{F}{F + n - 2}}$$

   where n is the number of observations.

6. If t-value of regression coefficient is reported, the regression coefficient (b) can be obtained by applying the formula

$$b = t \times SE$$

   where SE is the standard error of b. Then proceed via 4 above.

   If t-value is reported and there is only one independent variable, correlation (r) is obtained by applying the formula

$$r = \sqrt{\frac{t^2}{t^2 + n - 2}}$$

   where n is the number of observations.

Appendix B

Independence of the Studies Included in this Meta-Analysis

To ensure the independence of the studies included in this meta-analysis, we used the method developed by Wood (2008) and divided the studies into two groups: duplicate and independent. While the first consists of studies that share one or more authors, the second includes all of the remaining studies. According to Wood, significant difference between the two groups in the mean correlations of interest may indicate non-independence of the studies. As shown in Table B1, results of the group difference tests illustrate that none of the p-values for the t-test statistics is significant and thus do not indicate lack of independence of the studies included in this meta-analysis.

[3]Because correlations between other variables, which are needed to calculate the correlation of interest, are often not available, these formulas are not very helpful for meta-analysis studies such as this.

Table B1. Data Set Independence Test					
Correlation	Group	Mean	Standard Deviation	t value	p value
Usefulness & Intention	Duplicate Independent	0.64 0.65	0.17 0.16	0.09	0.93
Ease of Use & Intention	Duplicate Independent	0.48 0.51	0.19 0.18	0.59	0.56
Usefulness & Usage	Duplicate Independent	0.58 0.38	0.20 0.25	-1.45	0.16
Ease of Use & Usage	Duplicate Independent	0.31 0.32	0.13 0.14	0.15	0.88
Usefulness & Ease of Use	Duplicate Independent	0.59 0.53	0.18 0.17	-1.39	0.17

Appendix C

Meta-Analysis Data

Table C1. Meta-Analysis Data for Studies of Behavioral Intention

			Correlation			Reliability			Corrected Correlation			
No.	**Study (Source)**	**N**	**U&B**	**E&B**	**U&E**	**U**	**E**	**B**	**U&B**	**E&B**	**U&E**	**EBV**
1	Agarwal and Karahanna 2000 (J)	288	0.65	0.57	0.55	0.93	0.90	0.97	0.68	0.61	0.60	19.67
2	Agarwal and Prasad 1999 (J)	230	0.45	0.36	0.74	0.95	0.87	0.60	0.60	0.50	0.81	13.00
3	Aladwani 2002 (J)	387	0.44	0.39	0.37	0.87	0.90	1.00	0.47	0.41	0.42	7.33
4	An 2005 (D)	200	0.68	0.48	0.71	0.95	0.96	0.91	0.73	0.51	0.75	18.00
5	Busch 1995 (D)	249	0.57	0.23	0.21	0.87	0.80	0.80	0.68	0.29	0.25	14.67
6	Davis 1989 (J)	80	0.85	0.59	0.56	0.98	0.94	1.00	0.86	0.61	0.58	7.00
7	Featherman 2002 (D)	215	0.71	0.54	0.59	0.95	0.89	0.97	0.74	0.58	0.64	9.33
8	Featherman and Fuller 2003 (C)	167	0.72	0.58	0.63	0.88	0.84	0.94	0.79	0.65	0.74	9.67
9	Gefen and Straub 2003 (J)	161	0.48	0.38	0.64	0.93	0.92	0.88	0.53	0.42	0.70	8.67
10	Gefen, Karahanna, and Straub 2003a (J)	139	0.18	0.10	0.75	0.96	0.97	0.90	0.19	0.10	0.78	6.00
11	Gefen, Karahanna, and Straub 2003a (J)	178	0.38	0.35	0.72	0.96	0.95	0.89	0.41	0.38	0.75	6.00
12	Gefen, Karahanna, and Straub 2003b (J)	213	0.72	0.67	0.70	0.89	0.90	0.83	0.84	0.78	0.78	20.00
13	Gefen, Straub, and Boudreau (J)	160	0.47	0.36	0.63	0.95	0.94	0.95	0.49	0.38	0.67	7.33
14	Horton, Buck, Waterson, and Clegg 2001 (J)	386	0.40	0.30	0.37	0.88	0.89	1.00	0.42	0.31	0.42	8.00
15	Hsu and Lu 2004 (J)	233	0.24	0.57	0.22	0.83	0.86	0.81	0.29	0.68	0.26	18.67
16	Jones, Sundaram, and Chin 2002 (J)	164	0.79	0.37	0.52	0.98	0.97	0.99	0.80	0.38	0.53	14.00
17	Kim 2005 (D)	121	0.84	0.70	0.72	0.95	0.97	0.93	0.89	0.74	0.75	16.67

Table C1. Meta-Analysis Data for Studies of Behavioral Intention (continued)

No.	Study (Source)	N	Correlation			Reliability			Corrected Correlation			EBV
			U&B	E&B	U&E	U	E	B	U&B	E&B	U&E	
18	Koufaris 2002 (J)	280	0.62	0.47	0.68	0.92	0.93	1.00	0.64	0.49	0.73	6.33
19	Kulviwat 2004 (D)	230	0.48	0.41	0.57	0.90	0.92	0.92	0.53	0.45	0.63	6.33
20	Lee, Cheung, and Chen 2005 (J)	544	0.43	0.37	0.51	0.77	0.75	0.90	0.52	0.45	0.67	6.33
21	Lee 2001 (D)	259	0.65*	0.65*	0.57	0.91	0.88	0.92	0.72	0.72	0.64	6.33
22	Li, Day, Lou, and Coombs 2004 (J)	90	0.58	0.77	0.46	0.90	0.88	0.93	0.63	0.85	0.52	10.33
23	Lin and Lu 2000 (J)	139	0.72	0.68	0.68	0.88	0.85	0.82	0.85	0.81	0.79	6.33
24	Lou, Luo, and Strong 2000 (J)	192	0.75	0.56	0.62	0.88	0.91	0.76	0.92	0.67	0.69	12.33
25	Lou, Luo, and Strong 2000 (J)	193	0.75	0.43	0.36	0.85	0.90	0.78	0.92	0.51	0.41	12.33
26	Luo 2005 (D)	147	0.62	0.52	0.50	0.95	0.93	0.91	0.67	0.57	0.53	20.00
27	Luo 2005 (D)	242	0.54	0.46	0.55	0.95	0.94	0.93	0.57	0.49	0.58	20.00
28	Martins and Kellermanns 2004 (J)	243	0.49	0.43	0.49	0.94	0.91	0.91	0.53	0.47	0.53	5.33
29	Muthitacharoen, Palvia, Brooks, Krishnan, Otondo, and Retzlaff-Robert 2006 (J)	435	0.69*	0.55*	0.54*	0.85	0.79	0.83	0.82	0.68	0.66	20.00
30	Pavlou 2001 (C)	52	0.81	0.50	0.59	0.92	0.95	0.96	0.86	0.53	0.63	14.33
31	Pavlou 2003 (J)	102	0.63	0.38	0.63	0.92	0.92	0.94	0.68	0.41	0.68	8.67
32	Pavlou 2003 (J)	155	0.64	0.57	0.72	0.83	0.93	0.95	0.72	0.61	0.82	18.67
33	Saade and Bahli 2005 (J)	102	0.49	0.33	0.37	0.74	0.67	0.62	0.72	0.51	0.53	6.00
34	Sarker 2006 (C)	261	0.61	0.62	0.76	0.98	0.90	0.97	0.62	0.66	0.81	6.67
35	Stafford and Stern 2002 (J)	329	0.73	0.49	0.49	0.86	0.78	0.82	0.87	0.61	0.60	18.67
36	Szajna 1996 (J)	61	0.52*	0.35*	0.39*	0.96	0.94	1.00	0.53	0.36	0.41	10.00#
37	Taylor and Todd 1995 (J)	786	0.60	0.10	0.36	0.68	0.71	0.91	0.76	0.12	0.52	15.67
38	Teo, Chan, Wei, and Zhang 2003 (J)	69	0.67	0.56	0.61	0.83	0.89	0.88	0.78	0.63	0.71	8.00
39	Venkatesh 2000 (J)	58	0.52	0.34	0.33	0.93	0.92	0.92	0.56	0.37	0.36	5.33
40	Venkatesh 2000 (J)	145	0.55	0.30	0.35	0.91	0.93	0.90	0.61	0.33	0.38	5.33
41	Venkatesh 2000 (J)	43	0.56	0.24	0.39	0.91	0.96	0.90	0.62	0.26	0.42	5.33
42	Venkatesh and Davis 2000 (J)	77	0.47*	0.23*	0.28*	0.93	0.93	0.91	0.51	0.25	0.30	9.00#
43	Venkatesh and Davis 2000 (J)	79	0.46*	0.24*	0.30*	0.93	0.93	0.91	0.50	0.26	0.33	5.33#
44	Venkatesh and Morris 2000 (J)	342	0.49	0.30	0.22	0.93	0.92	0.88	0.54	0.33	0.24	8.33
45	Walker 2004 (D)	143	0.54*	0.32*	0.52*	0.94	0.91	0.85	0.60	0.36	0.56	6.33
46	Wang 2002 (J)	260	0.65	0.71	0.71	0.96	0.98	0.92	0.69	0.75	0.73	19.00
47	Wang and Benbasat 2004 (C)	120	0.54	0.42	0.42	0.93	0.83	0.93	0.58	0.48	0.48	15.00
48	Wang, Wang, Lin, and Tang 2003 (J)	123	0.68	0.75	0.81	0.94	0.97	0.81	0.78	0.85	0.85	20.00
49	Wilson, Mao, and Lankton 2005 (C)	201	0.37	0.31	0.59	0.88	0.92	0.96	0.41	0.33	0.66	8.00
50	Yi and Hwang 2003 (J)	109	0.52	0.35	0.29	0.95	0.96	0.87	0.57	0.38	0.30	11.33
E1	Fu, Farn, and Chao 2006 (J)	26,989	0.81	0.56	0.70	0.94	0.91	0.95	0.86	0.60	0.76	20.00
E2	Fu, Farn, and Chao 2006 (J)	31596	0.80	0.61	0.75	0.96	0.92	0.96	0.83	0.65	0.80	20.00

Table C2. Meta-Analysis Data for Studies of Usage												
			Correlation			Reliability			Corrected Correlation			
No.	Study (Source)	N	U&B	E&B	U&E	U	E	B	U&B	E&B	U&E	EBV
1	Adams, Nelson, and Todd 1992 (J)	62	0.44	0.42	0.75	0.93	0.95	1.00	0.45	0.43	0.79	14.33
2	An 2005 (D)	200	0.32	0.17	0.71	0.95	0.96	0.76	0.37	0.20	0.75	18.00
3	Bajaj and Nidumolu 1998 (J)	100	(0.20)	0.32	0.00	0.96	0.87	0.90	(0.22)	0.36	0.00	10.33
4	Burton-Jones and Hubona 2005 (J)	191	0.52	0.36	0.43	0.98	0.95	1.00	0.53	0.37	0.44	17.00
5	Davis 1989 (J)	184	0.63	0.45	0.64	0.97	0.91	1.00	0.64	0.47	0.68	8.67
6	Davis, Bagozzi, and Warshaw 1989 (J)	107	0.70	0.12	0.23	0.92	0.90	0.79	0.82	0.14	0.25	15.00
7	Hill 2001 (D)	70	0.60	0.35	0.41	0.96	0.90	0.82	0.68	0.41	0.44	10.67
8	Horton, Buck, Waterson, and Clegg 2001 (J)	386	0.34	0.23	0.37	0.88	0.89	1.00	0.37	0.24	0.42	8.00
9	Karahanna, Agarwal, and Angst 2006 (J)	278	0.45	0.34	0.59	0.96	0.94	0.93	0.48	0.36	0.62	13.33
10	Keil, Beranek, and Konsynski 1995 (J)	153	0.43	0.12	0.52	0.95	0.82	1.00	0.44	0.13	0.59	11.67
11	Lapczynski 2004 (D)	134	0.45	0.30	0.45	0.72	0.69	1.00	0.53	0.36	0.63	7.00
12	Lu and Gustafson 1994 (J)	40	0.27	0.48	0.43	0.83	0.94	1.00	0.29	0.49	0.49	12.33
13	Luo 2005 (D)	147	0.30	0.25	0.50	0.95	0.93	0.71	0.37	0.31	0.53	20.00
14	Luo 2005 (D)	242	0.41	0.27	0.55	0.95	0.94	0.78	0.48	0.32	0.58	20.00
15	Martins and Kellermanns 2004 (J)	243	0.26	0.18	0.49	0.94	0.91	1.00	0.27	0.19	0.53	5.33
16	Sambamurthy and Chin 1994 (J)	168	0.74	0.53	0.32	0.76	0.84	0.75	0.98	0.67	0.40	5.33
17	Szajna 1996 (J)	61	0.22*	0.24*	0.30	0.93	0.97	1.00	0.23	0.24	0.41	14.00
18	Taylor and Todd 1995 (J)	786	0.25	0.13	0.36	0.68	0.71	1.00	0.30	0.15	0.52	15.67
19	Teo, Lim, and Lai 1999 (J)	1370	0.31	0.32	0.37	0.89	0.87	1.00	0.33	0.34	0.42	18.33
20	Yi and Hwang 2003 (J)	109	0.03	0.23	0.29	0.95	0.96	1.00	0.03	0.23	0.30	11.33
21	Yi, Wu, and Tung 2005 (J)	88	0.35	0.25	0.23	0.94	0.87	1.00	0.36	0.27	0.25	7.67

Notes for Appendix C: N = sample size of original study; C = Conference Proceedings; D = Dissertation, J = Journal; E = Perceived ease of use; U = Perceived usefulness; B = Behavioral intention; G = Usage, EBV = Average environment-based voluntariness score of three raters.
*The simple average value of multiple tests.
[#]The simple average value of two sub-studies that are combined by original journal article authors; the sub-studies are first rated separately.

Appendix D

Summarization, Publication Bias, and Heterogeneity

Table D1 shows the results of summarizing the 71 studies. We used funnel plots and failsafe *Ns* to investigate publication bias. As a visual tool, funnel plots are simple scatterplots of the effect size (horizontal axis) against the sample size (vertical axis) (Cooper and Hedges 1994). In the absence of bias, a funnel plot usually shows a symmetric inverted funnel shape with effect sizes from small studies scattering widely at the bottom of the graph and the spread narrowing for studies with a larger sample size. Because publication bias may not be the only reason for problematic funnel plots, caution should be taken in interpreting plot results, and funnel plots should be viewed in conjunction with other tests such as failsafe Ns (Sabherwal et al. 2006). We developed a funnel plot for each of the five correlations. The funnel plots did not identify publication bias as a problem. We show a sample funnel plot (for the correlation between perceived usefulness and behavioral intention) in Figure D1.

For any relationship of interest, failsafe *N* represents the number of additional studies (with null results) needed to render the results for that relationship nonsignificant at a pre-specified level ($p \leq 0.05$ in this study) (Williams and Livingstone 1994). We calculated the failsafe *Ns* for the five correlations by using the values corrected for study artifacts.[4] As shown in Table D1, the failsafe *Ns* vary from 29 to 195, with an average of 115. They provide confidence in the robustness of this meta-analysis with respect to the possible exclusion of studies with non-significant results. (That is, for example, at least 184 additional studies with non-significant results would be needed to make the average usefulness/intention correlation shown in Table D1 non-significant.) Together, these results and the funnel plots indicate that publication bias is not a significant problem in this study.

Hedges (1982) and Rosenthal and Rubin (1982) propose that a heterogeneity (or homogeneity) test be used as an aid in deciding whether observed effect sizes are more variable than would be expected from sampling error alone. If they are, then there is a strong basis for searching for moderators (Hunter and Schmidt 1990). The heterogeneity test involves the Q statistic, in which the distribution is similar to chi-square with k-1 degrees of freedom where k is the number of studies included in the meta-analysis (Hedges and Olkin 1985). The Q statistic for each of the five correlations exceeded its cutoff, and thus the analyses confirmed heterogeneity for each ($p < 0.01$).[5] That is, of all the correlations vary across studies more than would be produced by sampling error. Thus, the results support our pursuit of moderators.

Table D1. Summary of the Findings of the 71 Studies

Correlation	Number of Observations	Mean	S.D.	Median	Maximum	Minimum	Sampling Error Variance	Failsafe N
Usefulness → Intention	50	0.64	0.15	0.64	0.92	0.19	0.002	184
Ease of Use → Intention	50	0.48	0.18	0.49	0.85	0.09	0.003	125
Usefulness → Usage	21	0.39	0.18	0.37	0.98	-0.22	0.003	44
Ease of Use → Usage	21	0.3	0.1	0.32	0.67	0.13	0.003	29
Ease of Use → Usefulness	63	0.56	0.16	0.59	0.85	0	0.002	195

Notes: S.D. = Standard Deviation. Numbers are all corrected for study artifacts. Appendix E presents the methods. See the Power Analysis for Effect Size section in Appendix F for the relevant power analysis.
Among the 71 (50 + 21) studies, 8 studies present data sets for both behavioral intention and usage. Thus, there are 63 (71 – 8) unique correlations between ease of use and usefulness.

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[4]Failsafe $N = k(\overline{r_k} / \overline{r_c} - 1)$; where *k* is the number of studies included in the meta-analysis, $\overline{r_k}$ is the mean of the correlation, and $\overline{r_c}$ is a pre-specified value of that correlation (Hunter and Schmidt 1990, p. 513).

[5]We conducted heterogeneity tests for each correlation based on the following procedures and formulas recommended by Hedges and Olkin (1985) and Cooper and Hedges (1994). The correlations were first normalized using Fisher's $z = 0.5 \times \ln((1 + r)/(1 - r))$. We then calculated weighted average *z*:
$\bar{z} = \sum n_i z_i / \sum n_i$, where n_i is the sample size in study *i*. Finally, we computed the Q statistic: $Q = \sum (n_i - 3)(z_i - \bar{z})^2$.

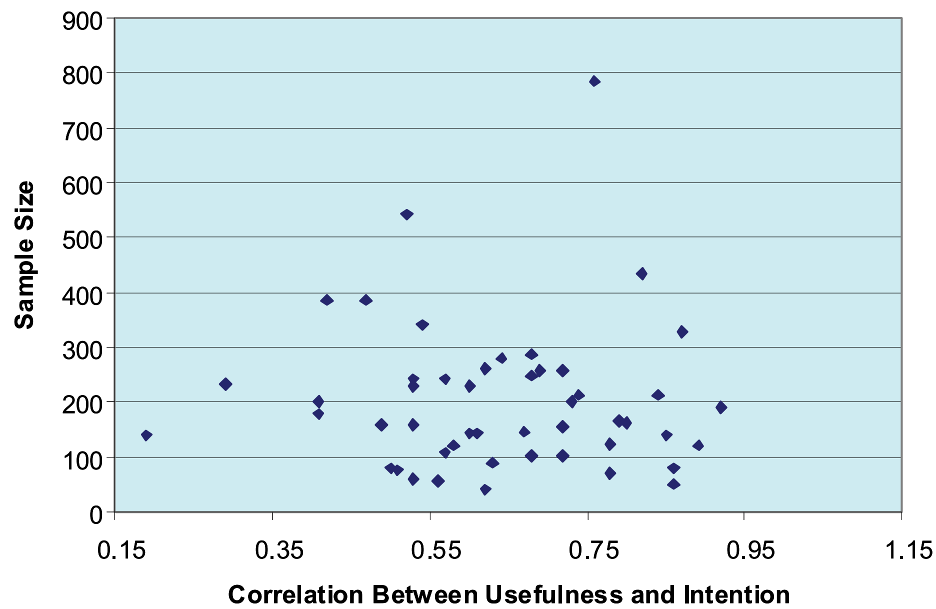

Figure D1. A Funnel Plot

Appendix E

Methods for Correcting Study Artifacts

Hunter and Schmidt (1990) provide the following methods to correct study artifacts:

1. Correct original correlations reported in individual studies for measurement error:

   Dividing reported correlation by the square root of the product of the reliabilities of the two variables.

2. Calculate a weighted average correlation in which each correlation is weighted by the number of observations in that study, and calculate a standard deviation corrected for sampling error:

(1) $\bar{r} = \dfrac{\sum [N_i r_i]}{\sum N_i}$, where $\bar{r}$ is the weighted average correlation, r_i is the correlation in study i, and N_i is the sample size in study i.

(2) $\sigma_r^2 = \dfrac{\sum [N_i (r_i - \bar{r})^2]}{\sum N_i}$, where σ_r^2 is the variance across studies.

(3) $\overline{N} = T / K$, where $\overline{N}$ is the average sample size across studies, T is the total sample size across studies, and K is the number of studies included in the meta-analysis.

(4) $\sigma_e^2 = (1 - \overline{r}^2)^2 / (\overline{N} - 1)$, where σ_e^2 is the sampling error variance.

(5) $\sigma_p^2 = \sigma_r^2 - \sigma_e^2$, where σ_p^2 is the estimate of the variance of population or the corrected variance across studies.

(6) $\sigma_p = \sqrt{\sigma_p^2}$, where σ_p is the estimate of the standard deviation of population or the corrected standard deviation across studies.

In Table D1, the corrected values are based on the corrected correlations obtained by applying method 1; the corrected mean is the weighted average correlation obtained by applying the first formula of method 2; and the corrected standard deviation is obtained by following all of the procedures in method 2.

Appendix F

Relevant Power Analyses

There are two potential types of power analysis in the current study. The first is the power analysis using the r-values that were reported in the original individual studies to test the effect size. The second is the power analysis using the r-square values to test the regression models regarding the research hypotheses (i.e., H1 through H5).

Power Analysis for Effect Size

The first power analysis tests whether the r-values ($r_{usefulness\text{-}intention}$, $r_{ease\text{-}of\text{-}use\text{-}intention}$, $r_{usefulness\text{-}usage}$, $r_{ease\text{-}of\text{-}use\text{-}usage}$, and $r_{ease\text{-}of\text{-}use\text{-}usefulness}$) reported in the original individual studies are significantly larger than 0 (Hedges and Pigott 2001). We followed Cohen (1988, pp.75-95) and analyzed the power for the five types of effect size. As shown in Table F1, the five power values are all higher than 0.80, indicating that all of the r-values are indeed significantly larger than 0. (For example, the power test for Usefulness & BI employed an r-value of 0.64 and a sample size of 204.)

Power Analysis for Hypotheses

The second power analysis tests whether the R^2 for the five regression models (i.e., the hypotheses) is significantly larger than 0. As shown in Table F2, the power values for H1 and H2 are both higher than 0.80, indicating that the number of behavioral-intention studies in the current meta-analysis is large enough and that voluntariness indeed plays an important role in moderating the beliefs–intention correlations (Cohen 1988, pp. 407-423). The power values for H3 and H4 are both below 0.80. Low power for nonsignificant results is a common situation, indicating that the sample size may be insufficient and that future research is needed to reinvestigate whether the phenomenon (related to the hypothesis) exists (Cohen 1998; Goodhue et al. 2007). Thus, the power analyses for H3 and H4 suggest that the number of usage studies in the current meta-analysis may be insufficient to detect the moderating effect of voluntariness on beliefs-usage correlations (as we suggest in the "Discussion" section), and that future research with more usage studies is needed to retest H3 and H4.[6] Because H5 is a no-effect hypothesis (i.e., a null hypothesis), the low power for H5 is not problematic.

[6] Only one usage study (Habelow 2000) was identified without the reliabilities of the measures, and it was therefore not included in the meta-analysis. If it were included using the average reliabilities of the other 21 usage studies, the results of hypothesis tests would not differ substantively, and the power values for H3 and H4 would be 0.28 and 0.34, respectively.

Table F1. Power Analysis for Effect Size

Correlated Constructs	Usefulness & BI	Ease of Use & BI	Usefulness & Usage	Ease of Use & Usage	Ease of Use & Usefulness
Average r-value	0.64	0.48	0.39	0.3	0.56
Number of Studies	50	50	21	21	63
Total Sample Size	10,182	10,182	5,119	5,119	13,127
Average Sample Size	204	204	244	244	208
Power	> 0.99	> 0.99	> 0.99	> 0.99	> 0.99

Note: Average sample size is obtained via dividing the total sample size by number of studies.

Table F2. Power Analysis for Hypothesis Testing

Hypothesis	H1	H2	H3	H4	H5
R^2	0.145	0.178	0.085	0.065	0.003
λ	8.48	10.83	1.95	1.46	0.19
Number of Observations	50	50	21	21	63
Power	> 0.82	> 0.88	0.27	0.21	0.06

Note: $\lambda = f^2 \times n$, where n is the number of observations and $f^2 = \frac{R^2}{1-R^2}$.