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ABSTRACT

As data warehousing has evolved to become the technology of choice for developing data infrastructure in virtually every large company and many other medium- and small-sized firms, data warehousing has also received extensive research attentions from both academics and practitioners. Although several previous studies have investigated success factors and implementation of data warehousing, only few of them have explored end users' perceptions of this system. Moreover, none of these previous studies was done on the company outside North America, especially in any Asian country. Thus, this study was conducted to identify factors affecting end users' usage and perceived impact of data warehouses in Korean financial companies. Results suggest that Data Quality and End User Support and Training are significant factors affecting end users' usage and perceived impact of data warehouses.

Keywords

Data Warehouse, Users' Perceptions, IS Success, Critical Success Factors, Technology Acceptance

INTRODUCTION

The fundamental business driver behind data warehousing is the desire to improve decision making and organizational performance (Gray and Watson 1998) since data warehousing helps managers discover problems and opportunities sooner, perhaps increases the extent of their analysis (Watson, Goodhue, and Wixom 2002). Meanwhile, researchers have studied various issues related to data warehousing (e.g., Counihan, Finnegan, and Sammon 2002; Hwang and Cappel 2002; Little and Gibson 2003; Mukherjee and D'Souza 2003; Shin 2002, 2003; Watson *et al*. 2002). However, from the review of literature in this area, we found only few studies (Chen, Soliman, Mao, and Frolick 2000; Shin 2003) exploring factors affecting user satisfaction with data warehousing and none of the previous studies has investigated usage and perceived individual impact from using data warehouses among those companies in Asia.

To motivate users to be responsible for finding the information they need, data warehouses need to be designed and evaluated from users' perspective. Therefore, the main objective of this study is to identify key factors affecting end users' usage and perceived impact from using data warehouses in Korean financial companies.

RESEARCH MODEL

Constructs in the Model

The proposed research model includes four independent constructs: Data Quality, Accessibility, Response Time, and End User Support and Training. As specified in the IS Success Model, information quality is one of the dimensions of IS success (DeLone and McLean 1992). Additionally, data accuracy, format, and preciseness were found as the factors affecting user satisfaction with data warehouses (Chen *et al*. 2000). Thus, similar to several previous studies on the effects of information quality upon IS success (e.g., Wixom and Watson 2001), in this study, we measure the independent construct: Data Quality, by assessing the accuracy, timeliness, completeness, relevance, and understandability of data.

Another dimension of IS success is system quality (DeLone and McLean 1992). System quality consists of a variety of measures including ease-of-use, functionality, reliability, flexibility, portability, integration, and importance. One of the reasons for this variety of measures for system quality is that IS success was investigated in different contexts. That is, in

determining system quality for IS success, there are important differences deriving from organizational, user, and system variations that can modify the view as to which attributes are important (Whyte, Bytheway, and Edwards 1997).

For data warehousing, accessibility problem with data access tools was reported in several organizations as one of data warehousing failures (Watson, Gerard, Gonzalez, Haywood, and Fenton 1999). Accessibility determines how users access the system to extract data. The system should provide sufficient data access tools with such necessary features as drill-down capability and trend analysis (McFadden and Watson 1996) and these data access tools should be easy to use and should support users to find data quickly. Thus, in this study, Accessibility is proposed as one of the measures for system quality of data warehousing.

Response Time is another selection for system quality of data warehousing. Compared to those of transactional databases, queries submitted to data warehouses, in general, require extensive computing because of their decision support nature (Shin 2003). Too much processing delay may force users to abandon the data warehouses because data warehouses may not be the only data source and using data warehouses may not be as mandatory as that of operational systems serving daily transactions. Additionally, it was expected that the number of data warehousing users would rapidly increase (Crofts 1997). As the number of users grows, response time of data warehouses becomes increasingly critical.

Several researchers suggested that service quality be one of the dimensions of IS success (Kettinger and Lee 1995; Li 1997). The commonly used measures of IS effectiveness focus on the products rather than the services of the IS function; thus there is a danger that IS researchers will mismeasure IS effectiveness if they do not include in their assessment package a measure of IS service quality (Pitt, Watson, and Kavan 1995). Similarly, supports provided to users were found as another factor affecting user satisfaction with data warehouses (Chen *et al*. 2000). Therefore, we include End User Support and Training as another independent construct in the proposed research model of this study.

The proposed research model also includes four dependent constructs: Perceived Usefulness, Perceived Ease of Use, System Usage, and Perceived Individual Impact. In this study, Perceived Usefulness is the extent to which a person believes that data warehouses will enhance his or her work performance. Perceived Ease of Use is the degree to which one believes that using data warehouses will be free of effort. We measure System Usage by user's self-reported frequency and volume of data warehousing use. Finally, Perceived Individual Impact is the strength of one's belief that his or her work performance has improved by using data warehouses. Perceived Individual Impact is measured in term of decision-making performance, priority-setting, and job performance.

Relationships among Constructs

Researchers have found that both information quality and system quality significantly affect users' perceived impact. For example, in an empirical investigation of the factors affecting data warehousing success, the results shown that high level of data quality and system quality are associated with a high level of perceived benefits (Wixom and Watson 2001). Thus, it is expected that Data Quality, Accessibility, and Response Time are significantly associated with users' perceived impact. Similar to information quality and system quality, since we proposed service quality as one of the quality dimensions of IS success, it is also expected that service quality will significantly affect users' perceived impact.

H1: Data Quality is associated with Perceived Individual Impact.
H2: Accessibility is associated with Perceived Individual Impact.
H3: Response Time is associated with Perceived Individual Impact.
H4: End User Support and Training is associated with Perceived Individual Impact.

The Technology Acceptance Model hypothesizes that exogenous variables influence both Perceived Usefulness and Perceived Ease of Use (Davis, Bagozzi, and Warshaw 1989). Additionally, several previous studies suggested that the exogenous variables affecting Perceived Usefulness and Perceived Ease of Use include computing support and training (Igbaria, Zinatelli, Cragg, and Cavaye 1997), system quality (Lucas and Spitler 1999), tool functionality and tool experience (Dishaw and Strong 1999), and output quality (Legris, Ingham, and Collerette 2003). Therefore, we expect that the four independent constructs: Data Quality, Accessibility, Response Time, and End User Support and Training, will be associated with Perceived Ease of Use and Perceive Usefulness.

H5: Data Quality is associated with Perceived Ease of Use.
H6: Accessibility is associated with Perceived Ease of Use.
H7: Response Time is associated with Perceived Ease of Use.
H8: End User Support and Training is associated with Perceived Ease of Use.
H9: Data Quality is associated with Perceived Usefulness.

H10: Accessibility is associated with Perceived Usefulness.
H11: Response Time is associated with Perceived Usefulness.
H12: End User Support and Training is associated with Perceived Usefulness.

The relationship between Perceived Ease of Use and Perceived Usefulness has received extensive attentions from IS researchers. A few number of previous studies found that Perceived Ease of Use is a dominant factor in explaining Perceived Usefulness (e.g., Davis *et al*. 1989; Igbaria *et al*. 1997; Lucas and Spitler 1999). Thus, it is also expected in this study that Perceived Ease of Use will be associated with Perceived Usefulness. Additionally, results of several previous studies indicated that Perceived Usefulness is an important factor in determining actual system usage (e.g., Davis *et al*. 1989; Igbaria *et al*. 1997). Therefore, we expect a significant relationship between Perceive Usefulness and System Usage. Finally, the association between actual system usage and users' perceived impact was investigated and found to be significant in several previous studies (e.g., Igbaria and Tan 1997; Teng and Calhoun 1996). Consequently, in this study, we expect that System Usage is significantly associated with Perceived Individual Impact.

H13: Perceived Ease of Use is associated with Perceived Usefulness.
H14: Perceived Usefulness is associated with System Usage.
H15: System Usage is associated with Perceived Individual Impact.

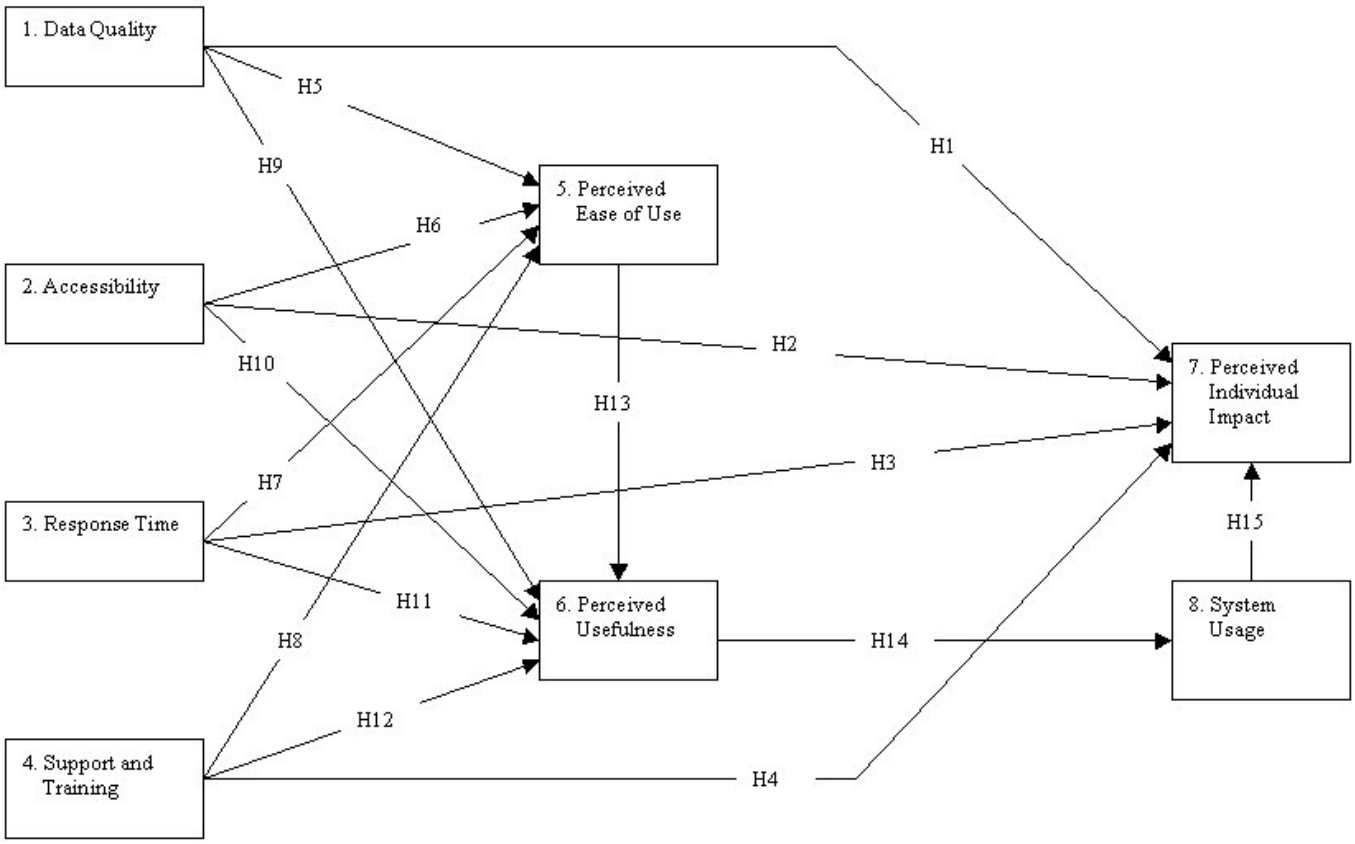

Figure 1. Proposed Research Model

RESEARCH METHODOLOGY AND ANALYSIS

Research Instrument and Data Collection

A questionnaire with 32 items was developed to measure all eight constructs in the proposed research framework. The questionnaire was translated into Korean language. Twenty-nine (29) items in the questionnaire were framed using a seven-point Likert scale anchored at: (1) Strongly Disagree, (4) Neither Disagree nor Agree, and (7) Strongly Agree. The remaining three items measuring self-reported System Usage (i.e., frequency and volume of data warehousing use) were framed using a seven-point scale as well. All measurement items and their descriptive statistics are presented in Appendix A.

The questionnaire was then administered by six managers from four leading companies in Korean financial sector. After three weeks, 115 of them were returned. All respondents have a college degree and are the end users of the data warehouses in their companies. They mainly use data warehouses for financial related analysis such as trend analysis, customer analysis, customer relationship management, and prevention of loan loss.

Data Analysis

The first step in data analysis included the tests of convergent validity and discriminant validity of the eight-construct measurement model. Convergent validity of constructs was assessed by Confirmatory Factor Analysis (CFA) and reliability analysis. Discriminant validity of constructs was assessed by pair-wise comparisons of constructs using chi-square difference test. Then, the next step in data analysis was to test the proposed hypotheses by Structural Equation Modeling (SEM).

For the original model with 32 measurement items, CFA results show that standardized loadings of all 32 items are higher than 0.5 and significant. Additionally, goodness-of-fit indices suggest a good fit of the model (see Table 1). Reliability analysis results show that all Cronbach alphas are higher than the suggested value of 0.8 for IS research (Straub 1989). These results suggest that the original measurement model with 32 items demonstrates a good fit to data. However, Hair *et al*. (1998) suggested that a good model should have less than 5.0 % of standardized residuals with absolute values greater than 2.58 (see Table 1). Based on this premise, three problematic items (i.e., item 8, 23, and 29) were dropped from the model. Then, the re-specified measurement model with 29 items was reevaluated. Standardized loadings of all 29 items are higher than 0.5 and significant. Goodness-of-fit indices and standardized residuals show a good fit to data (see Table 1). All Cronbach alphas are higher than 0.8.

Goodness-of-fit Indices	Desired value	Original model with 32 items	Re-specified model with 29 items	Structural model
SRMR	< 0.08	0.07	0.067	0.074
RMSEA	< 0.06	0.06	0.041	0.049
CFI	> 0.9	0.98	0.99	0.98
NFI	> 0.9	0.93	0.94	0.94
NNFI	> 0.9	0.97	0.98	0.98
χ^2 / df	< 3.0	1.49	1.28	1.37
% of absolute standardize residuals that are > 2.58	< 5.0%	6.82 %	3.45 %	n/a

Table 1. Goodness-of-fit Indices

Discriminant validity of the re-specified measurement model was evaluated by pair-wise comparisons using chi-square (χ^2) difference test. Results show that all the χ^2 differences are significant. These results imply that eight constructs in the re-specified measurement model are indeed distinct and thus suggest discriminant validity of the re-specified model.

The proposed hypotheses were tested by evaluating the structural model. Goodness-of-fit indices suggest that the structural model demonstrates a good fit to data (see Table 1). In addition, the explanatory power and the predictive validity of the structural model were assessed by inspecting the explained variance (R^2) for dependent constructs. Results show that the model accounts for 52.3 %, 63.7 %, 69.9 %, and 34.2 % of the variance in Perceived Ease of Use, Perceived Usefulness, Perceived Individual Impact, and System Usage respectively (see Table 2). This range greatly exceeds the 10.0 % variance

suggested as an indication of substantive explanatory power (Falk and Miller 1992). Thus, the structural model demonstrates high predictive validity.

Endogenous construct	Explained variance (R^2)	
Perceived Ease of Use	52.3 %	
Perceived Usefulness	63.7 %	
Perceived Individual Impact	69.9 %	
System Usage	34.2 %	
Hypothesis	Structural model	
	Std. loading	t-value
H1: Data Quality → Individual Impact	0.61	4.68 *
H2: Accessibility → Individual Impact	0.16	1.35
H3: Response Time → Individual Impact	0.08	1.35
H4: Support & Training → Individual Impact	0.23	2.39 *
H5: Data Quality → Ease of Use	0.32	2.24 *
H6: Accessibility → Ease of Use	0.03	0.22
H7: Response Time → Ease of Use	0.03	0.26
H8: Support & Training → Ease of Use	0.43	3.49 *
H9: Data Quality → Usefulness	0.54	4.14 *
H10: Accessibility → Usefulness	0.07	0.61
H11: Response Time → Usefulness	0.15	1.52
H12: Support & Training → Usefulness	0.17	2.08 *
H13: Ease of Use → Usefulness	0.22	2.16 *
H14: Usefulness → System Usage	0.58	6.35 *
H15: System Usage → Individual Impact	0.34	4.35 *

* t-value is significant at p = 0.05

Table 2. Test of Structural Model

Standardized loadings and their associated t-values (see Table 2) suggest that the structural model supports nine hypotheses. Specifically, both Data Quality and End User Support and Training significantly affect Perceived Ease of Use, Perceived Usefulness, and Perceived Individual Impact (i.e., H1, H4, H5, H8, H9, and H12). Perceived Ease of Use significantly contributes to Perceived Usefulness (H13) that leads end users to actually use Web data warehousing systems (H14). Finally, System Usage is also significantly associated with Perceived Individual Impact (H15).

DISCUSSION

The analysis based on survey data reveals factors that lead the data warehousing toward becoming a more effective environment. In particular, this study uncovers areas that warrant more attention if data warehousing is to affect end users' usage and perceived impact. Results of this study indicate that Data Quality significantly affect users' Perceived Ease of Use, Perceived Usefulness, and Perceived Individual Impact. Among various dimensions of Data Quality considered in this study, data relevancy received the highest rating (see Appendix A). Thus, currently the data warehousing systems seem to provide data relevant to users' needs. On the other hand, understandability (i.e., definition of data field, view, and table) appears to be particularly troublesome to users. Although systems provide a short description of each data field, view, and table, this short description is not sufficient for users to understand the data semantics. Accordingly, attention should be placed on providing clear and sufficient definition of data in the warehouses.

Similarly, End User Support and Training also significantly affect Perceived Ease of Use, Perceived Usefulness, and Perceived Individual Impact. For the four Korean financial companies participating in this study, managers have provided their employees sufficient encouragement, help, and support to use data warehouses to fulfill their tasks. Additionally, supporting staffs appear to have sufficient knowledge and experience that enables them to provide the effective solutions to fix technical problems for users. However, training is the issue that needs improvement. Users indicated that they did not receive relevant training that would help them effectively employ data warehouses for their tasks. Another issue where users perceived to be ineffective is the prompt responses from supporting staffs. Users need not only effective solutions to fix their

technical problems, but also quick responses from supporting staffs. Thus, companies may consider setting up a group of designated supporting staffs to provide users the initial responses to their problems.

This study renders some interesting results regarding Response Time and Accessibility. However, care should be given in interpreting these results. The results show that Response Time and Accessibility are not significantly associated with Perceived Ease of Use, Perceived Usefulness, and Perceived Individual Impact. It does not mean that these two constructs are not important for the implementation of data warehousing systems in these four Korean financial companies. A possible explanation for these insignificant results is from users' perception on management issues of data warehousing systems. That is, users perceive that management issues such as the lack of relevant training and subsequent system misuse significantly contribute to computing errors and slow system responses (Shin 2003). Because of the lack of relevant training, most users do not have sufficient knowledge to identify whether computing errors and slow system responses are from ineffective systems design and poor data access tools, especially when the system is relatively new (the four Korean companies in this study have been using their data warehouses for only approximately two years). Thus, users may weight more importance or their dissatisfaction on management issues, rather than technical aspects of the systems. Nevertheless, a firm explanation can only be supported with additional investigations.

Results of this study also support all hypotheses about the associations among Perceived Ease of Use, Perceived Usefulness, System Usage, and Perceived Individual Impact (i.e., H13, H14, and H15). These results are consistent with those findings in several previous studies (e.g., Davis *et al*. 1989; Igbaria *et al*. 1997); that is, Perceived Ease of Use is a dominant factor in explaining Perceived Usefulness; Perceived Usefulness is then an important factor in determining System Usage; and finally, System Usage significantly leads to Perceived Individual Impact.

CONCLUSION

The main focus of this study is to empirically investigate the factors that affect System Usage and Perceived Individual Impact of data warehousing users in four Korean financial companies. Results of this study suggest that Data Quality and End User Support and Training are significant factors affecting System Usage and Perceived Individual Impact. Additionally, this study provides consistent results to those results found in several previous studies, regarding the relationships among Perceived Ease of Use, Perceived Usefulness, System Usage, and Perceived Individual Impact. The results also reveal some concerns related to irrelevant user training and slow responses from supporting staff. These concerns may not be easily solved regarding the fact that data warehousing is relatively new for these four Korean companies.

We believe that further investigation of factors affecting System Usage and Perceived Individual Impact of data warehousing is warranted. Similar studies conducted on companies in different countries would provide more details for the generalization of study results. Additional studies to investigate the effects of users' limited technical and/or system knowledge on their perception of system errors would provide additional explanation for the insignificant results found in this study. Furthermore, since this study is cross-sectional, the findings represent a "snap-shot" in time. As users' perceptions may change after they have used data warehouses longer and are more familiar with the systems, a longitudinal study to monitor these changes and their effects would be of important value.

Similar to other empirical studies, this study has certain limitations. Limited sample size (115 respondents) might have affected the integrity of the statistical inference. Finally, certain system or non-system issues discussed in this study might be phenomena local to the studied industrial sector or country. In this sense, generalization of findings may be lacking and researchers should exercise their judgment in extrapolating results of this study from the responding sample to the broader population.

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Appendix A. Questionnaire Items and Descriptive Statistics

Item	Item Mean	Standard Deviation	Construct Mean
1. Data relevancy	4.90	1.22	Data Quality 4.72
2. Sufficiently detailed data	4.80	1.29	
3. Data accuracy	4.63	1.41	
4. Data currency	4.74	1.32	
5. Understandability	4.51	1.14	
6. Easy to locate data	4.67	1.30	Accessibility 4.40
7. Easy system access	4.61	1.15	
8. Easy-to-use data access tools	4.20	1.32	
9. Sufficient data access tools	4.12	1.27	
10. Need to wait (*reverse question*)	4.67	1.48	Response time 4.54
11. Fast response time	4.34	1.43	
12. Without much waiting	4.62	1.33	
13. Receiving relevant user training	3.70	1.16	Support and Training 4.12
14. Prompt response from supporting staff	3.91	1.40	
15. Effective fix from supporting staff	4.37	1.39	
16. Encouragement from management	4.53	1.35	
17. Help and Support from management	4.09	1.19	
18. Help finishing tasks quicker and easier	5.10	1.21	Perceived Usefulness 5.13
19. Useful to user's job	5.11	1.18	
20. Help improving job performance	5.09	1.24	
21. Important to user's job	5.23	1.27	
22. Easy to learn	4.43	1.27	Perceived Ease of use 4.65
23. Easy to get what user wants	4.93	1.15	
24. Easy to become skillful / expert user	4.53	1.17	
25. Easy to use	4.71	1.19	
26. Improved task outcomes	4.81	1.14	Perceived Impact 4.68
27. Improved performance	4.71	1.20	
28. Making better decisions	4.60	1.16	
29. Setting better priorities	4.58	1.18	

30. Overall usage	Frequency	Percent
• no use	0	0.0 %
• hardly use	9	7.8 %
• slightly use	23	20.0 %
• moderately use	37	32.2 %
• often	31	27.0 %
• quite often	10	8.7 %
• extensively use	5	4.3 %
31. Average usage		
• not at all	0	0.0 %
• 1 – 2 times a month	10	8.7 %
• 1 – 2 times a week	10	8.7 %
• 1 – 2 times a day	25	21.7 %
• 3 – 5 times a day	7	6.1 %
• 6 – 10 times a day	60	52.2 %
• more than 10 times a day	3	2.6 %
32. Average time spent per use		
• never use	0	0.0 %
• shorter than 15 minutes	13	11.3 %
• 15 – 30 minutes	34	29.6 %
• 30 minutes to two hours	27	23.5 %
• 2 – 3 hours	7	6.1 %
• 3 – 4 hours	34	29.6 %
• longer than 4 hours	0	0.0 %