Association for Information Systems
AIS Electronic Library (AISeL)

December 2001

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Abstract

Over the past decade, we have witnessed a proliferation of data warehouse. This study empirically examined the effects of thirteen factors on the extent of data warehouse implementation. Several hypotheses were set up to identify the relationships among these variables. And the survey instrument(questionnaire) was developed to collect data. Ultimately 183 questionnaires from 61 Korean firms were collected. Cronbach's alpha test and factor analysis were used to assess the reliability and validity of research variables. Subsequently, in order to test the hypotheses, multiple regression analysis and simple regression analysis were used. Findings showed that seven factors(having the right resources, management support, planning for the project, prototyping, quality of the data sources, having the right development tools, business need) affect positive effect on the extent of data warehouse implementation.

Keywords: data warehouse, IS Implementation, success factors

1. Introduction

Increasing levels of change in competition and technology in the business environment are causing organizations to dramatically modify their strategies, information architectures, and methods of conducting business. Many firms have turned to data warehouse to assist in making decisions about the changes needed(Little, 1998). Data warehouse has been cited in the literature as being one of the most powerful strategic weapons(Park, 1999).

Although data warehouse has received considerable attention in the trade journals and practitioner publications, little academic research has been conducted. And there has been much heated discussion over the failure rate of data warehouse project. As a result, performance or success of data warehouse becomes at issue.

So there has been a call for a rigorous empirical studies to examine data warehouse. In particular, it is important to understand the factors that affect successful implementation of data warehouse.

The purpose of this study is to identify factors affecting successful implementation of data warehouse. For this purpose, this study empirically examined the direct effects of thirteen factors on the implementation of data warehouse based on collected data from sixty one Korean firms which implemented data warehouse.

2. Theoretical Background

A data warehouse is a "subject-oriented, integrated, time-variant, non-volatile collection of information in support of management's decision-making process"(Inmon, 1992). Data warehouse was coined by Inmon in 1990. Since then, interest in data warehouse has grown because organizations realize improved performance, better data quality, and the ability to consolidate and summarize data from heterogeneous legacy systems.

Although data warehouse has received considerable attention, little academic research has been conducted. And high failure rate(above 50%) of data warehouse project was reported. So rigorous empirical studies on data warehouse are needed. In particular, it is important to study empirically the factors that make successful implementation of data warehouse. Therefore, this study addressed the following research question :

• *What factors are important to a successful implementation of data warehouse ?*
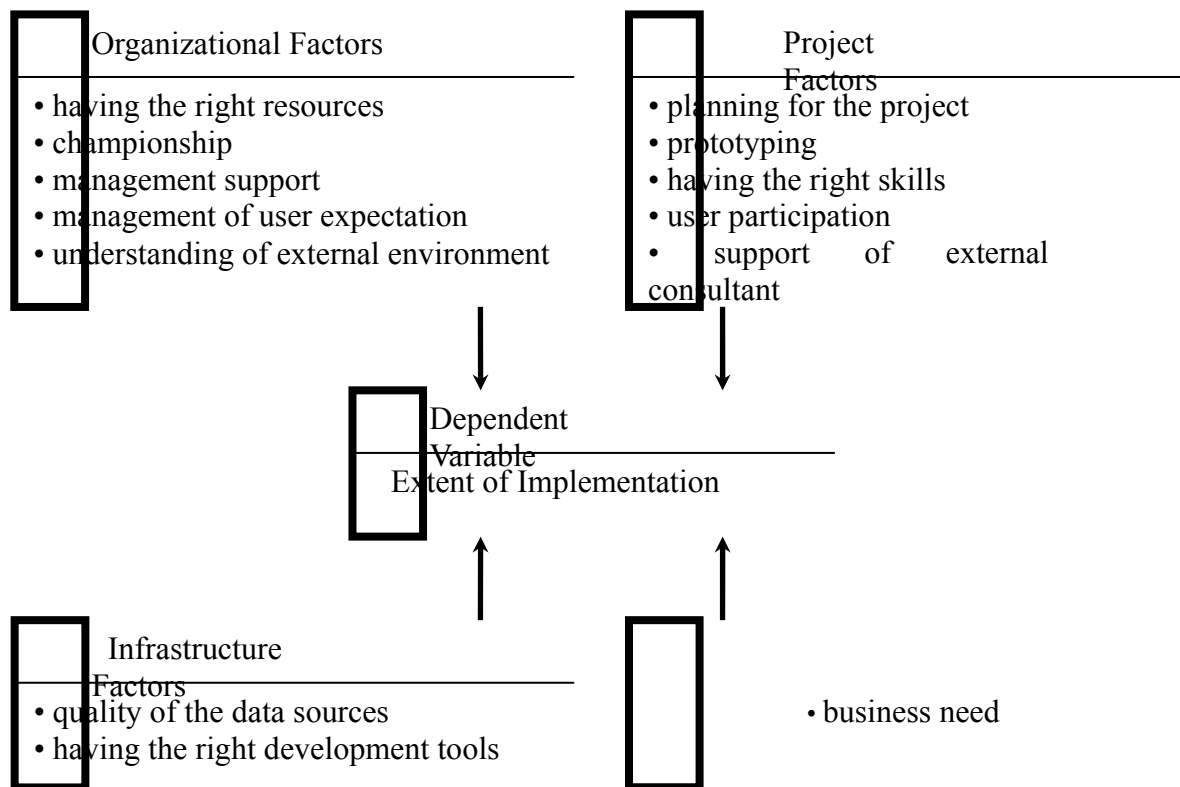
To answer this question, we studied prior research on data warehouse, IS implementation, and IS success. Finally thirteen factors were selected as independent variables for this study. And we grouped these factors to four groups based on criteria proposed by Haley(1997). Organizational factors are having the right resources, championship, management support, management of user expectations, and understanding of external environment. Project factors are planning for the project, prototyping, having the right skills, user participation, and support of external consultant. Infrastructure factors are quality of data sources and having the right development tools. Final group is including just one factor-business need.

IS implementation research has utilized an overwhelming number of dependent variables as surrogate measures of success. Researchers are charged with the task of understanding the nuances of the various measures and selecting the appropriate ones for study. In a review of 180 articles, DeLone & McLean(1992) organized the dependent variables that have been used to measure success into a taxonomy with six dimensions-information quality, system quality, use, satisfaction, individual impact, organizational impact. In a subsequent study, Pitt, et al(1995) extended the success model to include an additional component-service quality. The use of all seven dimensions of success would occasion a very large empirical research study. Time and resource limitations can drive the researcher to make a choices of success measure(s) that are more appropriate than others. DeLone & McLean(1992) encouraged the use of success measures that are directed at organizational impact. One approach that evaluate organizational impact is cost/benefit analysis, and another is extent of implementation. This study selected extent of implementation as dependent variable and surrogate measure of data warehouse success.

3. Research Model and Hypotheses

Based on prior literature, the research model for this study is designed to consist of four groups of independent variables:organizational factors, project factors, infrastructure factors, business need. These variables are hypothesized to influence the extent of data warehouse implementation. The model is illustrated in Figure 1.

[Figure 1]   Research Model

Organizational Factors
• having the right resources
• championship
• management support
• management of user expectation
• understanding of external environment

Project Factors
• planning for the project
• prototyping
• having the right skills
• user participation
• support of external consultant

Dependent Variable
Extent of Implementation

Infrastructure Factors
• quality of the data sources
• having the right development tools

• business need

3.1 Organizational Factors

Having the right resources: Data warehouse projects are expensive and time-consuming undertakings(Hildebrand, 1995; Sakaguchi & Frolick, 1997). Then resources must be available in the right form when needed. Otherwise, tasks cannot be completed, deadlines are missed, and requirement cannot be met even when other necessary factors are in place(Rettig & Simons, 1993). Therefore, having adequate resources is critical to their successful implementation(Watson & Haley, 1997; Adelman & Moss, 1999).

Championship: Many studies have found that at least one person(champion) within an organization must actively promote the IS implementation in order to succeed(Kimberly & Evanisko, 1981; Barrow, 1990; Howell & Higgins, 1990; Reich & Benbasat, 1990; Hoffer & Alexander, 1992; Rainer & Watson, 1995). Data warehouse project failure has been traces to lack of championship(Cafasso, 1996). Champion(s) is needed to provide information, material resources, and political support(Beath, 1991). Therefore continued championship is important throughout the entire implementation process for successful implementation of data warehouse(Haley, 1997; Reich & Benbasat, 1990).

Management support: Management support is another critical factors for successful IS implementation. Large, complex projects(e.g., data warehouse) induce change within the organization and cause resistance through a redistribution of organizational power(Franz & Robey, 1984; Markus, 1983). Management support can overcome such resistance(De Brabander & Theirs, 1984; Markus, 1983). The data warehouse literatures suggest that

management support is positively related to successful implementation of data warehouse(Watson & Haley, 1997; Haley, 1997; Little, 1998; Little & Gibson, 1999).

Management of user expectations: IS implementation failure might well result from the improper management of user expectations. Unrealistically high initial user expectations being followed by much reduced satisfaction with performance(Wanous, 1976). At the other end of the spectrum, however, many researchers report that individuals with unrealistically low expectations also experienced reduced satisfaction when the implementation was completed(Oliver, 1976). While these studies reflect apparently dichotomous results, they nonetheless indicate that proper management of user expectation is related to implementation success(Watson & Haley, 1997; McGee, 1997; Little, 1998; Little & Gibson, 1999; Adelman & Moss, 1999).

Understanding of external environment: The external environment discussed in this study is a concept that is pertaining to data obtained from sources external to the organization and pertaining to the firm's competitors. Understanding of organizational external environment is positively related to successful implementation of data warehouse too(Little, 1998; Little & Gibson, 1999).

H1 : Organizational factors will be positively related to the extent of implementation.
H1.a : Having the right resources will be positively related to the extent of implementation.
H1.b : Championship will be positively related to the extent of implementation.
H1.c : Management support will be positively related to the extent of implementation.
H1.d : Management of user expectations will be positively related to the extent of implementation.
H1.e : Understanding of external environment will be positively related to the extent of implementation.

3.2 Project Factors

Planning for the project : Good planning facilitates flexibility and the adaptability to changing requirements and ensures that goals are met in terms of schedule, budget, and functionality(Constantine, 1993; Waldrop, 1984). Good planning addresses the details of project impacts and evaluation criteria, and it guides the project team by keeping them focused on critical goals and pertinent issues(Rettig & Simons, 1993) and shilding them from unforeseen circumstances which could endanger the project(Ginzberg, 1981). Data warehouse projects are large and complex undertakings. Therefore Good planning is critical to successful implementation of it(Haley, 1997; Little, 1998) and planning must be carefully addressed(Sakaguchi & Frolick, 1997).

Prototyping: Prototyping uses an iterative working model of the system to elicit user requirements(Harker, 1993), and to improve the communication between the user and developer(Salaway, 1987). Data warehouse projects have changing requirements, and an approach such as prototyping best supports development efforts(Poe, et al., 1998). Prototyping offers a clear form of communication of data warehouse outcomes, even in the early stages of a project. Further, prototyping often is used as a proof of concept-tangible evidence that progress is being made for users and those providing resources. Therefore prototyping is positively related to the successful implementation of data warehouse(Haley, 1997; Little, 1998; Little & Gibson, 1999).

Having the right skills: The learning curve in implementing data warehouse is very steep, and the project suffers if the skills of project members are inadequate to complete the project tasks(Rist, 1997). These skills include the abilities to work and to communicate with users(Barquin, et al., 1997b). Only a high quality, competent team can perform in the way that complex projects require. Technology related data warehouse is very new and complex. Then development team must demonstrate essential skills that include both interpersonal skills and technical abilities. Otherwise, it is impossible to implement successful data warehouse project(McGee, 1997; Haley, 1997; Adelman & Moss, 1999).

User participation: User participation means activities involving a relationship between the user and the IS staff, the managerial or project management activities performed by the user, and hands-on systems development activities performed by the user(Barki & Hartwick, 1994). IS research has shown user participation to have positive impacts on implementation success(King & Rodriguez, 1981; Cheney, 1984; Franz & Robey, 1986; Necco, et al., 1987; Baronas & Louis, 1988; Doll & Torkzadeh, 1989; Reich & Benbasat, 1990; Lawrence & Low, 1993; Hartwick & Barki, 1994; McKeen, et al., 1994). In particular, user participation is important when the requirements for a system are unclear or undefined as is the case with data warehouse projects. Data warehouse literature suggests that user participation during data warehouse implementation increases the likelihood of meeting the requirements and managing the expectations of the user(Barquin, et al., 1997a; Rist, 1997; Stedman, 1997; Watson & Haley, 1997, Haley, 1997; Little, 1998; Adelman & Moss, 1999).

Support of external consultant; As discussed above, data warehouse project is very large and complex. And skill or technology related data warehouse is difficult. Therefore if project members within organization have not proper skills, using support of external consultant is the only alternative. Little(1998) claims that support of external consultant impacts on successful implementation of data warehouse positively.

  H2 : Project factors will be positively related to the extent of implementation.
H2.a : Planning for the project will be positively related to the extent of implementation.
H2.b : Prototyping will be positively related to the extent of implementation.
H2.c : Having the right skills will be positively related to the extent of implementation.
H2.d : User participation will be positively related to the extent of implementation.
H2.e : Support of external consultant will be positively related to the extent of implementation.

3.3 Infrastructure Factors

Quality of the data sources: A primary purpose of data warehouse is to integrate data from throughout the organization. However, it is difficult to integrate data properly, because data often lies diverse and heterogeneous sources(Bowen, 1995; Barquin, et al., 1997a). The quality of those data sources affects the integration process and facilitates implementation success(Watson & Haley, 1997; Haley, 1997; McGee, 1997; Adelman & Moss, 1999).

Having the right development tools: Development tools can largely affect the productivity and effectiveness of a project team(Finlay & Mitchell, 1994). Therefore, the tools involved in a system implementation must be considered with care. First, the tools used for a system implementation must be compatible with the organization's technical environment by fitting with the current equipment, task requirements, and skill base. Second, the tools must be

understood by the team members. The better these two points are achieved, the better the staff is able to implement successful project(Ross, et al., 1996). These are challenging requirements with data warehouse, which involves a wide variety of new hardware and software products supplied by different vendors(Appleton, 1995). Many of the problems stem from the integration of new data warehouse tools and technologies with existing systems. Organizations need to understand how to use tools to handle large volumes of data and to maximize performance. Otherwise, it is impossible to implement successfully(McGee, 1997; Haley, 1997; Little, 1998; Little & Gibson, 1999, Adelman & Moss, 1999).

  H3 : Infrastructure factors will be positively related to the extent of implementation.
H3.a : Quality of the data sources will be positively related to the extent of implementation.
H3.b : Having the right development tools will be positively related to the extent of implementation.

3.4 Business Need

A system that address business need can affect the usage rate of system and the recognition of system' value positively(Ginzberg 1978). The relationship between business objectives and technology has surfaced in the IS implementation literature and IS planning literature. Many data warehouse articles prescribe the presence of a clear business reason for the data warehouse project to ensure a successful outcome(Cafasso, 1996; Love, 1996; Strehlo, 1996; Watson & Haley, 1997; Poe, et al., 1997)

H4 : Business need will be positively related to the extent of implementation.

4. Research Methodology

4.1 Operationalization

The instrument used for the measurement of various research variables in this study is discussed below.
Extent of implementation was measured by four items-the size of raw data, the number of users that can access data warehouse, the number of types of applications that access data warehouse, the number of functional areas supported by data warehouse. These questions were developed based on questions asked by Olson & Lucas(1982) and the framework presented by Massetti & Zmud(1996).
Having the right resources was operationalized as the amount of time, money, and people that were available for the data warehouse implementation. Three questions were developed using the work of Haley(1997).
Champions are individuals who provide information, material resources, and political support(Beath, 1991). And championship is the degree of doing champion's role properly. Three questions were created to address each of theses three facets.
Management support was operationalized using instrument developed by Yoon, et al.,(1996). Three questions measure management support are management's encouragement of data warehouse use, the provision of help and resources by management, and management's interest in satisfying data warehouse users.

Management of user expectations was operationalized using instrument developed by Little(1998). Three questions are the degree of explanation about data warehose's general functions, the degree of explanation about scope of firm's data warehouse project, and the degree of explanation about organizational changes incurred by data warehouse implementation.

Understanding of external environment were comprised of two questions related to usefulness of external data, and one question related to the degree of understanding about competitor's data warehouse activity.

Planning for the project included two dimensions. The first dimension was project planning, the second dimension is project management. Four questions were developed based on the work of Ginzberg(1981) and Kavan(1997). The questions were related to concrete planning from starting point, managing the schedule, controlling the budget, and delivering the right product.

Purpose of prototyping is twofold-to elicit user requirements, to improve user and developer communications(Harker, 1993; Salaway, 1987). Two questions were created to measure the degree that prototyping was used for each purpose. A third question was added to measure if prototyping was used as a proof of concept during the data warehouse implementation.

Having the right skills is the degree of possessing both interpersonal and technical skills of the data warehouse project team members. Two questions were developed based on the work of Waldrop(1984) to assess the degree of interpersonal and technical skills of the data warehouse project members. And one question was developed based on the work of Haley(1997) to assess the degree of project team member's experience with data warehouse and large-scale systems implementation.

User participation is related to the IS-user relationship, the user's responsibility on the project, and hand-on activities performed by the user(Barki & Hartwick, 1994). Three questions were developed to measure the degree of each of these dimensions.

Support of external consultant was operationalized based on the work of Little(1998). Three questions are the degree of using external consultant support in an orderly fashion, the degree of understanding that external consultants provide significant leverage in implementing a data warehouse because of their experience, and the degree of using external consultant support to assist in transferring new technologies into the data warehouse infrastructure.

Quality of the data sources was operationalized based on the work of Wybo & Goodhue and Haley(1997). Five questions are the degree of common fields and definitions within the organization, the degree of systems or databases that adhere to standards, the degree of understanding of the data sources, the degree of if source systems had to be modified, and the degree of if data sources were assessed for quality.

Having the right development tools was comprised with four questions-if tools used to implement data warehouse was compatible with existing technology in the organization, work properly, address the technical needs of the project, and be understood by the developers.

Business need was comprised with six questions those related to the linkage between organization's objectives and data warehouse implementation. These were developed based on the work of Haley(1997) and Horner, et al.,(1996).

4.2 Data Collection and Sample Characteristics

A questionnaire that measures the various research variables was developed. And data collection process was started from searching Korean firms that implemented data warehouse in search engines such as Simmani, Yahoo Korea, Alta Vista Korea, Empas, etc. We found ninety Korean firms. Next, the questionnaire was mailed to three project members of each firm. Ultimately 183 questionnaires from 61 firms were collected.

The firms that participated in this study(See Table 1) were distributed across various industries. There was a wide distribution of companies ranging from relatively small firms(26.2%) with employee size below 1000 to large firms(32.8%) having over 5000 employees. Likewise, we noticed a fair distribution of companies with respect to IS employee size also, ranging from 26% of the firms with fewer than 100 employees to 16% of them having more than 200 employees.

[Table1] Sample Characteristics(Firms)

Criteria		Frequency(Percentage)
Industry	Banking	11(18.0%)
	Financial Services	16(26.2%)
	Telecommunications	8(13.1%)
	Retail/Wholesale	8(13.1%)
	Health	4(6.6%)
	Manufacturing	12(19.7%)
	Other	2(3.3%)
Number of Employee	Less than 1000	16(26.2%)
	1000~5000	25(41.0%)
	Above 5000	20(32.8%)
Number of IS Employee	Less than 100	26(42.6%)
	100~200	19(31.1%)
	Above 200	16(26.3%)

4.3 Reliability and Validity

The reliability of the research variables was assessed using cronbach's alpha. Table 2 describes the items used for measuring each variable and the corresponding alpha. All alphas were greater than 0.7 level, thereby implying an adequate level of internal consistency. One exception is the alpha coefficient for quality of the data sources. But this variable improved to .7063 after removing one item(and the degree of if data sources were assessed for quality). One of the most powerful methods to test validity is factor analysis. All items in the research variables were factor analyzed and loaded in accordance with the a priori theoretical expectations, then significant aspects of validity had been assessed(Criteria : rotation=varimax, extraction=principal component analysis, eigen value=above 1.0, factor

loading=above 0.4).

[Table 2] Reliability Analysis

Variable			No. of Items	Cronbach's alpha
Success Factors (Independent Variables)	Organizational Factors	Having the right resources	3	.8636
		Championship	3	.9297
		Management support	4	.8970
		Management of user expectations	3	.8623
		Understanding of external environment	3	.8486
	Project Factors	Planning for the project	4	.8320
		Prototyping	2	.9533
		Having the right skills	3	.8754
		User participation	3	.7135
		Support of external consultant	3	.9346
	Infrastructure Factors	Quality of the data sources	5	.5938*
		Having the right development tools	4	.9031
	Business Need		6	.8716
Dependent Variable	Extent of implementation		4	.8045

4.4 Hypotheses Testing

To test the research hypotheses, multiple regression and simple regression analysis were applied. Appropriate assumption tests for this technique(multi-collinearity, normality, variance equality, linearity) were performed. No assumption was violated.

Four regressions were computed to investigate between the dependent variable(extent of implementation) and each of the independent variable(success factors) groups. The results are described in Table 3.

The results showed that two organizational factors(having the right resources, Management support) significantly lead to better extent of data warehouse implementation, thereby supporting hypotheses 1.a, 1.c. Planning for the project and prototyping were found to affect positive effects on the extent of implementation, supporting hypotheses 2.a, 2.b. Two infrastructure factors(quality of the data sources, having the right development tools) were found to be significant predictors of the exetent of implementation, supporting hypotheses 3.a, 3.b. Finally business need was found to affect positive effect on the extent of implementation, supporting hypothesis 4.

[Table 3] Regression Analysis

Independent Variable	Statistics	Dependent Variable=Extent of Implementation	
		Beta	Sig of T
Organizational Factors	Having the right resources	.150130	.0431*
	Championship	.076778	.3574
	Management support	.323259	.0001*
	Management of user expectations	.033862	.6931
	Understanding of external environment	.052481	.4964
	R^2	.42376	
	Sig. Of F	.0000*	
Project Factors	Planning for the project	.266364	.0009*
	Prototyping	.172574	.0302*
	Having the right skills	.037486	.6861
	User participation	.100138	.2672
	Support of external consultant	.101642	.2365
	R^2	.38166	
	Sig. Of F	.00000*	
Infrastructure Factors	Quality of the data sources	.152952	.0466*
	Having the right development tools	.191359	.0131*
	R^2	.28381	
	Sig. Of F	.0005*	
Business need		.245638	.0008*
R^2		.24564	
Sig. of F		.0008*	

5. Discussion of Results

This study examined the effects of four groups of factors on the extent of data warehouse implementation. The survey instrument(questionnaire) was developed to collect data. Ultimately 183 questionnaires from sixty one Korean firms which implemented data warehouse were collected. Cronbach's alpha test and factor analysis were used to assess the reliability and validity of research variables. Subsequently, in order to test the hypotheses, multiple regression analysis and simple regression analysis were used.

Findings showed that two organizational factors(having the right resources, management support), two project factors(planning for the project, prototyping), two infrastructure factors(quality of the data sources, having the right development tools), and business need were found to be important factors of the extent of data warehouse implementation.

But three organizational factors(championship, management of user expectations, understanding of external environment), and three project factors(having the right skills, user participation, support of external consultant) didn't affect significant effects on the extent of implementation.

This study addressed a general need for data warehouse research. In fact, there were few, if

any, empirical studies on data warehouse. Hopefully this study will increase interest in data warehouse research and will provide guidance regarding possible directions for new investigations.

There are several limitations in this study. First, even though there are various influence factors, but only thirteen factors were considered in this study. Other factors must be included in future research. Second, the results can be affected by cultural characteristics or background in Korea, because we collected data from just Korean Firms. Thus, to be more general, it is necessary to extend the sample area.

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