INDUSTRY & PRACTICE

The Contribution of IT Governance Solutions to the Implementation of Data Warehouse Practice

Sutee Sujitparapitaya, California State University, Sacramento, USA
Brian D. Janz, University of Memphis, USA
Mark Gillenson, University of Memphis, USA

ABSTRACT

Information systems (IS) strategic planners debate what is the most appropriate data warehouse (DW) topology for an organization. The primary question is whether to start DW projects with enterprise-wide data warehouses (EDWs) or with smaller-scale data marts (DMs). This article examines the relationship between modes of IT governance and DW topology to determine whether or not the implementation differences in DW topology can be described by differences in IT governance arrangements. Three primary modes of IT governance–centralized, decentralized, and hybrid – were used to arrange key IT activities. A replicated case study approach coupled with a research survey was used to provide a comprehensive understanding of the relationship between modes of IT governance and DW topology. Utilizing information from six organizations, the empirical evidence presented indicates that the organizations with higher levels of centralized IT authority are likely to implement a more centralized data warehousing approach. Key implications for theory and practice are discussed.

Keywords: *cross case study, data warehouse topology, data warehousing success, data warehousing technology, IT governance*

INTRODUCTION

In the data warehouse literature, it is widely held that a data warehousing (DWG) technology is a cornerstone of the organization's ability to provide effective information processing (Inmon, 1997; Kelly, 1997b). Many MIS researchers define DW topology as a set of rules or structures, which provide a framework by identifying and understanding how data will move throughout the system and be utilized within the organization (Bischoff & Alexander, 1997; Hammergren, 1996; Inmon, 1997; Kelly, 1997b). DW topology also distinguishes what is being built and how DW should be built in order to offer data consumers current and historical decision support information (Bontempo & Zagelow, 1998; Devlin, 1997; Hackney, 1997b;

Kachur, 2000; Kelly, 1997b; Poe, Klauer, and Brobst, 1998). If implemented correctly, DWG technology can enable and share the discovery and exploration of important business trends and dependencies that otherwise would have gone unnoticed.

Information systems (IS) strategic planners debate what is the most appropriate data warehouse (DW) topology for the organization. The primary question is whether to start DW projects with enterprise-wide data warehouses (EDWs) or with smaller-scale data marts (DMs). Enterprise-wide DW are built in the interests of overall business decision support and contain historical data summarized and consolidated from detailed individual records from a number of operational databases. At the same time, organizations are increasingly turning to smaller-scale DMs as an alternative means of delivering information due to their quicker delivery, lower risk, and lower costs. DMs seem to provide specific solutions to specific business challenges.

In principle, DW can meet information needs and provide strategic business opportunities to enhance or transform products, services, business relationships, markets, and work processes. The conceptual and practical understandings of the underlying evolutionary nature of organizational IT governance arrangements become critically important in establishing appropriate IT decision rights in managing effective use of IT. Many IS researchers suggest that three primary modes of IT governance, including centralized, decentralized, and hybrid, can be used to arrange key IT activities. These three modes vary to the extent in which centralized IS, divisional IS, and line management are vested with authority for the key IT activities. Key IT activities refer to IT infrastructure, IT use, and project management. Thus, this study seeks to explain whether or not the outcome of differences in DW topology could be explained by differences in IT governance arrangements.

The primary emphasis of this study is to gain a comprehensive understanding of the relationship between modes of IT governance and DW topology. This is achieved through a research methodology based on a replicated case study design coupled with a research survey. The research question generally investigated in this context is: Are three essential modes of IT governance likely to differ with respect to the degree of centralization in their DWG implementation approach? The results of data analyses indicate that levels of IT decision-making authority were found to significantly affect the differences in the outcome of DW topology. A highly centralized IT decision-making authority has reflected a dominating enterprise-wide DWG implementation approach.

In today's highly competitive business environment, DWG technology can enable the discovery, exploration, and sharing of important business trends and dependencies that otherwise would go unnoticed. In this context, the question of whether DW architecture is to be implemented using an enterprise-wide DW or a divisional DM, is interesting but difficult to answer. This study seeks to explain whether or not the outcome differences in DW topology can be explained by differences in patterns of IT-related authority. A potential relationship between the patterns of authority for key IT activities and the choice of data warehouse topology is investigated by utilizing enriched information from each of the scenarios of multiple contingencies. Therefore, this study examines whether the IT governance arrangement lends itself to successful implementation of the data warehouse.

We expect that organizations with centralized IT-related authority are likely to implement an enterprise-wide DW architecture in order to build and sustain a lateral organization capacity across the corporation. Organizations with decentralized IT-related authority, on the other hand, are likely to implement a divisional DM architecture in order to build and sustain a lateral organization capacity across business units.

THEORETICAL FOUNDATIONS AND PRIOR RESEARCH

Data warehouse topology refers to a set of rules or structures that provide a framework by identifying and understanding how data will move throughout the system and be utilized within the organization. In addition, it distinguishes what is being built and how DW should be built in order to offer current and historical decision support information to data consumers (Bontempo & Zagelow, 1998; Devlin, 1997; Hackney, 1997b; Kachur, 2000; Kelly, 1997b; Poe et al., 1998).

Many DW researchers classify DW topology into two primary categories: enterprise-wide DW (Bontempo & Zagelow, 1998; Inmon, 1994; Poe, Klauer & Brobst, 1998) and divisional DM (Hackney, 1997b; Inmon, 1997; Simon, 1998). As illustrated in Figures 1 and 2, these two categories can be differentiated by *a data populating approach* from source data to target data. Typically, the source data in Form A (for both architectures--enterprise-wide DW and divisional DM) comes from the operational applications that maintain little historical data. An exception might be an operational data store (ODS) in Form B that is resided in data staging. ODS is used to hold detailed data as a DW data sourcing before performing data acquisition, cleanup, transformation, and loading. With simple processing and sequential processing, a staging area is a data store that is designed primarily to receive data into an intake layer. In many cases, data in the staging area does not need to be based on relational technology (only in a third normal form for further extraction). Data entering an enterprise-wide DW or a divisional DM is transformed into an integrated structure and format. The transformation process may involve data conversion, summariza-

Figure 1: Enterprise-Wide Data Warehouse Topology

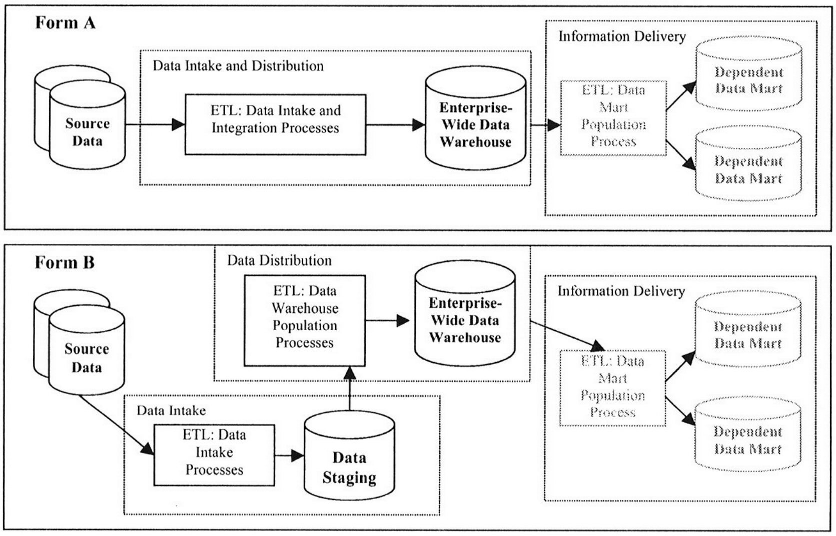
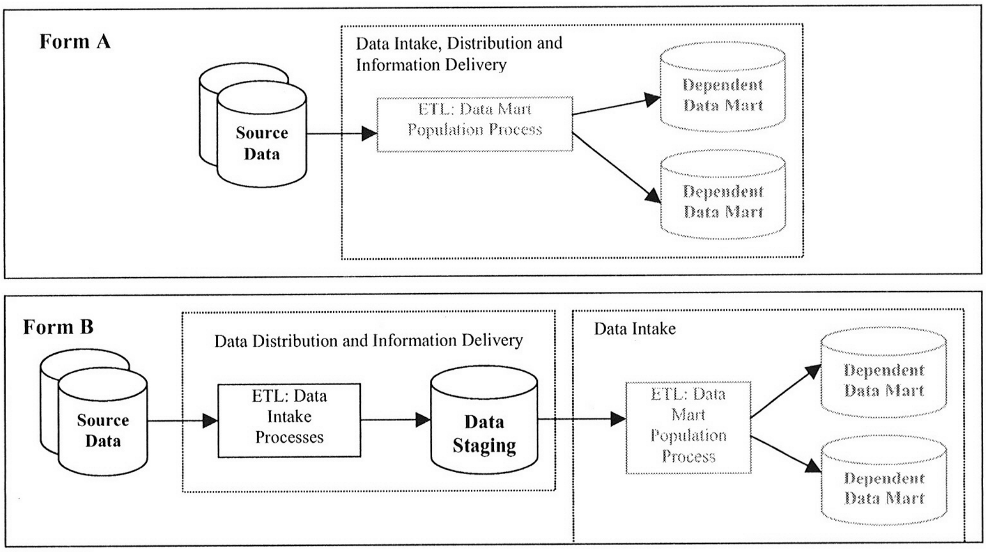


Figure 2: Divisional Data Mart Topology



Note: ETL = Data Extract, Transformation, and Loading.

tion, filtering, and condensation.

Bontempo and Zagelow (1998) suggest that regardless of the type of database system used for decision making, the topologies for developing the system should enable critical business intelligence functionality. They should be built within appropriate time frames and budgets, and with the flexibility needed to meet the company's ever-evolving requirements. IT strategic planners should begin by determining which DW topology would be the most suitable for their company in the way the business process is viewed.

Modes of IT Governance Arrangements

In this study, IT governance arrangements refer to the level of decision-making authority and responsibility for primary IT activities that are shared between two levels of IS management and service providers: *corporate IS from a centralized IT department, and divisional IS and/or line management from business functional areas* (Brown & Magill, 1994; Sambamurthy & Zmud, 1993). According to IS researchers (Cross, Earl, and Sampler, 1997; Sambamurthy & Zmud, 1994; Weil & Broadbent, 1998), IS management and service providers' decisions revolve around three primary activities: *IT infrastructure, IT use,* and *project management.* IT infrastructure decisions involve decisions that emphasize investment in new and upgraded hardware and software, data and networks, and policies and standards for acquisition and usage of IT assets (Von Simson, 1990; Weil & Broadbent, 1998; Wilder, 1990). IT use decisions refer to decisions that emphasize short-term and long-term IT planning, budgeting, prioritization of DW applications, and daily DW operations and services (Von Simson, 1990; Wilder, 1990). IT project management decisions emphasize the process of defining, planning, directing, monitoring, and controlling IT development and its deployment at a minimum cost within a specific time and budget (Curtis, Keasner, and Iscoe, 1988; Walz, Elam, and Curtis, 1993).

Organizing IT is an essential management issue. The economies of scale, connectivity, and control are forces that push many organizations towards a centralized IT decision mode, while decentralized structures favor effectiveness and responsiveness (Berger, 1990; LaPlante, 1991; Messmer, 1990, Von Simson, 1990; Wetherbe, 1988; Wilder, 1989). A centralized IT decision mode has the authority and responsibility for all three primary IT activities located at an organization-wide IS unit. With a decentralized IT decision mode, IT decision authority regarding three primary IT activities is pushed to the business unit or divisional IS unit which in turn reports to a business functional area. IT organizations have to find the correct hierarchical level at which to make decisions.

In the last several years, a hybrid (distributed) IT decision mode has been proposed. Such a mode allows corporate IS units and divisional IS units to assume primary authority and responsibility for specific IT activities (Brown & Magill, 1994; LaPlante, 1991; Von Simson, 1990; Zmud, 1988). With this mode, the decision for IT infrastructure, for example, is highly centralized by the corporate IS unit, but IT use and project management decisions are highly decentralized by the business unit or divisional IS staff. However, Sambamurthy & Zmud (1994) suggest that in modern organizations the decision authority for IT infrastructure located at the business unit or divisional IS unit is not practically feasible.

This study expands on the set of three traditional IT decision modes utilized in earlier empirical studies in order to address the choice of DWG approach that supports IS strategic alignment–the fit between business strategic orientation and IS strategic orientation. We propose that organizations with centralized IT decision modes where decision-making authority belongs to a central IS unit, are likely to implement enterprise-wide DW architectures. Divisional DM architectures, on the other hand, are expected to be implemented by organizations where the divisional IS staff has the primary IT decision-making authority.

Indicators of Success

Currently, MIS researchers may choose from a large number of information system success measures. This has tended to create some confusion, as many researchers and practitioners have had little guidance in identifying success constructs and measures. Adding to the confusion is the poor theoretical grounding of the information systems success instruments. As noted by Shirani, Aiken, and Reithel (1994), most of the existing instruments were developed through interviews and questionnaires, and from scales derived from other scales. They note that though this approach has intuitive appeal, a sound theoretical basis for their inclusion is often missing.

In the final section, our literature review focuses on the indicators of DWG success encountered during DW development. Many researchers and professionals define indicators of success in DW development as the factors that must work if an undertaking is to succeed. Indicators of DW success are presented in Appendix 1.

While many practitioner articles and books have addressed the success factors affecting the implementation of DWG in organizations, only two recent empirical studies have rigorously addressed such key factors. In the first study by Little (1998), the research discovered nine factors that impacted DW implementation, and eight factors affecting the implementation as perceived by project team members. Little's (1998) study suggested that members of the implementation project team, as well as the organization's management team, must understand the existing corporate culture and be prepared to deal with negative aspects during implementation. Such a finding might be combined with the findings of organizational management to help develop a normative model. This will assist researchers in understanding organizational issues affecting DW implementation.

The second empirical study by Haley (1997) examines a relationship between DW implementation factors and success factors. Only two of the three implementation factors, including project and organizational outcomes, directly relate to the success factors. Infrastructure outcomes, on the other hand, do not support her hypothesis, since they do not influence the success of the data warehousing initiative. Haley's study showed that organizational factors, such as having the right resources, a champion, and management support, were found to affect the success of DW projects. Such a finding suggests multiple avenues for future research. Additional research within the academic community is still needed regarding the organizational aspects and the success factors.

After reviewing the IS success theoretical literature, general systems theory, and several IS success instruments, we have identified three variables, which appear to be the core dimensions for measuring data warehousing success: systems quality, information quality, and technology acceptance from users' perspectives. The definition of an information systems success construct underlies the development of a cumulative MIS research tradition by allowing for cross-study comparisons and study replications. Key implications to this study are further discussed in the research findings section.

RESEARCH METHODOLOGY

A multi-method approach including replicated case studies and a research survey were used in this study to provide a comprehensive understanding of the relationship between IT governance arrangements and DW topology. Since the late 1990s, several organizations that have implemented DWG technology have relocated to the southern states, providing a convenient sample for the case selection. Six large organizations that had implemented DWG technology prior to our first on-site visit agreed to take part in the study. These six large organizations classified into two DWG approaches - three with an enterprise-wide DWG approach and three with a divisional DM approach.

The case study for each organization was addressed as a complete study for which the report explained how and why a particular proposition was demonstrated (or not demonstrated), and involved multiple forms of data collection. Multiple data collection methods allowed us to conduct a more thorough examination of each organization than is possible with a quantitative study alone. Researchers (Hersen and Barlow, 1976; Yin, 1994) indicate that with multiple sources of evidence from multiple case studies, they can address a broader range of historical and observational issues than would be possible in survey research alone. Multiple sources also help to prevent subjective bias. Finally, a cross-case study was conducted to examine the extent of the replication logic and to ascertain why certain cases were predicted to have certain results.

At each case site, a direct report to the DW manager or project manager served as the primary contact, which (a) provided relevant historical information about the company, the IT function, and DW implementation process; (b) assisted with identification and solicitation of the target participants; (c) scheduled all interviews; and (d) provided feedback for various confirmatory documents. In consultation with the researcher, a sample of DW and business functional managers–who provided similar stakeholder viewpoints across the six case sites and who were considered to be knowledgeable about DW implementation – were identified and asked to participate. The DW manager at each organization included the systems manager and project manager of either an enterprise-wide DW or business functional DM, as relevant. The DW business functional managers included two or more divisional/functional managers or department heads that heavily utilize DW/DM technology in order to gain competitive advantages for their business functional areas.

The follow-up interviews were conducted to collect information about the level of IT decision making that included the IT decision roles of corporate (centralized) IT units and divisional (decentralized) IS staff in primary IT activities: IT infrastructures, IT use, and project management. Levels of IT decision-making across business units of the sampled organizations were examined to detect whether or not there were any significant variations across units. In addition, data from Hoover's company profile database for American Public Companies 2000 was gathered on sales revenues, net income, number of employees, officer information, and business overview, over the three years prior to the data-gathering effort. Thus, DW implementation decisions and the size of each organization were used as the criteria for case site selection in selecting these six case sites.

Table 1 illustrates the summary information that provides the "snapshot" description of the overall organization, its DWG approach, firm size, and the degree of IT decision-making authority for DW activities. The differences between these sites highlight the importance of treating each site as an individual case study, which is done in the next section.

RESEARCH FINDINGS: CROSS CASE STUDY

We describe each DW topology via a broader perspective of the entire organization that offers a consistent approach in examining corporate data architecture across the organization. Two survey instruments with research surveys were developed to measure the patterns of authority for key IT activities that are assumed to make a significant contribution to the successful selection of a DWG implementation approach.

The research findings indicate that IT decision making has positive effects on the successful selection of a DWG approach. We also discovered that the integration of DW architecture into the existing system's architecture is not always straightforward. In this study, current transactional system architectures may be extremely sophisticated at some organizations, both by design and lack of design. In most cases, there have been some type of constraints set in implementing the DW architecture, which are used to explain the relationship between IT governance arrangements and DW topology. These constraints can be a variety

Table 1: Case Site Selection Criteria and Description

Organization	DW Approach	Firm Size	Mode of IT Governance	Description
A	Enterprise-wide DWG	Large [(a)] 141,000 Emps. $ 16.7 Billion	Hybrid toward Centralized	Multinational corporation pursuing the corporate strategy of effective delivery programs, order processing, and transportation management
B	Enterprise-wide DWG	Large [(b)] 8,324 Emps. $740 Million	Centralized	Prestigious Research I university that has emerged as a leading national and international research and teaching institution
C	Enterprise-wide DWG	Large [(a)] 5,260 Emps. $ 730 Million	Centralized	Leading provider of computer-based marketing information services
D	Divisional DM	Large [(a)] 40,500 Emps. $ 4.1 Billion	Hybrid toward Decentralized	Leading specialty retailer emphasizing the business transactions through both industrial and consumer markets
E	Divisional DM	Large [(a)] 19,330 Emps. $ 2.3 Billion	Decentralized	Manufacturer and distributor of electrical and electronic components.
F	Divisional DM	Large [(a)] 12,356 Emps. $ 1.7 Billion	Decentralized	Multinational healthcare organization that manufactures and sells medical and consumer healthcare products

(a) Based on 1999 Financial Report from Hoover's Company Profile Database, Hoover's Inc. Based on Fiscal Year of 1999 Budget Report to Arizona Board of Regents and 1999 IPED Report.

of technical, integrated, strategic, or political considerations that introduce limitations as to how the DW architecture can be implemented within these organizations.

The findings, based on the interview data, are summarized in Table 2. Results of this study support the notion that there is a greater degree of centralized IT decision authority for key IT activities in organizations with an enterprise-wide DWG approach, than in those using a divisional data mart approach. The evidence from Organizations A through C seems to support the common-sense notion that IT decision making for the three primary IT activities with wider spans of control is better accomplished with the centralized, enterprise-wide DWG approach. When divisional IS staff is increased, their IT authority within their own division is distributed across the organization. In such a circumstance, the divisional data mart approach appears to play a role in DW architecture design. In Organizations D through F, business functional units have essentially created divisional data marts for their data architecture.

Table 2 shows that the first three organizations (A through C) maintain a higher degree of centralization of IT decision-making authority by using an enterprise-wide DWG approach than the last three organizations (E through F) which use a divisional DM approach. This indicates that the separation of authority is obviously essential for understanding the control of IT resources and for differentiating strategic choices in DW implementation. Although those with formal authority may have the clout, others within the organization may have created strong power bases that allow them to have even greater influence over decisions.

Pfeffer (1981) suggests the evidence to support this notion. He indicates that decision authority is a structural phenomenon created by the division of labor and departmentalization. Horizontal differentiation inevitably creates some tasks that are more important than others. To use IT resources within each organization, those groups or departments performing the more critical tasks, or who are able to convince

Table 2: Interview Results on IT Decision Authority for Three Primary IT Activities

DW Imp. Approach	Organization	Level of Infrastructure Decisions	Level of IT Use Decisions	Level of Project Management Decisions	Degree of IT Decision-Making
Enterprise-Wide DWG Approach	A	Corporate IS	Divisional IS	Corporate IS	**Hybrid towards Centralization**
	B	Corporate IS	Corporate IS	Corporate IS	**Centralization**
	C	Corporate IS	Corporate IS	Corporate IS	**Centralization**
Divisional DM Approach	D	Corporate IS	Divisional IS	Divisional IS	**Hybrid towards Decentralization**
	E	Divisional IS	Divisional IS	Divisional IS and Line Management	**Decentralization**
	F	Divisional IS	Divisional IS and Line Mgmt	Divisional IS and Line Mgmt	**Decentralization**

others within the organization that their tasks are more critical, will have a natural advantage in the IT decision-making authority (Caufield, 1989; Miller, Glick, Wand, and Huber, 1991).

Based on the prior literature (DeSanctis & Jackson, 1994; Earl, 1989), large companies with decentralized IS decision-making authority are therefore least likely to invest in horizontal mechanisms for corporate/division collaboration. Companies with such IS contexts are likely to be organizations with highly autonomous business units. This will lead to the successful implementation of a divisional DM architecture. In contrast, large organizations with centralized IS governance are more likely to invest in horizontal mechanisms for corporate/division collaboration in order to achieve IS cost efficiencies through economies of scale and standardized infrastructures (Brown & Magill, 1998). In such a setting, the organizations tend to adopt an enterprise-wide DW architecture.

Other Findings: Data Warehousing Success

From our literature reviews of the IS success, three variables appear to be the core dimensions for measuring data warehousing success: systems quality, information quality, and technology acceptance from users' perspectives. Table 3 illustrates the comparison of IT staff and users' perspectives of data warehousing success for all six organizations.

Table 3 indicates that the majority of DW managers (DW technical staff) rated their systems with higher means for all three variables than the ones from DW business functional managers and divisional IS units (DW users) when an enterprise-wide DW architecture was implemented within their organizations (in above shaded areas). With the exception of Organization B, similar patterns with higher means occurred when the DW technical staff responded concerning perceived ease of use and perceived usefulness in comparison to the responses from DW users. During the follow-up interviews with Organization A, respondents indicated that the central IS unit has the technical competence to provide higher technical expertise to support a larger, more complex DW architecture. In general, a central IS can specialize and thus develop sufficient expertise to evaluate technologies. It can also function as a research unit for DWG technology by providing the necessary skills needed for cutting edge pilot

Table 3: Comparison of IT Staff and Users' Perspectives of DWG Success

DW Imp. Approach	Org.	Systems Quality			Information Quality			Technology Acceptance		
		Total	Tech	User	Total	Tech	User	Total	Tech	User
Enterprise-Wide DWG Approach	A	3.69	**4.04**	**3.33**	3.56	**4.21**	**2.92**	3.58	**4.08**	**3.08**
	B	3.74	**3.79**	**3.67**	3.59	**3.70**	**3.44**	4.65	4.58	4.75
	C	4.19	**4.38**	**4.13**	4.47	**4.88**	**4.32**	4.17	**4.25**	**4.13**
Divisional DM Approach	D	4.00	**3.94**	**4.07**	3.60	4.00	3.25	4.56	**4.50**	**4.63**
	E	3.71	**3.75**	**3.78**	3.79	**3.5**	**3.9**	3.56	**3.5**	**3.58**
	F	4.00	**3.94**	**4.05**	4.23	4.44	4.08	4.45	**4.25**	**4.58**

projects that cannot be undertaken by divisional IS units.

Unlike the results of DW success for an enterprise-wide DW architecture, DW business functional managers provided higher response rates to systems quality and user acceptance (shown in above shaded areas) when data architecture was implemented in a divisional DM environment. Such support by DW users produced an opposing disposition toward data warehousing success. This provides strong support for end user computing. Respondents from Organization E indicate that the functions of their system were defined to meet a set of users' specific needs. We believe the users seem to understand the problem areas better than corporate IS units. They also argue that the IS specialists, on the other hand, are experts in the technology, but not in the problem areas. By allowing divisional IS staff to develop their own divisional data marts, there is no need for communication with the corporate IS unit. Therefore, with divisional DM development, no communication gap exists.

Within this context, the evidence obtained from the six organizations suggests consistency with the evidence from our literature review. In light of this evidence, an enterprise-wide DW architecture allows for an integrated and complete view of the organization's information. Its projects involve a high level of complexity in development. In most cases, the unique architecture required for a customized DW divisional data mart structure must be built upon a set of business subject requirements that are derived from the individual needs of the organization. The analysis results in this study strongly support the theory that even if the implementation process is presented as being successful, a DW development team needs to ask a wide range of questions in building it. Regardless of the type of DW topology, DW designers need to pay as much attention to the business requirements, data definitions, and flow of data as they do to choosing hardware and software. Nevertheless, DW construction requires a sense of anticipation regarding future ways in which to use the collected records. DW developers need to be aware of the constantly changing needs of their company's business, and of the capabilities of the available and emerging hardware and software requirements.

Table 4 summarizes factors leading to the success of DW architecture for the six sample organizations that emphasize the construction of new warehousing projects. It is important to know that the above factors are not "critical success factors." According to Rockart (1979), critical success factors are the factors that are critical to success in performing functions or making decisions. They are the key areas of the job where things must work in order for the organization to flourish. For the current DW studies, researchers (Haley, 1997; Little, 1998; Wixom & Watson, 2001) may choose from a large number of DW critical success factor measures. This has tended to create some confusion, as many DW researchers and practitioners have had little guidance in identifying success constructs and measures.

Since they do not follow the rigorous standards set by Rockart (1979), the factors in Table 4 should not be considered to be DW critical success factors. As noted by Shirani, Aiken, and Reithel (1994), most of the existing instruments were developed through interviews, questionnaires, and personal experience, and from scales derived from other scales. They note that though this approach has intuitive appeal, a sound theoretical basis for their inclusion is often missing. To take this lack of theoretical basis into account, we refer to them as "factors for success" rather than critical success factors.

From a replicated case study approach coupled with a research survey, the empirical evidence indicates that only four factors of DWG success were counter-intuitive to the previously defined indicators of data warehousing success (see Appendix 1). Three of these four factors (Factors 3, 4, and 5) were directly related to the development team. Long-term commitment from DW development team, a good partnership between DW users and developers, and appropriate technical and business-related skills for developers were critical to provide immediate support, clear definition of users' needs, and ability to relate data warehouse goals to business needs. In addition, the last factor (Factor 7) applied specifically to the data. The required data had to exist and be included in the DW from both internal and external data sources. This also allowed development

Table 4: Factors for DWG Success Across Six Organizations

Factors for DWG Success	Supported by Previous DW Research
1. Ensure that upper management provides sufficient support and commitment during the DW development efforts.	Yes
2. Ensure that executive officers encourage the use of the DW architecture once it is built.	Yes
3. Ensure long-term commitment from DW development team that understands the users' needs.	**No**
4. Ensure that DW development team has both the necessary technical and business related skills.	**No**
5. Establish a good partnership between users and DW developers.	**No**
6. Transform and cleanse operational data to meet the DW quality standard.	Yes
7. Ensure that required data exists and can be obtained from internal and external data sources.	**No**
8. Ensure that the metadata provides a clear roadmap for all data in the warehouse.	Yes
9. Establish corporate-wide standards and procedures regarding data quality, access, exploitation, and presentation.	Yes
10. Select DW hardware and software to meet the project's requirements.	Yes
11. Use an appropriate DW development methodology and modeling technique to build the data architecture.	Yes
12. Match query tools with different users' access skills, preferences, and requirements.	Yes
13. Manage user expectations to obtain user buy-in by promoting the success of the initial project.	Yes
14. Provide appropriate user training and support programs.	Yes
15. Include users in the meetings that determine users' needs during the design of data subject areas.	Yes
16. Constantly adapt the system to meet changing business requirements over time.	Yes
17. Clearly define needed data and use appropriate modeling techniques during DW design.	Yes
18. Avoid bleeding-edge technology.	Yes

teams to define the adequate level of granularity that led to a manageable volume of data, yet offered enough details for business queries.

CONCLUSION

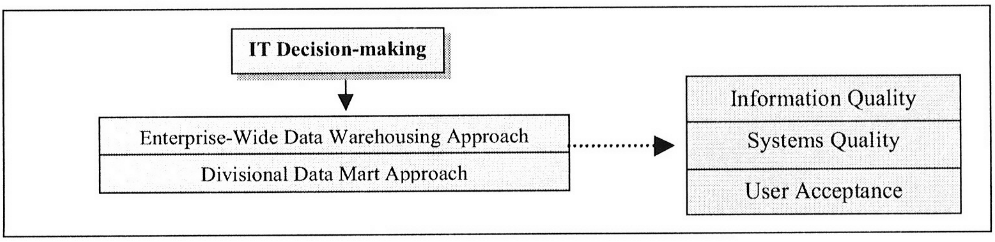
Many MIS researchers recognize the movement of IT governance for both specific organizations and for all organizations that transform through a recurrent centralization/decentralization cycle. Variations in IT governance arrangements depend in part on the IT goals and the environment. Our intention is to explain concepts of IT organizations and management as they relate to DW architecture design. This study was driven by a strong desire to provide empirical evidence in establishing appropriate IT decision rights to direct and coordinate an organization's effective use of and exploitation of DW technology.

From Figure 3, evidence obtained from three organizations (A through C) suggests that, consistent with the predictions of research study, highly centralized IT decision authority would reflect a dominating enterprise-wide DWG implementation approach. In the last three instances observed within the case sites (D through F), the dominating divisional data mart architecture resulted in a decentralized IT decision mode. The interviews made it clear that the mode of IT decision-making primarily influences the selection of DW architecture. Interviewees constantly stressed that since their organization was diversified into different businesses and across several countries, each operating division had to focus on the unique nature of its particular market. As a consequence, IT decision responsibility was being located deeply within operating divisions, so as to enable each business functional unit to shape its divisional data mart architecture for its market situation.

In addition, the evidence shows that enterprise-wide DW architecture as well as divisional data mart architecture can be effective. However, we cannot assume that every data architecture is an effective choice for every organization, especially from users' perspectives. Furthermore, the trade presses continue to remind us that the choices of DW architecture must support the organization's goals and missions (Berson & Smith, 1997). The predictive model in Figure 3 is a step toward sharing with the practitioner community our findings on "what support" in terms of the key variables for DW architecture decisions.

Several suggestions for future research were presented in the discussion of the hypotheses results. The measures used here were designed for only six specific organizations. Measures of greater breadth would be desirable in order to increase the level of consistency. Future researchers will need to determine whether the relationships shown here hold true for other industries.

Figure 3: Proposed Model for Data Warehouse Architecture Decisions



Appendix 1: Indicators of Data Warehousing Success

	Indicators	Sources
1.	Selecting the appropriate management sponsorship and maintaining approval of changes (such as high management commitment, universal approval, measures and rewards, and cross-functional sponsorship)	Anonymous 1998; Anonymous 1996; Devlin 1997; Dodge and Goreman 1998; Gray and Watson, 1998; Hammergren 1996; Kelly 1997; MacDonald, 1998; Onder and Nash, 1998; Perkins, 1999a; Stackowiak, 1997; Switzer 1997; Watson and Haley 1997; Wixom and Watson, 2001.
2.	Setting specific, achievable, and measurable goals	Gray and Watson, 1998; Onder and Nash, 1998; Stackowiak, 1997.
3.	Understanding business requirements	Adelman and Moss, 1999; Anonymous 1996; Dodge and Goreman 1998; Freed, 1996; Gray and Watson, 1998; Lehmann and Jaszewski, 1999; Perkins, 1999a; Stackowiak, 1997; Zimmer 1998; Wixom and Watson, 2001.
4.	Having user involvement, such as selecting a DW project leader and manager who is user-oriented rather than technology-oriented, applying technology to business needs, focusing on the business rather than on the technology, and including end-users on the implementation team.	Adelman and Moss, 1999; Anonymous 1996; Dodge and Goreman 1998; Hildebrand 1996; Kight 1996; Lehmann and Jaszewski, 1999; MacDonald, 1998; Mundy 1995; Onder and Nash, 1998; Poe, Klauer, and Brobst, 1998; Stedman 1997b; Stedman 1998; Watson and Haley 1997; Wixom and Watson, 2001.
5.	Planning and implementing the DW architecture and design – a subset of the enterprise architecture, such as scalability.	Perkins, 1999a; Perkins, 1999b; Stackowiak, 1997.
6.	Paying attention to assumptions and details in order to obtain high quality and detailed historical data used to answer business problems, such as clear data definition, appropriately detailed warehouse-stored information.	Adelman and Moss, 1999; Freed, 1996; Gray and Watson, 1998; Kelly 1997; Lehmann and Jaszewski, 1999; MacDonald, 1998; Onder and Nash, 1998; Perkins, 1999a.
7.	Planning and implementing well-defined metadata and its repository, such as having an information directory available.	Anonymous 1997a; Freed, 1996; Onder and Nash, 1998.
8.	Utilizing an appropriate DW development methodology and modeling technique in building the data architecture.	Adelman and Moss, 1999; Anonymous 1996; Devlin 1997; Gray and Watson, 1998; Handen and Boyle 1998; Inmon 1997; Perkins, 1999a; Stedman 1998; Watson and Haley 1997; Zimmer 1998.
9.	Transforming and cleansing operational data to meet the DW quality standard.	Ambrosio 1993; Burch 1997; English 1996; Foley 1997a 1997b; Kay 1997a; Watson and Haley 1997.
10.	Establishing corporate-wide standards and procedures regarding data quality, access, exploitation, and presentation.	Anonymous 1997b; Hamilton 1997; Mundy 1995.
11.	Selecting DW hardware and software to meet the project's requirements.	Raden and Peterson 1997; Beitler and Leary 1997; Anonymous 1996; Wixom and Watson, 2001.
12.	Matching query tools with different users' access skills, preferences, and requirements.	Beitler and Leary 1997; Kelly 1997.
13.	Managing user expectations to obtain user buy-in by promoting the success of the initial project.	Anonymous 1997a; Wixom and Watson, 2001.
14.	Providing the appropriate user training and support programs.	Mundy 1995.
15.	Constantly adapting the system to meet changing business requirements over time.	Anonymous 1998; Beitler and Leary 1997; Kay 1997b; Kight 1996; Mundy 1995; Switzer 1997; Teach 1996.
16.	Avoiding bleeding-edge technology.	Zimmer 1998.

In addition, multinational organizations should be considered to examine the relationships, especially concerning their global strategies. As a broader set of industries are added to this study, different organizational variables should be considered to develop a causal link between variables. Research studies that consider DWG technology and organizational structure measures before and after DWG technology implementation in a number of organizations should indicate whether it is indeed the changes in DW architecture that are driving the change in structure.

Assuming that a wide body of significant research findings can be developed to indicate the best fit of DWG approach for a given organizational setting, one more major effort will be possible. By adding studies of organizational strategy to the variables studied in this work, it may be possible to develop an even more complete picture of how DW architecture design should be conducted. Several researchers (Burns & Wholey, 1993; Daft & Weick, 1989; Egelhoff, 1991; Smith, Dykman, and Davis, 1989) suggest that organizations are information-processing systems. Understanding the effects of the DWG technology as well as the use of DWG products may provide the insights and mechanisms needed to build and test a complete model of DW architecture. This model supports an organization's goals with maximum returns on its investment.

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Sutee Sujitparapitaya is the Director of Institutional Research and Decision Support at California State University at Sacramento (CSUS). He received his Ph.D. from the University of Memphis in August 2000. Prior to joining CSUS in 2001, he was the Director of Systems Administration at the University of Memphis, where he was actively involved in many important University-wide and departmental systems design and development efforts. Dr. Sujitparapitaya's research interests focus on several areas of information technology in the organizational context: data warehousing technology, end user computing, integrated enterprise, and strategic planning. He has presented his work at both national and international conferences.

Brian D. Janz is an Associate Professor of MIS at the Fogelman College of Business and Economics at The University of Memphis where he teaches in the undergraduate, MBA, and Ph.D. programs. In addition, he is the director of the Center for Managing Emerging Technology and is past associate director for the FedEx Center for Cycle Time Research at the University of Memphis. Prior to receiving his Ph.D. in Management Information Systems from the Carlson School of Management at The University of Minnesota in 1995, Dr. Janz spent 12 years in the information systems field working for Fortune 100 companies.Dr. Janz's research interests focus on how information technologies affect organizational strategy, design, and knowledge worker behavior. Specifically, he is interested in the effects that self-direction, cooperation, and organizational learning have on organizational supply chain management and process cycle time, systems development, and the quality of systems delivery.

Mark L. Gillenson is Professor of Management Information Systems in the Fogelman College of Business and Economics of the University of Memphis in Memphis, TN. He received his B.S. degree in Mathematics from Rensselaer Polytechnic Institute, Troy, N.Y. and his M.S. and Ph.D. degrees in Computer and Information Science from The Ohio State University, Columbus, OH.

Dr. Gillenson's areas of interest are database management systems, particularly database administration and database design, electronic commerce, and computer and communications security. He is an associate editor of the Journal of Database Management and of the journal Pattern Recognition. Dr. Gillenson's research has appeared in MIS Quarterly, Communications of the ACM, Methods of Information in Medicine, and other leading journals. His books include Strategic Planning, Systems Analysis, and Database Design, 1984, and Database: Step-by-Step, Second Edition, 1990, both published by John Wiley & Sons.