

December 2002

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Recommended Citation

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APPLYING ADAPTIVE STRUCTURATION THEORY TO DATA WAREHOUSE IMPLEMENTATION: A FIELD STUDY

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Abstract

This paper presents observations derived from interviews conducted over a five month period with employees of a large U.S. based financial services organization. The focus of the paper is to differentiate between areas of the organization that successfully integrated data warehouse technologies into their everyday work environment versus those that did not. These differences are presented using a theoretical framework supplied by adaptive structuration theory (AST). AST recognizes that these organizational areas are comprised of social systems operating with specific social practices and norms. Furthermore, AST describes how new technological innovations (such as data warehouses) will both impact, and be impacted by, the social practices and norms of the adopting group. In other words, the differences between successful and unsuccessful integration cannot be evaluated outside the context supplied by the existing social systems.

This field study furnishes some indication that adaptive structuration theory provides a useful framework for explaining observed differences between social systems that successfully appropriated the data warehouse, and social systems that were unsuccessful in this appropriation. The study supports the notion that in examining the effects of introducing data warehouse technologies into an organization, it is important to account for contextual factors influencing the organization's various social systems. It also focuses attention on the factors effecting the generation of stable appropriations and the importance of these factors in the acceptance of a data warehouse by organizational social systems.

Introduction

Organizations are spending millions annually on developing data warehouse environments; however, the majority of these efforts do not succeed [Vatanosombut, 1999]. In fact, surveys indicate more than 50 percent of all warehouse development efforts either fall behind schedule or are placed on hold [Stedman, 1998]. Despite this high failure rate, very little research has focused on relating the problem of successfully integrating data warehouse technologies into the corporate environment to the existing body of theoretical research that focuses on the introduction and acceptance of complex technologies. A search of the literature revealed no studies relating data warehouse introduction to existing acceptance theories like adaptive structuration [Poole and DeSanctis, 1990], diffusion of innovations [Rogers, 1983], and the technology acceptance model [Davis, 1986].

While much has been written describing the “critical success factors” involved in data warehouse implementation, most of this work is based on personal development experience and other informal approaches [Vatanosombut, 1999; Sammon, 2000]. Very little work is based on formal research methodologies and linked to existing theory.

This paper presents observations derived from interviews conducted over a five month period with employees of a large U.S. based financial services organization. This organization was entering the sixth year of attempting to successfully integrate data warehouse technologies into the existing corporate structure. Some areas of the organization had accomplished this integration and had developed highly successful applications based on data in the warehouse. However, most organizational areas were finding this integration to be extremely difficult, and in fact some areas had given up any attempts to use the data warehouse in

a productive manner. The interviews mentioned above focused on past, present, and prospective warehouse users. They included both formal interviews targeting specific organizational areas and informal interviews with specific warehouse users. The focus of the paper is to differentiate between the organizational areas that successfully integrated the data warehouse technologies into their everyday work environment versus those that had not. Because of this focus on organizational areas (versus individual acceptance), adaptive structuration theory (AST) was chosen to provide a theoretical framework in which to analyze these differences. AST recognizes that these organizational areas are comprised of *social systems* operating with specific social practices and norms. Furthermore, AST describes how new technological innovations (such as data warehouses) will both impact, and be impacted by, the social practices and norms of the adopting group. In other words, the differences between successful and unsuccessful integration cannot be evaluated outside the context supplied by the existing social system.

The following section provides a brief overview of adaptive structuration theory, including a definition of important terms. Next the paper presents a description of the financial institution that is the focus of the interviews. The description will concentrate on those areas of the organization that are relevant to the study and will include a brief discussion of the structure of the organization's data warehouse. Following the organizational description will be a discussion of the predictions made by AST and how these predictions can be used to better understand the observed differences between successful and unsuccessful implementations identified in the interviews. Finally, the paper will provide recommendations to practitioners and suggestions for future research.

Adaptive Structuration Theory: An Overview

As described above, social groups are organized around a collection of practices and norms that provide the context under which group activities are conducted. The introduction of technological innovations into a social group will not suddenly alter the manner in which this group functions. In fact, the innovation is typically viewed, in part, as another social resource to be used in a manner consistent with the accepted practices and norms of the group. This is not to say that the innovation does not (or will not) impact these practices and norms. However, any impact resulting from the innovation's introduction will evolve over time in an iterative manner.

AST views a social group as a *system* pursuing practices and norms that are used to accomplish system tasks and meet individual needs. A *social system* is sustained through rules and resources that AST refers to as *structures*. These structures are not static, but evolve as system members seek to align the structures to the social system's practices and norms in a coherent manner. When a technological innovation is introduced, it adds its own set of structures (called the innovation's *structural features*) to the social system. An innovation also has a *spirit*, which is defined as the reasoning and motivation that determines the developers intended use of the innovation. AST highlights the notion that it is not hardware components or software code that is of paramount importance, but the new social structures that the technological innovation enables. AST also notes that the innovation's structural features operate independently from the innovation's spirit. In other words, the structural features of the innovation will not necessarily be used in a manner consistent with the innovation's spirit.

As system members use and reuse structures they are reproduced and possibly modified over time. AST refers to this reproduction and potential modification of structures as *structuration*. It is through the structuration process that structures introduced by a technological innovation are integrated into and become part of the social system. It is important to understand that structuration is an iterative process, and through this process both the social system and the structures will adapt to each other.

AST also states that structuration does not occur without a purpose. A social system adapts structures to meet or accomplish specific tasks, goals, and needs. AST refers to these adaptations of structures to specific purposes as *appropriations*; therefore, the structuration process is also an *appropriation process*. AST makes an important distinction between appropriations that align with the spirit of the technological innovation (i.e. the innovations intended use) and those that do not. Appropriations that are in alignment with the innovation's spirit are termed *faithful appropriations*, while those that do not are referred to as *ironic appropriations*. A faithful appropriation that is also supported by the members of the system in the sense that there is a consensus as to how the innovation's structures should be used, and the members understand and are comfortable with the technological innovation itself, is termed a *stable appropriation*.

The important components and relationships of AST are represented in Figure 1 [adapted from Poole and DeSanctis, 1990]. This figure describes AST along a technology dimension and a contextual dimension. The technology dimension relates to the introduction of structures into a social system through a technological innovation. These structures are defined by the structural features of the innovation and pertain to the innovation's spirit. The contextual dimension places limitations and constraints on

how the structural features of the innovation will be appropriated. These limitations and constraints depend upon social system factors such as task composition and complexity, political pressures, organizational obligations, and work schedules. The contextual limitations and constraints also depend on the degree of agreement among system members concerning the standards and norms used to determine acceptable system choices. This degree of agreement determines the level of conflict within the social system, which mitigates the manner in which an innovation's structural features are appropriated.

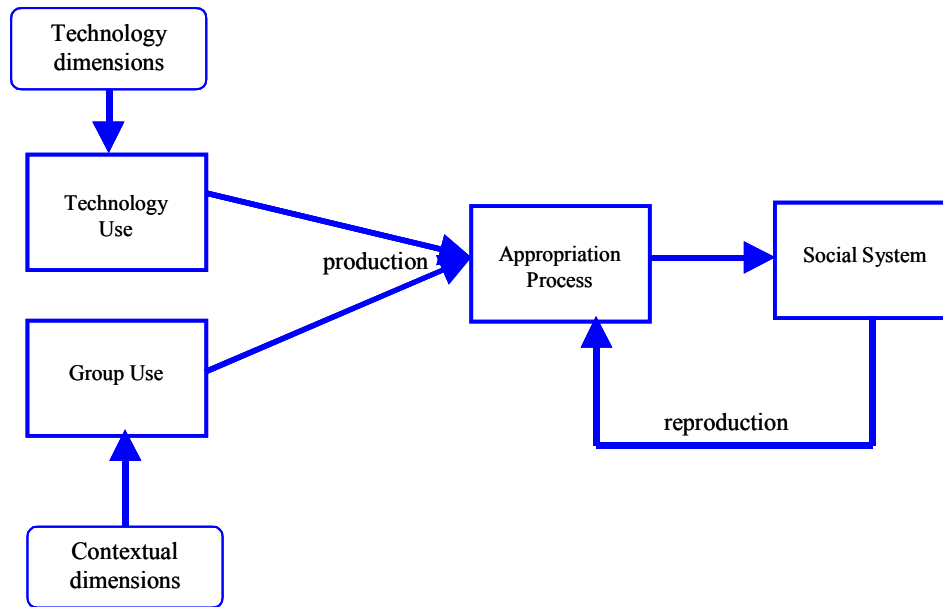


Figure 1. The Adaptive Structuration Process

The appropriation process produces context specific structures (i.e. appropriations), which impact and influences the social system, which in turn impacts the appropriation process through the reproduction of the structures.

Company Overview

The company that is the focus of this study is a large, global, financial institution based in the United States. The company is highly successful and enjoys an excellent reputation both within its industry and among its clients. The company's organizational culture can be described as very conservative and resistant to change. The years of success and profitability have led to an attitude within the company that can best be described by the expression "if it's not broke, don't mess with it." This is especially true among members who have been with the company for several years.

This conservative nature extends to the company's philosophy concerning technology. While the company believes that technology is important to its corporate success, its predominant preference is for technologies that have matured and are proven. The company also has a strong corporate belief in its uniqueness and the uniqueness of its business model, resulting in a strong bias for the in-house development of technological innovations. If tools or solutions are purchased they must be flexible enough to adapt to the way the company conducts business and not dictate business processes.

In 1995, the company began an in house development effort to design and implement an enterprise wide data warehouse. The company chose to model the warehouse using Inmon's paradigm [Inmon, 1997], which espouses a physically centralized database, referred to as the "data warehouse," that was used to integrate and store data extracted from the operational systems. This data warehouse, in turn, feeds area specific data marts. Since its inception, the data warehouse has grown in size and complexity as more of the operational systems have been integrated into the data warehouse environment. However, from the beginning, this development effort has been very much an IT driven initiative. The business justification for the warehouse was never fully developed, and the potential business uses of the warehouse were not considered beforehand. The prevailing assumption of the development team was that if the warehouse was built and filled with data, the business users would find a use for it. This

assumption has proven to be false. While some important and successful uses of the warehouse do exist, the predominant opinion (especially among senior members of the company) is that the warehouse is significantly underutilized and has not returned the value necessary to justify its existence.

During the fall of 2001, the company sponsored a controlled field study to evaluate its enterprise data warehouse environment, including how the warehouse was being used [Chenoweth, 2001]. As part of this evaluation process, representatives from the business areas impacted by the warehouse were interviewed to determine the nature of the impact and the degree to which each area had been able to successfully integrate use of the warehouse into the area's work environment. During these interviews, it became apparent that the most successful business areas shared common characteristics. First, the successful areas generally had a very firm and deep understanding of the business issues relevant to the area and how data available in the warehouse could be used to address these issues. Second, successful business areas developed in house experts who possessed an understanding of both the business implications of the warehouse and the technology behind the warehouse. These individuals understood not only how to apply the data from the warehouse to relevant business problems, but also how to extract the pertinent data from the warehouse. Third, the successful business areas had developed a good working relationship with the data warehouse development team. The development team became a support group, which an area could use to resolve warehouse related issues. Fourth, the successful areas generally had leadership that fully supported use of the warehouse within the area. Finally, most successful business areas accessed data from the warehouse via a data mart and not directly from the warehouse itself.

Application of Adaptive Structuration Theory

As discussed in the section providing an overview of AST, the integration of a technological innovation, such as a data warehouse, into a social system introduces a new set of structural features, which both impact and are impacted by the social system through the appropriation process. This section will analyze the characteristics shared by the areas of the company that were successful in their warehouse integration efforts using the framework supplied by AST. The goal of this analysis is to determine the degree to which AST is able to explain the existence of these characteristics.

For the purposes of this analysis, it is important to better define the statement "an area of the company has successfully integrated the warehouse into its work environment." If successful integration has occurred, then the data warehouse has become an integral (and indispensable) part of the everyday work environment for the area. One question that was asked of all impacted company areas was "If the warehouse were to vanish tonight, what would be the impact on your ability to function?" The predominant answer given by areas that had successfully integrated the warehouse was that they would not be able to function; the warehouse had become that central to their *social system*. Areas that were less successful or not successful answered the question by saying either that with adjustments they would function or that there would be little to no impact.

In terms of AST, this successful integration means that the structural features introduced by the warehouse have been appropriated by the *social system* (i.e. the organizational area) in a manner that has produced *stable appropriations*. This means that the appropriations are *faithful* (i.e. the warehouse is being used in a manner consistent with the business objectives of both the area and the organization as a whole), that there is a high level of agreement within the social system that the appropriations are appropriate, and that the social system has a high degree of both respect for the warehouse and comfort using the warehouse [Poole and DeSanctis, 1990].

In their description of AST, Poole and DeSanctis (1990) discuss various predictions on how technological innovations and context will combine to affect how the appropriation process will influence social system outcomes. Poole and DeSanctis present these predictions in the context of group decision support systems. The generalization of these predictions to a data warehouse environment is presented below, along with a discussion concerning how these predictions help explain the observed success characteristics defined above.

The lower the ambiguity of the data warehouse with respect to its use, the higher the probability that stable appropriations will occur.

The more confusion there is as to how a technological innovation is to be used, the greater the likelihood that conflict over this use will develop among the members of a social system. Conversely, the more structured the innovation and the fewer choices available to the social system members, the easier it will be to develop a consensus among the members as to how the innovation should be used and the appropriateness of that use. In addition, ambiguity as to use of the innovation will erode the level of comfort system members have for the innovation, which in turn will erode their respect for the innovation.

This prediction helps explain why, in general, those business areas within the company that accessed their data through data marts were more successful than those areas that did not. Data marts help reduce the inherent complexity associated with data warehouses by providing a slice of the warehouse tailored to meet the specific requirements of a specific business area. These data marts also allow for the relatively easy development of area specific applications that are designed to accomplish specific and redundant tasks.

These characteristics of the data mart reduce the level of warehouse specific knowledge required of the area members, thereby reducing the level of ambiguity associated with warehouse use. In addition, the applications developed that access the data marts reduce the options available to area members as to how to use the warehouse. The combination of factors just described will increase the comfort level and respect the area members have for the warehouse and enable these members to reach a consensus as to the appropriateness of this use with less conflict. In other words, these factors make it more likely that the warehouse structural features will be appropriated in a stable manner.

It should be noted that while, in general, successful use of the warehouse was via a data mart, there were instances of highly successful warehouse use that did not use a data mart. However, those areas where these successes occurred had specific contextual factors in common which required a more flexible approach to warehouse use not available via a data mart. How these instances fit within the framework supplied by AST will be described in the following prediction.

Task requirements interact with the degree of flexibility associated with the data warehouse to influence the ability of a social system to appropriate the warehouse's structural features in a faithful manner.

The previous prediction addressed the notion that the fewer choices available to members of an area the less ambiguous the innovation, which positively impacts the level of respect and comfort the users have for the innovation. The current prediction recognizes that limiting members' choices as to how an innovation is used also reduces the flexibility of the innovation. It is possible to reduce the innovation's flexibility to the point where it is no longer useful to the business area, making it impossible to appropriate the innovation's structural features in a faithful manner.

As noted above, there were instances where the warehouse was used successfully that did not include data marts. These instances shared common task characteristics requiring that the manner in which the warehouse was used be as flexible as possible. For example, those areas of the company that engaged in activities that required access to large quantities of data, and for which the scope of the data was indeterminate and highly fluid, generally felt that they needed access to all the data in the warehouse. In addition, the fluid nature of the data used by these areas required that the relevant warehouse applications be flexible enough to adapt as the nature of the data changed. In the view of the area members, a data mart would have restricted their ability to use the warehouse to the point where they would not have been able to accomplish their business objectives. In other words, the members of these social systems felt that not having access to all the data in the warehouse would make it impossible to faithfully appropriate the structural features provided by the warehouse.

The introduction of a data warehouse into a social system will generally result in misalignments between the warehouse and the existing practices and norms of the system, resulting in conflicts within the social system. Processes must exist to resolve these conflicts before stable appropriations will occur.

Conflict within a social system related to a technological innovation can be classified as either conflict between the members of the social system and the innovation itself, or conflict among system members because of the innovation. Conflict between system members and the innovation can reduce both the members' respect for and comfort with an innovation. Conflict among members of a system because of an innovation can negatively impact the consensus among system members as to how to use the innovation and the appropriateness of that use. Both classes of conflict must be resolved before stable appropriations are possible.

The business areas of the company that were successfully using the warehouse typically had two mechanisms to assist in resolving conflict. First, the successful business areas had established a good working relationship with the warehouse development team. Because of this relationship, members of the successful business areas were comfortable going to the warehouse development team with problems concerning their data warehouse applications. Conversely, those areas that were experiencing difficulty utilizing the warehouse generally characterized the development team as unresponsive and "difficult to deal with." The perceived availability of the data warehouse development team as a support group was an important factor in resolving the conflicts between area members and the warehouse. Second, most successful business areas had managed to develop within area experts who understood both the business issues facing the area and the data warehouse technology itself, at least to the degree necessary to

extract data relevant to the area from the warehouse. These experts were recognized as the authority concerning matters related to the warehouse and played a pivotal role in resolving both classes of conflict.

It should also be noted that the existence of a good working relationship with the warehouse development team and the presence of an area specific expert reduced the ambiguity associated with using the warehouse. As described above in the first prediction, lowering the ambiguity in this manner improves the probability that the appropriation process will generate stable appropriations for the structural features of the warehouse.

In order for the structural features of a data warehouse to be faithfully appropriated the members of a social system must have a clear understanding of the business problems impacting the social system and how the data in the warehouse relates to these problems.

It became clear during the interviews that the business areas within the company that were successfully using the warehouse clearly understood the relationship between the warehouse and the business issues relevant to the area. Critical to the development of this understanding was the attitude of an area's leader toward the warehouse. If an area's leader viewed the warehouse as a valuable tool with the potential to dramatically improve the area's ability to function, then the tendency was for members of the area to adopt the same attitude. In addition, area leaders who were positively disposed toward the warehouse were much more likely to allocate resources to understanding the warehouse. For instance, area leaders positively disposed toward the warehouse would assign members to become the area's warehouse experts. This assignment became the primary function of these members within the area. Leaders who were not positively disposed toward the warehouse either ignored the warehouse or, more typically, asked members of the area to learn about the warehouse "during their spare time." Since spare time was nonexistent within the company, this ensured that the learning never took place.

This and the previous predictions begin to highlight the critical roles played by an area's leader and its warehouse expert in appropriating a warehouse's structural features in a stable manner. These roles are explicitly described in the next prediction.

For stable appropriation of a data warehouse to occur within a social system, the leader of the social system must fully support the warehouse and a warehouse expert internal to the system must be developed.

As described above, a necessary condition for an area within the company to successfully use the warehouse (i.e. appropriate the warehouse in a stable manner) was for the leader of the area to be positively disposed toward the warehouse. The attitude of an area's leader either directly or indirectly impacted all the factors leading to stable appropriations. If an area's leader had respect for the warehouse then the inclination of the other area members was to also respect the warehouse. If an area's leader made it clear that he/she felt the warehouse was important to the area's ability to function, then area members were more likely to work through conflicts involving the warehouse, thereby increasing their respect for, comfort with, and consensus on the use of the warehouse.

A leader that is positively disposed toward the warehouse was also a necessary condition for the development of an area specific warehouse expert. There were no instances in the company where an expert emerged within an area that had a leader with a negative attitude toward the warehouse. These within area experts were critical to both resolving conflict and developing an understanding of the warehouse's relationship to the business issues facing the area. As such, an area specific expert was also a necessary condition for an area to generate stable appropriations from the warehouse.

Conclusion

This field study furnishes some indication that adaptive structuration theory provides a useful framework for explaining observed differences between social systems that successfully appropriated the data warehouse, and social systems that were unsuccessful in this appropriation. The study supports the notion that in examining the effects of introducing data warehouse technologies into an organization, and examining the organization's acceptance or rejection of that technology, it is important to account for contextual factors influencing the organization's various social systems.

For practitioners, the study focuses attention on the factors influencing the generation of stable appropriations and the importance of these factors in successfully using a data warehouse. The study also described social system characteristics that seemed to positively influence these factors. These characteristics included the presence of a leader who supported the warehouse, and an internal expert who understood both the business perspectives of the social system and the data warehouse technologies. The

study also explained the importance of having mechanisms in place to facilitate the integration of the warehouse into a social system by mitigating system conflict caused by the warehouse.

Despite the fact that organizations are spending millions each year on data warehouse development and that the majority of the efforts will fail [Vatanosombut, 1999], little is understood as to why these failures occur or how to prevent them. This study provides some insight into the problem, however more rigorous and empirical based studies are necessary to validate and extend the observations made in this paper. For example, this study considers only adaptive structuration theory. Other theories, such as diffusion of innovations [Rogers, 1983] and the technology acceptance model [Davis, 1986], could provide additional insights into the data warehouse acceptance problem. In addition, this analysis focused on social systems at low levels of the organization. It provides no guidance concerning the role of senior management in warehouse acceptance or rejection. Additional research is also necessary to determine the impact of other conditions on the factors influencing stable appropriations. For example, what is the relationship between training and stable appropriations? Poole and DeSanctis (1990) suggest that training on the spirit of a technological innovation impacts stable appropriations more than training on the use of an innovation. Is this true for data warehouses? Finally, additional field study work in a variety of organizational setting is needed to verify the findings of this study and validate the appropriateness of other technology acceptance theories.

The issue of data warehouse acceptance is an important and poorly understood problem. Increased attention from the research community is needed to identify and explore the factors influencing the acceptance/rejection of warehouse technology. A better understanding of these factors will enable the business community to improve the focus of the resources directed toward warehouse development, and increase the probability that data warehouse development will result in successfully implemented warehouses that are accepted by the user community.

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