Approaches to Decision Support Systems at Traditional Firms in the US and China: Which Side Has Fared Better?

Myron Sheu
California State University
Wang C. Wong
California State University
Zhiyuan Xu
Tongji University

Abstract

Relying on decision support systems (DSS) to improve corporate competitiveness is a risky yet crucial enterprise undertaking. Corporate America has taken on such complex and daunting tasks for decades, and has paid a high price for learning tricks in dealing with related issues. Recently, Chinese companies began to look into information technology for ways to improve their global competitiveness. Their information systems have since evolved from being transactional to informational. The Chinese companies now face the same pitfalls of developing and operating DSS that have tripped many American firms. While it is natural to expect that followers will learn from mistakes of their predecessors, it is unfortunate that history often repeats itself. Are Chinese firms able to take a shortcut on modernizing their business operations through DSS, or must they also go through the painstaking process of trial and error? In search of clues to answer these questions, we have analyzed the approaches to DSS taken by one firm in the US and the other in China. The two firms have similar histories and are of similar repute in their respective countries. This paper presents intriguing results of their different strategies and practices on DSS and analyzes the findings and implications.

Introduction

Enterprises gain competitive advantages through DSS because managers at different levels can easily retrieve information to support their decision-making. However, since data can come from diversified sources across both contemporary and legacy systems, the value of DSS depends on cost-effective transformations from disparate data into highly integrated information entities. Such dependency is critical especially for traditional firms because the majority of their enterprise infrastructures consist of hard-wired and disparate legacy systems.

For decades Corporate America has paid a high price on developing a strategic DSS on top of legacy systems. Recently, Chinese companies began to look into information technology for ways to improve their global competitiveness. Their information systems have since evolved from being transactional to informational. The Chinese companies now face the same pitfalls in developing and operating a cost-effective DSS that have tripped many American firms. While it is natural to expect that followers will learn from mistakes of their predecessors, it is unfortunate that history often repeats itself. Are Chinese firms able to take a shortcut on modernizing their business operations through DSS, or must they also go through the painstaking process of trial and error? To answer the questions, this research investigates the approaches to DSS taken by two traditional firms – one in the US and the other in China – amid their very different corporate and social cultures. Our case study focuses on how the two firms have managed such critical issues as IT infrastructure, implementation strategy, operational efficiency, and cost effectiveness. The rest of the paper is organized as follows: Section 2 reviews existing approaches to DSS. Section 3 presents two cases of DSS implementation to illustrate their different approaches on developing and operating DSS. Section 4 analyzes the strategic implications of their unique situations. Finally, section 5 offers conclusive remarks.

Review of Existing Approaches to DSS

Developing a DSS in support of enterprise competitiveness is a complex and challenging task, requiring data from all three major business functions, namely enterprise resource planning (ERP), supply chain management (SCM), and customer relationship management (CRM). Lee et al. (2003) proposed an extension to the traditional scope of DSS by introducing the concept of enterprise application integration. In their view, an enterprise DSS represents the integration of various applications so that they may share information and processes possibly at all four major levels (Linthicum, 2000): data, application interface, method (or process), and user interface level. Among intense efforts on combing these business components to support an enterprise DSS (Handfield & Nichols, 1999; Simchi-Levi, Kaminsky, & Simchi-Levi, 2000; Hayya, Chu, He, & Chatfield, 2003), two approaches are commonly used in the US: the strengthening of enterprise integration by replacing heterogeneous legacy systems and the creation of a totally new informational system to collect transactional data. Although researchers differ in approaches to achieving internal enterprise integration, they agree on the necessity of enterprise data integration for a DSS, driven by the need to transfer data flows from various operational systems to one or more informational systems (Swaminathan & Tayur, 2003). According to Swaminathan and Tayur, informational systems should possess four characteristics, namely integration, currency, availability, and accuracy. While these four characteristics depict an ideal information infrastructure for DSS, they stop short and leave us to figure out what it takes to develop such a system.

A possibly complete migration from disparate transactional systems to enterprise resource planning (ERP) systems has initially made many believe this is the quick way to build an enterprise DSS. To promote such a belief, major application vendors, such as SAP and Oracle, have enhanced their products to facilitate enterprise integration (Gurin, 1999). In a survey of 479 manufacturing firms, Mabert, Soni, and Venktarmanan (2000) found that 32% of the firms implementing packaged ERP systems soon afterward added some decision support mechanisms. However, these enhancements are ultimately in vain. As demands for new functions and/or features continuously emerge, enterprise integration relying on a monolithic system has been and remains to be fragile (Rundensteiner, Koellwe, & Zhang, 2000). The resultant inability to extend and to assimilate often seriously undermines the reliability of a DSS (Ballou & Tayi, 1999). Therefore, although some US firms can afford to take a big-bang approach to accomplishing enterprise integration, many of them recognize that endorsing a monolithic system likely creates its own new problems such as inflexibility and updatability (Hagel & Brown, 2001).

Meanwhile, most traditional firms have to develop an enterprise DSS incrementally. Due to a long history of evolvement, enterprise data is often lodged in highly heterogeneous platforms and disparate database systems (Hummingbird Corp., 2000, p. 5). To provide DSS with comprehensive data flows, firms often have to patch stovepipe legacy systems that run on obsolete technologies. There is no easy way to integrate these heterogeneous legacy systems since each system usually operates in its own locale for a long time. Although efforts have been made to incorporate legacy systems into contemporary information systems, businesses typically stay connected to their legacy systems because the knowledge housed and the business protocols embedded in these legacy systems are usually too inconsistent to be transported to a new platform (Gupta, 1997). It is extremely difficult, if not impossible, for informational systems created for decision support (Rob & Coronel, 2000, p. 579) to integrate data when legacy systems are highly heterogeneous throughout an enterprise.

Amid irresolute technical options, traditional firms face other kinds of implementation issues (Bingi, Sharma, & Godla, 1999; Ng, Ip, & Lee, 1999; Roberts & Barrar, 1992). The issues of enterprise integration for DSS is tied not only to enterprise infrastructure but also to business processes; the latter could be further interrelated to organizational integration (Sheu & Kim, 2005) and even inter-enterprise coordination (Kopczak & Johnson, 2003). Such intertwining impact seems particularly challenging to Chinese firms since most of DSS and underlying MIS products were designed in light of corporate practice in the western countries (Chen, 2004). For example, Parnell studied similarities and differences of participative decision making in China, Mexico, and the US (Parnell, 2002), and although inclusive, he observed vast discrepancies in this arena particularly between China and the US. Our initial review of existing DSS approaches has motivated us to choose and examine two traditional firms—one in China and the other in the US—to find out how they deal with the major issues of developing and operating a DSS. In what follows we first present and then analyze our case study.

Case Study

The chosen firm in the US is a strategic business unit of a large and well-established aerospace company in the western US, hereafter referred to as Western Aerospace (WA). The firm is financially independent from its parent company and its revenues come mainly from high-tier aerospace products with annual sales approximately at $2 billion in recent years. In accordance, we have chosen to examine a DSS case at a large, state-sponsored automotive firm in Northern China, hereafter referred to as Northern Automotive (NA). NA has similar corporate maturity with annual sales approximately at $300 million. At first glance, WA may dwarf NA in terms of sales revenues, but they are indeed comparable when we consider the difference of the cost of living between the two countries. Besides, both companies have roughly the same head count in their workforces and are both producing transportation vehicles. In both firms IT typically plays a supporting role. Mechanic and electronic engineers at the two firms are considered line functions while IT professionals are considered staff functions. Lastly, NA holds similar status and reputation in China as WA does in the US.

The major DSS implementation at WA started in 1996 and dragged on through many incremental smaller-scale projects. We observed the DSS activities at WA over a six-year period ending early 2003. Conversely, NA has a short history of DSS endeavors, beginning in 2002 and lasting for about a year. In each case, we interviewed both functional and technical people who were directly involved in DSS development and maintenance, and reviewed functional and technical documents across both development and operational phases. What follows in this section describes our findings about their handlings on such critical issues as IT infrastructure, implementation strategy, operational efficiency, and cost effectiveness.

IT Infrastructure

Having gone through several stages of downsizing due to shrinking commercial aerospace markets in the past decade, WA strictly imposed its IT expenditure to within 5 to 7 percent of its annual revenue as benchmarked by outside consultants. Consequently, WA was unable to fund certain major IT projects or to upgrade its IT infrastructure, and its IT investment strategy was a typical short-term, piecemeal style. WA eventually reached the point at which its current IT infrastructure could no longer function due to heavy reliance on extremely heterogeneous legacy systems and inconsistent database systems. Such a heterogeneous IT environment complicated any efforts on enterprise integration. WA soon realized that its competitors with long-term strategic plans had total cumulative IT expenditures much less than their own. A few years ago when both user satisfaction and productivity significantly declined, WA was forced to completely restore its IT management team in search of a cost-effective IT solution.

On the other side of the Pacific Ocean, NA also experienced relentless turbulence in the past decade because of the fundamentally changed business environment. As NA struggled with sluggish sales and state funding, a unprecedented challenge was the rising need for predicting sales and managing partnerships because NA was accustomed to a well-planned national economy by the central government. In the past several decades NA knew who would buy its products, where the raw materials would be, and how much the materials would cost. The planning part was simple and could be handled by someone with little financial background. In recent years the traditional production planning structure, which depended on a strict quota system, was essentially disabled.

To rectify the situation, NA considered modernizing its operations management via IT. The status quo of its enterprise infrastructure was quite primitive when the decision about an enterprise-scale DSS was in the making. All available computing services were concentrated in two separate business areas: engineering design and accounting control. It had multiple product data systems along with many kinds of engineering data that were still processed manually. Multiple accounting systems operated in their locale for specific purposes such as purchase orders and payrolls, and many of these information systems had already lost support from their original vendors. In addition, the majority of its enterprise infrastructure was not connected to the Internet. The rest used Internet connections only for basic needs such as emails and file transfers. No remote business-to-business transactions were conducted over the Internet. Some forms of electronic data interchange (EDI) did exist but were strictly point-to-point exchanges with a small amount of transaction data such as payments and invoices. Data sharing was minimal. Consequently, the same set of data often was manually entered multiple times into multiple systems likely in different formats.

In contrast to a matrix organizational structure in WA, the organizational structure in NA remained to be a traditional hierarchy. Accordingly, it was ineffective to command across business units unless someone from the top of its organizational hierarchy pushes through. When in need of building a project team, all team members, including the project manager, was loaned from their original business units. The project management had little control on granting incentives or promotions. There were no stable organizational entities that were dedicated to coordinating a series of projects to pursue specific corporate goals. While there was a group responsible for enterprise network backbones and enterprise computing services, the group had no responsibility for the business applications running on top of the enterprise computing platforms, nor did the group have any interest or knowledge to get involved. Interestingly, the average age of the network infrastructure group is much younger than any functional group.

Implementation Strategy

Decisions on DSS at WA were initially driven by specific needs of certain functional groups. Pushed by discrete demands, it initially built several data marts to modernize its decision support function around the traditional organizational structure. These data marts were mostly used in coordinating order fulfillment processes for immediate operational needs but ineffective in supporting strategic, enterprise-wide initiatives, such as handling both allocation and coordination issues in global supply chain networks. Therefore, the resulting data marts seemed tactically helpful in the immediate future but not strategically sustainable in the long-term. When these data marts could no longer support the actual information needs for the ever-increasing supply chain complexity and eventually when the cost of maintaining these data marts could not be justified, the decision to create a data warehouse for consolidating all existing data marts was reached. Regardless of concerns from IT professionals and end-users, the decision to develop the centralized data warehouse came from senior management without much involvement from functional users. The project team was pushed to build the data warehouse system to integrate data from various sources, but was not empowered to deal with unforeseeable problems during the project implementation.

In its five-year plan, NA made the decision to implement an ambitious modernization project that included the installation of an enterprise DSS for which it allocated a lump-sum portion of its long-term budget that essentially relied on pro forma sales. The firm made its decision to develop a brand new comprehensive DSS with a hope that such a big-bang approach would quickly change the firm's business operations to fit the market economy. The major component of the proposed DSS was a data warehouse for managing informational data. Because of its well-known corporate brand name and reputable social status, NA could have had many willing partners to work together on its DSS initiative. Unfortunately, many of the bureaucratic constraints prevented NA from keeping these options viable.

The first significant challenge was the difficulty in finding a commercially available software package that could accommodate the business regulations without the need for rudimentary and expensive customization. In a critical debate over whether or not the firm should endorse global business standards or hold the flexibility of evolving its own business models at its own pace, top management finally decided to go with the latter, namely, to develop its own business models. The decision was out of the concern about possible inconsistency with the government bureaus to which it reported and with most of its partners with which it heavily traded. The profound decision soon proved to be the first major setback from reaching its initial goal of modernize its business infrastructure for competing in the market economy. By deciding to find pieces to put together as its own DSS, the management was open for resistance to changing its existing business norm.

The second challenge was to find a reliable consulting firm. Unlike in the US, consulting business was still in its infancy in China and only a few immature consulting firms were specialized in the ERP arena. There was an alternative, however, which was to hire a research institute at a reputable university to provide consultancy services. The challenge did not go away but was shifted to a different focus: Academia was not used to consulting business and disliked dealing with corporate politics.

The third problem was attributed to the scale and complexity of the intended system, which was too overwhelming for any individual vendor to take on it alone. Consequently, several domestic institutes were retained to develop specific modules for the system over different periods. While the application code was customarily developed, the application development tools, data storages, and platforms were purchased mainly from US companies.

As the development neared its completion, it was evident that the system was conceptually innovative but executively unadventurous. In terms of its initial design, the system incorporated many contemporary standards and protocols such as XML and web services. However, the design was not actually implemented due largely to insufficient facilitation from the enterprise infrastructure on which the new DSS ran. Additionally the embedded business rules were not as rigid as it needed to be. Loopholes and gaps widely existed.

Operation Efficiency

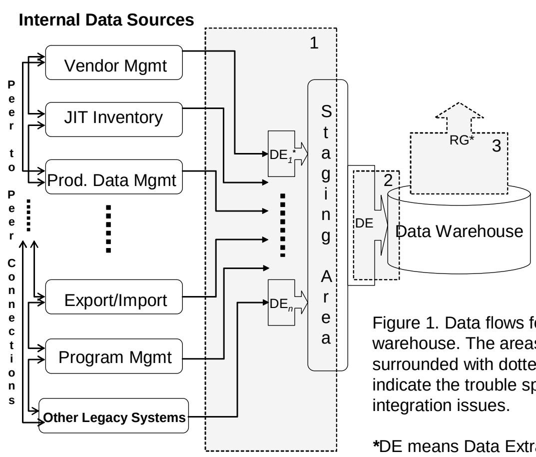

Figure 1. Data flows for the data warehouse. The areas surrounded with dotted lines indicate the trouble spots due to integration issues.

*DE means Data Extraction
*RG means Report Generation

Our case study then looked into the resultant operation challenges to each DSS approach. Organizationally, the DSS at WA was owned by the IT business unit because of its enterprise scope, which means that the operation expenses were not justified by direct benefits to any specific groups. Since its inception, it became clear that the level of data integration required for the DSS to meet the expectations from user groups was underestimated due largely to an inadequate understanding by the management of the scope of and readiness for such a system. Consequently, the DSS has been struggling with collecting disparate data in a cumbersome way.

Figure 1 depicts the data flows of the DSS at WA, where the areas surrounded with dotted lines indicate the trouble spots due to integration issues. Specifically, the main challenge in the first trouble spot is about data extractions from the heterogeneous systems. Data from these heterogeneous systems often have to be cleansed and corrected manually before they can be transferred to the staging area. It is because the raw data might have a wide variety of inconsistent data definitions and formats. The process of extracting operational data thus merely makes the data formats acceptable to the main data warehouse, which consequently generates heavy data traffic on a regular basis from many legacy systems to the staging area. However, the more the data in the staging area, the more complex the task to synthesize and synchronize the data. Due to the complexity in size and structure, the staging area logically consists of multiple smaller staging areas to keep track of different subjects and different levels of aggregated data. Data error rates were so high during the first phase of data extrapolation that WA needed a separate team dedicated to fixing the data problems manually. The remaining phases of data extrapolation bear high uncertainty because of the dependence on the data-cleansing phase. Subsequently, moving data from the staging area to the main data warehouse, indicated in Figure 1 as the second trouble spot, also faces challenges. One difficulty is the maintenance of an appropriate number of dimensions so that every involved functional group can easily generate the decision support reports from the data warehouse. The other difficulty is the expertise required to unify the semantics of the data in the staging area. Because of the heterogeneity of operational systems and the homogeneity of the informational system, the third difficult area in operating the DSS is knowledge retrievals from the data warehouse. Functional groups are invited to help standardizing the interpretation of aggregated data so that the reports generated from the data warehouse would make sense to them. Although efforts had been made, users still rapidly lost their interest in leveraging the DSS because they perceived little value of the reports derived from the data warehouse. Oftentimes, a meeting on data conversion has to involve many functional groups, and efforts by all participants on leveraging large amounts of data impose a difficult consolidation task on the DSS group. It is no coincidence that the DSS operations bring about plenty of complaints and plenty of frustration from both users and managers. The users complain that generating reports with the DSS creates considerably more work whereas the managers complain that the DSS drains financial resources but generates little direct and tangible benefits.

At NA, after a prolonged delay, the first version of its ambitious DSS was finally delivered to the production environment. Although it was unable to operate totally as designed, it was considered a huge accomplishment. However, the functional users who were responsible for the automated business functions were not adequately trained. New comers were interested in technology but did not grasp an understanding of business functions. Thus, neither original users nor new comers could handle the operation alone. Subsequently, the size of the operation team has increased rather than reduced. Meanwhile, resistance quickly emerged. Since business operations often could be conducted in various ways, any new ways of running business, especially imposed externally through IT, seem difficult to take over common business practices. Not for long, whichever parts the system allows an alternative for manual processing had quickly fallen back to a manual process. A few months later, it became a norm to rely on manual processes to move data from one module to another. The mixture of computer automation and heavy human intervention further worsened the burden on operation budget.

The initial architecture unrealistically relied on the compatibility of adjacent information systems to leverage web services. As shown in Figure 2, nearly all functions to be furnished through web services were actually replaced with manual interventions. The core functions that benefited from data sharing were little beyond what the original transaction systems could do albeit the main achievement was the connection between the product data system and the inventory control system. The data exchanges with external systems largely depend on manual duplication rather than, as initially intended, on provision from suppliers and buyers. Moving data from one subsystem to another within the DSS also often has to be handled through manual processes. Therefore, the DSS is conceptually integrated but practically fragmented. Nearly all previous data problems and inefficiency caused by stovepipe systems remain to be unresolved.

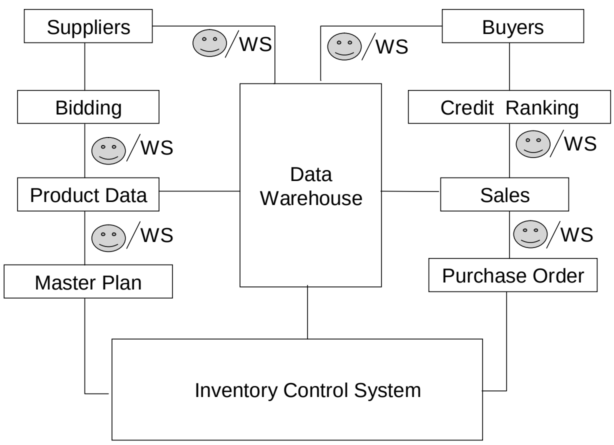

Figure 2:
Firm NA's DSS has to Substitutes Manual Processes for initially Planned Web Services

Cost Effectiveness

When questioned about the performance measurement of the DSS at WA, one of the executives put it this way, "Our competitors have done it and we have to do it, too. Otherwise, we will suffer from opportunity costs." The main challenges in assessing such an IT project as the data warehouse are (a) there are both tangible and intangible benefits that sometimes are not quantifiable and (b) it is often very difficult to isolate the contribution of a single IT project from the overall economic impact and other related IT projects. WA was under a strict annual IT budget, but it in fact spent cumulatively much more than the de facto standard. Amid a $10 million annual operation expenditure, WA still experienced a higher volume of complains from functional groups than before, which led to several attempts to dismantle the underpinning data warehouse altogether. As the improvement on operating the DSS itself became an ongoing project with continued time slippage and low achievement, WA, nevertheless, hoped that the DSS would eventually live up to its anticipated benefits and contribute to the firm's long-term competitiveness.

In a similar situation, the top management at NA looked into strategic reasons to justify its heavy investment in its DSS amid few immediate benefits resulting from its plan for modernizing enterprise operations. It argued that the DSS was its first bold endeavor to transfer its fragile, outdated information infrastructure to a modern, robust enterprise platform. The senior management ultimately in charge of the system development insisted that the new DSS set a framework of data and process flows so that employees become aware of the firm's policies, business regulations, and standards. Although many of these processes are still handled manually, the specifications of these processes were hard to skip anymore. At the very minimum, each process is recorded and can be traced if needed, which offers much better management capability than before when only final transactions were recorded and little information about how the transactions are processed is available. Therefore, the DSS did substantially improve the operation management.

However, the original purpose of having a DSS has not been fulfilled because the decision makers still largely rely on their intuitions to make their production plans and manually incorporate the production targets set up by its government bureaus. That is, business is as usual in terms of decision process. Several reasons are behind their distrust in the new DSS. The first reason was the lack of confidence in the predictability of the historical data of the company. It was a quick decision not to convert the data from many of its legacy systems because of the incompleteness and inaccuracy of the data. In this regard, the management, however, is confident that overtime the system will increase its decision support value as it accumulates more data. The second reason for a slow utilization of the DSS is psychological fear of using it to make strategic decision in part because of the incompetence of the senior management in comprehending the DSS. As the educational and professional qualifications of the leadership team at NA are gradually improved, this problematic phenomenon should also diminish. The third reason was the inadequate analytical tools for data analysis. For instance, procuring a sophisticated data-mining package was considered a low-priority request. As more systems are connected to provide data, such analytical tools would be crucial.

While the DSS was not considered reliable for planning, reports were generated on a regular basis and were used more as references by middle managers as input to their superiors, and the development and operation of such a DSS did offer the entire workforce of NA rich learning experience and brought about the awareness of and familiarity with modern business management.

Analysis of Managerial Implications

Comparison of IT Strategy

Table 1:
Comparison of IS Strategies between WA and NA

Characteristic	Shared Characteristic	Distinct Characteristic
IS Development	The standard system development life cycle is followed. Review processes largely remain formalistic and review criteria are vague.	WA uses commercial package versus NA develops own package. WA avoids changing software whereas NA avoids changing business norm
IT Infrastructure	Nearly all IT decisions are made in a top-down fashion.	At WA the functional side dominates; at NA the IT side dominates.
Approach	Both firms lag a concrete long-term strategy due however to different reasons	WA closely followed a piecemeal approach and NA attempted a big-bang approach
Technology	Technology is equally available to both firms. Both firms have strong IT staff.	As a pioneer, WA learned own lessons. As a late comer, NA envisions how to catch up.
Resource	The IT role is similar in both firms and consequently IT expenses in both firms are usually controlled.	WA is somewhat constrained by the cost on IT consulting services whereas NA is somewhat constrained by the cost on IT platforms.
Organization	Conflicts of interest between user and IT groups remain significant.	WA has a matrix organizational structure whereas NA is hierarchical.
Success	Gain on long-term competence is uncertain	WA met its short-term needs. NA made initial progress toward its long-term plan

It is evident that the two firms' IT strategies, if any, share some characteristics while differentiating in some others. Table 1 gives a summary of those characteristics.

The above comparison is not meant to tell wrong or right doings since each firm faced unique challenges. WA first created several functionally specific DSS systems and then consolidated these specialized systems into an enterprise-wide DSS. On the other hand, NA tried to build an enterprise-wide DSS directly even though it had a much weaker enterprise IT infrastructure. The result of each method is significantly different; WA's subject-specific DSSs successfully gained immediate benefits, whereas NA's enterprise DSS was architecturally sound. In our view, the IT staff at NA understood the design principles of a large-scale DSS as well as, if not better than, their western counterparts. However, neither firm had a solid long-term IT strategy due to different reasons. IT at WA played a supporting role and its budget was strictly controlled. IT at NA was leveraged as a turnaround agency in response to a changed market condition, but it still merely had a tactical role. Because WA could not commit to a long-term strategic plan, it built several small informational systems that only satisfied immediate needs (Ball, Ma, Raschid, & Zhao, 2002). In contrast, NA did show a theoretical understanding of the DSS architecture, but its inadequate resources and inexperience failed its design. We believe both situations reveal a common problem: Traditional firms, especially in the manufacturing sector where IT plays a supporting role, may have to take a piecemeal approach to implementing an enterprise DSS. However, IT advances so rapidly that often the pieces that are gradually developed are not consolidated quickly enough before they become obsolete. An example of such a phenomenon is the implementation of a data mart on a Sybase platform at WA. Several years after the system entered in production, the data mart proved to be too costly to migrate after the initial vendor dropped the support. Similar to WA, NA laid out an ideological blueprint of its enterprise infrastructure, but the reality of carrying out the design was impossible from the beginning because they did not plan to obtain resources in a timely manner. Therefore, while it is technically feasible to eventually convert data marts into an integrated data warehouse to support enterprise business decisions, this option is an idealistic approach that usually results in more expensive and less operational enterprise infrastructure. In fact, industrial standards have gone through turbulent changes. Information technologies are heavily influenced by oligopoly competitive vendors who increasingly prefer exclusion to inclusion. This imposes great risk on any firm that does not have a clear strategy and a timely execution plan for its enterprise undertakings. In reality, many data marts at WA soon joined other legacy systems before they were migrated to a part of an enterprise DSS. Like many US firms, WA considered trying a conversion strategy by wrapping an obsolete system through a third party software, but eventually dropped the idea because it became too costly. The lessons from WA is clear: it is wise to realistically take into account the tradeoff between initial development costs and successive operation expenses, including frequent upgrades and inevitable conversions. Particularly such tradeoff analysis must be conducted by all stakeholders (Du, Wong, & Lee, 2004).

The above analysis merely touches the observable tips of the iceberg. As pointed out by Martinsons and Hempel (1998) and later again by Martinsons (2004), the ability to adopt new information technology depends on many fundamental aspects, including various social, economic, and political factors. Among them, in our view, the most important aspect is the existing business norm, which may explain why, despite the fact that technology is equally accessible to nearly every corporation in both the US and China, the outcome from leveraging technology varies from one corporation to another and, more dramatically, from one country to another. In what follows we discuss the managerial implications of the two cases in the context of enterprise integration.

Conventional Implications of Enterprise Integration

Platform Integration. Historically, most corporations narrowly interpret the implications of enterprise integration as the compatibility and interoperability of hardware and software that construct information systems. In the early 1990s when the concept of enterprise integration drew attention from corporate executives, major corporations in the US and other industrialized nations focused on integrating function-specific information systems into a coherent, enterprise-wide information infrastructures (Fan, Stalert, & Whinston, 2000). A study conducted by AMR Research (2002) on 100 US companies with at least 1,000 employees reported that ERP penetration in 2000 increased from 57% to 65% in 2001. Unfortunately, without well-planned, robust transactional systems in place, enterprise integration would not sustain. Based on survey responses from HR executives of 100 US companies, the Conference Board (2004) reported that a key obstacle to enterprise integration is the simple fact that "IT systems don't mesh, making it difficult to consolidate data across the organization." This precisely describes the problem of DSS implementation at WA, indicating that the intent of taking on a DSS to remedy the infrastructure integration is simply not effective. In the case of NA, relying on a DSS initiative to jump-start an enterprise infrastructure would just bury bottom-layer issues deeper, making these issues further complicated.

Data Integration. While it is possible to guard platform standards with enterprise integration in mind, many companies have quickly realized higher urgency for enterprise integration at the data level. However, many of these companies, including both WA and NA, do not realize their failure in integrating data until they have actually started building their enterprise DSS. For example, in a patch-mode approach, WA overlooked semantic consistency across data dictionaries for a variety of ISs (Linthicum, 2000; Singh, 2003). As a result, manual translations based upon subjective judgments become necessary for peer-to-peer data exchanges. In fact, functionally identical items are often stored under inconsistent names, causing certain items to be incapable of merging in an automated supply chain system unless a manual process match these synonymous items. The direct effect of data disintegration is inaccurate business reports and inefficient supply chain management. In the past, WA kept a huge inventory that was constantly worth more than $150 million even with the control of a just-in-time (JIT) inventory system. NA was in a similar situation. No significant improvement on its supply chain management could be attributed to its DSS implementation because most critical processes that were meant to be computerized require heavy human intervention and are consequently prone to human errors. Evidently, being a visionary in setting up IT strategies may not necessarily warrant the materialization of envisioned advantages if such initiatives are intended to merely to cover a fragile infrastructure.

Although both WA and NA created a standardized data vocabulary as a potential solution to remedy fragile data integration, in practice the solution remained largely ineffective. A reason for the futility is that the rapid evolution of information technology constantly requires modifications and expansions to current data dictionaries and current systems (Bowersons, Closs, & Stank, 2000). Another reason is that inconsistencies between operational systems and informational systems do not disappear mainly because there are many different vendors and different interfaces from surrounding systems (Brereton, 2004). There is also no common set of vocabulary acceptable to both internal and external parties, and changes for compliance to common vocabulary often incur an infeasible cost on data conversion (Inmon & Kelley, 1994). As an alternative, albeit with less preferred performance, WA maintained a standard dictionary and required all vendors and internal developers to comply with the dictionary. However, since there is no rigorous enforcement on the consistency between the standard dictionary and a custom dictionary, such a remedy cannot guarantee data integrity either. NA took yet a simple-minded measure on the issue by enforcing the consistency only in the final accounting documents. Since the data exchanges among different functional systems relied on manual processes, NA basically manually consolidated the data from various sources. Such practice nevertheless broke the automation and caused higher error rates.

In both cases, we have observed that the anticipated advantages of a DSS lie heavily in the integration of operational infrastructure. The lessons learned from both cases clearly tell us that a strategic plan of the alignment between an informational system and the transaction systems must be in place as early as possible. Preferably, a higher degree of data integration among the transaction systems must be seriously upheld because it will improve the cost-effectiveness of a resultant informational system. A general DSS architecture consisting of multiple domain-specific decision-support functions backed up by a comprehensive data warehouse. Figure 3 depicts a tightly coupled relationships between operational and historically data storages and between transactional and informational systems. We observe that operational efficiency of a DSS profoundly relies on the enterprise integration and that such integration profoundly relies on all major transactional systems. Any oversight of these fundamental dependencies would lead to developing an enterprise DSS that could only bring about strategic disadvantages, as we are reminded in both WA and NA cases.

Enterprise Integration in a Far-Reaching Sense

While enterprise integration is traditionally referred to data and platform integration, the cases of WA and NA have revealed other interrelated factors of enterprise integration that could even more strongly affect the success of DSS. The situations at both firms have illustrated that data and platform integrations are merely the foundation of enterprise integration; while they are necessary, they are far from being sufficient to warrant the success of a DSS. In comparison to other kinds of integration, the bottom-layer enterprise integration is relatively easy to be confined. Furthermore, , as shown in Figure 4, it is difficult to explain the fundamental problems of these two firms without having a much broader framework of enterprise integration in mind. We believe the ineffectiveness of their DSS strategies, to various extents, is largely attributed to their failure in addressing high-level issues of enterprise integration.

In light of a broad scope of enterprise integration, we sense that any project-specific efforts on enterprise integration cannot result in sustainable improvement. For example, individual groups for near-term needs pushed the DSS strategy at WA, and each subsequent development could possibly create additional barriers to ultimate enterprise integration. In the case of NA, without keen participation from all functional groups, an ideological strategy for data integration would only bring about high costs and little effectiveness. To be specific, in the following we discuss the high-level issues of enterprise integration in the context of the two cases.

Process Integration. Indicated in Figure 4, the process integration in our proposed enterprise integration framework is one level higher than data integration. Process integration should encompass all explicit and implicit business operations, and has the capability of being methodically enforced and voluntarily executed when fully prepared. Upheld by the organization rather than by the management, process integration directly influences data integration because business processes determine data flow. We also believe process integration reflects the integration of stakeholders as the stakeholders are the driving force behind all processes.

To further illustrate the implication of process integration on a DSS strategy, let us consider the development cost against the operation cost—an issue frequently encountered at both WA and NA—to see the impact of cost allocation during the two major phases of a DSS project. Consider the graphs in Figure 5; x_0 indicates the most effective cost allocation, at which the system has reached a minimum overall total cost. A reasonably well developed system will lead to relatively low operation costs and higher levels of customer satisfaction. However, both WA and NA shifted extraordinary burdens from development to operations without a tradeoff analysis. As established companies, both had many issues concerning their legacy systems that required attention prior to DSS integration. In the case of WA, if the integration readiness is properly addressed, the total cost of owning a DSS could have been much lower than what actually incurred. However, due to a lack of cooperation among different functional groups and an unrealistic project schedule, it did not access its legacy systems as it could have. It is clear that when pressure mounts, all the intangible quality attributes of system development are compromised. In both cases, we observed that the resources dedicated to systems testing had only taken 5% of the whole project budget while in most cases it usually takes 50% of the budget. Such a misallocation spelled more trouble for NA as its DSS system consisted largely of custom code. Additionally, the data warehouse was not completely planned across all functions; NA had its data warehouse running too long without an appropriate online analytical processing (OLAP) tools for data mining, and consequently the DSS could not provide much business intelligence (Berson & Smith 1997, p. 113).

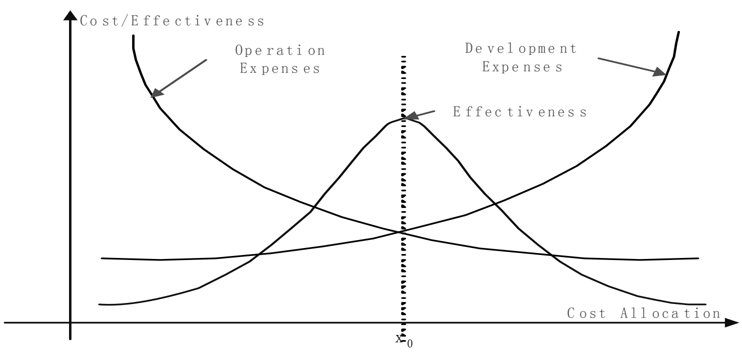

Figure 5 :
Balance between Operation Expenses and Development Expenses requires Strategic Planning.

Stakeholder Integration. The lack of intimate cooperation among stakeholders contributes to the phenomenon that most DSS initiatives come from the senior management, as the senior management at WA and NA did. Bingi et al. (1999) reports that top management commitment is one of the 10 critical success factors an organization should address before implementing such IT projects as ERP and DSS.

Unfortunately, top management often does not have enough information to make a long-term commitment. Because such a level of commitment bears the highest level of risk, the two cases reacted differently: The senior management at WA did not want to commit while the senior management at NA attempted to make a commitment but could not keep it. Similar to reliance on a DSS strategy in achieving enterprise integration before fixing integration issues at the core, dependence on a commitment from senior management to drive cooperation from peers is doomed to fail. We do not deny the importance of a commitment from the top management, but we question the motivation for such commitment; if it were leveraged to borrow the authority for high-degree cooperation, the commitment would do more harm than good.

The effect of the integration of stakeholders on the success of DSS appears evident also as we compare the ways of how a DSS was implemented at WA and NA. As we mentioned earlier, WA employed a matrix organizational structure whereas NA remained a hierarchical organization. The structural difference between the two firms resulted in different levels of stakeholder integration, which in turn brings about differences on how an enterprise project should be conducted. At WA, all projects were overseen by ***programs,*** and conflicts across projects were capable of being mediated at a program level. The project team could thus deal with conflicts of interest across functional groups in an impartial position. As a comparison, project teams at NA consisted of people who were temporarily loaned from the traditional hierarchy and served on the interest of their own groups. As a result, these project teams did not agree on the tasks in the other phases of a system life cycle and were unable to make tough decisions that affect the following phases. Such project development structure unsurprisingly demands support from top management to keep the project running. Subsequently, from the financial point of view, WA treated the project cost more as an expense than an investment, and NA treated it in exactly the opposite way. Since it is difficult to show explicit financial benefits in a DSS, NA may never materialize either near-term or long-term benefits if it does not have a rigorous strategy to pursue the long-term goal of its DSS implementation.

Organizational Integration. We consider organizational integration an ultimate form of functional integration, representing the mentality of all other lower-level integrations, albeit enterprise integration can be achieved without a high degree of organizational integration. We believe an enterprise undertaking, like DSS, requires the presence of strong enterprise integration if the resultant system is going to contribute to corporate competitiveness.

Since a DSS strategy deals with the integration of all legacy systems developed over time, it often triggers significant organizational change (Ng, Ip, & Lee, 1999). As concluded in the research by McNurlin (2001) and Mabert et al. (2001), user training and change management, risk management, continued executive commitment, cross-functional implementation teams, strong execution, and rigorous process for transferring knowledge, all attribute to the success of an enterprise project such as a DSS. Our observations at both WA and NA could not agree more. For example, the lack of adequate training for functional groups in NA remains one of the key obstacles in DSS utilization. If users were decidedly supportive of the system, many loopholes could be avoided. When a high degree of enterprise integration does not exist, an organization does not have the agility in response to all of these resultant changes and effects. The much weaker organizational integration at NA may explain why its final DSS could only achieve the system integration at the user interface level. It shows the lack of underlying integration such as the application interface layer, database layer, and even network connection layer.

Conclusive Remarks

The above discussion derives several clarifications. First, a successful DSS strategy must align with available resources and specific foundation of the organization; otherwise, the DSS may not live up to its expected functionalities and anticipated benefits. Second, although the two firms share many important corporate characteristics, but because they operate in different economic and social environments, there is no common set of criteria that could apply to assess their DSS strategies uniformly simply because they have different goals, different resources, and thus different constraints. Third, neither near-term nor long-term benefits alone would be able to warrant the successes of a DSS strategy, but any variations of a balance between the two goals must be strategized. Because WA is a public company and has to care about the interests of its stockholders, it is highly sensitive about near-term cost effectiveness and risk tolerance. On the contrary, NA is a state-sponsored business, and it has embarked on modernizing its business infrastructure for its long-term competitiveness. While NA has the potential to outperform its American counterpart if it could methodically proceed with its DSS strategy, NA takes more risk—it has not achieved immediate financial benefits and faces greater challenges as the remaining portion of its DSS implementation depends on a high-degree enterprise integration. Fourth, time is critical to the success of a DSS strategy because information technology rapidly advances and obsolesces, too. Such urgency appears crucial to an incremental approach to DSS. A senior manager at WA often emphasizes that the key to the success of a business strategy is execution, execution, and execution. This is a major challenge to a firm like NA due to its corporate culture as a state-sponsored business, in which execution is not always critical. Fifth, an enterprise DSS often inevitably brings about organizational change, which is especially true for traditional firms, the firms should take a cohesive approach to a DSS initiative so the improvement on each layer of enterprise integration sustains.

Lastly but not the least, the DSS implementation is a direct result of the corporate IT strategy and an indirect result of industrial maturity in IT. The valuation of a DSS varies across business environments; it is difficult to copy another's approaches and even dangerous to do so when two firms have a very different set of decision factors. It is also difficult to arbitrate which approach is more appropriate, even for the short-term. The advice applicable to both firms in our case analysis, and likely to most traditional firms, is that the endorsement of a strategic approach demands relentless efforts on enterprise integration. Without consistency and persistency, a cost-effective transformation from disparate data into a highly integrated informational system for decision support is out of reach and subsequently the value of the DSS strategy will inevitably diminish.

In conclusion, as a vast number of corporations in China are determined to catch up with the industrialized nations on modernizing their business operations to boost their global competitiveness (Quan, Hu, & Wang, 2005), the task of building an enterprise DSS is extremely challenging and calls for not only corporate-level strategic efforts but also industrial maturity for the strategic uses of IT. Although firms in China may understand the lessons learned by the US firms and intend to take shortcuts to establish their DSSs, they might still have to cultivate the groundwork before taking any ambitious endeavor. Through these challenges, they will likely have gained lessons uniquely invaluable to them.

References

AMR Research (2002, accessed on Aug. 26). AMR Research's survey results that ERP is far from dead, *www.amrresearch.com*.

Ball, M., Ma, M., Raschid, L., & Zhao, Z. (2002). Supply Chain Infrastructures: System Integration and Information Sharing. *ACM SIGMOD Record, 31* (1), 61-66.

Ballou, D., & Tayi, G.. (1999). Enhancing Data Quality in Data Warehouse Environment. *Communications of the ACM, 42* (1), 73-78.

Barquin, R., & Edelstein, H. (1997). *Planning and Designing the Data Warehouse*, Upper Saddle River, NJ: Prentice-Hall.

Berson, A., & Smith, S. J. (1997). *Data Warehousing, Data Mining, and OLAP*, New York: McGraw-Hill, 1997.

Bingi, P., Sharma, M., & Godla, J. K. (1999). Critical issues affecting an ERP implementation, *Information Systems Management, 16* (3), 7-14.

Bowersons, D., Closs, D., & Stank, T. (2000). The Mega-Trends that Will Revolutionize Supply Chain Logistics. *Journal of Business Logistics, 21* (2), 1-16.

Brereton, P. (2004). The Software Customer/Supplier Relationship. *Communications of ACM, 47*(2), 2004, 77–81.

Chen, W. H. (2004). An enterprise model and the organization of ERP, *International Journal of Computer Applications in Technology, 21(3)*, pp. 79-86.

Du, T., Wong, J., & Lee, M. (2004). Designing data warehouses for supply chain management, *Proceedings of the IEEE International Conference on E-Commerce Technology,* San Diego, 170-177.

Fan, M., Stalert, J., & Whinston, A. (2000). The adoption and design methodologies of component-based enterprise systems. *European Journal of Information Systems, 9* (1), 25-35.

Gary, P., & Watson, H., (1998). Present and future directions in data warehousing. *Database, 29* (3), 83-90.

Gupta, V. (1997). *An Introduction to Data Warehousing,* Chicago, IL: System Services Corporation.

Gurin, R. (1999). Software Systems Make the ERP Connection. *Automatic I.D. News, 15* (2), 18.

Hagel J., & Brown, J. (2001). Your next IT strategy. *Harvard Business Review, October 2001*, 105 – 113.

Handfield, R., & Nichols, E. L., Jr., (1999). *Introduction to Supply Chain Management*, Upper Saddle River, NJ: Prentice Hall.

Hayya, J. C., Chu, C. H., He, X. J., & Chatfield, D. C., (2003). Supply chain information technology metrics. *International Journal of Operations and Quantitative Management, 9* (1), 33 – 48.

Hummingbird Corporation (2000). *SAP R/3 Data Warehousing and Application Integration,* Ontario, Canada: Hummingbird Corporation.

Inmon, B., & Kelley, C. (1994). The twelve rules of data warehousing for a client/server world. *Data Management Review, 4* (5), 6-16.

Kopczak, L. R., & Johnson, M. E. (2003). The supply-chain management effect. *MIT Sloan Management Review, Spring 2003,* 27 – 34.

Lee, J., Siau, K., & Hong, S. (2003). Enterprise integration with ERP and EAI, *Communications of the ACM, 46* (2), 54 – 60.

Linthicum, D. S. (2000). *Enterprise Application Integration*. Boston, MA: Addison Wesley.

Mabert, V., Soni, A., & Venkatarmanan, M. A. (2000). Enterprise resource planning survey of U.S. manufacturing firms. *Production and Inventory Management Journal, Second Quarter, 2000,* 52 – 58.

Martinsons, M. G. (2004). ERP in China: one package, two profiles. *Communications of the ACM, 47* (7), 65 – 68.

Martinsons, M. G., & Hempel, P. S. (1998). Chinese Business Process Re-engineering. *International Journal of Information Management, 18* (6), 393-407.

McNurlin, B. (2001). Will users of ERP stay satisfied? *MIT Sloan Management Review, 42,* 13.

Ng, J. K. C., Ip, W. H., & Lee, T. C. (1999). A paradigm for ERP and BPR integration. *International Journal of Production Research, 37* (9), 2093 – 2108.

Quan, J., Hu, Q., & Wang, X. (2005). IT is not for everyone in China, *Communications of the ACM, 48* (4), 69 – 72.

Parnell, J. A. (2002). Propensity for participative decision making: a cross-cultural investigation, *International Journal of Management and Decision Making, 3(3/4)*, 305-318.

Rob, P., & Coronel, C. (2000). *Database Systems* (4th Ed.), Cambridge, MA: Course Technology.

Rundensteiner, E., Koellwe, A., & Zhang, X. (2000). Maintaining data warehouses over changing information sources. *Communications of the ACM, 43* (6), 57 – 62.

Sheu, M., & Kim, H. (2005). Should we consider user readiness a prerequisite for information system development? *Journal of Academy of Business and Economics, 4(1).*

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2000), *Designing and Managing the Supply Chain*, Boston, MA: Irwin/McGraw-Hill.

Singh, N. (2003). Emerging technologies to support supply chain management. *Communications of ACM, Vol. 46* (9), 243 – 247.

Swaminathan, J. M., & Tayur, S. R. (2003). Models for supply chains in e-business. *Management Science, 49* (10), 1387 – 1406.