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IMPLEMENTING ERP SYSTEMS IN CHINA

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ABSTRACT

This paper reports the findings of an exploratory study of R/3 users in China which was conducted in Spring 2000. The broad purpose of the study is to identify crucial implementation process and context variables which warrant closer attention in the study of IT-enabled organizational change. As companies display a great variety of ownership structures in China (including state-owned, foreign-invested, and privately-held firms), the role of ownership can be studied in relatively greater depth there than elsewhere. While it turns out that ownership is strongly associated with implementation process characteristics, the association of ownership structures with implementation results is much less pronounced. It was found that project governance, specifically the role and decision making style of the steering committee, can be associated with a broad set of outcome variables after controlling for ownership and other important context factors.

Keywords: ERP systems, systems implementation, organizational change

I. INTRODUCTION

ERP systems are a new type of information system whose main characteristic is that they integrate operational processes across organizational functions via a single database. The concept of an ERP system also stands for the idea of packaged business software [Markus and Tanis, 2000; Klaus et al., 2000; Davenport, 1998]. For these reasons, implementation of ERP systems presents new challenges: First, an ERP system affects the whole of an organization simultaneously rather than a single department as was the case with functional information systems in the past whose implementation was mostly limited to departmental boundaries. Second, it may change the way an organization operates because ERP developers must create the system without knowing the exact requirements of their future customers and because, for many companies, the principle of cross-functional integration via a single database is new.

However, the rationale behind implementing an ERP system often is to replace so-called legacy systems in order to externalize system development and maintenance. In these cases, it is less likely that company operations are affected in a fundamental way through the implementation of

an ERP system. Companies in mature economies predominantly decide to implement an ERP system for this reason [Mabert et al., 2000].

The situation in China, however, is very different. There, implementing an ERP system is often seen as a means to modernize the firm and prepare it either for going public or for the expected significant effects of the economic opening in the wake of China's WTO accession or both. For this reason, the motivation to implement an ERP system, in many cases, is the explicit attempt to change, i.e. modernize, the way the organization operates. Thus, the study of ERP implementation processes in China is also a study of change management on a large scale.

In this paper, we want to present such a study. Specifically, we want to address two questions not commonly addressed in studies on IT project management or ERP implementation processes.

1. Under the assumption that the working principles of an ERP system do not deviate very much from a company's existing operations, the main problems of managing an ERP project are of a project management type: given the project manager does the right things and the team members have the right skills and motivation, the project can be expected to be successful. If this assumption does not hold, i.e. if the working principles of an ERP system are not in line with a company's current mode of operation, as can be assumed in the Chinese context, factors outside the scope of project management come into play. It might be assumed that a company's structural characteristics impact the ease of changing its mode of operation, such as ownership, size, and incentive system. Specifically, companies with a strong Western influence through, for example, a joint venture structure would be expected to experience fewer difficulties in adapting to the working principles of an ERP system than those under Chinese control. Therefore, we wanted to know whether structural characteristics of companies, especially different ownership structures, would impact the outcomes of their ERP implementation projects. Currently the Chinese corporate landscape is characterized by a unique variety of ownership structures (ranging from wholly foreign-owned companies and joint ventures to publicly, privately, or state-owned Chinese companies), so that studying ERP implementation processes in the Chinese context provides an ideal setting for this question.
2. In addition, we want to explore whether the organizational set-up of an ERP project can facilitate or hamper adaptation to the working principles of an ERP system *given* a company's organizational characteristics. Decisions about factors such as the structure of the project team, the steering committee, and/or the timing and the extent of training might all help or hinder a company's ability to change its organizational structures and processes according to those incorporated in an ERP system. This issue is especially relevant for traditional Chinese companies that try to use an ERP implementation process to modernize their processes and structures.

II. LITERATURE

The empirical literature on ERP frequently refers to 'critical success factors' which need to be identified to enable project managers and management boards to improve the results of their ERP implementation projects. This implies that

- managers control these factors fully, i.e. they can change them at will, and
- that these factors are causally linked with a 'successful' project outcome (cf. Rockart [1979] for the concept of critical success factors).

Our aim here is, rather, to identify critical points which merit further investigation as to whether these two conditions are met. However, propositions about critical success factors have been made and we want to review them briefly here.

Several papers address the issue of critical success factors directly. Table 1 summarizes these studies in terms of identified or mentioned critical success factors. We excluded articles which

Table 1. Critical Success Factors Mentioned in the Literature

	a	b	C	d	e	f	g	h
Support / commitment by top management*		✓	✓	✓	✓	✓	✓	✓
Team configuration / teamwork*	✓	✓			✓	✓	✓	✓
Personnel*		✓	✓	✓	✓	✓	✓	
Customization; "Vanilla" approach		✓	✓	✓	✓	✓	✓	
Project management (schedule and plans; deliverable dates)*	✓+	✓	✓			✓	✓	✓
Consultation / consultants*			✓	✓	✓		✓	✓
Business vision/ goals / justification*		✓	✓			✓	✓	✓
Reengineering / commitment to change			✓		✓	✓	✓	✓
Training*		✓		✓			✓	✓
Phased vs. Big Bang*	✓		✓		✓			
Range of functionality / project scope*			✓		✓	✓		
Legacy system / integration / architecture*			✓	✓			✓	
Project manager; champion*						✓	✓	✓
Communication		✓	✓					
Project team empowerment*		✓				✓		
Relationship with vendors				✓			✓	
Implementation time*				✓				
Client acceptance*			✓					
Monitoring and feedback*			✓					
Troubleshooting			✓					
Employee retention				✓				
User involvement*								✓
Project incentives*				✓				
Incentive alignment*	✓							
Interdepartmental communication*							✓	
Management of expectations							✓	
Package selection							✓	
Data conversion							✓	
Dedicated resources							✓	
Use of vendor tools							✓	
Use of steering committee*							✓	
Decision making process / style*		✓						

Legend:

* The factor has been included in our questionnaire.
+ The authors mention this factor but say that it is overestimated.
Studies: a: Austin and Nolan, 1998; b: Cameron and Meyer, 1998; c: Holland and Light, 1999; d: Bingi et al., 1999; e: Brown and Vessey, 1999; f: Parr et al., 1999; g: Somers and Nelson 2001; h: Sumner, 1999

emphasize only a single factor. Examples are Davenport [1998], who emphasizes the mediating role of top management, and Glover et al. [1999] who emphasize risk management.

From this table, it is clear that there seems to be a broad consensus on a number of factors including top management involvement, team configuration, qualification of project team members, and so on.[1] However, critical success factor studies generally suffer from a lack of theoretical support and practical usefulness as pointed out by Robey et al. [2000] with regard to most studies listed in Table 1: "The factors … related to ERP implementation success appear especially obvious and [are] not clearly distinguishable from the outcomes of implementation success that they supposedly predict. Thus, these "findings" may be somewhat tautological." [Robey et al. 2000, p. 7].

Markus and Tanis [2000] proposed a research framework for studying the ERP implementation process consisting of four phases with each phase characterized by a set of key actors, typical

[1] Based on two case studies, Shanks et al. [2000] compare critical success factors between two cultural/institutional contexts (China and Australia). They found no differences in top management participation/support and project team composition. In the Chinese Joint Venture three factors seemed to be critical which were not in the Australian context (external expertise, project management, data quality).

activities, characteristic problems, typical (or appropriate) performance metrics, and possible outcomes. Their phases are:

- The chartering phase
- The project phase
- The shakedown phase
- The onward and upward phase.

The theoretical underpinning of this model is that phases are linked in a specific way, namely that activities in one phase can be the cause of problems in subsequent phases. The outcomes of one phase are thereby explained as interactions between external conditions and activities in that phase. For this reason, the course of an ERP implementation process is not deterministic. Although problems of one phase can be partly explained as results of activities in earlier phases, actions and (changing) conditions can always change the course of an implementation process.

Markus and Tanis also argue that implementation success is a multi-dimensional and dynamic concept, i.e. there is no single measure which can capture all dimensions of ERP implementation success and that the appropriate measures are different for different points in time (phases). In addition, success is relative to some type of benchmark. The authors define a concept of "optimal success" that could be achieved given the company's specific situation. It is argued that a company's goals are not an appropriate benchmark since they could be over-ambitious or insufficiently ambitious. However, it is also conceded that this definition may be impossible to operationalize.

In an empirical study involving 16 case studies, Markus et al. [2001] find partial support for their framework. First, it appears that early success (failure) is not closely related to later (sustained) success (failure) and second they confirm that problems surfacing in later phases are partly caused by unresolved problems of earlier phases that themselves are caused by interactions of activities and conditions in that earlier phase.

This framework provides a first attempt at building a theoretical foundation for studies of ERP implementation processes.[2] It also conceptualizes an ERP implementation process as a cycle within the larger IT adoption and use process which significantly broadens the perspective to include the ‘chartering’ phase in which the future course of the ERP project is planned and the use of the system after the company returns to normal operations.

Another strong point of this theory is the way it links the several phases. Specifically, it is argued that "[i]f the experience is not terminated, the interactions in one phase [between starting conditions, goals, and actions] result in starting conditions for the next." [Markus and Tanis, 2001, p. 199]. In this way, it is possible to identify unique characteristics and problems of each phase while at the same time dynamically linking all phases.

However, we feel that the full potential of this approach is not yet realized. Specifically, it is not sufficiently acknowledged that activities and decisions in the earlier phases not only shape the system itself, but also provide the social form for activities and decisions in subsequent implementation phases. For example, early in an ERP implementation process the project team and the steering committee will be formed. While it is recognized in the Markus and Tanis framework that the composition of the project team is important (for example knowledgeable members of all departments affected by the future system should be represented) the division of competencies between the steering committee and the project team is not mentioned. In fact, the setting up and the composition of the steering committee are not mentioned as activities at all throughout all the phases of an ERP implementation process. Therefore, we think that this aspect

[2] Boudreau and Robey (1999) also offered a framework for ERP research which, however, we do not find it helpful since it is not specific enough (being a description/classification of all theories of organizational change).

should receive more attention, especially under external conditions which could be characterized as hostile to the working principles of an ERP system, which is arguably the case for China.

III. METHOD

Our approach was to conduct a broad exploratory study of ERP implementation processes in China through in-depth case studies and a questionnaire survey. Although in this paper we only present the results from the questionnaire survey, our understanding of the results and the design of our questionnaire greatly benefited from the in-depth case studies.

The 14-page questionnaire includes sections about:

- the respondent's involvement in the project,
- the company's general background,
- project characteristics,
- project team composition,
- organizational characteristics,
- top management participation,
- project team motivation,
- steering committee, and
- implementation outcomes.

All questions (except those about the respondent) are listed in Appendix I in a condensed format).

Two initial case studies led us to modify our questionnaire significantly by emphasizing variables regarding the role and structure of the steering committee and by measuring the implementation scope on the level of functions rather than modules (which are a rough grouping of functions). The questionnaire was then pre-tested by two IT managers from two companies, one French and one Chinese.

The population of our study was the group of SAP's R/3 users in China. We limited our study to R/3 users for two reasons.

1. It is currently difficult to obtain accurate address material about companies in China. Therefore, we made use of SAP's customer list which was made available to us as part of a general agreement in which SAP Greater China supported our study financially and provided assistance in accessing companies. Also, SAP had the most ERP installations in China at the time of the survey, thus providing the broadest possible population of users of any particular ERP software package in China. SAP did not exert any influence on the design or conduct of the study. No contractual agreement was made about the type of outcome or research methodology adopted other than that the final report would be made available to SAP.
2. Limiting the survey to one ERP brand eliminates variation in the data due to variation in the systems themselves; thus, all variation in the data must be due to other factors such as industries, institutional forms, and implementation approaches.

At the time of the survey (March 1 to May 31, 2000), the customer list provided by SAP Greater China consisted of 143 addresses. Excluding addresses which involved several projects within one company coordinated by the same project manager (12), the addresses of companies which had been studied or were scheduled to be studied in-depth as part of our case studies (5), and those companies of which we were not able to obtain an accurate telephone number, we obtained a list of 118 companies. All of these companies were then contacted by telephone to confirm address information and the project manager's name and to build initial support for the study. During these calls, ten companies informed us that they did not want to participate in our study. The remaining 108 companies were then express-mailed our questionnaire plus the annual customer satisfaction questionnaire from SAP. In all cases, we addressed our letter to the ERP project manager or IT manager.

To increase the response rates, we gave companies a follow-up call if we did not receive their questionnaires two weeks after sending them out. By the middle of May we stopped making follow-up calls and no company received more than three follow-up calls. We received a total of 80 usable questionnaires yielding a response rate of 74%. Seven companies informed us that they returned the questionnaires which, however, we never received.

Answers were then coded and extensively checked for validity. All answers whose validity seemed dubious were discarded. Since only 61 companies completed the implementation project at the time of the survey, 19 questionnaires did not include answers about project outcomes. Moreover, questions often were not answered, which increased the number of missing values. Removing dubious answers increased this number even more. Therefore, the analysis of the data was limited to simple correlation analysis since building models including several independent variables would frequently reduce the number of usable observations to below 30.

The analysis proceeded as follows:

- First, correlation analysis was conducted for all variables.
- Then, all statistically discernible associations were marked and copied into a spreadsheet.
- Next, these associations were studied in detail; specifically, they were checked for plausibility and tentatively interpreted.
- Finally, all remaining associations were extensively checked for possible mediating effects as explained below before finally interpreting these findings.

We used the product-moment correlation coefficient whenever cardinal measures were implied. In the case of ordinal measures, we used the Spearman correlation coefficient. Similarly, we used Least Square Regression analysis when controlling for variables expressed by cardinal measures and the Logistics procedure when variables were expressed on an ordinal scale. All analyses were conducted using SAS's statistical software package version 6.12.

The process of checking for possible mediating effects is illustrated in Figure 1. We first grouped all variables into three categories:

- organizational characteristics,
- implementation process characteristics, and
- project outcomes.

We then looked for 'direct effects', i.e. statistically discernible associations of variables between these three categories and controlled for other variables in the same group of variables that are associated with variables involved in these associations (termed 'interaction' in Figure 1); for example, when we found an association between the size of the company and certain outcome or process variables we controlled this relationship for ownership since, in our sample, size is related to ownership. The final step in our analysis was to control associations between implementation process characteristics and project outcomes for organizational context factors which are associated with either implementation process characteristics or project outcomes and thus possibly mediate the relationship between process and outcome variables (termed 'mediating effects' in Figure 1). Only if such potential mediating effects could be ruled out did we interpret the association between process and outcome variables.

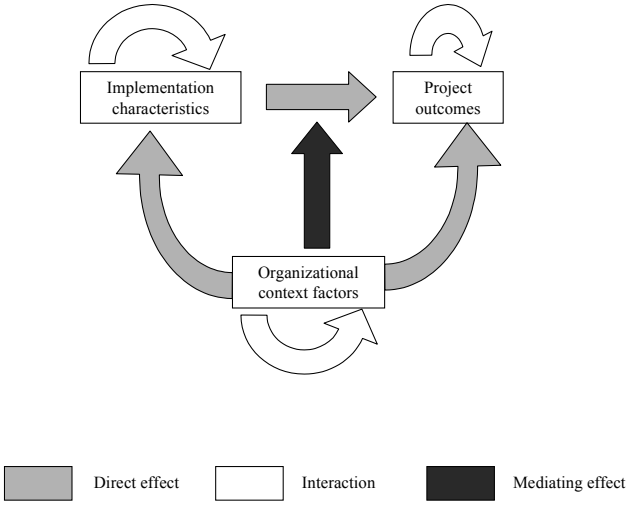

Figure 1. Analysis Procedure

The sample we obtained from this survey is clearly not representative of the total population of Chinese companies because it is heavily tilted towards foreign-invested or controlled companies. The extent of foreign investment in the sample was:

No foreign investment	10% of companies
Foreign equity is smaller than 50%	30% of companies
Control by foreign entity	57% of companies
50-50 joint ventures with a foreign entity	13% of companies

Nevertheless, we consider the variation in the sample sufficient to control for the effect of ownership since 30% of companies were controlled by a Chinese entity and 57% by a foreign entity. 89% of companies in the sample are manufacturers. On average, annual company sales were 3.8 billion RMB ($465 million USD) with 2786 employees.

IV. RESULTS

The results are presented in Tables 2 through 4 at the end of this Section. These results were obtained according to the analytical process described in Section III. The results presented in Table 4, describing associations between implementation process and implementation outcome variables, were not found to be mediated by likely context factors according to the results presented in Tables 2 and 3. Moreover, the results presented in Tables 2 and 3 (the associations between context factors and implementation process and outcome variables), were also checked for likely mediating effects and found not to be mediated by other context factors.

The main characteristics of these results are:

1. Whereas ownership is associated with a number of variables describing the implementation process (implementation motives, implementation scope, level of cross-functional implementation conflicts, degree of consultants' experience, top management participation, duration of running parallel systems, (Table 2)), ownership cannot be associated with implementation results (apart from data maintenance problems after cut-over (Table 3)).
2. However, ownership can be associated with both
    - specific implementation motives and

- specific sources of realized financial benefits.

Specifically,

- state-owned companies were more likely to implement the ERP system to improve management controls and to realize financial benefits due to lower purchasing costs.
- foreign-controlled companies were less likely to reap financial benefits from reducing overhead costs and
- collective units were more likely to hope that they can use the system to adapt business processes to international best practice
- privately-held Chinese companies were more likely to realize financial benefits due to reduced levels of bad debt (Tables 2 and 3).

3. Whereas a number of context factors can be associated with both implementation process and implementation result characteristics, only the degree of job security is associated with the risk of budget and/or schedule overruns and the degree of management satisfaction with project results (Table 3).
4. Whereas the extent of top management participation and support is indeed associated with some outcome characteristics (specifically the degree of user acceptance and the extent of automated cross-functional data exchange relationships), it is the *type* of top management participation which is most broadly associated with implementation results (namely the degree of management satisfaction, the extent of budget and/or schedule overruns, and the extent of lead-time reductions). Specifically, a management system characterized by majority-based or consensus-based decision making in the steering committee and delegation of decision-making authority to the project team is associated with more satisfactory results whereas a management system characterized by seniority-based decision making in the steering committee and centralized decision making is associated with more negative implementation results (Table 4).
5. Whereas the degree of consultants' experience is broadly associated with more satisfactory implementation results, we also found that projects which are (also) initiated by the IT department are even more broadly associated with unsatisfactory results (Table 4).

V. DISCUSSION

EFFECT OF OWNERSHIP ON PROJECT RESULTS

Probably counter-intuitive, we did not find strong support for the idea that foreign-controlled companies are doing better in their implementation projects than their Chinese peers in terms of project results. Nevertheless, ownership is associated with a broad range of implementation *process* characteristics. Thus, ownership possibly affects the way a company is implementing an ERP system but does not predict the outcome of the ERP implementation project. This result confirms the main finding of Markus et al. [2001] who concluded that "the connections between starting conditions, experienced problems, and outcomes in the ERP experience are not deterministic." [p. 19]. In addition, these results also indicate that, although not determining the outcomes of an implementation process, starting conditions shape the subsequent process as proposed in the theory of ERP implementation processes by Markus and Tanis [2000].

Table 2. Implementation Process And Context Factors

	Implementation motive:						
	Improve management control	Adapt business to intern. best practice	Implementation scope[1]	Implementation conflict[2]	Degree of experience of consultants[3]	Top management participation[4]	Duration of parallel systems operation
Ownership							
State-owned[5]	.23; 08; 62		-.26; 04; 62	P-M: .46; .001; 47 F-P: .41; .005; 45 F-M: .32; 03; 46	-.23; 07; 63	-.40; .002; 61	
Foreign-controlled				P-M: -.54; .0001; 47	.26; 04; 63*	.32; .01; 61	-.49; .006; 30*
Collective[5]		.30; 02; 62	-.30; 02; 62				.60; .0004; 30
Privately Chinese-held[5]							.68; .0001; 30
Other							
Relative size of IT budget					.29; .04; 53		
Formal forms of employee representation[6]			-.45; .0001; 70			-.26; .03; 70	
Degree of job security[7]					.33; .005; 72		

Legend:

Cell contents: x; y; z: x: correlation coefficient; y: probability of association being non-significant; z: number of cases; P: purchasing; M: manufacturing; F: finance; an "*" indicates that foreign share in equity is used rather than foreign control

[1] Number of modules implemented

[2] Scale: 1: no conflicts emerged; 2: minor conflicts emerged during the implementation phase which, however, were quickly settled by the project team; 3: major conflicts emerged during the implementation phase which could, however, be resolved by the project team; 4: major conflicts emerged during the implementation phase which had to be resolved by the steering committee; (5) major conflicts emerged during the implementation phase which have not yet been resolved

[3] On a 10-point Likert scale with "1" for "very inexperienced" and "10" for "very experienced"

[4] Senior manager(s) participated in the implementation project

[5] Percentage of equity

[6] Employees can report concerns about working conditions to workers' councils or regular workers' meetings

[7] On a 10-point Likert scale with "1" for "very insecure" and "10" for "very secure"

Table 3. Implementation Results and Context Factors

				Reasons for realized financial benefits:					
	Extent of budget and/or schedule overruns[1]	Degree of management satisfaction[2]	Degree of acceptance by users[3]	Reduced inventories	Lower purchasing costs	Reduced workforce	Reduced levels of bad debts	Lower overhead	Data maintenance problems after cut-over[4]
Ownership									
State-owned[5]					.55; .01; 20				MMD: .31; .01; 46
Foreign-controlled								-.49; .03; 20	MMD: -.31; .04; 46 BOM: -.30; .05; 45
Privately Chinese-held[5]							.43; .06; 20		
Other									
Manufacturing				.46; .03; 23					
Relative size of IT budget						-.58; .004; 22			
Regular cross-departmental meetings									BOM: -.30; .03; 51
Standing cross-departmental committees									BOM: .29; .04; 51
Formal forms of employee representation[6]			-.28; .03; 57						
Degree of job security[7]	B:-.48; .0004; 50 S: -.21; .10; 58	.42; .001; 59							BOM: -.48; .0003; 52

Legend:
Cell contents: x; y; z: x: correlation coefficient; y: probability of association being non-significant; z: number of cases; MMD: Material Master Data; BOM: Bill of Materials
[1] Scale: Budget (B): 1: less than 5%, 2: more than 5%, 3: more than 10%; Schedule (S): 1: less than one month, 2: more than one month, 3: more than three months
[2] Scale: 1: no improvements realized 2: results below original expectations; 3: original expectations met; 4: original expectations surpassed
[3] On a 10-point Likert scale with "1" for "very strong resistance towards the system" and "10" for "no resistance at all"
[4] Scale: 1: no conflicts emerged; 2: minor conflicts emerged which, however, were quickly settled by the involved departments; 3: major conflicts emerged which could, however, be resolved by the involved departments; 4: major conflicts emerged which had to be resolved by top management; (5) major conflicts emerged which have not yet been resolved
[5] Percentage of equity
[6] Employees can report concerns about working conditions to workers' councils or regular workers' meetings
[7] On a 10-point Likert scale with "1" for "very insecure" and "10" for "very secure"

Table 4. Implementation Results And Implementation Process

	Degree of cross-functional implement. conflict	Degree of user acceptance	Degree of mgmnt. satisfaction	Extent of budget and/or schedule overruns	Extent of automation of individual functions[1]	Extent of automated cross-functional data exchange[2]	Extent of lead-time reductions	Likeli-hood of service-level declines	Degree of data main-tenance problems after 'cut-over'	Likelihood of knowing the project's ROI
Extent of top management participation										
Frequency of steering committee meetings	M-S: -.61; .0004; 30 P-I: -.41; .02; 33	.35; .02; 44				.42; .02; 30				
Top management participated in project		.26; .05; 56								
Intensity of top management participation[3]		.34; .03; 39								
Type of top management participation										
Seniority-based decision making in Steer. Comm.			-.44; .003; 45	B: .44; .005; 39						
Majority-based decision making in Steer. Comm.			.37; .01; 45							
Consensus-based decision making in Steer. Comm.				B: -.33; .04; 39			Pr: [.67; .02; 11]	.47; .01; 33		
Centralized decision making in Steer. Comm.			-.29; .05; 46	S: .35; .02; 43						-.53; .0001; 35
Delegation of decision making authority to the project team				B: [-.31; .05; 45]			Pr: [.66; .03; 11]			
Other factors										
Experience of consultants	P-I: -.26; .06; 51 P-F: -.28; .04; 54 S-F: -.35; .01; 49				-.36; .02; 44					
IT-initiated projects			-.32; .01; 59	S: .39; .003; 59		-.31; .05; 39	PP: -.55; .03; 17		BOM: .31; .02; 52	

Legend:
Cell contents: x; y; z: x: correlation coefficient; y: probability of association being non-significant; z: number of cases; brackets indicate that these associations could not be controlled for possible mediating variables; M: manufacturing; S: sales; P: purchasing; I: inventory; F: finance; Pr: production; PP: production planning

[1] Index: number of functions which were not automated as a result of the project multiplied by the number of modules implemented; thus a high value of this index indicates that a large number of functions has not been automated although a broad range of modules has been implemented whereas a low value indicates that only a small number of functions has not been automated although only few modules have been implemented; thus, the index can be considered to measure the failure to automate functions as a result of the implementation project

[2] Index: total number of cross-functional data exchange relationships which have been automated as a result of the implementation project divided by the number of modules implemented

[3] Measured as the product of no. of senior managers who participated in the implementation project and the average percentage of their total working time devoted to the project

POST-INSTALLATION CONTEXT AND OUTCOME

In considering the associations between context and outcome variables, one type of outcome does show a strong association with context variables, namely problems with data maintenance after going live. These problems seem to occur more often in state-owned companies and in companies that use standing committees as cross-departmental coordination devices and less often in foreign-controlled companies and companies that use regular meetings as coordination devices. This observation points to an issue which might be specific to state-owned companies, namely a tendency of employees to identify with departments rather than the whole company. Because implementing an ERP system implies that master data are maintained in one department but are actually used by other departments, smooth master data maintenance involves a high degree of cross-functional collaboration and understanding which might be lacking in state-owned enterprises. This hypothesis is supported by the association of state-owned enterprises with relatively higher levels of cross-functional conflicts during implementation while foreign-controlled companies are associated with relatively lower levels of cross-functional implementation conflict (Table 2). In addition, regular meetings seem to be more effective at cross-departmental coordination than standing committees, an issue which deserves further study.

MANAGEMENT PARTICIPATION

State-owned and foreign-controlled companies also seem to display a mirror image with respect to top management participation and the extent of consultants' experience. Foreign-controlled companies are more likely to involve top management participation in the implementation project and to hire relatively more experienced consultants while the opposite is true for state-owned companies (Table 2). The relatively lower involvement of top management in state-owned firms (as compared to foreign-invested ones) could be explained by a different attitude towards the role of leadership (paternalistic vs. participatory, for example). The relatively lower extent of prior implementation experience of external consultants might reflect a stronger emphasis on containing implementation costs in state-owned firms.

Foreign-invested companies are associated with relatively shorter periods of parallel systems operation after cut-over whereas collective units and privately-held Chinese companies are associated with relatively longer periods (Table 2). This finding points to an issue of trust which we also found in our in-depth case studies. Managers in traditional Chinese companies do not trust the system in terms of data quality and also in terms of appropriateness of suggested decisions. Therefore, managers tend to modify quantities recommended by the system (based on their own experience) and request alternative sources of information to verify the accuracy of data provided by the system. Obviously, existing systems (which are meant to be replaced by the new ERP system) can be considered such an alternative source. However, because employees are required to maintain two systems simultaneously, actual data accuracy might indeed suffer thus seemingly confirming managers' suspicions and creating a self-fulfilling prophecy.

PREDICTING PROJECT SUCCESS

The one context factor which seems to predict project success is the perceived degree of job security (Table 3). This finding is surprising insofar as the literature about information systems implementation has not yet paid attention to it. It may be interpreted as echoing anxieties regarding business process reengineering which was often understood as a euphemism for downsizing [cf. Knights and McCabe, 1998]. Probably, similar feelings accompany an ERP implementation project funneling significant energies into efforts aimed at securing jobs and promotion opportunities rather than implementing the system (or even aimed at limiting the scope of the implementation). Another indication for this interpretation is the negative association between implementation scope and formal forms of employee representation (Table 2). Although employee participation might lead to a better understanding of the nature of the project and thus less resistance, formal forms of employee representation (such as workers' councils or regular

meetings) might be used to limit the scope of the project and thus possible (perceived) negative results for employees. This interpretation could also account for the association between formal forms of employee representation and user resistance to the system (Table 3).

MANAGEMENT INVOLVEMENT

The most striking result about the relationship between implementation process variables and implementation outcomes is that whereas the extent of top management support indeed bears on some project results, it is the type of management involvement which possibly makes the difference between successful and unsuccessful projects as expressed by a broader set of indicators (Table 4).

As pointed out in Section III, top management support is the most commonly mentioned success factor in the literature (Table 1). However, extensive involvement of top management cannot ensure successful implementation in terms of in-budget/on-time implementations as well as the extent of management satisfaction with project results. But it does help with respect to two other types of outcomes:

- the degree of user acceptance and
- the extent of automated cross-functional data exchanges (Table 4).

The first type of impact can be explained in three, not necessarily mutually exclusive ways.

- A strong presence of top management may discourage open forms of resistance. When we asked project managers to evaluate the degree of user acceptance, covert forms of resistance may have evaded their attention.
- A strong presence of top management may also signal the importance given to the project thus increasing users' sense of the issues at stake. They might simply feel that increasing effort levels are required for the company to survive or prosper.
- A strong presence of top management could have a motivating impact on users by setting an example. If users are aware of senior managers spending a lot of time on the project, they might wish to make a bigger effort themselves by, for example, learning how to use the system properly.

Among the other outcome characteristics, the extent of top management involvement is only associated with the extent of automated data exchange relationships (via the frequency of steering committee meetings (Table 4)). The explanation for this result could be that automating data exchange relationships often benefits one side more than the other. Departments generally cannot compensate for such imbalances. Only authoritative decision making or compensating rearrangements of resources can resolve resulting conflicts of interests blocking efforts of extending the scope of automated data exchanges across departmental borders.

DECISION MAKING STYLE

We found that two features of management involvement are related significantly to project success:

- the method of decision making in the steering committee and
- the delegation of decision making authority to the project team[3]

Combining these two features one might summarize the findings reported in Table 4 by associating positive results with 'modern' management systems characterized by majority- or consensus-based decision making in the steering committee and delegation of decision making

[3] It is sometimes called "empowerment" in the literature and listed as a success factor for ERP projects, (Table 1).

authority to the project team and negative results with a 'traditional' management system characterized by seniority-based decision making in the steering committee and retaining of decision making authority in the steering committee. This way of summarizing is justified by a principal component analysis of steering committee characteristics which demonstrates that the first two components describe just these two forms of management systems.[4]

We believe that this result can be explained in at least three ways:

- Centralized decision making in the steering committee may lead to some delay in the decision making process, thus causing schedule and possibly budget overruns.
- Seniority-based decision making enables senior management to unilaterally change some project parameters without necessarily being aware of these decisions' impact on the project schedule and budget while a consensus-based or, less pronouncedly, a majority-based decision-making principle would enable other managers to block such decisions.
- A 'modern' management system may simply be more compatible with the philosophy underpinning an ERP system, which enables decentralized decision making by bringing information relevant for decision making to the operational level.

In contrast, a company which tries to increase centralized control and decision making through an ERP system might ultimately find the system ill-suited to this purpose. This latter interpretation is also supported by the positive association between lead time reductions and both consensus-based decision making in the steering committee and delegation of decision making authority to the project team.

We also found that consensus-based decision making in the steering committee is associated with an increased likelihood of service level declines after cut-over. A possible explanation is that this form of decision making gives departments effectively a veto-right which they might use egotistically risking severe problems after cut-over. Thus, consensus-based decision making poses threats to an ERP implementation project as well as opportunities.

OTHER PROCESS CHARACTERISTICS

Apart from the extent and type of top-management involvement we only found two other process characteristics which can be broadly related to implementation results:

- the degree of experience of external consultants and
- whether or not the project is (also) initiated by the IT department (Table 4).

The first characteristic is frequently mentioned in the literature as a success factor (Table 1), the second received only sparse attention so far. it seems worthwhile look at the differential impact of these two factors in more detail. IT initiation is related to

- project management targets,
- the degree of management satisfaction with project results,
- the degree of data maintenance problems after cut-over, and
- lead time reductions.

The experience of consultants is related to

[4] The first component loads high on seniority-based decision making in the steering committee and centralization of decision making authority in the steering committee and the second component loads high on majority-based decision making and delegation of decision making authority to the project team with these two components accounting for 50% of the variation of all seven variables characterizing the steering committee decision making style and role.

- implementation conflict and
- the number of functions automated as a result of the implementation project.

From this pattern, it may be concluded that the effect of the consultant's extensive prior project experience is based upon superior knowledge (which may help to prevent cross-functional implementation conflict and also train users to take advantage of more functions incorporated in the software) whereas IT-initiated projects may suffer from the lack of the IT department's authoritative resources to enforce strict project milestones (leading to budget and/or schedule overruns and thus management dissatisfaction) and to sanction other departments (leading to data maintenance problems after cut-over).

VI. LIMITATIONS

Our study is subject to three possible threats of external validity.

- The total sample size is rather small; obtaining more robust results would require a sample size of several hundred companies.
- Perhaps even more important is the problem of missing values because these values might be a source of significant bias in our results. For example, companies which did not find that they could realize noticeable cycle time decreases might have preferred not to answer the questions about cycle time reductions.
- Linked to these two limitations is the necessity of a "manual" approach towards identifying possible mediating variables. We relied on a stepwise selection of candidate variables (Section III). To avoid the potential bias inherent in this approach one would wish to use more powerful statistical procedures such as path analysis which, however, require significantly larger samples sizes.

A possible source of threats to construct validity of results might be the translation of our questionnaire and the limited number of pretests. The translation was done by an MBA student who actively participated in an ERP implementation project for three months during his internship. We think that these experiences and the in-depth case studies that we conducted before sending out the questionnaire limit any such threats.

Thus, we conclude that there are significant possible threats to external validity which can only be removed by replicating our findings on a larger scale.

VII. CONCLUSION

We conclude that this study gives some first clues about the areas which warrant more focused attention when studying IT-enabled organizational change or transformation. This tentative area should be the *governance of implementation projects* as characterized by methods of decision making in the steering committee and the extent of delegation of decision making authority to the project team. However, thus far we begged the question of whether or not it is possible to leverage this finding to actively improve ERP implementation results. Since we tried to control for a huge number of possible mediating variables, we are confident that our results can be used as a preliminary indication of general associations. However, it remains an open question whether these findings can be used as levers in terms of project management. Specifically, would prescribing the decision making method of the steering committee and delegating decision making authority to the project team lead to better project results? In other words, do companies need to transform themselves before embarking on an ERP implementation project, or can they use the ERP implementation project to facilitate organizational change as is frequently proposed [cf. Orlikowski and Hofman, 1997; Malone, 1997; Riggs et al., 1996; Swanson, 1994; Applegate et al., 1988]?

A possible theoretical explanation for this type of IT-enabled transformation relates to the organization of the implementation process itself. Implementing a large-scale information system

may provide a unique opportunity to set up a project organization which would otherwise not be compatible with existing organizational practices. This new form of organization may then spread throughout the whole organization since the configuration or the ERP system will reflect this new form and the momentum behind the implementation effort may be sufficient to sustain this new form until it has become a standard practice itself.

However, these hypotheses can only be investigated by means of in-depth, longitudinal case studies. The purpose of this study was to guide such further inquiry by focusing attention on some variables which seem to play a crucial role in ERP implementation projects.

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APPENDIX. QUESTIONS USED IN THE QUESTIONNAIRE

Organization characteristics

- In which industry is your firm doing business? (Multiple answers are possible): Manufacturing (unit-oriented, process-oriented), Retailing, Wholesale, International trade, Telecommunication, Banking, Utilities, Health, Public service, Other
- Who owns your firm (in percent): State, Collective entity, Private Chinese entity, Foreign entity, The public (stocks)
- What were the revenues of your firm in the last fiscal year? (in Chinese Yuan)
- How many employees has your firm currently? (No. of employees)
- In how many years during the past five years has your firm been profitable? (No. of years)
- What is the average percentage of your IT budget (for HW and SW) with respect to your firm's revenues? (<1%, 1-2%, 2-3%, 3-4%, 4%)
- Please indicate computer-based information systems which have been used prior to the ERP implementation project according to the following scheme: Columns: Did not / Did have a computer-based information system before ERP implementation which was developed by external supplier (please indicate name) / internally; Rows: Finance, Cost control, Purchasing, Inventory, Production planning, Production control, Sales and Distribution, Human Resources
- Your firm's "reward system" is primarily based on (please tick only one alternative): The promise of promotion, A bonus system, Assignment of more attractive tasks, Other
- Your firm's "punishment system" is primarily based on (please tick only one alternative): The threat of dismissal, The threat of degradation (lower job title), The threat of assignment of less attractive tasks, Other
- Does your firm have a formal proposal system to reward employee initiated process innovations? (Yes/No)
- Does your firm have any of the following organizational means of cross-functional coordination? (Multiple answers are possible): Regular positions whose task is to improve coordination between functional departments, Regular cross-departmental meetings, Standing cross-functional/departmental committees
- If workers have concerns about their working conditions, which means are available to them to express these concerns: Report to superiors, Report to workers' councils, Report on regular workers' meetings, A petition system (a system for forwarding anonymous messages to top management), Other
- What is the average level of education of your end users: Below BA level, BA level, Above BA level
- How would you characterize the degree of job security in your firm according to the following scale in which 1 stands for "very insecure" and 10 for "very secure"?

Implementation process characteristics: General

- Your firm does not / belongs to a foreign-invested corporation and the ERP implementation project is/was part of a global roll-out / is/was initiated and controlled by the Chinese entity
- Your firm does not belong to a group of legally independent firms which are controlled centrally / belongs to a group; the ERP implementation project will be/is carried out in all firms

of the group / in some firms of the group which autonomously initiate and control the ERP implementation project / in some firms of the group but the implementation project is/was initiated and controlled centrally.

- Your firm implements/implemented only one module / several modules all simultaneously ("Big Bang" strategy) / in the following order (please indicate by filling in 1, 2, 3 …): FI, CO, MM, SD, PP, HR, Other
- Your firm implements/implemented the system only in one organizational entity / in several organizational entities; in all entities in China simultaneously / in the following order (please indicate by filling in 1, 2, 3 …and leave a blank for entities which do not exist in your firm): head office, regional offices, manufacturing subsidiary, sales subsidiary, other
- Has the R/3 implementation project been initiated upon request of: internal functional departments, the IT department, the CEO or the deputy CEO, important customers?
- What have been the original expectations regarding the outcome of the ERP project? (only the two most important alternatives): Standardization of processes, Adaptation of processes to international best practice, Improvement of existing customer-facing services, Creation of new types of customer-facing services, Improved internal logistical processes, Improved management controls, Enabling of future growth, Increasing the firm's flexibility to respond to new market opportunities, Other
- Has the project scope been changed after the budget and the time schedule had been fixed? (Yes; the following types of changes had been made: Additions of modules, Additions of functions within modules, Additions of sites / No, none of these changes in project scope have been made)
- Please specify the degree to which conflicts between functional departments emerged during the implementation phase by ticking the appropriate cells: Rows: Cross-functional relationship does not exist in the ERP implementation project, No conflicts emerged, Minor conflicts emerged which were quickly settled by the project team, Major conflicts emerged which could, however, be resolved by the project team, Major conflicts emerged which had to be resolved by the steering committee, Major conflicts emerged which have not yet been resolved; Columns: Purch.-Manuf., Purch.-Finance, Purch.-Finance, Manuf.-Finance, Manuf.-Sales, Sales-Finance, HR-Finance
- How many weeks of R/3 training did end users and key users receive on average? (End users/Key users {weeks})
- In which phase of the project have end users been trained? (Note: Multiple answers are possible: During the design phase, During prototyping and installation, During the testing phase, Just before cut-over
- Have you done a formal evaluation of the outcome of the implementation project after cut-over? (Yes/No)
- If you had prior information systems for any of the functions involved in the implementation project, did you run the new and the old system(s) in parallel after cut-over? (Yes {months} / No)
- If you employed external consultants, for how long after cut-over did they offer on-site support? (months)
- Did you offer an internal hot-line for users after cut-over? (Yes {months} / No)
- Does/did the management of your firm explicitly promise to employees that there will be no dismissals as a result of the R/3 implementation project in order to diffuse possible user resistance? (Yes / No)
- Are end users promised a reward if they make useful proposals regarding the ERP implementation project? (Yes / No)

Implementation process characteristics: Project team composition & motivation

- Please specify the project team composition according to the following scheme: By function and total number: Senior manager(s), Dept. director(s), Key user(s), End user(s); only total number: IT director, External consultant(s)
- How would you characterize the general ERP experience of the external consultants involved in the project according to the following scale in which 1 stands for "very inexperienced" and 10" for "very experienced"?
- How would you characterize the focus of external consultants' competence in terms of the following scale in which 1 stands for "exclusively focused on software" and 10 for "exclusively focused on business processes"?
- What is/was the maximum time of R/3 planning experience for determining project budget and time schedule any one member, including external consultants, has/had in your project team? (years)
- Are managers (including IT managers) who participate in the implementation project motivated by the explicit promise of promotion upon successful project completion? (Yes / No)
- Are project participants promised a bonus upon successful completion of the project? (Yes / No)

Implementation process characteristics: Top management participation & steering committee

- Has the R/3 implementation project been initiated by a senior manager (a manager being at least on the deputy general manager level)? (Yes / No)
- How many senior managers participated in the implementation project and how much of their total working time (in percent) do/did they, on average, actually dedicate exclusively to the project by, for example, attending project or steering committee meetings? (Senior managers did not participate in the implementation project / senior managers participated in the implementation project; they devoted on average about …% of their total working time to the project)
- If senior managers participated in the implementation project, please indicate their functional responsibilities by ticking the appropriate cells in the following scheme: Columns: Manuf., Purch., Sales, Finance, HR, IT, R&D; Rows: 1st, 2nd, 3rd, 4th senior participant
- Please specify the steering committee composition according to the following scheme: By function and total number: Senior manager(s), Dept. director(s), Key user(s), End user(s); only total number: IT director, Project manager, External consultant(s)
- Are decisions made in the steering committee based on: the consensus principle, majority voting, the seniority principle?
- Please indicate the two most important functions of the steering committee: Make critical implementation decisions, Approve critical implementation decisions made by the project team, Motivate project members, Resolve conflicts between project team members, Other
- How often did/does the steering committee meet during implementation? (Less than once a month, About once a month, More often than once a month)

Project outcomes

- Project implementation has been more than 3 months over schedule, more than 1 month over schedule, less than 1 month over schedule
- Actual project budget has been more than 10% over planned budget, more than 5% over planned budget, less than 5% over planned budget
- How long did it take after cut-over to stabilize the new system (i.e. until operations were at least as reliable as before implementation)? (weeks)
- What has been the general outcome of the implementation project with regard to original expectations? (Outcome surpassed original expectations, Outcome met original expectations, Outcome below original expectations but still some improvements realized, No improvements realized)
- How would you describe the degree of resistance by end users towards the system after cut-over according to the following scale in which 1 stands for "very strong resistance" and 10 for "no resistance at all"?
- Please characterize the extent to which business processes are automated according to the following scheme: Columns: Process automated as a result of ERP implementation / process automated prior to ERP implementation / Process not automated after implementation; Rows: Sales Planning, Sales and Operations Planning, Production Planning, Production Control, Material Requirements Planning, Purchase Order Creation, Delivery Planning, Credit Management, Invoice Verification, Cost Center Planning, Overhead Costing, Product Costing, Profitability Analysis, Fixed Assets Accounting, Legal Consolidation, Other
- Please indicate the automation degree of data exchange between processes by ticking the appropriate cells in the following scheme: Columns: Automated data exchange without manual intervention / Data exchange involves manual intervention; Rows: Sales planning data to production planning, Sales planning data to profitability analysis, Production planning data to purchase requisition, Production planning data to cost center planning, Material requirements planning data to cost center planning, Material requirements planning data to production orders, Other
- Have structural changes resulted from the R/3 implementation project? (Note: If there are changes, please fill in the number of changes in the brackets) Yes, a total number of ( ) new reporting relationships / ( ) new positions with new job descriptions has been created / No, none of these changes have occurred as a result of the implementation project
- Please indicate the extent to which problems have emerged between functional departments regarding maintenance of master data by ticking the appropriate cells in the following scheme: Columns: Material Master Data, Vendor Master Data, Customer Master Data, Bill of Materials; Rows: No conflicts emerged, Minor conflicts emerged which were quickly settled by the involved departments, Major conflicts emerged which could, however, be resolved by the involved departments, Major conflicts emerged which had to be resolved by top management, Major conflicts emerged which have not yet been resolved
- Please indicate to which extent business processes have been shortened as a result of the implementation project according to the following scheme: Before/After ERP implementation: Purchasing lead time (in weeks), Delivery lead time (in weeks), Production lead time (in weeks), Production planning lead time (in days), Monthly financial closing time (in days)
- Has the percentage of in-time deliveries temporarily declined after cut-over? (Yes; for about … months / No, the share of in-time deliveries did not decline after cut-over)
- If known, please give the Return on Investment for the ERP implementation project and indicate its main sources by ticking not more than the three most important types of benefits according to the list below: Return on Investment not known / Return on Investment is ca. …%; its main sources are: Reduced work force, Reduced inventory levels, Lower purchasing

costs, More flexible pricing, Lower rate of bad debt, Lower costs due to more accurate material supplies, Lower costs due to more accurate specification of required material quality, Lower costs due to more accurate deliveries, Lower overhead costs, Reduced share of unprofitable products (due to the availability of the profitability analysis function), Other

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