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An Empirically Derived Taxonomy of Information Systems Integration

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ABSTRACT

Information systems integration (ISI) represents the degree of cooperation in information system practices between business functions within a firm and between a firm and its trading partners. Although the establishment of information systems integration objective has been reported as one of the key concerns of top management because ISI enhances the firms' competitiveness and growth, the classification of the information system practices and its managerial implications are still vaguely developed. The two objectives of this paper are: (1) to develop a taxonomy of information systems integration (ISI) called ISI-Matrix, and (2) to report managerial implications for matching each information system class with business process applications. By using a systematic research investigation approach, two ISI structures are identified: Internal ISI (IISI) and External ISI (EISI) from the responses of 220 firms. The ability to identify and understand the implications of the ISI-Matrix is of critical importance to both academic and management practitioners.

INTRODUCTION

The rapid changes in perspective toward globalization of markets and manufacturing has forced management to re-configure the traditional views of business functions and replace them with business processes. The process view of organizations embraces cross-functional teams which penetrate networks of inter-organizations and intra-organizations. Within the process, a project team performs many tasks across functional barriers (with a firm and between a firm and its trading partners) to meet corporate goals in a more seamless way. This increased emphasis on improving business processes has triggered the need for placing information systems (IS) in a strategic role of corporate strategy as opposed to a supportive role in the traditional view (Raghunathan & Raghunathan, 1990; Chan et al., 1997; Goodhue et al., 1992). A review of the empirical literature reveals that one issue, the linkage of IS practices with organizational objectives, has been among the top problems reported by information systems (IS) managers and business executives (Reich and Benbasat, 1996; Computerworld, 1994; Lederer and Mendelow, 1986; Earl, 1989).

Information Systems Integration (ISI) is the degree of cooperation between business functions within the firm and between a firm and its trading partners on an internally consistent set of strategic, operational, and infrastructural information systems practices using information systems (IS). In a broader sense, ISI often represents as a pressing concern of misalignment of information system practices between two business processes (King and Teo, 1997; Segars and Grover, 1998). In this context, information system practices, which are utilized to accomplish process tasks at each end, lack degree of congruence when certain processes/tasks involve cross-functional boundaries at the other end. Consequently, the first objective of this paper is to identify a set of IS practices that is shared by process team members. Therefore, ISI represents the degree of cooperation in information system practices between business functions within a firm and between a firm and its trading partners.

ISI has been reported to facilitate the possibilities of increased productivity, customer responsiveness, and the synchronization of diverse organizational settings. It has been documented that the introduction and utilization of ISI enhance firms' competitiveness and growth, product quality, productivity, machine utilization, space management, and logistics efficiency and flexibility (Gross, 1984; Kaltwasser, 1990; Noori and Mavaddat, 1998). A higher degree of ISI creates information visibility and captures the moments of information which enable collaborative members of the supply chain to manage their business processes and share information better (Lummus and Vokkurka, 1999; Gunasekaran and Ngai, 2004; Bourdreau and Couillard, 1999; Williams et al., 1997; Gangopadhyay and Huang, 2004). Although ISI has been reported to positively impact firm performance, the classification of the information system practices and its managerial implications are still vaguely developed. The classifications of ISI in the current literature are extremely broad and fragmented. There is no consensus on what constitutes an ISI taxonomy. Our goal is to develop a comprehensive ISI taxonomy to aid organizations whose ability to harness the power of IS practices is critical to their success. Development of valid and reliable instruments to be used in large-scale surveys is an important first step toward this goal. The resulting taxonomy should help organizations to match information system class with their current business process applications which should enhance a firm's internal and external integration.

In a narrow sense, focusing on the survey approach, this study arguably classified ISI into two main categories namely Internal Information Systems Integration (IISI) and External Information Systems Integration (EISI). In each category, ISI construct is also clustered into three levels namely Strategic Integration, Operational Integration, and Infrastructural Integration. Infrastructural integration is also subdivided into two sub-constructs: Data Integration and Network Integration. Table 1 shows the components of ISI classifications. By deploying this classification scheme, the second objective of this paper is to propose a classification matrix (ISI-Matrix) which will be used to provide managerial implications for both researchers and practitioners.

The next section of this paper defines and discusses the ISI taxonomy. The following sections describe the research design and discuss the candidate measured used to evaluate the degree at different ISI levels. The subsequent section presents the results, and the final section discusses the implications of our findings for researchers and practitioners.

Table 1: Information System Classifications.

Internal Information System Integration (IISI)	**External Information System Integration (EISI)**

• Strategic Integration – Internal
• Operation Integration – Internal
• Infrastructural Integration – Internal
    o Data Integration – Internal
    o Network Integration – Internal
	• Strategic Integration – External
	• Operation Integration – External
	• Infrastructural Integration – External
	    o Data Integration – External
	    o Network Integration – External

INFORMATION SYSTEMS INTEGRATION TAXONOMY

A description of previous taxonomies

The rapid changes in the role of information systems (IS) are presenting firms with significant challenges and dramatic opportunities. Revolutionary advances in hardware and software capabilities coupled with reduced prices have shifted numerous applications from infeasible to feasible, changed the structure of organizations, and forced management to rethink the classification of IS. The terms taxonomy and framework are sometimes used interchangeably in the literature (Doke and Barrier, 1994). However, a clear distinction between the two is identified: taxonomy is generally used to describe a classification scheme for "things" such as IS. Although framework is sometimes used as a synonym for taxonomy, it is more often used to describe models that organize and group "concepts and relationships" (Doke and Barrier, 1994). The taxonomy is derived from the characteristics of the measured subjects, so the categories are both exhaustive and mutually exclusive (Fiedler, Grover, and Teng, 1996). This method is especially useful when one is examining unexplored phenomena because both methods must be empirically examined to evaluate the representativeness and generalizability of the classifications to the population they are mean to describe. Unlike the predetermined, idealized categories of a typological methodology that lend themselves to prescriptive hypothesizing, taxonomy's classifications emerge from analysis so that the classification is derived (Doty and Glick, 1994; Hair, Anderson, Tatham, and Black, 1998). Developing a taxonomy can be viewed as a multistep process including the classification scheme, measurement development, multivariate analysis of the classification criteria to produce the item groupings, and the evaluation of the classification groupings (Fiedler, Grover, and Teng, 1996). The classification systems should "mirror the real world…describe organizational reality in a way that is recognizable to and consistent with the vision of practitioners and researchers alike as a viable reproduction of the diverse world in which we live in" (Rich, 1992). Since the focus here is the classification of ISI, a taxonomy will be used to classify these models

Dimensions of a Taxonomy

Integration is "to make into a whole" (Oxford English dictionary). The study of ISI classifications started as early as 1985 by Mudie and Schafer. They analyzed ISI in process terms, as they believed ISI should not only facilitate the process of development and use of data, applications, and other processing technology, but also should provide the flexibility to meet the future business demands in workstations, processing types, and applications. Wyse and Higgins (1993) defined ISI as the extent to which data and applications through different communication networks can be shared and accessed for organizational use. They defined ISI into two components: data integration and technical integration. Data integration refers to the relevancy of the information that is collected, processed, and disseminated throughout the firm. Technical integration concerns the physical or formal linkage of information systems and subsystems that are used by the firm. Webber and Pliskin (1996) defined ISI in the merger or acquisition context as the extent of the integration of IS and data processing functions with financial systems, which are usually a critical component of the IS. The findings point to a positive relationship between ISI and effectiveness only when controlling IT intensity and organizational culture differences between the joining firms. Stylianou et al. (1996) also studied an ISI framework in the merger and acquisition context. The framework examines the relationships between the measure of ISI success and the components that affect it. ISI success was measured using a multidimensional attribute as: 1) IS-assessment of the success of the integration process and integrated systems; 2) the ability to exploit to avoid opportunities arising from a merger; 3) the ability to avoid problems stemming from the merger; and 4) the end-user satisfaction with the integration process and integrated systems. Following this study, Robbies and Stylianou (1999) modified the ISI success measure to fit with the post-merger system integration context. The improved IS capability construct was added. They argued that the measure relating to improved IS capabilities that helped support the underlying motives for the merger is important and should be included.

Bhatt (2000) studied the relationship between ISI and business process improvement. He argued that, at a conceptual level, ISI can be viewed as data architectures, communication networks, and support firms. He used two aspects to measure the degree of ISI: Data integration and communication networks integration. The data integration was defined as the extent to which different firms can share a number of databases for coordinating their activities. Communication networks integration was defined as the extent to which different information systems can communicate with other wide information systems to coordinate present and future activities depending on network connectivity and network flexibility.

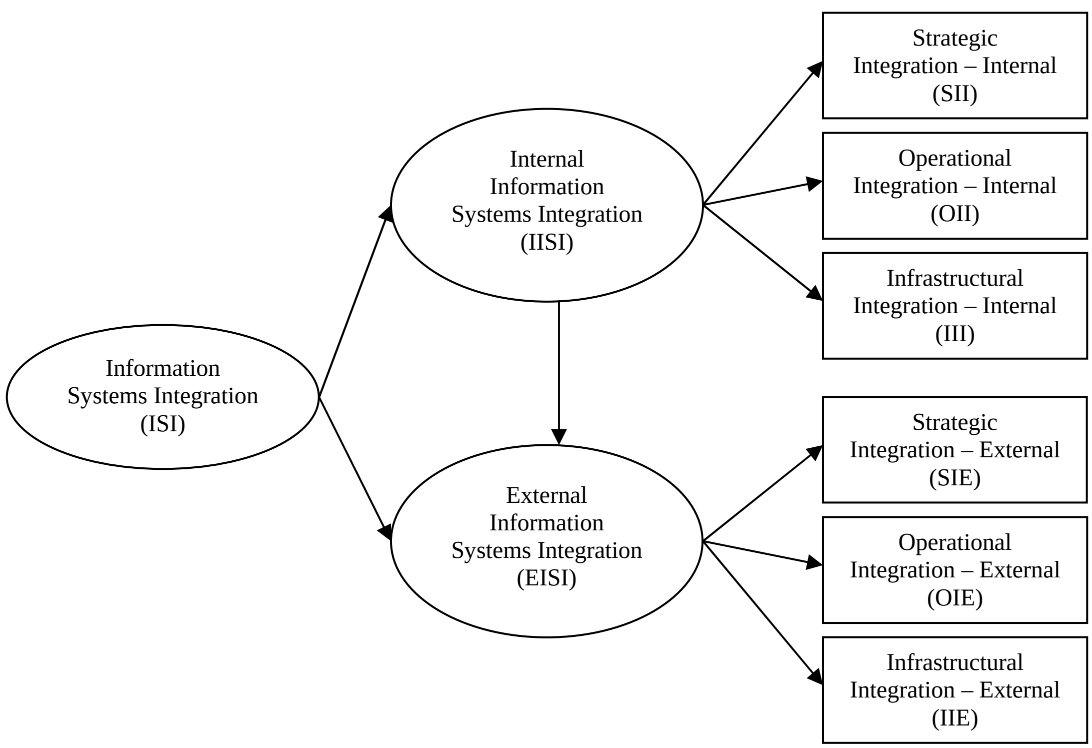
The Evolution of an Information Systems Integration Taxonomy

Previous studies have discussed the role of ISI in tactical and operational perspectives suitable for the context of studies such as process development, financial research or merger and acquisition. Researchers mostly looked at only functional aspects of ISI, for instance, data integration and communication networks integration (Madnick, 1991; 1995; Wyse and Higgins, 1993; Bhatt, 2000; Wainwright and Waring, 2004; Themistocleous et al., 2004), the extent of IS and data processing functions and the extent of integration of financial systems (Webber and Pliskin, 1996). Others investigated the integration of heterogeneous information systems, databases, or application software, integration of different physical stages in business processes, and integration of subsystems into a well-coordinated network system (Sikora and Shaw, 1998; Cohen and Lee, 1988; Fedorowicz, Gogan, and Ray; 2004). None of the previous studies focused on ISI research at the strategic level. In addition, previous studies considered ISI as a success measure, not as a practice (Stylianou et al., 1996; Robbies and Stylianou, 1999).

In the inter-and intra-organizational context where integration of corporate entities can produce dynamic and synergistic opportunities, ISI should not only be viewed as traditional back office and processing support, but also as strategic support (Johnson, 1999). Porter and Millar (1985) asserted that management of information systems can no longer be the only provision of functional activities such as accounting and record keeping. The use of advanced information systems in value chain activities allows companies to enhance competitive differentiation as well as attain cost leadership and sustainable competitive advantage (Kim and Narasimhan, 2002). McFarlan and McKenny (1984) showed in their information systems strategic grid that the role of IS should change from operational supporter to strategic enabler in order to form competitive success.

In this study, from a firm's perspective, ISI is the degree of cooperation between business functions within the firm (IISI) and between a firm and its trading partners (EISI) on an internally consistent set of strategic, operational, and infrastructural information systems practices using information systems (IS). ISI can be defined using two sub-constructs – IISI and EISI. Strategic integration represents a set of strategic information system practices, which promote cooperation of various business functions within the firm or between a firm and its trading partners. Strategic integration concerns how well integration practices meet the corporate long-term goals. Operational integration is defined as a set of operational information system practices, which promote cooperation of various business functions within the firm or between a firm and its trading partners. Operational integration concerns how well integration practices between two parties meet day-to-day goals. Infrastructural information system integration represents a set of information system practices to facilitate information sharing and to coordinate work activities, which promote integration within firm. Infrastructural integration consists of data integration and network integration. Infrastructural integration concerns the improvements of information systems and information sharing to harmonize the efforts of managers from different parts of the organization and enable them to make decision consistent with organizational goals. Figure 1 displays the ISI classification framework.

Figure 1: Information Systems Integration (ISI) Classification Framework.



RESEARCH METHODOLOGY

The development of the instruments for the ISI constructs was carried out in three phases: (1) item generation, (2) pilot study, and (3) large-scale data analysis and instrument validation. First, an extensive and comprehensive literature review was conducted to identify the content domain of major constructs in the current research framework. Initial items and the definitions of each construct were generated from the literature review. The pilot study was conducted using the Q-sort method. After that, analysis of inter-rater agreement about the items' placement identifies both bad items and weakness in the original definitions of the constructs. The third phase was tested based on the large-scale data analysis.

Item generation

Proper generation of measurement items of a construct determines the validity and reliability of empirical research. The basic requirement for a good measure is content validity, which means the measurement items contained in an instrument should cover the major content domain of a construct (Churchill, 1979). Content validity is usually achieved through comprehensive literature review and interviewing practitioners and academic experts. A list of initial items for each construct was generated based on a comprehensive review of relevant literature. The general literature bases for items in each construct are briefly discussed below.

Thirty items (30) were developed for Internal Information Systems Integration (IISI) and twenty nine items (29) were developed for External Information Systems Integration (EISI). Once item pools were created, items for the various constructs were reviewed by five academicians and re-evaluated through structured interviews with two practitioners. The focus was to check the relevance of each construct's definition and the clarity of wordings of sample questionnaire items. Based on the feedback from academicians and practitioners, redundant and ambiguous items were either modified or eliminated. New items were added whenever deemed necessary. Tables 2&3 show the items for IISI and EISI constructs.

Table 2: The Items for IISI Constructs.

Coding	Items
The use of Information Systems (IS) facilitates **manufacturing department and *other internal business functions* to work together to…**	
Strategic Integration - Internal (SII)	
SII1	Formulate long-term collaborative decision making.
SII2	Justify long-term business plans.
SII3	Analyze long-term business plans.
SII4	Develop long-term business opportunities.
SII5	Identify new markets
SII6	Identify long-term technology justification and planning.
SII7	Study strategies of competitors.
SII8	Define long-term competitive positioning.
SII9	Set long-term strategic goals.
Operational Integration – Internal (OII)	
OII1	Adjust daily manufacturing processes.
OII2	Adjust daily product development processes.
OII3	Control daily product quality.
OII4	Manage daily order quality.
OII5	Exchange daily inventory information.
OII6	Select suppliers.
OII7	Manage daily logistical activities.
OII8	Establish daily product forecasts.

Infrastructural Integration – Internal (III)	
Data Integration – Internal (DII)	
DII1	Use standard data definitions and codes.
DII2	Use standard information/data format.
DII3	Use standard presentation format.
DII4	Use centralized databases.
DII5	Use database synchronization system.
DII6	Integrate data and information.
Network Integration – Internal (NII)	
NII1	Use IS networks to communicate with other departments.
NII2	Use IS networks to connect to each other's database.
NII3	Use IS network applications.
NII4	Use IS networks to share information with other departments.
NII5	Use IS networks to connect to centralized databases.
NII6	Use IS networks to facilitate periodic interdepartmental meetings.
NII7	Use compatible network architectures.

Table 3: The Items for EISI Constructs.

Coding	Items
The use of Information Systems (IS) facilitates **manufacturing department and *__its suppliers and customers__* to work together to…**	
Strategic Integration - External (SIE)	
SIE1	Formulate long-term collaborative decision making.
SIE2	Justify long-term business plans.
SIE3	Analyze long-term business plans.
SIE4	Develop long-term business opportunities.
SIE5	Identify new markets
SIE6	Identify long-term technology justification and planning.
SIE7	Study strategies of competitors.
SIE8	Define long-term competitive positioning.
SIE9	Set long-term strategic goals.
Operational Integration – External (OIE)	
OIE1	Adjust daily manufacturing processes.
OIE2	Adjust daily product development processes.
OIE3	Control daily product quality.
OIE4	Manage daily order quality.
OIE5	Exchange daily inventory information.
OIE6	Select supplier
OIE7	Manage daily logistical activities.
OIE8	Establish daily product forecasts.

Infrastructural Integration – External (IIE)	
Data Integration – External (DIE)	
DIE1	Use standard data definitions and codes.
DIE2	Use standard information/data format.
DIE3	Use standard presentation format.
DIE4	Use centralized databases.
DIE5	Use database synchronization system.
DIE6	Use compatible database systems.
Network Integration – External (NIE)	
NIE1	Use IS networks to communicate with each other.
NIE2	Use IS networks to connect to each other's database.
NIE3	Use IS network applications.
NIE4	Use IS networks to share information with each other.
NIE5	Use IS networks to facilitate periodic meetings.
NIE6	Use compatible network architectures.

Survey Methods, Data Collection, and Sample Characteristics

A cross-sectional self-administered mail survey was conducted. All data for eight constructs were generated from questionnaire responses by using a five-point Likert scale. The sampling frame was obtained from the Society of Manufacturing Engineers (SME). The initial mailing list of 4,000 names was randomly selected from 120,000 SME members East North Central and West North Central regions. Of 4,000 mailed questionnaires, 579 did not reach the targeted respondents because of bad addresses. A large number of (235) respondent refused to participate in the survey. In addition, 14 questionnaires were returned empty. Therefore, the number of complete and usable responses was 220, representing a response rate of 6.91% (calculated as 220/(4000-579-235)). Table 4 shows sample characteristics by job functions and job titles.

Table 4: Sample Characteristics.

Job Functions (261)		**Job Titles** (220)	
Corporate Executive	6.51% (17)	CEO/President	6.82% (15)
Purchasing	6.13% (16)	Director	7.27% (16)
Transportation	2.30% (6)	Manager	53.18% (117)
Manufacturing Production	41.38% (108)	Supervisor	27.27% (60)
Distribution	1.15% (3)	Engineer	4.55% (10)
Sales	6.13% (16)	Other	0.91% (2)
Unidentified	13.41% (35)		
Other	22.99% (60)		

N = 220; * some items were counted more than 2 times.

Test of Non-Response Bias

One concern of the survey is non-response bias. Non-response was estimated by testing differences between early and late respondents (Armstrong and Overton, 1977). The date used to differentiate early and late respondents was the day that survey returns. The 148 responses from the first mail were considered to be early respondents and the 72 received from the second wave are considered late respondents. To test the non-response bias for early and late respondents for this study, the annual sales were explored using chi-square tests for randomly selected items. No significant differences were found between the early and late respondents.

Table 5: Test of Non-Response Bias.

Variables	First-wave	Second wave	Second wave	Chi-square Test
	Frequency (%)	Expected Freq. (%)	Observed Freq. (%)	
Sales Volume in millions of $ (220)				
<5	20	7	0	χ^2 =10.78 df=6 p>.10
5 to <10	10	5	6	
10 to <25	28	13	11	
25 to <50	13	8	12	
50 to <100	20	9	6	
Over 100	33	17	20	
Unidentified	24	13	17	

The calculation formula $\chi^2 = \sum (f_e - f_o)^2 / f_e$

LARGE SCALE INSTRUMENT ASSESSMENT METHODOLOGY

Once the data was collected, the survey instrument used in the large-scale study was submitted to rigorous reliability and validity assessment using the 220 responses. As per the guidelines of Bagozzi (1980), the important properties for measurement to be reliable and valid include content validity, internal consistency of operationalization (unidimensionality and reliability), and construct validity (discriminant and convergent).

Content validity refers to the representativeness of item content domain. If the measures adequately cover the topics that have been defined as the relevant dimensions, then it can be concluded that an instrument has good content validity (Kerlinger, 1978). An instrument has content validity if there is a general agreement among the subjects and researchers that the measurement items that cover all-important aspects of the variable being measured. In this study, content validity can be assessed by two important processes – (1) a comprehensive review of the literature and (2) a panel judgment on the measurement items.

The unidimensionality (and convergent validity) criteria require that there be one single latent variable underlying a set of measurement items (Anderson and Gerbing, 1984). The degree of unidimensionality is indicated by the Goodness of Fit Index (GFI) and the Adjusted Goodness of Fit Index (AGFI). The GFI indicates the relative amount of variance and covariance jointly explained by the model. The AGFI differs from the GFI in adjusting for the number of degrees of freedom (Byrne, 1989). Both range from 0 to 1. Values of 0.9 or more are considered a good fit (Hair et al., 1998). The next set of fit statistics focus on the root mean square error of approximation (RMSEA). The RMSEA takes into account the error of approximation and is expressed per degree of freedom, thus making the index sensitive to the number of estimated parameters in the model; values less than 0.05 indicate good fit, values as high as 0.08 represent reasonable errors of approximation in the population (Browne and Cudeck, 1993), values range from 0.08 to 0.10 indicate mediocre fit, and those greater than 0.10 indicate poor fit (MacCallum et al., 1996).

Discriminant validity refers to the independence of the dimensions. The constructs are considered to be distinct if the hypothesis that the two constructs together form a single construct is rejected. To test this hypothesis, a pair-wise comparison of models was performed by comparing the model with correlation constrained to one with an unconstrained model. A different between the χ^2 value (df = 1) of the two models that is significant at $p < 0.05$ level would indicate support for the discriminant validity criterion (Joreskog, 1971).

Reliability of the measurements can be assessed using Cronbach's alpha (Nunnally, 1978). The recommended Cronbach's alpha value is more than 0.7 for the reliable measurement.

LARGE-SCALE MEASUREMENT RESULTS

The following section presents the large-scale instrument validation results on each of the two main constructs: Internal Information System Integration (IISI) and External Information System Integration (EISI). For each construct, the instrument assessment methodologies described in the previous section were applied.

Internal Information System Integration (IISI)

The Internal Information System Integration (IISI) construct was initially represented by four dimensions and 30 items, including Strategic Integration – Internal (SII, 9 items), Operational Integration – Internal (OII, 8 items), Data Integration – Internal (DII, 6 items), and Network Integration – Internal (NII, 7 items).

Convergent Validity: The initial model fit indexes for SII consist of GFI = .72, AGFI = .54 and RMSEA = .24. These indexes show poor fit indexes; therefore, further model modifications were made. Based on the modification indexes, four items (SII2, SII5, SII7 and SII8) were dropped. The new model fit indexes improved significantly to GFI = .98, AGFI = .94, and RMSEA = .07. The initial model fit indexes for OII consist of GFI = .92, AGFI = .89 and RMSEA = .09. These indexes showed a reasonable fit; however, further model modifications were made to achieve an improved fit. Based on the modification indexes, OII2 – Adjust daily product development processes and OII6 were dropped. The new model fit indexes improved significantly to GFI = .97, AGFI = .94, and RMSEA = .07. The initial model fit indexes for DII consist of GFI = .88, AGFI = .72 and RMSEA = .20. These indexes showed unreasonable fit; therefore, further model modifications were made to achieve an improved fit. Based on the modification indexes, one item (ISID-I4 – Use centralized databases) was dropped. The new model fit indexes improved significantly to GFI = .99, AGFI = .96, and RMSEA = .07. The initial model fit indexes for NII consist of GFI = .91, AGFI = .82 and RMSEA = .15. These indexes showed unreasonable fit; therefore, further model modification was examined. Based on the modification indexes, two items (ISIN-I5, and ISIN-I6) were dropped. The new model fit indexes improved significantly to GFI = .98, AGFI = .94, and RMSEA = .08. Table 6 shows the model fit indexes for IISI construct.

Table 6: Model Fit Indexes for Internal Information System Integration.

Coding	Items	Initial Model Fit	Final Model Fit
Strategic Integration - Internal (SII)			
SII1	Formulate long-term collaborative decision making.	**GFI = .72** **AGFI = .54** **RMSEA = .24**	**GFI = .98** **AGFI = .94** **RMSEA = .07**
SII2	Justify long-term business plans. *		
SII3	Analyze long-term business plans.		
SII4	Develop long-term business opportunities.		
SII5	Identify new markets. *		
SII6	Identify long-term technology justification and planning.		
SII7	Study strategies of competitors. *		
SII8	Define long-term competitive positioning. *		
SII9	Set long-term strategic goals.		
Operational Integration - Internal (OII)			
OII1	Adjust daily manufacturing processes.	**GFI = .92** **AGFI = .89** **RMSEA = .09**	**GFI = .97** **AGFI = .94** **RMSEA = .07**
OII2	Adjust daily product development processes. *		
OII3	Control daily product quality.		
OII4	Manage daily order quality.		

OII5	Exchange daily inventory information.		
OII6	Select suppliers. *		
OII7	Manage daily logistical activities.		
OII7	Establish daily product forecasts.		
Infrastructural Integration – Internal (III)			
Data Integration - Internal (DII)			
DII1	Use standard data definitions and codes.	**GFI = .88** **AGFI = .72** **RMSEA = .20**	**GFI = .99** **AGFI = .96** **RMSEA = .07**
DII2	Use standard information/data format.		
DII3	Use standard presentation format.		
DII4	Use centralized databases. *		
DII5	Use database synchronization system. *		
DII6	Integrate data and information.		
Network Integration - Internal (NII)			
NII1	Use IS networks to communicate with other departments.	**GFI = .91** **AGFI = .82** **RMSEA = .15**	**GFI = .98** **AGFI = .94** **RMSEA = .08**
NII2	Use IS networks to connect to each other's database.		
NII3	Use IS network applications.		
NII4	Use IS networks to share information with other departments.		
NII5	Use IS networks to connect to centralized databases. *		
NII6	Use IS networks to facilitate periodic interdepartmental meetings. *		
NII7	Use compatible network architectures.		

* Items were dropped to improve divergent validity

Discriminant validity: Table 7 shows the results from discriminant analysis. The differences between χ^2 values from every pairs are statistically significant at the $p < 0.0001$ level thus indicating high degree of discriminant validity among constructs. The results prove that the constructs are theoretically and statically different from each other as hypothesized in the measurement development section.

Table 7: Pairwise comparison of χ^2 values for Internal Information System Integration.

Construct	**SII** (χ^2)			**OII** (χ^2)			**DII** (χ^2)		
	Free	Fix	Dif.	Free	Fix	Dif.	Free	Fix	Dif.
SII									
OII	103.71	175.81	**72.10**						
DII	55.58	132.43	**76.85**	82.64	149.24	**66.60**			
NII	74.88	146.50	**71.62**	73.46	122.68	**49.22**	125.98	192.33	**66.35**

External Information System Integration (EISI)

The External Information System Integration (EISI) construct was initially represented by four dimensions and 29 items, including Strategic Integration - External (SIE, 9 items), Operational Integration - External (OIE, 8 items), Data Integration – External (DIE, 6 items), and Network Integration – External (NIE, 6 items).

Convergent Validity: In this step, 29 EISI items were then submitted to a measurement model analysis to check model fit indexes for each sub-construct (Table 7). The initial model fit indexes for SIE consist of GFI = .81, AGFI = .67 and RMSEA = .18. These indexes showed unreasonable fit; therefore, further model modification was further modified. Based on the modification indexes, three items (SISI-E5, SISI-E7 and SISI-E8) were dropped. The new model fit indexes improved significantly to GFI = .98, AGFI = .90, and RMSEA = .10. The initial model fit indexes for OIE consist of GFI = .94, AGFI = .89 and RMSEA = .10. These indexes show a reasonable; however, RMSEA is considered low and further model modification was necessary. Items OIE6 – Select supplier and OIE7 – Manage daily logistical activities were dropped because the concepts were already covered in OIE5 – Exchange daily inventory information. The final model fit indexes improved significantly to GFI = .98, AGFI = .95, and RMSEA = .05. The initial model fit indexes for DIE were GFI = .77, AGFI = .45, and RMSEA = .30 and they showed unreasonable fit. Items DIE5 – Use database synchronization system and DIE6 – Use compatible database systems were dropped because the concepts were already covered in DIE4 – Use centralized databases. The final model fit indexes improved significantly to GFI = 1.00, AGFI = .99, and RMSEA = .00. The initial model fit indexes for NIE consist of GFI = .89, AGFI = .75 and RMSEA = .19. These indexes showed nowhere near a reasonable fit; therefore, further model modification was necessary based on modification indexes (MI) for both measurement error correlations and item correlations (multicolinearity). Based on the modification indexes, two items (NIE3 and NIE6) were dropped. NIE3 – Use IS network applications was dropped because the item was unclear and showed low regression weight. NIE6 – Use compatible network architectures was dropped because it was repeated in NIE2 – Use IS networks to connect to each other's database. The new model fit indexes improved significantly to GFI = .99, AGFI = .94, and RMSEA = .09.

Table 8: Model Fit Indexes for External Information System Integration.

Coding	Items	Initial Model Fit	Final Model Fit
Strategic Integration - External (SIE)			
SIE1	Formulate long-term collaborative decision making.	**GFI = .81** **AGFI = .67** **RMSEA = .18**	**GFI = .98** **AGFI = .90** **RMSEA = .10**
SIE2	Justify long-term business plans.		
SIE3	Analyze long-term business plans.		
SIE4	Develop new business opportunities.		
SIE5	Identify new markets. *		
SIE6	Identify long-term technology justification and planning.		
SIE7	Study strategies of competitors. *		
SIE8	Define long-term competitive positioning.*		
SIE9	Set long-term strategic goals.		
Operational Integration – External (OIE)			
OIE1	Adjust daily manufacturing processes.	**GFI = .94** **AGFI = .89** **RMSEA = .10**	**GFI = .98** **AGFI = .95** **RMSEA = .05**
OIE2	Adjust daily product development processes.		
OIE3	Control daily product quality.		
OIE4	Manage daily order quality.		
OIE5	Exchange daily inventory information.		
OIE6	Select supplier. *		
OIE7	Manage daily logistical activities. *		
OIE8	Establish daily product forecasts.		
Infrastructural Integration – External (IIE)			
Data Integration - External (DIE)			

DIE1	Use standard data definitions and codes.	**GFI = .77** **AGFI = .45** **RMSEA = .30**	**GFI = 1.00** **AGFI = .99** **RMSEA = .00**
DIE2	Use standard information/data format.		
DIE3	Use standard presentation format.		
DIE4	Use centralized databases.		
DIE5	Use database synchronization system. *		
DIE6	Use compatible database systems. *		
Network Integration - External (NIE)			
NIE1	Use IS networks to communicate with each other.	**GFI = .89** **AGFI = .75** **RMSEA = .19**	**GFI = .99** **AGFI = .94** **RMSEA = .09**
NIE2	Use IS networks to connect to each other's database.		
NIE3	Use IS network applications. *		
NIE4	Use IS networks to share information with each other.		
NIE5	Use IS networks to facilitate periodic meetings.		
NIE6	Use compatible network architectures. *		

* Items were dropped from the initial model

Discriminant validity: Table 8 shows the results from discriminant analysis. The differences between χ^2 values from every pairs are statistically significant at the $p < 0.0001$ level thus indicating high degree of discriminant validity among constructs. The results prove that the constructs are theoretically and statically different from each other as hypothesized in the measurement development section.

Table 8: Pairwise comparison of χ^2 values for External Information System Integration.

Construct	**SIE** (χ^2)			**OIE** (χ^2)			**DIE** (χ^2)		
	Free	Fix	Dif.	Free	Fix	Dif.	Free	Fix	Dif.
SIE									
OIE	109.71	153.69	**43.98**						
DIE	126.36	178.49	**52.13**	92.32	133.99	**41.67**			
NIE	93.88	132.38	**38.50**	86.41	118.35	**31.94**	80.07	123.29	**43.22**

Reliability Analysis Table 9 shows the reliability coefficients for IISI and EISI construct.

Table 9: Cronbach's Alpha of Scales.

Variables	**Number of Items**	**Reliability**
Internal Information Systems Integration (IISI)		
Strategic Integration – Internal (SII)	9	.93
Operational Integration – Internal (OII)	8	.88
Data Integration – Internal (DII)	6	.80
Network Integration – Internal (NII)	7	.94
External Information Systems Integration (EISI)		
Strategic Integration – External (SIE)	9	.97

Operational Integration – External (OIE)	8	.93
Data Integration – External (DIE)	6	.89
Network Integration – External (NIE)	6	.93

Discriminant Validity (second-order construct)

The second-order factor is explaining the covariation among first-order factors in a more parsimonious way (i.e., one that requires fewer degrees of freedoms). Therefore, even when the higher-order model is able to explain the factor covariations, the goodness-of-fit of the higher order model can never be better than the corresponding first-order model (Segars and Grover, 1998). In this sense, the first-order model provides a target or optimum fit for the higher-order model. It has been suggested that the efficacy of second-order model be assessed through the examination of a target (T) coefficient (where T= χ^2 first-order model/χ^2 second-order model) (Marsh and Hocevar, 1985). The T coefficient .80 to 1.0 indicates the existence of a second-order construct since most of the variation shared by the first-order factors is explained by a single second-order factor. Table 10 shows the calculated target coefficient between the first-order model and the second-order model. This value suggests that the addition of the second-order model does not significant increase χ^2. Therefore, the second-order model represents a more parsimonious representation of observed covariances and it should be accepted over the first-order model as a "truer" representation of model structure. The results prove that the second-order constructs do really exist as hypothesized in the theory development section.

Table 10: Goodness of Fit Indexes for First and Second Order Model.

Construct	Model	Chi-Square (df)	Chi-Square/df	GFI	AGFI	RMSEA	T coefficient
IISI	First-Order	408.48 (164)	2.50	0.86	0.82	0.08	98.42%
	Second-Order	415.03 (166)	2.50	0.85	0.81	0.08	
EISI	First-Order	461.47 (164)	2.81	0.83	0.79	0.09	89.94%
	Second-Order	463.62 (166)	2.79	0.83	0.79	0.09	

DISCUSSION AND IMPLICATION

The current research represents one of the first large-scale empirical efforts to systemically investigate the complex classifications of information systems integration. It aims to answer the following important questions: 1) What are the key dimensions of information systems integration? 2) What are the managerial implications of an information systems integration taxonomy? Currently, there is no clear definition of constructs and conceptual frameworks of information systems integration (ISI) in the current literature and most empirical research mainly focuses on the physical aspects of ISI integration such as data integration and network connectivity. The few studies that have attempted to empirically study the concept of information systems integration are not clearly focused and mainly relate to infrastructural integration. The current study provides a complete set of measurements for information systems integration consisting of strategic integration, operational integration and infrastructural integration. Based on the data collected from 220 top managers and executives, the model was tested using structural equation modeling methodology. The study contributes to our understanding of information systems integration and supply chain research a number of ways.

First, this research provides a theoretical framework that identifies the detailed dimensions of information systems integration. The measurement instruments included in this study were tested through rigorous statistical methodologies including pre-test, pilot-test using Q-sort method, confirmatory factor analysis, unidimensionality, reliability, and the validation of second-order construct. All the scales are shown to meet the requirements for reliability and validity and thus, can be used in future research. Such valid and reliable scales have been otherwise lacking in the literature.

Second, this study provides supporting evidence to the conceptual and prescriptive literature about previously inconclusive statements regarding the relationship between internal information systems integration (IISI) and external information systems integration (EISI). From the predictive validity results, this research argues that the nature of the information systems integration process occurs in a sequential manner. The integration process starts with collaborating activities between departments such as collaborating and developing business plans, identifying new markets, adjusting manufacturing and logistics processes, setting up network connectivity, and etc. Once the internal integration is firmly rooted, the process of external information systems integration is begun by involving their trading partners (Koufteros et al., 2005; Peterson et al., 2005). Therefore, the internal integration process is crucial and a pre-requisite for the success of a supply chain.

Third, after empirically investigating the information systems integration classifications concept, three distinct dimensions for each ISI construct emerge including Strategic integration, Operational integration, and Infrastructural integration. ISI dimensions determine how information systems are designed relative to the kinds of resources needed, how resources are apportioned between them, and their key characteristics. For example, end users use strategic information systems to deal with long-term related decisions which have future positive impacts to the organization. Such decisions include setting up the budgetary plan for the new market, justifying long-term business plans, and studying the competitors. End users who deal with operational decisions use operational information systems to cope with day-to-day operations such as managing inventory, updating purchase orders, and justifying customer demands. Lastly, end users who are responsible for data communication and network connectivity are most likely to deal with infrastructural information systems. Examples of infrastructural integration decisions include setting up standard data definitions and formats, setting centralized databases, designing network architectures, and maintaining network connection. Understanding the connections between types of integration and the corresponding information system decisions helps the manager detect possible misalignments in processes, paving the way for reengineering and process improvements.

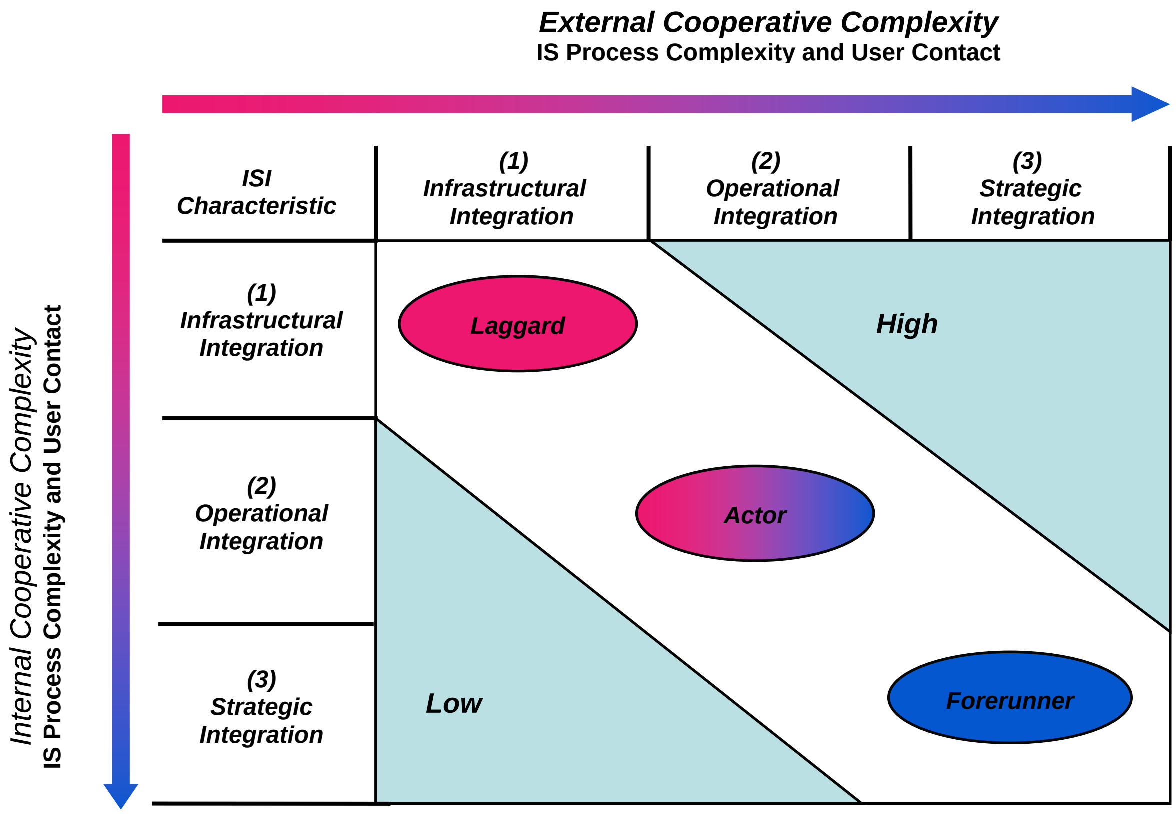
ISI-Matrix

Beginning points for making ISI decisions are internal cooperative complexity and external cooperative complexity. Internal cooperative complexity represents the degree of cooperation between functions within the organization on information system activities. External cooperative complexity represents the degree of cooperation between a firm function and its business partners on information system activities. Cooperative complexity degree can be described by the level of IS process complexity and the level of interaction between users – User contact. IS process complexity is the extent to which the process is highly customized with each user. If the process changed with each user activity such as requesting a long-term budget plan and required users to interact with each other regularly, then the IS process in very complex. User contact is the extent to which the user is actively involved and pays personal attention during the process. The two extremes of user contact include active users and passive users. Active users are very involved in the creation of the process outcomes. The users interact with each other to personalize the process to suit their needs and decide on what level of involvement to perform such as analyzing a business plan. On the other hand, passive users are not involved in tailoring the process to meet special needs. Users may simply wait for the process to provide the service such as printing monthly report.

From figure 2, ISI-Matrix represents internal cooperative complexity on the vertical bar and external cooperative complexity on the horizontal bar. The columns of the matrix represent the levels of external information systems integration going from infrastructural structural integration on the left-hand side to strategic integration on the right-hand side. The rows represent the levels of internal information systems integration going from the infrastructural integration on the top to strategic integration on the bottom. Infrastructural integration is considered the lowest extent of cooperative complexity because information system activities in this group are not required special attention from top management. Most activities are routine, pre-formulated, and standard including setting up network connectivity, setting up standards for report, and setting up remote access points between locations. IS activities in this type of integration are considered less complex and are required less user contact. The outcomes of this type of integration have short-term impacts on organizations. Operational integration is considered moderate complex and requires moderate relationship between parties. Operational integration deals with day-to-day IS activities including checking up inventory level, updating sales information, and checking the production status. Strategic integration is considered the highest extent of cooperative complexity. Information system activities in this group are required special attention from top management. Because the decisions are very complex, no two decisions are alike. Information systems are used mainly to cooperate between top management from both parties to agree on strategic plan, marketing positioning, new markets, new products, and competitor analysis. The outcomes of this type of integration have long-term impacts on organizations.

The possible desirable positions in the matrix that effectively connect the internal information systems practices with the external information systems practices. The manager has three possible process choices to choose from: *(1) Laggard, (2) Actor*, and *(3) Forerunner*. Because the level of internal information systems integration is crucial and a pre-requisite of the success of external information systems integration, it is unlikely that a process is operating in the lower-left corner area. Firms operating in the lower-left corner are considered low performers. Operating in such an area can lead to high out-of-pocket costs because the firm has invested in expensive information system projects that are rarely utilized because the need for the system to integrate with external trading partners is low. Firms operating in the top-right corner of the matrix are called high performers because firms use limited system capabilities to interact with their trading partners whose systems are far more advanced. Operating in such are can also lead to high opportunity costs because the firm is attempting to connect to external partners using the limited resources; though it is possible to operate in the triangle, too much interruption because of the system mismatch might warrant low efficiency such as low performance and lost sales. Operating in the diagonal area exhibits a benchmark. Some deviation from the diagonal is expected and even desirable, allowing for special niches. However, the extreme positions are to be avoided. A laggard process has low user contact and little service customization. The process characterizing this group uses standardized system formats and routine network services. Firms operating in the actor group use information systems to interact with each other on a day-to-day basis. Firms use information systems to actively involve in adjusting production schedule, managing quality control, managing order quantity, constructing forecast, and monitoring inventory level. Firms operating in the forerunner area use information systems to collaborate with each other in setting strategic goals. Information systems are used to formulate long-term business plan, identify markets, investigate new technologies, define new products and processes, and study competitors.

Figure 2: ISI-Matrix.



Implications for Practitioners

The results of this study have several important implications for practitioners. First, as today's competition is moving from competing between firms to competing between supply chains, more organizations are increasingly adopting information technologies, hoping improve operational and firm performance. The findings of this research assure the practitioners that, to achieve a high level of integration with suppliers and customers, internal information systems integration is imperative. The direct relationship between internal information systems integration and external information systems integration implies that, in order for information systems to be integrated; the process of integration occurs in a sequential manner from internal integration to external integration. The ISI-matrix shows that firms with a high degree of internal integration such as firms in the forerunner group (e.g., firms successfully implement enterprise-wide information systems such as SAP and MRP) are more likely to integrate with their external partners than firms with low level of internal information systems integration such as firms in the laggard group. Internal information systems integration projects are time consuming and capital intensive. Not all the firms implementing internal integration system can be successful. However, firms successfully implementing internal integration have more chances to integrate with other firms using existing compatible systems.

The research identifies the key dimensions of information systems integration that a firm can adopt to interact with its trading partners. The dimensions of information systems integration include two dimensions namely internal information systems integration and external information systems integration each with three sub-dimensions namely strategic, operational, and infrastructural information systems integration. Infrastructural information systems integration consists of two sub-constructs – Data integration and Network integration. These dimensions provide precise information to assist top management when implementing information systems. The findings demonstrate to the practitioners that, in order to gain overall benefits, top management should establish information system that best serves their internal firm needs before attempting external integration.

For strategic managers, the ISI-matrix can be used as a bench marking tool to construct a gap analysis. The bench marking integration position is where the information system activities match the current IS capabilities and where the internal integration activities match with external integration. Strategic managers should be able to realize the organizational current situation of information system integration. Knowing the current position in ISI-matrix helps managers answer following important strategic questions: What are the types of information systems to be implemented? What are the new products offering? What will be the new markets, and whether or not new IS investments should be warranted. For example, if the current position of the organization in the low performer area, IT investments must be set as a high priority in the strategic plan in order to close the gap between internal IS capabilities and external IS capabilities. If managers do not react quickly, the organization might lose business. On the other, if the current position of the organization in is in the high performer area, managers must find ways to balance the high technology investment cost such as offering new products, penetrating new markets, or offering subcontracting/out sourcing excess IS capacities to other organizations.

Implications for Researchers

First, the study provides the inferences made from an instrument that is valid and reliable for the current study's context for evaluating an organization's level of information systems integration. The study provides the inferences made from an instrument that is valid and reliable for the current study's context to measure the concept of information systems integration. With two sub-dimensions of information systems integration, the new instrument helps expand ideas for researchers who might adopt these measures to study the factors affecting information systems integration such as culture. These measures are also useful to researchers who are interested in studying the effects of information systems integration on other important management variables such as top management support and mass customization.

Limitations of the Research

While the current research made significant contributions from both a theoretical and practical point of view, it also has limitations, which are described below. First, because of the limited number of observations (220), the revalidation of constructs was not carried out in this research. This needs to be addressed in future research. New mailing lists and research methods may be applied to improve the response rate. Second, in this research, individual respondents (manufacturing managers and top management) in an organization were asked to respond to complex information systems integration issues dealing with all the participants across the organizations. However, no person in an organization is in charge of the entire process span across the organization: for example, manufacturing managers are mainly responsible for procuring raw materials and parts and managing production, and may not be in an appropriate position to answer the supplier/customer-related questions. The main area of manufacturing managers is production and they may not have thorough knowledge of their suppliers, customers, and firm performance. Therefore, the use of single respondent responses may generate some measurement inaccuracy. Third, the response rate of 7%, even though comparable to similar studies, is considered low. The length of questionnaire may have contributed to the low response rate. Time constraints of top management, manufacturing managers and executives make it unlikely that they will participate in a lengthy survey. This issue can be addressed in future research by reducing the number of items in the questionnaire and concentrating the focus of the questionnaire to the areas requiring further clarification.

Recommendations for Future Research

Definition and measurement items should be refined based on the results of the measurement model analysis. Future research should not only attempt to develop better definitions and sub-dimensions but also use the least amount of parsimony. Since the usefulness of a measurement scale comes from its generalizability, future research should revalidate measurement scales developed through this research by using the similar reference populations.

Future research should apply multiple methods to obtain data. The use of a single respondent to represent what are supposed to be intra/inter-organization wide variables may generate some inaccuracy and more than the usual amount of random error (Koufteros, 1995). Future research should seek to utilize multiple respondents from each participating organization as an effort to enhance reliability of research findings. Once a construct is measured with multiple methods, random error and method variance may be assessed using a multitrait-multimethod approach. Future studies can also examine the relationships by bringing some variables into the model such as information technology utilization, supply chain integration, operational performance and organizational performance (Ragatz et al., 1997; Roth, 1998)). It will be intriguing to investigate how ISI practices differ across organization size. It will also be interesting to examine the impact of supply chain structure (supply chain length, organization's position in the supply chain, channel structure, and so on) on ISI practice and performance (Rosenzweig et al., 2003). Future research can expand the current theoretical framework by integrating new constructs from other fields. For example, one might incorporate top management support and mass customization into the existing framework.

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