Aligning Supply Chain Management Characteristics and Interorganizational Information System Types: An Exploratory Study

Rachna Shah, Susan Meyer Goldstein, and Peter T. Ward

Abstract—Supply chain management (SCM) and interorganizational information systems (IOIS) have gained significant importance in recent years, aided by anecdotal success stories of firms obtaining competitive advantage using these systems. Historically, the two streams of research have developed relatively independently, with operations and logistics researchers studying supply chains and information systems/information technology researchers covering the IOIS domain. Here, we describe the enhancement of knowledge that can be obtained by juxtaposing these two areas. This research study proposes a framework, the “supply chain management–interorganizational information system (SCM–IOIS) matrix,” to help understand the alignment of IOIS capabilities with the needs of supply chain members. The framework is validated using data from IndustryWeek’s census of manufacturers. The findings from this exploratory study support our proposition that firms align the levels of IOIS with the sophistication and coordination of their SCM efforts.

Index Terms—Customer management orientation, information system integration, interorganizational information system, supplier management orientation, supply chain coordination, supply chain management.

I. INTRODUCTION

Supply chain management (SCM) and interorganizational information systems (IOIS) have gained significant importance in recent years, aided by anecdotal success stories of firms obtaining competitive advantage using these systems. Firms from many industries have reported the positive impact of SCM on performance. For instance, Procter & Gamble has reported generating more than U.S. $325 million in supply chain savings. Similarly, IOISs are shown to provide the necessary capabilities to electronically integrate a set of firms, thereby enabling better performance in the marketplace [20].

Historically, the two streams of research for SCM and IOIS have developed relatively independently, with operations and logistics researchers studying supply chains and information systems/information technology (IS/IT) researchers covering the IOIS domain. While SCM researchers concentrated on the movement of materials [7], IOIS researchers focused on electronic flows of information [35]. Recently, researchers have recognized the synergies that can be achieved by integrating the distinct SCM and IOIS research streams [25], [33].

Supply chains exist at various stages of coordination among members, ranging from an unlinked arm’s length relationship to complete functional coordination [24]. SCM is a set of practices and strategic initiatives taken by supply chain members that are intended to support the business strategies of firms in the supply chain. These practices and initiatives often require using information intensively and thus, require the support of IOIS capabilities to enact the SCM strategy effectively. In short, IOIS comprises the requisite infrastructure capabilities that should be aligned with appropriate supply chain activities. Using a manufacturing firm’s management initiatives in its interactions with suppliers and customers as a proxy to measure supply chain relationships, we posit that supply chains at different stages of coordination have different IOIS requirements.

In this paper, we propose a conceptual framework to study the alignment of IOIS capabilities with the needs of the supply chain members. The framework, which is presented in Section III below, is based on the existing SCM and IOIS literature, which are briefly reviewed in Section II. We validate the framework empirically using data from IndustryWeek’s census of manufacturers. In addition, we also examine the performance implications suggested in the above framework. This exploratory analysis is described in Section IV. Finally, Section V provides a discussion of the findings and future research areas.

II. SCM AND IOIS

Our integrative framework is based on the conceptual progress made separately by researchers in SCM and IOIS. We briefly review the evolution of the two literatures with particular emphasis on interactions (between a manufacturing firm and its suppliers and customers) underlying supply chain relationships and IOIS capabilities as they relate to supply chain strategies. To be consistent throughout the paper, we use the term “coordinate” to describe relationships among firms in a supply chain and “integrate” to describe the extent of IOISs that are used among firms.

A. Supply Chain Coordination

Since its emergence in the literature in the mid-1980s, SCM has gained considerable attention from both practitioners and academicians. Designing and managing a tightly coordinated supply chain is one of several strategies firms use to generate uh
distinctive and sustainable competitive advantage and, hence, improve organizational performance [14].

An important aspect of SCM research has been in developing a view of the supply chain as the coordination of formerly discrete supply chain activities into a system of value-adding processes [6], [10]. A coordination view emphasizes a focus on customer satisfaction regardless of the specific configuration of the functional areas in the supply chain. Earlier work in SCM [6], [10] viewed the coordination in terms of physical processes and did not specifically consider information flows. This view is reflected in the popular supply chain operation reference (SCOR) model which assumes that all firms include sourcing, making, and delivering processes strategically linking suppliers and customers to manufacturers (see www.supply-chain.org). However, more recent research on supply chains has incorporated information flows, yielding the following definition: “a set of three or more organizations directly linked by one or more of the upstream (supplier-related) and downstream (customer-related) flows of products, services, finances, and information [emphasis added] from source to a customer” [28].

This theoretical conceptualization of SCM has not yet translated into practical or empirical reality. Most manufacturing firms still view their supply chains as separate interactions with their suppliers on one end and customers on the other end. Similarly, manufacturing firms may undertake different initiatives to manage their interactions with suppliers and customers. Empirical research in SCM also reflects this reality, as most articles are limited to either upstream or downstream interactions. Further, as Eloranta and Hameri [11] note, inbound and outbound logistics tend to be separated in research, with an unbalanced emphasis on the supply or purchasing side. A notable exception includes Frohlich and Westbrook [13] who use the notion of “arcs of integration” to represent the direction of integration toward suppliers and/or customers and the degree of integration activity and classify manufacturers’ integration strategies into five groups. Specifically, their research question was to investigate whether it is more important to integrate with suppliers or customers or both. Our research question is different: we propose to test the alignment of a manufacturing firm’s orientation toward its suppliers and customers and the capabilities of its information systems.

While there are many ways to characterize supply chains (for a comprehensive review, please see [16]), the issue of type and extent of relationships among supply chain members has been thematic in supply chain research [6], [39], [47]. Lambert et al. [24] recognize that supply chain relationships typically share some common characteristics, but that those characteristics are best viewed on a continuum rather than as discrete categories. We use the management initiatives that a manufacturer undertakes in its interactions with its suppliers and customers to measure the type and extent of supply chain relationships. Length of time and breadth of coordination are critical issues in SCM research that are well understood and, hence, an appropriate framing for exploratory empirical work. In the interest of brevity and simplicity, we use only these two facets of supply chains in this research. Thus, restating the conceptual work of Lambert et al. [24], we suggest the four most pertinent stages of supply chain relationships. These stages range from the simple arm’s length relationships to enrolling coordinated relationships.

Arm’s length relationships describe a pure exchange relationship between the supply chain members in which two firms have single or multiple exchanges over a short or a long period of time. There is no joint commitment or joint operation: when the exchanges end, the relationship ends. The second stage is a Type I (short-term) relationship in which the organizations recognize one another as partners on a limited basis and coordinate some activities and planning. Partners with Type I relationships usually have a short-term focus and involve the single division or functional area from each firm. For example, ordering and payment systems between manufacturers and suppliers may be coordinated and communicated on a fairly regular basis. Firms with Type II (long-term) relationships coordinate activities involving multiple divisions and functions within the firms (e.g., integration with both suppliers and customers) and generally have a long-term focus. Firms with Type III (coordinated) relationships view the other firms or customers processes as an extension of their own. Type III relationships are very long-term in nature, with no end for the partnership envisioned.

Lambert et al.’s [24] characterization of the supply chain is focused on the relationships between a firm and its key supplier(s). However, the same arguments and, hence, the same classification scheme can be applied to relationships between a firm and its key customers. For instance, a transaction-based approach between a firm and its customer is a Type I relationship, while a long-term strategic relationship is a Type III relationship.

Typically, there is no one “ideal” supply chain relationship that is appropriate for all conditions. The choice of type of coordination should be based on the needs and conditions of the supply chain partners. A number of evaluative frameworks and measurement tools to assess the needs and conditions of two firms interested in partnering are available to make such an assessment [24], [47]. While few manufacturing firms undergo extensive needs assessment formally in developing their relationship with suppliers or customers, most initiate a distinct set of practices in their interactions with the suppliers and customers. We use these practices to measure the interactions between a manufacturing firm and its suppliers and customers.

In practice, firms may choose to focus their SCM efforts on only suppliers or only customers or both. In the literature, the focus of a supply chain toward suppliers or toward customers is referred to as the orientation of the supply chain [22]. Here, we refer to the practices that a firm uses in its interactions toward managing suppliers as supplier management orientation (SMO). For practices used in managing customers, the term customer management orientation (CMO) is used. Therefore, we model supply chain relationships at a dyadic level to capture upstream and downstream interactions separately.

B. IOIS Types

Interest in IOIS can be traced back to 1966, when Kaufman [21] predicted that computer networks would improve coordination between organizations and radically alter traditional billing and payment practices. However, it was not until 1982 that Barrett and Konsynski [2] first used the term “IOISs” to characterize those information systems that cross organizational boundaries linking one or more independent organizations. IOIS
has been alternatively described as an information and communication technology-based system that transcends legal enterprise boundaries [1], [3].

IOIS involves the cooperation and commitment of all participating members that are not as tightly coupled by structural authority as usually exists in vertically integrated hierarchies. Kumar and van Dissel [23] describe IOIS as planned and managed cooperative ventures between otherwise independent agents. More recently, IOIS has been referred to as an extranet and has been defined as the application of systems that link various partners in a supply chain using a public or private telecommunications infrastructure [33].

Control of the electronic medium used for information sharing remains an issue. Electronic data interchange (EDI) is the most commonly used private communication technology infrastructure [30]. Web-based interchange (WBI) is fast becoming the most commonly used public communication technology infrastructure. WBI encompasses a wide range of specific technologies including email, order placement systems, and cost and delivery tracking systems. The focus of this research is on business capabilities developed by firms via electronic medium rather than specific technologies used to engender the capabilities. Both EDI and WBI enable firms to take advantage of the “electronic integration” effect [27] and can significantly alter how they interact with their suppliers and customers.

The framework for the levels of IOIS that are defined here is adapted from a framework presented by Riggins and Mukhopadhyay [36] who categorize firms into three levels of IOIS usage, depending on their use of information technologies to integrate with partner firms. Riggins and Mukhopadhyay [36] define Level 1 users as transmitting a small number of documents to a limited set of suppliers or customers. IOIS technology is used at a departmental level where one functional department or division communicates with its counterpart in the partner firm. For example, procurement capabilities between two firms, such as customers entering orders on a firm’s website such as “Dell’s direct model” or a firm procuring raw material from its suppliers through an EDI, indicate Level 1 use of IOIS.

Level 2 firms communicate with suppliers and customers using multiple document sets, but partner firms have limited ability to manipulate shared data sets and documents. Shared ordering and scheduling systems are examples of Level 2 IOIS technologies. While Level 1 firms communicate with either suppliers or customers (but not both), Level 2 firms use technology to communicate with both suppliers and customers. Therefore, Level 2 users require higher IOIS capabilities than Level 1 users.

Level 3 firms utilize complete systems integration, including the ability of each supply chain partner to change the shared data. Use of these IOIS by the partner firms is frequent and much of each firm’s systems are integrated with its partners within the supply chain. For instance, collaborative new product development across firms using electronic medium such as EDI or WBI require that each supply chain partner have the ability to manipulate and make changes to shared design. Unlike serial development processes in which the original equipment manufacturer (OEM) creates the product design and specification and vendor firms supply components within given specifications, collaborative development requires the OEM and vendor share common protocols in their design, development, and communication systems. Similarly, business forecasting across supply chain partners requires the ability to make dynamic and interactive changes supported by integration across multiple departments in each partner firm.

III. SCM–IOIS MATRIX

Based on the juxtaposition of the SCM and IOIS classifications presented in Section II, we propose a “supply chain management–interorganizational information system matrix (SCM–IOIS Matrix)” to depict the important relationship between the orientation of a particular supply chain and the extent of interfirm linkage provided by IOIS. The matrix is shown in Fig. 1. The SCM–IOIS Matrix provides a means to align the needs embodied in supply chain interactions with the capabilities provided by the IOIS. Underlying the notion of alignment is the notion of fit. Alignment can be conceptualized as a theoretically defined match between two related variables, independent of any performance anchor [48]. Further, it can be defined as the extent to which the two variables meet the theoretical norms of mutual coherence [31]. Alignment as a match between SCM and IOIS is the ideal perspective to invoke because we do not assign causality from one axis to the other, but we argue that if the IOIS lacks the capabilities required to meet the needs of the supply chain, there is an inherent inefficiency in the system in terms of a timely and appropriate information availability. In contrast, if IOIS capabilities exceed the needs of the supply chain, there is an opportunity cost of over-investment in information technology.

An appropriate level of information system sophistication is needed to realize a corresponding level of supply chain coordination. However, supply chains exhibit significant differences based on the relational characteristics among members [24], [44]. Furthermore, supply chains whose members exhibit different relational characteristics have different information requirements and necessitate different capabilities from their IOIS.

Since an IOIS provides the fundamental infrastructure for linking members of a supply chain, proper alignment between the developmental stage of the supply chain and the integrating
capabilities of IOIS is critical. This alignment enables firms to achieve the desired benefits they seek through efficient management of their supply chain. The proposed SCM–IOIS Matrix provides a map for aligning the level of coordination among supply chain members with the extent of IOIS integration.

The rows in the SCM–IOIS Matrix represent relational characteristics among members of a supply chain. The top row of the SCM axis represents the baseline model of an arm’s length relationship, with relatively independent functional departments. Firms with Type I and Type II relationships suggest increasingly coordinated supply chain practices. The bottom row represents Type III relationships of a highly coordinated supply chain with long-term relationships among supply chain members.

The columns represent the extent of integration achieved through the various levels of IOIS, ranging from no electronic integration in the far-left column to complete integration in the far-right column. The first column on the far left represents no electronic linkage between supply chain partners (Level 0). The second column represents electronic linkage between a firm and either its suppliers or its customers (Level 1). The third column represents electronic linkage between a firm and both its suppliers and its customers (Level 2). Finally, the fourth column represents extensive electronic linkage and collaboration among all three supply chain partners—the firm, its suppliers, and its customers (Level 3).

A firm can be characterized as occupying a particular region in the SCM–IOIS Matrix as determined by the relational characteristics of its supply chain members and the extent of IOIS integration with other firms. We postulate that successful supply chain relationships are located near the diagonal of the matrix from the upper-left to the lower-right, and that the upper-right and lower-left corners represent apparent mismatches between supply chain needs and information system capabilities.

Firms that are near or on the diagonal have aligned their supply chain strategy and practices with the capabilities of their IOIS. In contrast, the area in the upper-right corner of the matrix characterizes firms whose supply chain members are relatively independent while their information systems provide tight integration. While we expect few firms to position themselves here, a tightly integrated IOIS without closely coordinated interactions between supply chain members may offer some advantages, although the integrated IOIS may not be used to its full potential. Likewise, the lower-left corner represents a closely linked supply chain with a nonintegrated IOIS and although this suggests a conceptual mismatches, it may occur in practice as supplier coordination even without tightly integrated IOIS may have benefits. The SCM–IOIS Matrix illustrates our argument that firms that align the needs of their supply chains with the capabilities of their IOIS gain more from their capabilities than firms that exhibit misalignment.

Stock and Tatikonda [46] investigate a similar issue of alignment between organizational interaction and technology uncertainty. They develop the organizational interaction construct using the notion of “differences in degrees of interorganizational relationships.” This is similar to our SCM axis which we develop using the supply chain partnership/relationship literature and operationalize using initiatives that a firm takes in its interactions with its suppliers and customers. However, there are salient differences in the two studies. Stock and Tatikonda’s matrix is a typology that represents a fit between information processing requirements inherent in technology transfer and information processing capabilities. In contrast, our SCM–IOIS Matrix represents a fit between SCM needs and IOIS capabilities. The unit of analysis for Stock and Tatikonda is at the project level while our analysis is conducted at the strategic business unit level. Stock and Tatikonda provide four case examples from one firm to illustrate the usefulness of their typology.

IV. VALIDATION OF SCM–IOIS MATRIX

While numerous matrices have been presented in the literature on a variety of management issues, most are presented as theoretical classification systems or as decision-making tools, lacking empirical validation and assessment of some measure of performance which is proposed to “improve” as firms align themselves “correctly.”

A small number of empirical validations have been attempted for matrices, including Safizadeh et al.’s [38] test of Hayes and Wheelwright’s product–process matrix for manufacturing. The product–process matrix, which identifies the matrix diagonal as the best choice for aligning process choice with product volume and variety, is arguably the most well-known theoretical matrix for a manufacturing management [17]. Safizadeh et al. use single-question measures of each axis to show correlation between the two axes. In the service literature, Silvestro et al. [41] and Collier and Meyer [5] use multiple-item measures of their axes to show empirical evidence of alignment of the two axes of their respective service process matrices.

An empirical test of the SCM–IOIS Matrix was conducted to validate our proposition that firms align their supply chain needs with an appropriate level of IOIS integration. To the best of our knowledge, there is no prior literature that has explored this problem explicitly. The SCM literature takes the existence of IOIS as a necessary and given condition. Empirical research on IOIS on the other hand, stresses the role of information technology in enabling the transition from interfirm competition to cooperation and uses the supply chain as the context for its studies. Much of this literature stream focuses on a specific type of IOIS (e.g., EDI, ERP) and investigates the antecedents, drivers, and consequences of the implementation across firm boundaries [23], [34]. Thus, we make an initial attempt to integrate the two research streams through the SCM–IOIS Matrix. Further, we conduct exploratory analyses to examine whether there are performance implications for on-diagonal versus off-diagonal firms. The data used in the empirical analysis of the SCM–IOIS Matrix are described in the following.

A. Instrument Development and Data Collection

Penton Media Inc., publishers of IndustryWeek and other manufacturing-related publications, conduct an annual survey of manufacturing managers and made their 1999 data available to the authors. IndustryWeek is an industrial magazine targeted at executives and managers of U.S. manufacturing firms. Penton Media Inc. and PricewaterhouseCoopers jointly developed a mail survey with input from a number of manufacturing
TABLE I
DISTRIBUTION OF FIRMS IN SAMPLE BY INDUSTRY (n = 1349)

<table>
<thead>
<tr>
<th>Industry (SIC code)</th>
<th># of firms in sample</th>
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<tbody>
<tr>
<td>Food and products</td>
<td>50 (3.7%)</td>
</tr>
<tr>
<td>Tobacco products</td>
<td>1 (0.1%)</td>
</tr>
<tr>
<td>Textile mill products</td>
<td>29 (2.1%)</td>
</tr>
<tr>
<td>Apparel and other textile</td>
<td>15 (1.1%)</td>
</tr>
<tr>
<td>Lumber and wood</td>
<td>28 (2.1%)</td>
</tr>
<tr>
<td>Furniture and fixtures</td>
<td>46 (3.4%)</td>
</tr>
<tr>
<td>Paper</td>
<td>58 (4.3%)</td>
</tr>
<tr>
<td>Printing and publishing</td>
<td>17 (1.3%)</td>
</tr>
<tr>
<td>Chemicals</td>
<td>100 (7.4%)</td>
</tr>
<tr>
<td>Petroleum and coal</td>
<td>6 (0.4%)</td>
</tr>
<tr>
<td>Rubber and misc. plastic</td>
<td>84 (6.2%)</td>
</tr>
<tr>
<td>Leather</td>
<td>5 (0.4%)</td>
</tr>
<tr>
<td>Stone, clay, and glass</td>
<td>40 (3.0%)</td>
</tr>
<tr>
<td>Primary metal</td>
<td>70 (5.2%)</td>
</tr>
<tr>
<td>Fabricated metal</td>
<td>161 (11.9%)</td>
</tr>
<tr>
<td>Machinery, except electronic</td>
<td>244 (18.1%)</td>
</tr>
<tr>
<td>Electric and electronic equip.</td>
<td>177 (13.1%)</td>
</tr>
<tr>
<td>Transportation equip.</td>
<td>107 (7.9%)</td>
</tr>
<tr>
<td>Instruments and related products</td>
<td>85 (6.3%)</td>
</tr>
<tr>
<td>Misc. manufacturing</td>
<td>26 (1.9%)</td>
</tr>
</tbody>
</table>

experts external to both firms. The survey included four pages of questions related to human resource management, quality issues, customer and supplier relations, and technology.

The study sample consists of approximately 28,000 subscribers to Penton Media Inc.’s manufacturing-related publications and includes managers of plants belonging to manufacturing firms (SIC codes 20–39). Survey recipients hold titles such as plant manager, plant leader, and manufacturing manager. The unit of analysis in the present study is the Strategic Business Unit and the respondents characterize activities with suppliers and customers from that perspective. Each individual in the sample was sent a letter describing the survey, a survey, a business reply envelope, and a separate participation card to ensure anonymity of responses. The questionnaires were mailed in mid-April 1999 and completed questionnaires were accepted through early June 1999. A total of 1757 completed surveys were received corresponding to a response rate of approximately 6.7%. While the response rate is smaller than many empirical studies, it compares favorably with large sample operations surveys (e.g., [37], [45]). In light of the low response rate, nonresponse bias was assessed by comparing the proportion of respondent firms to proportion of total mailed surveys for each SIC code. The data indicate no significant difference ($\chi^2 = 10.2, df = 19$, and $p = .92$).

Fig. 2 shows distributions of the size and age of respondent firms.

B. Operational Measures of SCM and IOIS

Measurement items were developed to represent operational measures of the conceptual framework presented in the SCM–IOIS Matrix shown in Fig. 1. We assess the extent of firms’ planning and coordination with firms in their supply chain using nine measurement items from the IndustryWeek survey. The items address key SCM issues relevant to a firm’s relationship with its suppliers and with its customers. Each of these items has significant support in the literature.

A measurement item for “suppliers evaluated on total cost, not unit price” suggests that lowest unit price may not be the most important criteria for supplier selection. Emphasis on “total cost” includes cost of poor product quality in supplier selection. “Quality” has historically been one of the most important performance criteria in supplier selection [4], [8], [18]. Using structural equation modeling to empirically test the impact of supplier management orientation (SMO) on constructs for supplier’s operational performance and buyer’s competitive priorities, Shin et al. [40] found that “quality
focus in selecting suppliers” has the highest path loading in each of the models they tested. This means that “quality focus in selecting suppliers” explains the most variance in SMO, irrespective of the operationalization of supplier and buyer performance.

The items used here are intended to capture the extent of supplier and customer relationships, respectively. Supplier and customer relationship items are reported in Table II. Results of factor analysis of the nine supplier and customer relationship items indicate that the items load on two factors, which we label SMO and customer management orientation (CMO). Factor loadings are shown in Table II.

A continuous scale for modeling relationships among firms in the supply chain is preferred over a discrete scale as it is well recognized that relationships exist on a continuum rather than discrete categories [22], [24] and SMO and CMO items are measured on a three-point scale (1 = no implementation; 2 = some implementation; 3 = extensive implementation). Scale length has been the focus of considerable discussion in the survey methods literature. While some research shows that reliability increases with scale length [19], [26], there is no clear-cut relationship between validity and scale length [42], [43]. Specifically, Morrison [29] shows that three-point scales capture most real information about construct relationships.

Cronbach’s coefficient alpha indicates reliability by assessing interitem correlation among items of a factor and is the most commonly used method in the management literature for estimating reliability. The Cronbach alpha for SMO and CMO are 0.74 and 0.54, respectively. Nunnally [32] proposes that existing scales should have an alpha value of 0.70 or higher, while new scales should have an alpha value of at least 0.60. While SMO meets the 0.70 guideline, the alpha for CMO is lower than recommended. Future research may be needed to investigate the CMO factor further.

A measure of each firm’s IOIS level was also developed. These items measure actual current capabilities that the firms have using electronic means of integration. Respondents were asked whether each of the six capabilities listed in Table III are provided to the firm via EDI or WBI, two frequently used IOIS. This results in a dichotomous (yes–no) scale. While EDI was commonly used in the past for transferring and sharing proprietary data and information, WBI is quickly becoming a major component of many firms’ information system architecture [15]. Our method for measuring IOIS capabilities is preferred over requesting information regarding specific technologies because there is a plethora of specific technologies that can provide the indicated capabilities. The focus of these measurement items is on the firm’s IOIS capability using electronic media rather than the specific technologies used.

The IOIS items reflect a progression in typical information interchanges and data sharing involving firms (and customers) within a supply chain. Information interchanges typically begin with exchanges of basic customer service and other help-desk information while data sharing often involves inventory, order, and payment data. More advanced and extensive interfirm exchanges involve activities, which support strategic and operational planning. Strategic planning may require collaboration in forecasting or new product and service development cycles. These exchanges, which enhance the cohesiveness of supply chain relationships, require technology support to be most effective. The capabilities required for these interfirm exchanges are measured here.

Firms that responded that they do not have any of the listed capabilities are coded as Level 0, indicating that their information systems do not support interfirm activities electronically. Firms indicating their information systems support capabilities directed toward interfirm activities with either suppliers or customer for the items shown in Table III are coded as Level 1. Supplier items address direct material procurement and invoice and payment systems while customer items include electronic order entry and help desk activities. Level 2 firms are those indicating they participate in both the supplier and customer interfirm integration activities of Level 1. Level 3 capabilities indicate an increasingly integrated IOIS. The IOIS levels are reported in Table III. In sum, 316 firms are at Level 0, 192 firms at Level 1, 211 firms at Level 2, and 630 firms at Level 3.

<table>
<thead>
<tr>
<th>TABLE II</th>
<th>MEASURES FOR SUPPLIER MANAGEMENT ORIENTATION AND CUSTOMER MANAGEMENT ORIENTATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMO measures:</td>
<td>Mean</td>
</tr>
<tr>
<td>Key suppliers deliver to plant on JIT basis</td>
<td>1.88</td>
</tr>
<tr>
<td>Suppliers manage inventory</td>
<td>1.64</td>
</tr>
<tr>
<td>Supplier rationalization</td>
<td>1.62</td>
</tr>
<tr>
<td>Suppliers evaluated on total cost, not unit price</td>
<td>1.82</td>
</tr>
<tr>
<td>Suppliers contractually committed to annual cost reductions</td>
<td>1.59</td>
</tr>
</tbody>
</table>

CMO measures: | Mean | Standard Deviation | Factor 1 | Factor 2 |
| Continuous–replenishment programs for customers | 1.61 | 0.65 | .198 | .411 |
| Customer participate in new–product development | 1.95 | 0.66 | -.064 | .779 |
| Customers interact with production employees | 1.54 | 0.59 | -.102 | .775 |
| Customer satisfaction surveys | 1.88 | 0.70 | .132 | .535 |

1 all items measured on 3-point scale, where 1= no implementation; 2=some implementation; 3=extensive implementation
TABLE III
MEASURES FOR LEVELS OF INTERORGANIZATIONAL INFORMATION SYSTEMS

<table>
<thead>
<tr>
<th>IOIS level</th>
<th>Measurement items</th>
<th># Firms at level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td><em>no measurement items</em></td>
<td>316</td>
</tr>
</tbody>
</table>
| Level 1    | **Supplier:** Direct material procurement Invoices and/or payments
  - or -
  Customer: Customers enter orders
  Customer service and/or help desk | 192             |
| Level 2    | **Supplier:** Direct material procurement Invoices and/or payments
  - and -
  Customer: Customers enter orders
  Customer service and/or help desk | 211             |
| Level 3    | Collaborative business forecasting with customer and/or suppliers
  Collaborative new product development with customers and/or suppliers | 630             |

1 IOIS items measured by respondent indicating 1=implemented using EDI; 2=implemented using web/internet-enabled technologies; 3=not implemented electronically (note: coded for analysis as 0=not implemented; 1=implemented either EDI or web/internet or both)

C. Firm Positioning on SCM–IOIS Matrix

Knowing a firm’s level of IOIS as well as its score on SMO and CMO measures (i.e., supply chain coordination with suppliers and customers), we are able to identify its location on the SCM–IOIS Matrix. Within each IOIS level, average SMO and CMO factor scores are calculated for all firms at that level. Those averages (± standard error) are shown in Fig. 3 and there is an identifiable tendency for firms at lower levels of IOIS to have low scores on both SMO and CMO while firms at higher levels of IOIS also score higher on SMO and CMO. In effect, Fig. 3 provides empirical support for the SCM–IOIS Matrix, the conceptual model derived from the literature shown in Fig. 1.

SMO and CMO group means are evaluated to determine whether they differ significantly by IOIS level. Pairs of mean SMO and CMO factor scores at each IOIS level (0–3) are compared using a Tukey HSD test which controls for Type I errors across multiple comparisons. Results of the Tukey test, reported in Table IV, indicate five of six comparisons are significant at \( p < 0.05 \) for SMO (the sixth is significant at \( p = 0.055 \)) and four of six comparisons are significant at \( p < 0.05 \) for CMO. (Note: All comparisons are significant without adjustment for multiple comparisons.) The nonsignificant pairs of means (one for SMO, two for CMO) are for adjacent IOIS levels, indicating that the variation in the data is too great to statistically delineate between these IOIS levels. However, differences in SMO and CMO scores for all nonadjacent IOIS levels are significant.

The data we use to assess the validity of the SCM–IOIS Matrix, as reported in Tables II–IV and shown in Fig. 3, provide general support for our proposition that firms align their IOIS investments with the sophistication and coordination of their SCM efforts. On average, SMO practices with regard to supplier coordination and CMO practices with customer coordination are quite similar as indicated in Fig. 3. Therefore, firms that invest little effort into coordinating their supply chain with their suppliers also tend to invest little effort into coordinating their activities with customers. In contrast, some firms invest considerable effort on both of these fronts.

While average SMO and CMO scores clearly indicate a diagonal tendency in Fig. 3, it is worth noting that numerous firms are located off of the apparent diagonal. These firms do not appear on the figure because they are small in number relative to average firm scores.

D. Testing Alignment of SCM–IOIS Matrix Axes

We undertook further analysis to assess alignment of the SCM–IOIS Matrix axes by evaluating firms’ operational performance relative to their position on the matrix. We use cell level analysis (see cells in Fig. 1) to assess whether there...
is a significant difference in on-diagonal versus off-diagonal performance. Three operational performance measures are used in our analysis. First, the plant’s on time delivery rate, that firms reported as a percentage, measures their ability to coordinate information and finished product flows to ensure on-time delivery to customers. Second, percent of incoming materials not inspected, measured using six categories [see Table V(b)], addresses trust in relationships with suppliers. Third, firms’ response of the dollar value of plant shipments per employee provides a measure of firm’s overall productivity. These three performance measures provide assessments of supplier relationships (percent incoming materials not inspected), customer relationships (on time delivery rate), and internal performance (productivity).

We test alignment of the matrix axes by evaluating the operational performance of firms on and off the matrix diagonal. Since the underlying theory of the matrix is that firms on the diagonal have the best alignment between their SCM and IOIS, we suggest a performance disadvantage in being off of the diagonal. Safizadeh et al. [38] test such a diagonal performance effect in their analysis of the product-process matrix. Their measures of business performance were obtained by asking managers to rate their plant performance against corporate performance criteria and against the performance of other plants in their industry (on five-point scales). They show a significant on-versus off-diagonal performance effect for just one of four studied process types (i.e., “continuous shop,” [38, p. 1588]).

Here, we assess on-versus off-diagonal performance for the three measures of operational performance. These analyses provide specific insight into cell-level performance differences. To analyze the data at the matrix cell level, we first divide firms into four quartiles based on their SMO scores and with the four IOIS levels previously defined, firms are assigned to one of 16 cells. The average performance of firms within each cell is reported in Tables V(a)-(c). The shaded cells are the on-diagonal cells and the unshaded cells are off-diagonal.

The difference between each pair of cells is calculated and averages are reported beside each performance table in Table V. A t-test is conducted to determine whether the diagonal cell differences are significantly different from the nondiagonal cell differences and its significance is reported in Table V. The results of the t-tests indicate that diagonal and nondiagonal cell differences are significantly different for all three performance measures and in each case, the on-diagonal performance difference is significantly greater than the off-diagonal cell difference. In other words, average firm performance increases more as firms move down the diagonal than when firms move to off-diagonal positions on the matrix. We conducted similar cell-level analysis to evaluate performance implications with CMO scores and found nearly identical results.

This empirical analysis of 1349 manufacturing firms provides a snapshot of current practices in regards to both SCM and IOIS capabilities. This exploratory analysis begins to validate the correspondence between SCM characteristics and IOIS level that we have posited in this paper. The empirical analyses suggest that some level of alignment between information needs and system capabilities is generally achieved in the majority of firms observed. However, the data also reveal that there are a number of nonaligned firms extant. The reasons for and consequences of such nonalignment suggest interesting questions for future research.

V. DISCUSSION, IMPLICATIONS, AND CONCLUSION

In this section, we discuss the definition and validation of the SCM–IOIS Matrix and the performance implications of alignment on the matrix. We also evaluate generalizability of our findings and implications for future research.
A. SCM–IOIS Matrix

In this study, we present the SCM–IOIS Matrix to provide a framework for considering the alignment of firms’ supply chain coordination efforts and their investments in IOIS capabilities. This framework combines previous research from both the SCM literature and the information systems/information technology literature. The SCM axis is operationalized using the notion of SMO and CMO and the IOIS axis is operationalized using the current capabilities firms have using electronic (EDI or WBI) means of integration.

For both SMO and CMO, the results of the exploratory study indicate that a majority of firms align their supply chain coordination efforts with their IOIS capabilities (see Fig. 3). The data (see Table IV) bear out the SCM–IOIS Matrix by indicating most firms do achieve a rough correspondence between coordination efforts and IOIS capabilities. However, there is no “correct” location on the SCM–IOIS Matrix. Rather, firms should align their IOIS capabilities with the requirements embodied in their interactions with suppliers and customers. Although a majority of firms have achieved this alignment, as indicated by the data mapped in Fig. 3, numerous firms in the study sample are off the diagonal of the matrix, seemingly not taking full advantage of alignment of their supply chain coordination efforts and their IOIS capabilities.

In the empirical analysis, we measure IOIS capabilities provided by electronic and web-based technologies (EDI and WBI). Global portability leading to easy accessibility and the ease of use of web-based interchange capabilities has made it increasingly popular among firms that wish to pursue a highly coordinated and closely linked supply chain with both suppliers and customers. We provide rudimentary empirical validation for the conceptual argument that supply chain strategies are accomplished in conjunction with appropriate information system capabilities.

Firms may evolve from an arm’s length approach to SCM and no electronic integration with suppliers (customers)—down the matrix diagonal—to a Type I–III coordination of their supply chain and a Level 1–3 integration of their IOIS (see Fig. 1). However, some firms make immediate jumps to a position on the diagonal that signifies a coordinated supply chain and an integrated IOIS without progressing down the diagonal from upper left to lower right. Firms succeed in doing this by designing and managing their supply chain in alignment with the capabilities enabled by a highly integrated IOIS.
Firms in many industries including some recently founded web-based firms have achieved this “leap” down the matrix diagonal without the evolutionary process of progressing down the diagonal over time. Such firms have learned from other firms’ efforts to increase cooperation and use of IOIS within their supply chains. These firms are not saddled with large technology investments in a proprietary or homegrown IOIS, nor are they encumbered by a history of less than cooperative supply chain relationships [49]. For example, Amazon.com is able to transfer its SCM and IOIS strategies and practices from its experience in the U.S. to its European operations [9] and, therefore, initial position of these operations on the SCM–IOIS Matrix is toward the lower right (see Figs. 1 and 3).

B. Performance Implications of Alignment

Results from cell-difference analyses suggest two main findings. First, as firms move either down a column (coordinating more with either suppliers or customers for a given level of IOIS integration) or across a row (higher integration through IOIS for a given level of supplier or customer coordination), they generally improve on each of the performance variables. Second, the average gain in performance is significantly greater for firms on the diagonal than for off-diagonal firms.

These results imply that firms should invest time and effort in assessing the needs of their supply chain by evaluating their current and future extent of interaction with suppliers and customers and align their IOIS capabilities accordingly. This has critical implications for managers, especially in this era of fast paced change. Should all manufacturing firms closely coordinate their orientation toward all of their suppliers and customers? If not, how do firms determine the suppliers or customers with whom to coordinate closely? Moreover, should firms use electronic media such as EDI and WBI to integrate? While the answers are not clear or easy to determine at the present time, the strategic implications are apparent.

C. Limitations

Due to the exploratory nature of this research, the scale items used to measure SMO, CMO, and IOIS were purposefully kept simple. Future research could include more comprehensive scale items to address the complexities of these constructs. Additionally, although there is nothing inherently wrong with three-point scales, a longer scale might increase the reliability of the scales (with particular attention to the CMO scale which has a less than desirable Cronbach’s alpha). Since the focus of this research is on business capabilities developed by firms using EDI or WBI, we do not address the efficacy issue of specific technologies (e.g., email, CAD, ERP, etc.). Finally, general weaknesses associated with all ex post facto research include the inability to manipulate the independent variables, lack of power to randomize, and risk of improper interpretation.

D. Future Research

Despite these limitations, there are numerous research opportunities presented by the linkage of the SCM and IOISs research streams generally and the SCM–IOIS Matrix specifically. In developing our framework, we focused on two dimensions of supply chains—degree and extent of coordination. Future research can include other prevalent issues such as “power” and “trust” between firms and their suppliers and customers.

Understanding how firms move down the diagonal of the SCM–IOIS Matrix as their supply chain strategies and practices change would enhance our understanding of the evolution of supply chain development. In contrast, determining how firms accomplish a “jump” down the diagonal to a highly coordinated supply chain and tightly integrated IOIS (without progressing through each of the antecedent levels) would result in better understanding of modern supply chain practices. Additional areas for future research include the proliferation and business value of expanding web-based technologies and practices. Whether firms realize the total business value of these technologies and how firms integrate web-based capabilities into existing supply chain practices is an area of interest to practitioners (as well as researchers). An interesting yet unexplored issue is one of impact of WBI on close coordination among supply chain links. While WBI might enable firms to integrate inexpensively and extensively, it also makes it possible for firms to switch suppliers more easily. Thus, whether firms always move down the diagonal or move across the supply chain axis is an interesting question to study in a longitudinal design.

Finally, our study sample is limited to U.S. manufacturing firms. Whether the relationships identified here are also found in service supply chains or manufacturing supply chains outside the U.S. is not known, but both are interesting areas for future research.

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