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Managing beyond the factory walls: Effects of four types of strategic integration on manufacturing plant performance

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Abstract

In this paper we focus on the integration of strategic objectives and process knowledge that a manufacturing factory collects from its external interfaces. Using data from a variety of manufacturing industries, this study examines four different types of strategic integration at the manufacturing plant level. We use a path analytic approach to simultaneously assess the contributions of the various types of integration to manufacturing-based competitive capabilities and business level performance. In addition, we examine the intervening roles that manufacturing-based competitive capabilities play in mediating the relationships between strategic integration and business performance. We find that each type of integration activity has unique benefits and detriments. These findings extend prior studies of manufacturing and supply chain integration by broadening the theory relating to strategic integration. The results also provide implications for manufacturing managers who seek to design integration policies and associated resource deployments.
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1. Introduction

Various integration concepts have received attention from operations management researchers in recent years. In this paper we focus on manufacturing strategic integration, the integration of strategic and technical knowledge that a manufacturing factory collects from external interfacing sources. We view strategic integration as a *process*, rather than an outcome. An integration process includes activities that acquire, share, and consolidate strategic knowledge and information with parties outside the immediate organization. We argue that factories which engage in such activities will outperform their less-integrated peers, because they achieve better alignment of objectives and business processes, coordination, and fit.

Our research takes the perspective that manufacturing is part of an overall value chain of activities, which include product supply and distribution, as well as corporate strategy and technology development activities. Research studies of integration have tended to focus on vertical supply chain activities, technology related activities, or strategy formulation activities (Hayes and Wheelwright, 1984; Hill, 1994; Frohlich and Westbrook, 2001; Rosenzweig et al., 2003; Vickery et al., 2003; Swink and Calantone, 2004). Our study is one of the first to simultaneously examine the relative influences of strategic integration in each of these

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areas on manufacturing-based competitive capabilities. Evaluating and comparing a more complete set of integration aspects than has been done in prior studies is important given that manufacturing managers have limited resources and must choose the most effective deployment of these resources. Further, where other researchers have focused on tactical or operational integration of supply chain activities (Frohlich, 2002; Frohlich and Westbrook, 2001; Sahin and Robinson, 2002), we investigate integration of strategic information and knowledge. This focus places our research in the realm of manufacturing strategy.

Like most foregoing manufacturing strategy research, our unit of analysis is the manufacturing plant. Plant level studies are important since optimal deployment of resources must eventually be made at the plant. The findings thus provide extensions to prior manufacturing strategy studies in this stream. The results also provide implications for manufacturing managers who seek to design strategic integration policies and associated resource deployments. For researchers, the study extends existing supply chain integration theories to develop a more comprehensive strategic value chain integration theory.

We use a path analytic approach to simultaneously assess the relative contributions of various types of strategic integration to manufacturing competitive capabilities and business performance. In addition, we examine the intervening roles that manufacturing competitive capabilities play in mediating the relationships between integration and business performance. Prior studies indicate that mediation effects are important, but they have not been tested comprehensively or holistically (Rosenzweig et al., 2003; Vickery et al., 2003). A multivariate approach is important given the typically high correlations among integration activities and among manufacturing competitive capabilities. The multivariate analysis clarifies the unique influences of each integration type on various dimensions of capability and performance, controlling for spurious associations. Furthermore, path analysis affords the ability to test mediation hypotheses directly, rather than inferring them from associations in methods such as regression.

In addition, our study employs measures of practice implementations as reflective indicators of types of strategic integration, rather than simply asking informants ‘‘are you integrated?’’ This approach reduces the threat of common method variance. More importantly, the results suggest how strategic integration might be achieved, as well as what the relative importance of various integration types might be. The sample data for the study are drawn from multiple manufacturing industries, providing an extension to other studies that have focused on consumer, automotive, or other industries.

The objectives of the study can be summarized in the following research questions:

1. What are the specific effects on performance of various types of strategic integration activities in which manufacturing plants engage?
2. Do strategic integration activities foster manufacturing-based competitive capabilities, or are they mainly direct drivers of business performance?

These questions have been unaddressed in prior research. However, there are substantial related studies that provide a theoretical grounding and basis for comparing our research findings. In the next section, we review these studies and develop the theoretical grounding for our hypotheses.

2. Literature review and theoretical model

In this paper we study the influences that integration of strategic information and knowledge from outside the walls of a manufacturing plant has on the development of the plant's competitive capabilities and business performance. We first describe the theoretical constructs central to our study. This discussion is followed by the development of our theoretical model and related hypotheses.

2.1. Types of value chain integration

Porter's (1985) value chain framework provides a useful theoretical foundation for integration concepts. His discussion of linkages among value-adding activities includes two primary dimensions. First, Porter advocated making *vertical* linkages across supply chain activities including those executed by suppliers and customers. A second dimension of integration involves *horizontal* linkages within a firm, that is, linkages of direct value chain activities (e.g., production) with supporting activities such as corporate strategy and new product development. In the framework illustrated in Fig. 1, we identify four types of strategic integration which exist along these vertical and horizontal dimensions: supplier integration, customer integration, product–process technology integration, and corporate strategy integration. Fig. 1 illustrates how strategic integration activities create information and knowledge flows related to the manufacturing plant. According to this framework, a manufacturing plant's

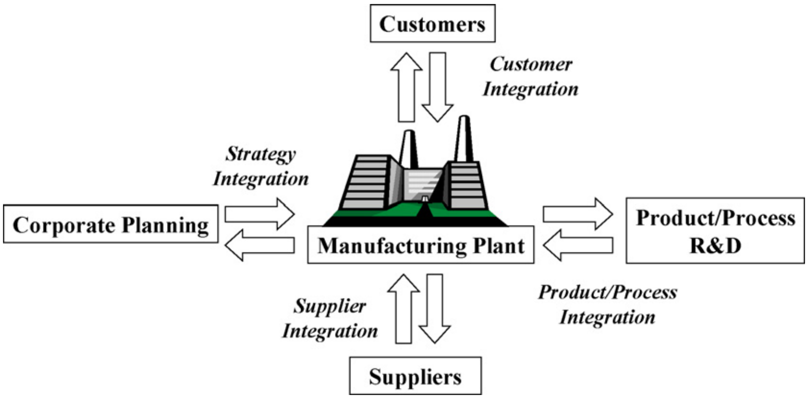

Fig. 1. Four types of strategic integration in the value chain.

operations can be influenced by the acquisition of technical knowledge and planning information from external sources including suppliers, customers, product–process technology developers, and corporate strategy managers. Porter and others suggest that stronger linkages and higher degrees of integration across these functional and organizational boundaries lead to better performance for the focal organization.

A number of recent research studies conceptualize vertical, supply chain integration as the combination of efforts to integrate supplier and customer information and inputs into internal planning (Frohlich and Westbrook, 2001; Vickery et al., 2003; Rosenzweig et al., 2003). This conceptualization reflects external integration expressed in an organization's cross-business relationships upstream with suppliers and downstream with customers. It also includes internal practices (such as cross-functional teams) used to internalize and share these external inputs within the organization. The vertical, supply chain dimension shown in Fig. 1 illustrates these aspects of integration.

A further distinction of supply chain integration concepts, however, pertains to the *level* and *primary intent* of integration activities. Some researchers have addressed supply chain integration as a set of *operational* activities, mostly concerned with better coordination of daily or short-term flows, including transactions, material movements, and ordering processes (see Sahin and Robinson, 2002 for a review of this literature). Shah et al. (2002) refer to this level of coordination as involving "arm's length" and "Type 1" relationships. These types of relationships have a short-term focus, involving only limited levels of information exchange and some operational coordination. They lack joint commitment and joint operation over a long term. The installation of a transactional system such as a coordinated ordering and payment system between a supplier and a customer is an example of Type 1 relationship. In contrast, supply chain integration activities can also be of a more strategic nature (Vickery et al., 2003; Narasimhan and Das, 1999). Strategic integration activities (associated with Types 2 and 3 relationships in the vernacular of Shah et al.) are more long-term and collaborative, including relationship building, joint development activities, and sharing of cost and capability information (Narasimhan and Kim, 2002; Shah et al., 2002). Firms involved in strategic integration relationships view their partners' processes as extensions of their own. Our research addresses these strategic processes. Accordingly we refer to supply chain integration types as "strategic supplier integration" and "strategic customer integration" in order to distinguish them from other, more operationally oriented integration concepts.

While supply chain research has focused on vertical integration concepts, separate research literatures address horizontal, internal integration activities linking manufacturing and product–process development, and manufacturing and corporate strategic planning, respectively. Concepts related to product–process technology integration have been construed rather narrowly in past research. For example, design-manufacturing integration (DMI) has been conceptualized as the degree to which manufacturing process knowledge is integrated into new product design concerns (Adler, 1995; Ettlie, 1995, 1997; Rusinko, 1999; Swink and Calantone, 2004). This conceptualization focuses on NPD projects as the unit of analysis, neglecting the broader effects of product–process integration on the manufacturing plant.

Skinner (1969) was among the first to forcefully argue the need for greater corporate strategy integration in manufacturing. Corporate strategy integration has been discussed as the extent to which a manufacturing plant makes use of interactions with other intra-organizational units to make its program objectives and practices consistent with its internal and external requirements. In the years since Skinner's seminal observations, researchers have responded by developing manufacturing strategy concepts and frameworks that emphasize strategic focus; they have exhorted operations managers to select primary competitive priorities based on customers' needs, production capabilities, and technical limitations (Hayes and Wheelwright, 1984; Hill, 1994).

As Fig. 1 suggests, our research examines strategic integration activities in each of the four areas, carried out at the manufacturing plant level. We focus on the plant's sharing of strategic information and knowledge with four sources external to the plant, though not necessarily external to the firm. These sources include customers, suppliers, product–process technology developers, and corporate strategy decision makers. We define strategic integration in each of these areas as follows.

- *Strategic customer integration* is the process of acquiring and assimilating customer requirements information and related knowledge. Strategic customer integration is done in manufacturing plants in order to gain and incorporate a better understanding of customers' preferences (what is preferred and why), and to build relationships (intimacy) with customers. Activities commonly associated with building greater strategic customer integration include frequent customer contacts, communication of satisfaction surveys, and both formal and informal direct employee–customer interactions.
- *Strategic supplier integration* is the process of acquiring and sharing operational, technical and financial information and related knowledge with the supplier and vice versa. Strategic supplier integration is done in manufacturing plants in order to better meet product and production requirements through developing and more effectively exploiting both the supplier's and plant's capabilities and cost structures. Activities commonly associated with strategic supplier integration include partnerships, co-development activities, joint planning meetings, and shared information systems.
- *Product–process technology integration* is the process of co-developing products and processes and sharing specification information and related knowledge. Product–process technology integration is pursued in manufacturing plants so that manufacturing processes may incorporate a better understanding of product requirements and so that product designers may incorporate a better understanding of manufacturing process capabilities into product specifications. Activities commonly associated with product–process technology integration include design-for-manufacture analyses, formal design approvals, design and manufacturing job rotations, and published design guidelines.
- *Corporate strategy integration* is the process of acquiring and sharing objectives, plans, and related knowledge pertaining to business and manufacturing strategies. Corporate strategy integration is required in order to improve the alignment between business level and plant level decisions, including the setting of performance targets and the deployments of resources. Activities associated with corporate strategy integration include formal and informal communications among different levels of the organizational hierarchy, frequent strategic planning meetings, and clearly documented plans.

Our conceptualizations of these different types of strategic integration are consistent with the arguments of Skinner (1969) and others, that a manufacturing plant's investments and practices should be in concert with the demands placed upon it by the limits of its suppliers and its own internal capabilities, by the objectives of higher order business and functional strategies, by the specifications of the products it produces, and by the requirements of the markets and customers it serves.

In the following section we develop the logic for hypotheses relating integration types to manufacturing-based competitive capabilities and business performance. Some confusion exists over the term, "capability," as it has been used to describe both process abilities and operational outcomes. We adopt the definition provided by Rosenzweig et al. (2003, p. 438), who state that a manufacturing-based competitive capability represents "the manufacturer's actual or 'realized,' competitive strength relative to primary competitors in its target markets (Stalk et al., 1992; Ward et al., 1994)." While a wide array of notions regarding business performance exist, our conceptualization focuses on performance aspects that can be logically affected by manufacturing plant outcomes. We focus on market response and customer satisfaction.

2.2. Linking strategic integration activities, manufacturing competitive capabilities, and business performance

Fig. 2 illustrates the relationships forming the theoretical model that we sought to test in this study.

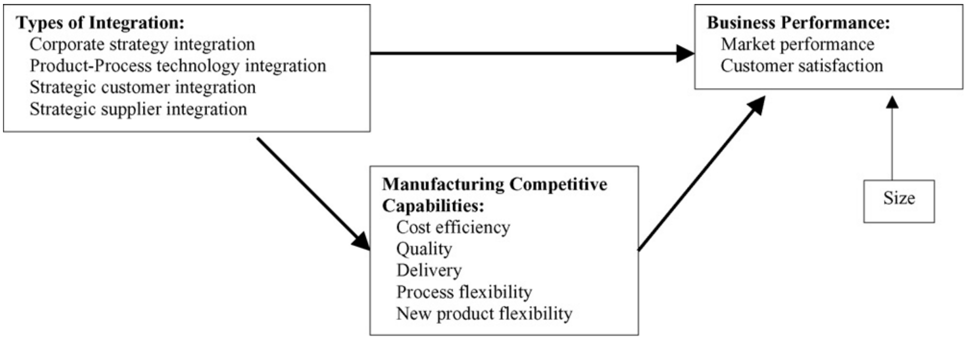

Fig. 2. Summarized conceptual model of relationships among types of strategic integration, manufacturing competitive capabilities, and business performance.

In our discussion of these hypothesized relationships we draw upon several theories, including strategic fit theory, information processing theory, and the knowledge-based view (KBV) of organizations.

Strategic fit theory suggests that strategic integration plays a strong role in the development of organizational capabilities leading to competitive advantage (Lawrence and Lorsch, 1967; Powell, 1992). Strategic integration helps organizations to match resource deployments with strategic demands, thus achieving a fit between manufacturing competitive capabilities and the environment. Wheelwright (1984) suggested that effective strategies are characterized by synergies across key decision areas. He further defined the notion of strategic fit, stating the need for consistency between manufacturing strategy and business strategy, other functional strategies, and the competitive environment, respectively.

An information processing perspective (Galbraith, 1973) offers a deeper interpretation of the effects of strategic integration activities. Rich communications among manufacturing decision makers, workers, and external sources of information and knowledge related to requirements, capabilities, technologies, and strategies affecting the manufacturing plant should collectively lead to greater opportunities for waste reduction, since value- and non-value-added activities are more easily recognized (Rosenzweig et al., 2003). Similarly, these communications enable the manufacturing plant organization to anticipate and more fully respond to changes in customers' specific needs, new markets, and technological opportunities. In the parlance of the knowledge-based view (KBV) of the firm, strategic integration involves knowledge dissemination and sharing activities that create new knowledge, which in turn improves organizational capabilities (Grant, 1996). Thus, all three perspectives, strategic fit, information processing, and the KBV suggest that integration activities should lead to superior manufacturing competitive capabilities.

Having laid the theoretical foundation for a general relationship between strategic integration activities and manufacturing competitive capabilities, we now explain how this effect is manifested in the four focus areas: customer integration, supplier integration, product–process technology integration, and corporate strategy integration. The primary benefits credited to strategic supplier and strategic customer integration activities are new knowledge creation, establishment of cooperative relationships and practices, and reduced complexity. Activities that promote integration of customers and suppliers into a manufacturing plant's planning and execution processes increase the variety of functional expertise that is brought to bear upon decisions, thus improving them through the creation of new knowledge (Grant, 1996; Kogut and Zander, 1992). Strategic supply chain integration also leads to better, more efficient problem solving, as it promotes cooperation, joint work, and the creation of problem solving routines (Flynn and Flynn, 1999; Frohlich and Westbrook, 2001; Narasimhan and Jayaram, 1998). Finally, because integration activities are not cost-free, they require focus on relationships with key customers and suppliers. This focus serves to reduce complexity and to clarify priorities regarding which manufacturing competitive capabilities are likely to be most important.

Nascent empirical evidence supports supply chain integration–capability relationships. A recent survey of 57 automotive suppliers (Vickery et al., 2003) showed that overall supply chain integration was associated with higher customer service (delivery was a part of the service construct), which in turn was associated with higher perceived financial performance. In a study of consumer products manufacturers, Rosenzweig et al. (2003) uncovered associations between overall supply chain integration and manufacturing-based competitive capabilities in terms of quality, delivery reliability, process flexibility, and cost leadership. Trans-regional business level data analyzed by Frohlich and Westbrook (2001) showed that units with the highest levels of ‘‘outward-facing’’ integration activities had better reported improvements in multiple dimensions of manufacturing capability. Narasimhan and Kim (2002) provide evidence that strategic supply chain integration expands a firm's abilities to exploit greater product and geographical market diversification strategies.

The emerging evidence suggests that supply chain integration activities are powerful drivers of manufacturing competitive capabilities. However, past research provides little information regarding the relative and respective contributions of strategic customer integration and strategic supplier integration activities.

Hypothesis 1a. Strategic customer integration is positively associated with manufacturing competitive capabilities.

Hypothesis 1b. Strategic supplier integration is positively associated with manufacturing competitive capabilities.

Empirical study of technology integration and corporate strategy integration links with manufacturing competitive capabilities is somewhat more mature than that in the supply chain area, yet research at the plant level is scarce. Numerous researchers have examined aspects of the integration of manufacturing with new product development (NPD) (Adler, 1995; Ettlie, 1995, 1997; Rusinko, 1999; Swink and Calantone, 2004). However, most of this research has concentrated on the relationships of integration to NPD project outcomes and new product success. Little attention has been given to the impacts of integration on manufacturing plant competitive capabilities.

Given the past research on new product development, we expect that product–process technology integration activities will be associated with greater capabilities in manufacturing plants to quickly and efficiently bring new products to full scale production. However, greater integration of product and production process knowledge within the plant should also create benefits to product cost, quality, and delivery once production ramp-up targets are reached. Improving the fit between product design specifications and initial process capabilities leads to higher quality, more producible products (Swink and Calantone, 2004). In addition, a greater awareness and dissemination of technological knowledge promotes problem solving and continuous improvement activities (Leonard-Barton, 1992).

Hypothesis 1c. Product–process technology integration is positively associated with manufacturing competitive capabilities.

Literature discusses the integration of manufacturing strategy with higher order business or corporate strategy (Skinner, 1969; Hayes and Wheelwright, 1984; Hill, 1994). Since the time of these seminal works, manufacturing strategy researchers have empirically evaluated the business performance impacts of the fit between manufacturing strategy and competitive strategy (Vickery et al., 1993; Miller and Roth, 1994; Williams et al., 1995; Gupta and Lonial, 1998; Ward and Duray, 2000).

Based on the arguments and evidence from this research, we expect that corporate strategy integration activities are helpful in determining and defining manufacturing competitive capabilities (Garvin, 1993). For example, greater corporate strategy integration provides market and strategic inputs that enable managers to know which aspects are most important and what levels of capability are required (Flynn et al., 1994). Researchers have discussed the importance of the integration of corporate strategy and manufacturing concerns when cost efficiency and flexibility are pursued (Pine, 1993; Kotha, 1995). Others have documented the problems associated with strategic misalignment with regard to manufacturing competitive capabilities (Schiller et al., 1992; McLaughlin and Victor, 1995; Moran, 1996; Berry and Cooper, 1999).

Hypothesis 1d. Corporate strategy integration is positively associated with manufacturing competitive capabilities.

While aforementioned researchers have begun to explore focal types of integration individually, no one has analyzed all four-dimensions simultaneously. We were particularly interested in the evidence our study would provide regarding the unique contribution of each type of strategic integration to each manufacturing capability. It is believed that integration, in general, is beneficial, and more integration is assumed to be better than less integration. Firms compete, however, on specific manufacturing competitive capabilities. Given the fact that strategic integration activities consume resources, it is important to discern the impacts of individual integration types so that manufacturing plant managers might deploy resources optimally given their strategic priorities.

2.3. The mediating role of manufacturing-based competitive capabilities

Many studies have empirically associated manufacturing-based competitive capabilities with business performance (Cleveland et al., 1989; Ferdows and DeMeyer, 1990; Flynn and Flynn, 1999; Kim and Arnold, 1996; Miller and Roth, 1994; Swamidass and Newell, 1987; Vickery et al., 1993, 1994; Ward et al., 1994, 1995; White, 1996). However, the associations of specific manufacturing capability types to business performance in foregoing research studies have often been non-significant, or inconsistent (Wood, 1991; Feigenbaum and Karnani, 1991; Narasimhan and Jayaram, 1998; Vickery et al., 1997). For example, Rosenzweig et al. (2003) found that process flexibility was associated with customer satisfaction, but not with sales growth. Cost leadership was associated with sales growth, but not with customer satisfaction. Thus, while general linkages between capabilities and business performance are well acknowledged, inconsistencies across previous research studies suggest the need for further research and hypothesis testing.

Hypothesis 2. Manufacturing competitive capabilities are positively associated with business performance.

Taken together, Hypotheses 1a–d and 2 imply that manufacturing competitive capabilities mediate the relationships between integration activities and business performance. Prior studies of integration activities have often neglected the capability link (Rosenzweig et al., 2003 offer a notable exception). Thus, an interesting test of our proposed model involves the direct examination of a mediating effect. A full mediation hypothesis would suggest that strategic integration activities drive better business performance *only* because the deeper knowledge of organizational goals, customer needs, and operating constraints emanating from the practice of integration has positive influences on the development of manufacturing competitive capabilities. In this case, manufacturing competitive capabilities would be seen to be the *generative means* by which strategic integration practices affect business performance.

Hypothesis 3a. A direct positive association of customer integration with business performance is mediated by manufacturing competitive capabilities.

Hypothesis 3b. A direct positive association of supplier integration with business performance is mediated by manufacturing competitive capabilities.

Hypothesis 3c. A direct positive association of product–process technology integration with business performance is mediated by manufacturing competitive capabilities.

Hypothesis 3d. A direct positive association of product–process technology integration with business performance is mediated by manufacturing competitive capabilities.

3. Research method

3.1. Data collection

Data were collected from manufacturing plant managers via a combination of e-mail- and Internet-based survey methods. Seven manufacturing managers and three academics reviewed the pre-questionnaire to improve clarity and identify and resolve any unfamiliar or unclear wording. The administration of the subsequent survey followed the method proposed by Dillman (1978, 2000). An Internet-based form of the questionnaire was developed. Manufacturing plant managers were invited by mail to participate in the survey; the mailing list was obtained from Harris InfoSource, with selection criteria including manufacturing plants with at least 100 employees in discrete and assembled product industries (SICs included 31 and 34–39). Invitation letters were sent to 2100 North American plant managers. Approximately 200 letters were returned due to inaccurate addresses. The invitation letter directed respondents to the Internet site address which hosted the survey. Following the initial invitation, two reminder postcards were sent at 2-week intervals. A total of 255 surveys were returned; 224 surveys were at least 90% complete, yielding a usable response rate of 13.4% (224/1900). The respondents were mainly plant managers or their direct reports. Follow-up phone calls were made to 31 respondents of incomplete surveys. No serious biases were indicated in their comments. The reasons they cited for non-completion were mostly that they either were reticent to share sensitive data or that they did not have time to complete the survey. As a further check of respondent bias, the responses of first, second and third wave respondents were compared. Later wave respondents are considered equivalent to non-respondents since responses are obtained with the use of considerable stimuli (Armstrong and Overton, 1977). There were no significant differences between early and late responders in terms of plant size (workers or sales), international vs. domestic sales, number of major products, or predominant production process type (based on t-tests).

As a test of the representativeness of the data sample, we compared general performance metrics between respondents and a random sample from the SIC ranges represented in the data. Respondents were asked to provide ROA data as well as an estimate of the annual percentage change in sales that they experienced from the previous year to the current year. Comparisons (t-tests) of the performance scores for the response sample against the scores for a random sample for the SIC populations indicated that the two groups did not differ significantly ($p > .05$) on either of the performance metrics. Therefore, we concluded that the response sample is not significantly biased in terms of performance. The sample spans a diversity of industries, plant sizes, and process types. Table 1 provides descriptive data for the sample.

3.2. Measures

The perceptual measures of strategic integration, manufacturing competitive capabilities, and *business* performance used in this study were mostly drawn from existing scales found in previous research studies. New items required for the study were motivated by published conceptual discussions of the constructs that the items were intended to reflect. Appendix A provides the measurement scales, along with their psychometric properties. In the case of strategic integration practices, respondents were asked to rate the extent to which statements regarding practice implementation applied to their plant, as compared to their industry average

Table 1
Sample descriptive data

	Mean	S.D.
No. of employees	558.5	543.6
Total sales (US$ 1,000,000)	164.2	329.2
No. of major products	34.5	84.1

	Percent of sample (%)
Major product line delivery	
ETO	25.4
MTO	37.5
ATO	17.4
MTS	19.6
Industry	
Electronics	44.2
Machinery	35.0
Industrial	9.6
Basic	7.6
Consumer	3.6

(1 = much less, 4 = about the same, 7 = to a much greater extent). Respondents were asked to rate their plant's manufacturing competitive capabilities as indicated by performance relative to that of their principal competition (1 = much worse, 4 = about the same, 7 = much better). This approach has the benefit of standardizing industry effects.

Some researchers have measured integration of suppliers and customers using combined ''metascales'' such as supply chain integration, supply chain integration intensity, and outward-facing supply chain strategy (Vickery et al., 2003; Rosenzweig et al., 2003; Frohlich and Westbrook, 2001). However, we sided with others who have kept the supplier and customer elements of integration separate, in order to ascertain their potentially distinct relationships with manufacturing competitive capabilities and business performance (Narasimhan and Kim, 2002; Shah et al., 2002). Our strategic supplier integration scale items ($N = 6$) address information sharing and supplier involvement activities (Flynn et al., 1994, 1995a,b; Dow et al., 1999; White et al., 1999). The strategic customer integration scale items ($N = 4$) address customer intimacy, as well as the measurement of and communication of customer satisfaction information (Flynn and Flynn, 1999; Flynn et al., 1994, 1995a,b; Bolden et al., 1997; Dow et al., 1999; Cua et al., 2001).

Our product–process technology integration scale items ($N = 6$) address the use of mechanisms such as DFMA and job rotation to promote product design and manufacturing knowledge integration (Ettlie, 1995, 1997; Swink, 1999; Flynn et al., 1994, 1995b; Sakakibara et al., 1997; Hayes and Wheelwright, 1984; Ahmed et al., 1996; Kim and Arnold, 1996; Cua et al., 2001). The corporate strategy integration scale items ($N = 6$) tap the degree to which manufacturing strategy is well communicated and driven by corporate strategy (Flynn et al., 1994, 1995a,b; Ahmed et al., 1996; Sakakibara et al., 1997; Bolden et al., 1997; Dow et al., 1999; Cua et al., 2001).

Our measures of manufacturing competitive capabilities and business performance are grounded in seminal manufacturing research works (Hayes and Wheelwright, 1984; Wheelwright, 1984; Giffi et al., 1990), and are very close to those used in manufacturing capability studies (Ferdows and DeMeyer, 1990; Miller and Roth, 1994; White, 1996; Safizadeh et al., 1996; Boyer and McDermott, 1999; Boyer and Lewis, 2002; Rosenzweig et al., 2003; Ward et al., 1998). We included scales addressing five capability areas: cost, quality, delivery, process flexibility, and new product flexibility. We measured two aspects of business

Table 2
Variable descriptive data

		Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
1	Corporate strategy integration	4.763	1.137											
2	Product–process integration	3.994	1.221	**.531**										
3	Strategic customer integration	4.829	1.121	**.290**	**.342**									
4	Strategic supplier integration	3.876	1.084	**.534**	**.694**	**.258**								
5	Cost	3.783	1.178	.002	.040	−.052	.063							
6	Quality	5.342	.928	**.202**	**.337**	.103	**.140**	**.132**						
7	Delivery	4.898	1.180	**.266**	**.314**	**.193**	**.284**	.043	**.412**					
8	Process flexibility	4.949	.895	**.254**	**.155**	**.144**	**.205**	**−.220**	**.284**	**.502**				
9	New product flexibility	3.821	1.155	**.263**	**.400**	.109	**.223**	−.114	**.163**	**.203**	**.258**			
10	Market performance	4.622	1.352	**.314**	**.223**	−.017	**.293**	−.068	**.292**	**.514**	**.345**	**.291**		
11	Customer satisfaction	5.205	1.399	**.312**	**.280**	**.319**	**.201**	.005	**.473**	**.514**	**.213**	.106	**.336**	
12	Size (no. of employees)	559.2	541.2	.090	.038	−.034	.075	.083	.079	−.050	.010	.046	−.013	−.012

All bold numbers are significant, $p < .05$.

performance: market performance and customer satisfaction. The market performance scale items assess plant sales, market share, and profitability, relative to competitors. We measured managers' perceptions of customer satisfaction with a single item. These measurement items are similar to those used in prior studies of manufacturing business level performance (Swamidass and Newell, 1987; Vickery et al., 1993, 1997; Boyer, 1999; Rosenzweig et al., 2003). Finally, we included a measure of plant size (number of employees) as a control for differences in performance that may be explained by scale effects (Roth and Miller, 1992).

For the multi-item scales we executed principle components factor analysis in order to determine scale unidimensionality. In each case all the items loaded significantly on only one factor with an eigenvalue greater than 1. For each scale (except one) the item scores explained more than 50% of the factor variance. Coefficient alpha exceeded .70 for each of the scales, save one (see Appendix A). These results provide evidence of unidimensionality and acceptable reliability for the scales. The only problematic scale was process flexibility. The explained variance (45%) and coefficient alpha (.57) for this scale would have been improved to levels above commonly accepted norms had we dropped one of the four scale items, the "ability to customize products." However, because this item has been included in process flexibility scales by previous researchers, we elected to keep the item to preserve content validity and comparability with other studies.

Prior studies have demonstrated that perceptual measures of manufacturing competitive capabilities and performance can be considered reliable indicators of actual values (Dess and Robinson, 1984; Vickery et al., 1997; Ward et al., 1994; Ketokivi and Schroeder, 2004). In order to assess the criterion validity of our perceptual measures, we correlated them with less perceptual measures also included in our survey. The perceptual business performance measures are highly correlated ($p < .05$) with managers' estimates of market share, ROA, ROI, change in market share, and change in profitability. Unfortunately, managers are often unwilling to provide actual performance numbers; responses for these data ranged from $N = 62$ to 177. Thus, missing data prevented us from using these less perceptual metrics in further analyses.

Table 2 provides descriptive statistics and the inter-correlation matrix for the variables. Predictive validity is indicated in the correlations, as each of the integration variables is significantly correlated with several of the manufacturing capability variables and at least one of the business performance variables.

4. Analysis and results

We employed a structural equation path modeling approach to test the hypothesis and to gain interpretational clarity of the relationships among the constructs (Anderson and Gerbing, 1988). We input the covariance matrices derived for the variables into EQS v. 6.1 and specified a model matching our hypothesized model (Fig. 2). The four strategic integration variables were allowed to co-vary in the path model in order to evaluate the partial, unique relationship of each dimension of integration with each of the manufacturing competitive capabilities.

The overall fit for the path model was very good ($\chi^2 = 21.95$; d.f. = 15; CFI = .990; RMSEA = .046). Table 3 provides the values of the direct, indirect, and total effects along with test statistics (parameter estimates, t-values, and fit indices). Fig. 3 also provides the parameter values for significant paths in the model.

Table 3
Path analysis results for strategic integration types model

	Cost	Quality	Delivery	Process flexibility	New product flexibility	Market performance			Customer satisfaction		
						Direct	Indirect	Total	Direct	Indirect	Total
Corporate strategy	−.035	.084	.105	.201*	.109	.175*	.078^{+}	.253**	.168*	.039	.207*
integration	(−.419)	(1.086)	(1.356)	(2.525)	(1.442)	(2.647)	(1.848)	(3.305)	(2.640)	(.873)	(2.725)
Product–process	.025	.442**	.169^{+}	−.061	.453**	−.205*	.208**	.003	−.073	.208**	.134
tech integration	(.260)	(4.832)	(1.833)	(−.643)	(5.080)	(−2.345)	(3.313)	(.033)	(−.875)	(3.243)	(1.495)
Strategic customer	−.072	−.018	.081	.075	−.042	−.174**	.031	−.143*	.205**	.022	.227**
integration	(−1.003)	(−.276)	(1.208)	(1.089)	(−.638)	(−3.049)	(.861)	(−2.151)	(3.747)	(.581)	(3.449)
Strategic supplier	.082	−.206*	.089	.120	−.139	.219*	−.022	.197*	−.007	−.054	.061
integration	(.857)	(−2.295)	(.986)	(1.297)	(−1.582)	(2.778)	(−.430)	(2.200)	(−.098)	(−.999)	(−.693)
Cost						−.095^{+}			−.080		
						(−1.711)			(−1.505)		
Quality						.126*			.337**		
						(2.051)			(5.711)		
Delivery						.418**			.399**		
						(6.038)			(6.284)		
Process flexibility						.001			−.151*		
						(.001)			(−2.375)		
New product						.184**			−.035		
flexibility						(3.127)			(−.617)		
Size						−.033			−.013		
(no. of employees)						(−.627)			(−.254)		

Standardized estimates (*t*-values); fit indices: BBNFI = .971; BBNNFI = .956; CFI = .990; χ^2 = 21.95; d.f. = 15; p = .109; RMSEA = .046 (.000, .084).
* $p < .05$.
** $p < .01$.
$^{+}$ $p < .10$.

The results of the analyses provide mixed support for the hypotheses. Hypothesis 1a (strategic customer integration is associated with manufacturing competitive capabilities) is not supported. None of the parameters linking customer integration to the five manufacturing competitive capabilities was significant at $p < .10$. Similarly, Hypothesis 1b (strategic supplier integration is associated with manufacturing competitive capabilities) is not supported. Interestingly, strategic supplier integration is associated with poorer quality capability, and potentially with poorer new product flexibility capability (though this negative association falls short of conventional levels of significance). On the other hand, Hypothesis 1c (product–process technology integration is associated with manufacturing competitive capabilities) is supported. Product–process technology integration is significantly associated with better quality, delivery, and new product flexibility. While the parameters linking product–process integration to quality and new product flexibility are highly significant, the link to delivery capability is only marginally significant. The results support Hypothesis 1d (corporate strategy integration is associated with manufacturing competitive capabilities), as corporate strategy integration is significantly associated with better process flexibility capability.

Hypothesis 2 (manufacturing competitive capabilities are associated with business performance) is supported by the results, but only for certain manufacturing competitive capabilities. Quality, delivery, and new product flexibility are each significantly associated with better market performance. Quality and delivery are also each significantly associated with increased customer satisfaction. Contrary to the hypothesis, cost capability is negatively associated with both business performance measures (though one of the associations is only marginally significant). Process flexibility is also negatively associated with customer satisfaction.

Hypothesis 3a is not supported by the results. The absence of positive direct associations of strategic customer with manufacturing competitive capabilities negates the possibility of significant mediation effects. Regarding Hypothesis 3b, the results do indicate that a mediation effect is present. However, the significantly negative association of supplier integration with quality indicates that the indirect effect of supplier integration

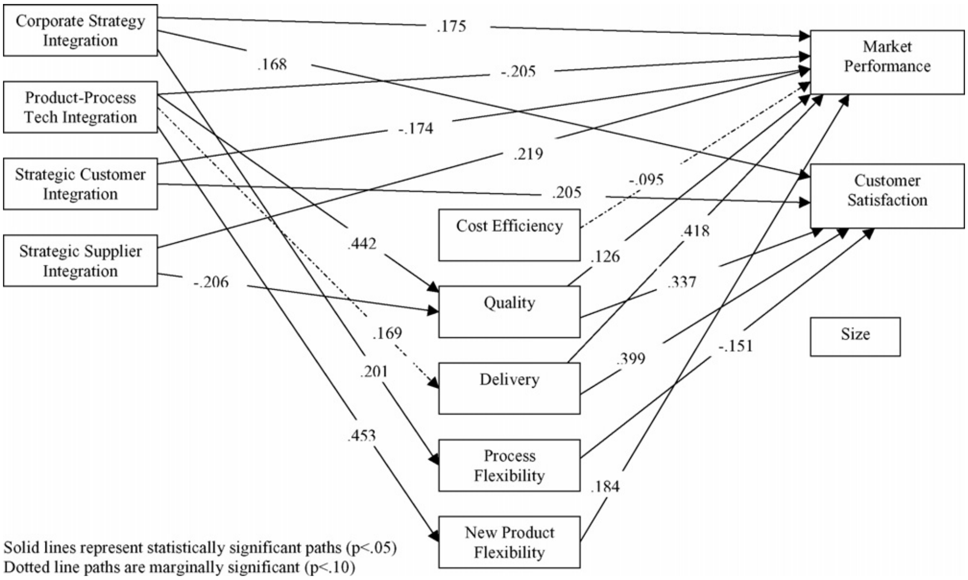

Fig. 3. Statistically significant paths for individual strategic integration types model. Solid lines represent statistically significant paths ($p < .05$); dotted line paths are marginally significant ($p < .10$).

on both market performance and customer satisfaction is negative. Hypothesis 3c is supported. Most of the positive effect of product–process technology integration on customer satisfaction and on market performance is attributable to indirect effects through quality, delivery, and new product flexibility capabilities. Hypothesis 3d is also supported. There is a significant indirect effect of corporate strategy integration on market performance. The significant coefficients indicate that corporate strategy integration leads to delivery and flexibility capabilities that in turn lead to greater market performance.

5. Discussion

The results of the study have implications for the interpretation of previous integration research, for managerial policy regarding integration activities, and for future research opportunities.

Our findings regarding strategic supply chain integration are in some ways consistent and in some ways in contrast with prior research studies. Like prior studies, our findings suggest that customer and supplier integration activities create benefits for business performance. However, these benefits do not appear to be universal. Strategic supplier integration is significantly linked to market performance, but not to customer satisfaction. Strategic supplier integration may prompt suppliers to offer useful market knowledge that may result in better long term market and product planning for growth and profitability. It may be, however, that actual customer satisfaction is more closely associated with operational integration efforts.

Even more distinct are the total effects of customer integration on business performance. Strategic customer integration is positively associated with customer satisfaction as expected, yet it is negatively associated with market performance. Kaplan and Norton's (1996) ''balanced scorecard'' approach advocates consideration of both financial and customer perspectives when assessing business performance. However, our findings imply that managers considering investments in strategic customer integration activities may face a trade-off between the two emphases. Perhaps too much focus on a limited set of customer needs leads to poorer profits and declining overall market share. This is an interesting finding that deserves future research.

A difference of our findings with those of prior studies is the absence of significant positive mediation effects of manufacturing competitive capabilities on supply chain integration–business performance relationships. Significant positive associations of strategic customer integration and strategic supplier integration with manufacturing competitive capabilities are evident in bivariate correlations (see Table 2). However, these associations disappear in the path analysis. This result indicates that the bivariate correlations may be spurious. When other aspects of integration are accounted for, there is little evidence suggesting that direct positive associations between strategic customer integration or strategic supplier integration and manufacturing competitive capabilities exist. Thus, the significant effects of strategic customer integration and strategic supplier integration on business performance are mainly direct; they are not explained by improved manufacturing competitive capabilities at the plant level. It may be that manufacturing competitive capabilities are primarily driven by more operational supply chain integration efforts (Frohlich and Westbrook, 2001; Rosenzweig et al., 2003; Vickery et al., 2003). Another interpretation of this finding is that firms do not consistently gain manufacturing-based competitive capabilities from information and knowledge sharing interactions with their suppliers and customers; instead, competitive capabilities are grown more from internal knowledge sharing processes (e.g., product–process integration). A resource-based view (RBV) argues that because real capabilities are unique and difficult to imitate, they are necessarily proprietary and internal to the firm (Grant, 1996; Teece et al., 1997; Eisenhardt and Martin, 2000). Knowledge assets gained from interactions with suppliers and customers can be replicated by competitors who also have access to the same suppliers and customers. Thus, while customer and supplier integration activities may lead to operational performance improvements in absolute terms, they are less likely to yield improvements which create distinct competitive capabilities relative to competitors' abilities.

As a case in point, our results indicate that strategic supplier integration is actually *negatively* associated with a plant's manufacturing quality capability relative to its competitors. We posit two possible explanations of this finding. First, an RBV-based interpretation would argue that plants which place more emphasis on strategic supplier integration may indeed see quality improvements, but they will improve quality *at a slower rate* than competitors who may invest in other, more efficacious company-internal types of integration. Our results suggest, for example, that product–process integration investments would yield greater returns to competitive capabilities related to quality. A second explanation is that supplier integration actually impedes improvements in quality capability. This explanation is consistent with recent arguments and empirical findings indicating that too much supplier integration in can foster negative effects. Das et al. (2006) show that deviations from "optimal" levels of supplier integration are negatively associated with manufacturing performance. Agency theory suggests that firms who integrate too closely with suppliers open themselves up to risks including adverse selection, moral hazard, and opportunity costs (Eisenhardt, 1989; Rossetti and Choi, 2005). For example, suppliers may be less motivated to provide high levels of performance if they feel that their business interests are secured. Further, as a firm integrates it may be less open to opportunities offered by new or previously unknown suppliers, or it may incur switching costs that make it difficult to take advantage of these opportunities. These considerations, along with the emerging empirical findings, argue for more research on the pros and cons of strategic supplier integration. Future research needs to include "deep" studies which comprehend multiple dimensions of supplier integration.

The hypothesis that manufacturing-based competitive capabilities are significant mediators of integration–performance relationships was supported, but not for all capabilities. The results indicate that quality, delivery, and new product flexibility-based capabilities do indeed serve as the generative means by which certain types of strategic integration affect market performance and customer satisfaction. On the other hand, cost efficiency and process flexibility are either non-significantly or negatively associated with these aspects of performance. Thus, no positive mediation effect is indicated. It may be that cost efficiency and process flexibility are important for only certain, narrowly defined market and technology environments. In general, a focus on cost efficiency may forfeit growth opportunities and thus be associated with poorer market performance. Other research studies have also shown negligible associations between process flexibility and market performance (Vickery et al., 1997; Swink et al., 2005). Generally, new product flexibility appears to be a more important competitive capability.

Three important research factors may account for differences between our findings and those of prior supply chain integration studies. First, we study integration of strategic knowledge and information, where others have focused on operational or tactical integration, or coordination of supply activities (Frohlich and Westbrook, 2001; Sahin and Robinson, 2002). Second, we examine the individual effects of strategic customer integration and strategic supplier integration efforts. Other studies have treated supply chain integration as a single construct involving both types of integration (Rosenzweig et al., 2003; Vickery et al., 2003). Third, we executed a multivariate analysis of manufacturing competitive capabilities, where others have examined links of supply chain integration to each manufacturing competitive capability using separate models (Frohlich and Westbrook, 2001; Rosenzweig et al., 2003).

Regarding relative benefits of strategic integration types, our study offers new findings not shown in prior research. Of the four integration types, corporate strategy integration and product process integration appear to be the stronger individual drivers of manufacturing capability development at the plant. The total effects of corporate strategy integration on both market performance and customer satisfaction are significantly positive. Corporate strategy integration has direct positive effects, suggesting that consideration of manufacturing competitive capabilities and constraints leads the firm in successful directions. However, there is also a marginally significant indirect effect of corporate strategy integration on market performance, suggesting that strategy integration leads to competitive capabilities that are valued in the market place.

The data indicate that product–process technology integration significantly affects the largest number of manufacturing competitive capabilities, and thus offers the strongest case for the mediated relationships we expected. Most of the positive effect of product–process technology integration on customer satisfaction is attributable to indirect effects through quality, delivery, and new product flexibility capabilities. Interestingly, the total effect of product–process technology on market performance is not significant. A trade-off appears to be at work. While product–process technology integration is positively associated with the manufacturing competitive capabilities mentioned above, its direct association with market performance is negative. One explanation is that increased manufacturing influences on product development may lead to products that are less desirable in the market place. Other researchers have discussed the possibility that improved product manufacturability might come at the expense of product innovativeness (Gerwin, 1993; Swink, 2005). The implication is that managers must find the proper balance in product–process integration efforts, or they must develop integration approaches that do not unnecessarily restrict product innovation or other market-based initiatives. In addition, the positive impacts of product–process integration on customer satisfaction through improved manufacturing competitive capabilities should also be considered.

In sum, the results indicate that independent integration activities in each of the four strategic integration areas are likely to produce benefits to manufacturing competitive capabilities, market performance, or customer satisfaction. However, three of the four integration types also involve potential costs to either market performance or product quality. Corporate strategy integration appears to be the safest and most efficacious of the individual types of integration. *Ceteris paribus*, a plant manager faced with a choice may want to invest in corporate strategy integration activities first. Managers developing product–process or strategic customer integration programs should be careful not to let integration activities dominate other decision processes that may be important to the marketability and profitability of products. Individual strategic customer or supplier integration efforts appear to be of little value to manufacturing capability developments, though they do offer benefits to market performance and customer satisfaction. This finding points up a challenge in the research of supply chain integration, as operational and strategic integration concepts are often confused. The supply chain integration concept is not monolithic; different levels of integration activities exist. Future research studies need to examine the interplay of strategic and operational supply chain integration activities in order to determine their respective roles in contributing to manufacturing competitive capabilities as well as other elements of business performance.

It has been proposed that implementing a wider range of supply chain integration elements is better than implementing only a few (Frohlich and Westbrook, 2001; Rosenzweig et al., 2003). However, a theory of complementarities among strategic integration elements has not been put forward or tested. The components of a system are complementary if doing more of any one component increases (or at least does not decrease) the marginal effectiveness of the other components in the group (Milgrom and Roberts, 1992, p. 108). Components may also be considered complementary if the presence of a certain individual component in the system mitigates or compensates for the limitations of another component.

Strategic integration activities have inherent limitations, and they may relate mutually to mitigate these limitations in several different ways. First, integration activities are not cost free. Personal time, communication media, and information systems are required to collect and assimilate knowledge from external partners. If multiple strategic integration activities share and more completely use required resources, then the cost to benefit ratios of each individual integration activity might be improved. Second, myopic focus on a single type of integration may lead to an oversimplified view of the manufacturing task. The productivity and profitability of a manufacturing plant might suffer, for example, if the plant is overly focused on customer concerns. Simultaneous pursuit of multiple types of strategic integration might provide balance among competing constraints and objectives represented by each of the integration elements. Third, knowledge and information gained from one type of strategic integration activity might increase the usefulness or improve the application of knowledge gained from another type of integration. For instance, the knowledge of corporate plans and goals gained from better corporate strategy integration is likely to enable better application of a plant's knowledge of its supplier's capabilities and constraints. An important extension of our study would be to examine potential complementarities among combined integration programs.

6. Limitations and conclusions

The limitations of this study should be considered along with the results. As noted earlier, our study focuses on strategic integration processes at the plant level, as opposed to more operational activities enacted at business unit levels. These differences should be considered when our results are compared to prior research. Another limitation stems from our reliance on sole respondents as sources of data. The positions of the respondents, as well as steps take in data collection and analyses argue against serious effects of bias and common method variance. However, the potential of these threats to validity cannot be completely ruled out. We also address a somewhat limited set of business performance measures. While our measures of market performance and customer satisfaction were correlated with more "objective" measures including market share, ROI, and ROA, the observations were insufficient to provide a more comprehensive set of measures of business performance.

An important contribution of this study stems from its emphasis on studying detailed dimensions of strategic integration. Our findings point up the limitations of research which views integration as a monolithic concept. Aggregated measures of integration fail to surface the details and interactions of various integration types.

Using data from a variety of manufacturing industries, this study examines four different types of strategic integration at the manufacturing plant level. The results show that each type of integration activity has differential and unique merits. Corporate strategy and product–process integration have greater impacts on manufacturing competitive capabilities at the plant level than strategic supplier and customer integration do. Nevertheless, each of the strategic integration types appears to be associated with benefits, and some types may involve detriments as well. Overall, the results of this study highlight the important competitive gains that can be obtained when manufacturing managers develop effective knowledge integration processes that extend beyond the factory's walls. Much of the past manufacturing strategy research has focused on internal manufacturing processes and technologies. Our study argues the need for additional study of external strategic integration processes as well.

Appendix A. Construct reliability and validity analysis

Construct-item	Factor loading	Construct statistics
Strategic customer integration		
We maintain close contacts with our customers	.760	Eigenvalue = 2.350, % var. explained = 58.7, coefficient alpha = .76
Results of customer satisfaction surveys are shared with all employees	.821	
We actively create opportunities for employee–customer interaction	.738	
We have a formal "customer satisfaction" program in place	.744	
Strategic supplier integration		
We share our cost information with our major suppliers	.740	Eigenvalue = 3.183, % var. explained = 53.1, coefficient alpha = .82
We require cost information sharing by our suppliers	.789	
We require major suppliers to contribute to cost/quality improvement	.735	
We share real time production schedule information with suppliers	.740	
We emphasize early supplier involvement in product design	.682	
We use buyer–supplier councils	.679	
Product–process technology integration		
We have created new ways to coordinate design/manufacturing issues	.616	Eigenvalue = 3.318, % var. explained = 55.3, coefficient alpha = .84
We use design-for-manufacture/assembly (DFMA) methods	.780	
Manufacturing involvement and sign-off is required for new products	.695	
We practice job rotation between design and manufacturing engineering	.741	
Our product designers make use of manufacturability guidelines	.806	
Product designers and manufacturing staff have equal status in NPD projects	.806	

Appendix (*Continued*)

Construct-item	Factor loading	Construct statistics
Corporate strategy integration		
Manufacturing strategy is well aligned with corporate strategy	.863	Eigenvalue = 3.955, % var. explained = 65.9, coefficient alpha = .90
We have clearly defined strategic manufacturing goals and objectives	.826	
Our firm's strategy leverages existing capabilities	.795	
Corporate strategy at our firm drives manufacturing decisions	.776	
Manufacturing strategies and goals are communicated to all employees	.794	
Manufacturing strategy is frequently reviewed and revised	.815	
Cost		
Initial purchase cost	.862	Eigenvalue = 1.486, % var. explained = 74.3, Pearson corr. = .486
Manufacturing overhead cost	.862	
Quality		
Product overall quality performance	.719	Eigenvalue = 3.053, % var. explained = 61.1, coefficient alpha = .84
Product reliability	.805	
Product features	.883	
Product conformance	.733	
Product durability	.756	
Delivery		
Delivery accuracy (correct items were delivered)	.778	Eigenvalue = 2.672, % var. explained = 66.8, coefficient alpha = .83
Delivery dependability (delivered on the agreed upon date)	.828	
Delivery availability (the probability that items will be in stock at order time)	.816	
Delivery speed (short elapsed time)	.845	
Process flexibility		
Ability to adjust production volumes	.810	Eigenvalue = 1.803, % var. explained = 45.1, coefficient alpha = .57
Ability to respond to changes in delivery requirements	.834	
Ability to customize products	.428	
Ability to produce a range of products	.518	
New product flexibility		
Lead time to introduce new products	.827	Eigenvalue = 1.367, % var. explained = 68.3, Pearson corr. = .367
Number of new products introduced each year	.827	
Market performance		
Growth rate in unit sales	.888	Eigenvalue = 2.176, % var. explained = 72.5, coefficient alpha = .81
Market share of major product line	.854	
Profitability	.811	

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