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Success Factors for Integrating Suppliers into New Product Development

Gary L. Ragatz, Robert B. Handfield, and Thomas V. Scannell

Faster, better, cheaper—these marching orders summarize the challenge facing new product development (NPD). In other words, NPD teams must find the means for speeding time to market while also improving product quality and reducing product costs. Cross-functional teams have proved effective for meeting these challenges, and such teams may extend beyond company boundaries to include key materials suppliers.

Effective integration of suppliers into NPD can yield such benefits as reduced cost and improved quality of purchased materials, reduced product development time, and improved access to and application of technology. As Gary Ragatz, Robert Handfield, and Thomas Scannell point out, however, those benefits do not automatically accrue to any NPD team that includes representatives from a supplier's company. In a study of 60 member companies from the Michigan State University Global Procurement and Supply Chain Electronic Benchmarking Network, they explore the management practices and the environmental factors that relate most closely to successful integration of suppliers into the NPD process.

The study identifies supplier membership on the NPD project team as the greatest differentiator between most and least successful integration efforts. Although the respondents reported only moderate use of shared education and training, the study cites this management factor as another significant differentiator between most and least successful efforts. Respondents listed direct, cross-functional, intercompany communication as the most widely used technique for integrating suppliers into NPD.

To integrate suppliers into NPD, a company must overcome such barriers as resistance to sharing proprietary information, and the not-invented-here syndrome. The results of this study suggest that overcoming such barriers depends on relationship structuring—that is, shared education and training, formal trust development processes, formalized risk/reward sharing agreements, joint agreement on performance measurements, top management commitment from both companies, and confidence in the supplier's capabilities. Overcoming these barriers also depends on assett sharing, including intellectual assets such as customer requirements, technology information, and cross-functional communication; physical assets such as linked information systems, technology, and shared plant and equipment; and human assets such as supplier participation on the project team and co-location of personnel.

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Introduction

Within the last decade, the rapid rate of technological change, shortened product life cycles, and increasing global competition have made new product development a critical concern of U.S. manufacturers. Monczka and Trent [17] reported that procurement managers expect that over the next 5 years, competitive pressures will require manufacturers to reduce costs by 5–8% per year (after inflation) and continue to improve product quality, while simultaneously reducing time to market by 40–60%.

In this competitive environment, suppliers are an increasingly important resource for manufacturers. Across all U.S. manufacturers, purchased materials account for over 50% of the cost of goods sold. In addition, suppliers have a large and direct impact on cost, quality, technology, speed, and responsiveness of buying companies. Effective integration of suppliers into the product value/supply chain will be a key factor for some manufacturers in achieving the improvements necessary to remain competitive.

A study conducted by Computer-Aided Manufacturing International (CAM-I) concluded that while the concept and design engineering phases of new product development incur only 5–8% of the total product development costs, these two activities commit or "lock in" 80% of the total cost of the product. Decisions made in the design process can have a significant impact on the resulting product quality, cycle time, and cost [9]. As the development process continues, it becomes increasingly difficult and costly to make design changes. It is crucial then, for firms to bring to bear as much product, process, and technical expertise as possible early in the development process.

There is intuitive appeal to the idea that using the knowledge and expertise of suppliers to complement internal capabilities can help reduce concept-to-customer cycle time, costs, quality problems, and improve the overall design effort. Reports in the popular press indicate that leading companies in a variety of industries have made successful efforts at involving suppliers in the new product development process and that interest in such efforts is growing (see for example [19–21]).

This research examined the extent of use of various management practices for integrating suppliers into new product development efforts in different competitive environments. Sixty companies each identified a most and least successful case of supplier integration

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Professor Ragatz is co-author of the book, *Supplier Bar Coding: Closing the EDI Loop*, published by the National Association of Purchasing Management, and his work on production scheduling and capacity planning has appeared in *Decision Sciences, Journal of Operations Management, Production and Inventory Management Journal, International Journal of Purchasing and Materials Management, Computers and Operations Research,* and *International Journal of Production Research.* Professor Ragatz's current work focuses on three areas: industry strategies and best practices in integrated supply chain management, integration of suppliers in new product/process development, and short-term scheduling/capacity planning systems.

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His research interests include time-based competition, environmentally friendly purchasing, and integrated global strategic sourcing. He has written articles on all of these subjects in *Production and Inventory Management, International Journal of Operations and Production Management, International Journal of Production Research, Journal of Business Logistics, Decision Science, Journal of International Marketing, Journal of Operations Management,* and *International Journal of Purchasing and Materials Management.* He is the author of a book entitled *Re-engineering for Time-Based Competition* (Quorum Press), and co-author of *Principles of Purchasing* (to be published in 1997).

Dr. Handfield has received several awards, including doctoral grants from NAPM and Richard D. Irwin Inc., a grant from the U.S. Department of Education to study global TQM practices, and co-investigator of an NSF grant to study supplier integration into new product development. He is also a Faculty Research Associate on the Global Procurement and Supply Chain Benchmarking Initiative. He has conducted seminars at several NAPM and APICS meetings, as well as within several major North American corporations. Over the last 10 years, he has interviewed managers at over 100 manufacturing plants in Japan, North America, and Europe.

Thomas V. Scannell is a Doctoral candidate in the Operations and Sourcing Management program at Michigan State University and a Research Associate in the MSU Global Procurement and Supply Chain Benchmarking Initiative. He has over 10 years of industry experience in manufacturing engineering, electronics design, systems engineering, and program management in the consumer electronics and aerospace/defense industries. His research interests include integrative new product/process development, design for the environment, flexible manufacturing systems, and supply chain management. He holds B.S. in Electrical Engineering and M.B.A. degrees from Western Michigan University.

and rated the extent of use of various management practices generally associated with supplier integration efforts.

The next section of this article reviews the literature, which provides a foundation for the research. The research methodology is then described, followed by the presentation of results. Differences in the extent of use of key management practices and differences in the level of various environmental factors between the most successful and least successful supplier integration cases are then examined and discussed in greater detail. Finally, conclusions and recommendations for further research are presented.

Literature Review

A considerable amount has been written documenting the integration of suppliers in the new product development process. Clark [2] and Clark and Fujimoto [3] discuss the use, by Japanese manufacturers, of suppliers in the new product development process and the potential benefits of such supplier involvement. Kamath and Liker [10] also examine Japanese product development practices and identify a variety of roles that suppliers may play. Mabert et al. [14] found supplier involvement to be an important part of the strategy of five out of six firms they examined who were attempting to collapse new product development time.

Birou and Fawcett [1] compared the experiences of U.S. and European manufacturers with supplier integration into new product development. They found a number of differences in practices between the two geographical regions, and found that generally, U.S. manufacturers are more extensively involving suppliers in new product development. The study, however, stops short of examining which practices lead to *successful* supplier integration.

Eisenhardt and Tabrizi [5] looked at supplier involvement as one factor in reducing product development times within the computer industry. They found that it was positively related to accelerated development time, but only when the product line involved was mature and the goals of the product development effort were well defined.

LaBahn and Krapfel [11] examined factors that affect supplier interest in early involvement in new product development. They found that when a manufacturer is more strongly committed to a supplier and has a history of adhering to agreements, the supplier is more likely to be actively interested in early involvement. To the extent that supplier interest will have an impact on success of the supplier integration effort, this study may help identify some of the success factors in supplier integration.

Though not necessarily a strategic alliance, supplier integration into new product/process/service development (NPD) efforts are often pursued by strategically allied partners. As such, it is useful to review critical success factors of successful strategic alliances as they relate to the more specific case of supplier integration. Gulati [7] identified equity sharing as a key alliance characteristic. Trust, co-location, asset specificity and information sharing have also been identified as critical alliance attributes by a number of researchers [6,12,15,16,18,23].

Ring and Van de Ven [22] developed a framework suggesting that a balance between formal (economic and legal) and informal (social-psychological) factors is necessary for successful long-term relationships. Handfield [8] identified joint sharing of new technology, cost savings sharing, and supplier development as characteristics of successful industrial purchasing relationships.

Littler et al. [13] examined the key success factors for collaborative new product development efforts in 106 U.K. firms in which the collaborative partner could be a supplier, customer, or competitor. They concluded that frequent intercompany communication, building trust, establishing partnership equity, ensuring that parties contribute as expected, and employing a product or collaboration champion increased the likelihood of success.

Dyer and Ouchi [4] suggest that the length of a buyer/supplier relationship positively impacts product development efforts. The supplier's existing knowledge of the buying firm's internal processes and objectives enables the supplier to plan for future product development efforts and to develop, in advance, the capabilities to meet those needs.

While it is clear that supplier involvement in new product development is happening, and at least in some cases has significant potential benefits, further research is required to determine when such integration is necessary or desirable, and how such integration efforts should be planned and managed. The purpose of this article is to provide insights into these research questions. The results presented here do not give a complete picture of what leads to successful integration of suppliers into the NPD process. Rather, they identify a number of key issues for managers to

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consider and which require greater exploration in future research.

Methodology

A survey instrument was prepared and distributed to the 210 members of the Michigan State University Global Procurement and Supply Chain Electronic Benchmarking Network (GEBN). Members of the GEBN have agreed to participate in a series of benchmarking surveys conducted each year as part of a larger research initiative. The member companies are permitted to "opt out" of up to two of the surveys each year. A total of 83 companies responded to the supplier integration into new product development survey. Of these 83 responses, 60 companies provided complete and detailed information regarding both their most and least successful supplier integration cases.

The survey was comprised of four parts. The first was a profile section which asked for general information about the responding business unit. The second section was a set of open-ended questions that asked for information about the business unit's management practices and implementation processes for supplier integration into the new product development process. The third section contained general check-off questions dealing with the business unit's use of suppliers in new product development. The final section was another set of check-off questions that asked for more detailed information regarding the business unit's experience in two specific cases of supplier integration into new product development. The two cases the respondents were asked about were those the business unit considered to be its "most successful" and "least successful" cases of supplier integration. Each of these cases focused on the integration of the supplier of a single commodity, purchased item, subsystem or system. It was left to the respondents to determine which of their experiences was the most and least successful.

A five-stage NPD model was presented in the survey as a reference point. The five stages precede full scale production and include idea generation, preliminary business/technical assessment, product/process/service concept development, product/process/service design and development, and prototype build, test and production ramp up. The following definition of supplier integration into new product development was also included in the questionnaire to provide a solid base for response analysis.

> Supplier integration into new product/process/service development suggests that suppliers are providing information and directly participating in decision-making for purchases used in the new product/process/service. This integration can occur at any point in the five-stage new product/process/service development model.

Results

A total of 83 companies (39.5%) responded to the supplier integration questionnaire. Response rates on individual questions varied somewhat. The responses provided some clear indications of the companies' overall experience with supplier integration. The responding companies have, on average, had their expectations met in their efforts at integrating suppliers into NPD as indicated in Figure 1. There is however, clearly room for improvement, as nearly a third of the responding companies have achieved results below their expectations.

The responses also suggest that integration of suppliers into NPD is of increasing strategic importance to responding companies (Figures 2 and 3). The majority of respondents clearly feel very strongly that they should be involving suppliers at an earlier stage in NPD efforts, and that they are expecting to move rapidly toward greater integration of suppliers into NPD in the future.

This analysis focuses on a comparison of the practices and environmental factors the responding companies reported for their "most successful" versus their "least successful" supplier integration effort. We are interested in differences in the practices applied and

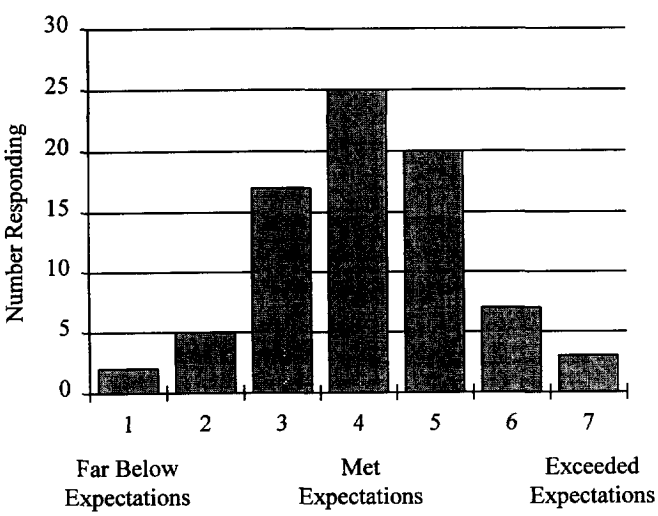

Figure 1. Overall satisfaction with supplier integration into new Product/Process/Service development.

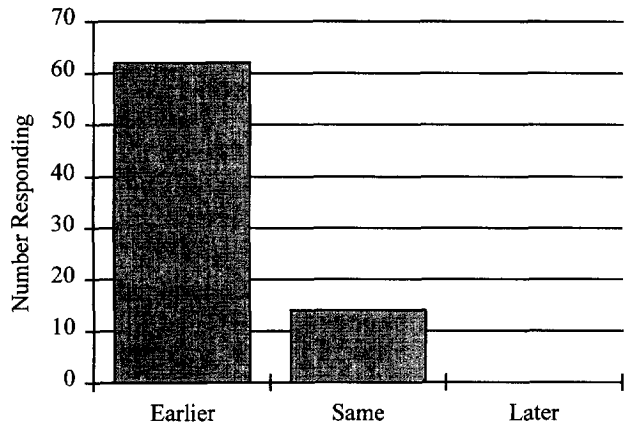

Figure 2. When should suppliers be integrated into NPPD, compared to when they are now?

the project environment in which the supplier integration occurred, with the idea that certain practices and environmental factors will be more associated with successful integration. Only those companies who provided responses regarding both a most successful and a least successful integration effort are considered in this analysis. This allows us to analyze, company by company, the differences between the two cases.

Of the 83 responding companies, 60 provided useable responses regarding both a "most successful" and "least successful" case. "Success" was not defined for the respondents, but they were asked to report on the results of each integration effort in three different ways: (1) rate their "overall satisfaction" with the effort, (2) rate the "degree of achievement of established goals" of the effort, and (3) identify and report on up to five key performance metrics of their own choosing. This approach allowed the respondents to define success in their own way for each effort, and also provided two overarching measures, in terms of satisfaction and goal achievement.

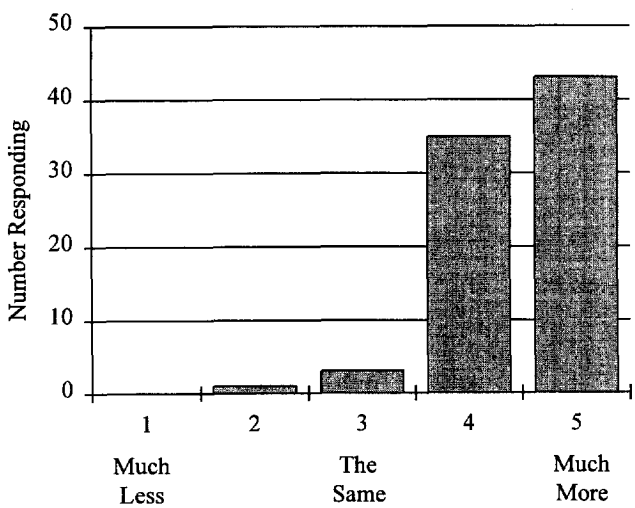

Figure 3. Extent to which you will integrate suppliers into New Product/Process/Service development in the year 2000, compared to today.

The results for the two overarching measures, satisfaction and goal achievement are presented in Table 1. As expected, there were clear and significant differences between the most and least successful cases.

Purchased material costs, purchased material quality, and development cycle time were the three dominant key performance measures reported by the respondents. Results are summarized in Table 2. Again, the results indicate clear differences between the most and least successful cases. The results also show that supplier integration does not always generate improvement, suggesting that it is a process that must be applied and managed properly.

Many of the respondents also indicated that "soft" benefits were realized through their supplier integration efforts. These benefits, although not necessarily directly measurable in terms of "new product success," were identified as having long-term positive effects on the efficiency and effectiveness of new product development. The most frequently cited soft results included:

- closer, more open, and trusting long-term supplier relationships
- easier access to supplier knowledge and expertise
- clearer focus on what's really important to the success of joint development projects
- improved communication

Table 1. General Performance Differences between Most and Least Successful Efforts

Question	Most Successful Mean Score	Least Successful Mean Score	Difference	*p*
Overall degree of satisfaction with results	5.57	2.90	2.67	0.000
Overall degree of achievement of established goals	4.52	2.61	1.91	0.000

"Satisfaction" scale: 1 = very low, 7 = very high.
"Goal Achievement" scale: 1 = results far worse than goals, 7 = results far better than goals.

Table 2. Median Percent Improvement Resulting from Supplier Integration

Parameter	Most Successful Cases	Least Successful Cases
Purchased material cost (relative to historical costs for this item or similar item).	15.0%	(5.0%)[a]
Purchased material quality (relative to historical quality for this item or similar item).	40.0%	(7.5%)[a]
Development cycle time	25.0%	(30.0%)[a]

[a] Figures in parentheses indicate a deterioration on the performance dimension.

We now turn to an analysis of the management practices and environmental factors that differentiate the most and least successful efforts. Table 3 summarizes the results of a series of paired *t*-tests for 22 management practices related to supplier integration into NPD. The results in the table are ranked by the significance (*p*-value) of the individual tests. When a set of multiple tests such as this is performed, the significance of the individual tests must be interpreted conservatively. In order to hold the experimentwide error rate to a desired level, only the individual differences found to be significant at a more stringent level should be considered truly significant. The Bonferonni method for multiple pairwise comparisons suggests that to hold the experiment wide error rate to $\alpha = 0.05$ with 22 comparisons, the threshold *p*-value for individual comparisons should be 0.05/22, or approximately 0.002.

Similarly, Table 4 summarizes the results of a series of paired *t*-tests for 16 factors related to the product development project environment for the project in which suppliers were integrated. To hold the experimentwide error rate to $\alpha = 0.05$ with 16 comparisons, the threshold *p*-value for individual comparisons should be 0.05/16, or approximately 0.003.

Twelve management practices (P1 through P12) and four environmental factors (E1 through E4) were found to be statistically significant differentiators between most and least successful supplier integration efforts. In the remainder of this section, the differentiating management practices and environmental factors are discussed in greater detail. Insights and examples gleaned from responses to the open-ended part of

Table 3. Extent of Use of Management Practices for Supplier Integration Into New Product/Process/Service Development: Comparison of Most Successful and Least Successful Efforts

	Factor	Most Success	Least Success	Diff.	*p*
P1	Supplier membership/participation on buying company's project team	5.02	3.73	1.29	0.000
P2	Direct cross-functional, intercompany communication	6.05	4.87	1.18	0.000
P3	Shared education and training	3.44	2.29	1.15	0.000
P4	Common and linked information systems (EDI, CAD/CAM, e-mail)	4.07	2.96	1.11	0.000
P5	Co-location of buyer/seller personnel	2.95	1.84	1.11	0.000
P6	Technology sharing	4.84	3.77	1.07	0.000
P7	Formal trust development processes/practices	4.14	3.07	1.07	0.000
P8	Customer requirements information sharing	5.72	4.74	0.98	0.000
P9	Technology information sharing	5.12	4.22	0.90	0.000
P10	Shared physical assets (plant and equipment)	2.44	1.62	0.82	0.000
P11	Formalized risk/reward sharing agreements	3.13	2.47	0.65	0.001
P12	Joint agreement on performance measurements	5.07	4.20	0.88	0.002
P13	Confidentiality/nondisclosure agreements	5.34	4.46	0.88	0.008
P14	Cost information sharing	4.29	3.59	0.70	0.011
P15	Licensing agreements between buyer and seller	3.00	2.18	0.82	0.012
P16	Joint target setting (price, cost, weight, etc.)	4.23	3.60	0.63	0.014
P17	Formal assessment of supplier's capability	5.02	4.43	0.58	0.017
P18	Cross-functional teams for supplier selection and planning	5.05	4.41	0.64	0.022
P19	Formalized processes to select supplier(s) to be integrated	4.80	4.30	0.50	0.060
P20	Supplier involvement in establishing NPD project goals	4.57	4.17	0.40	0.185
P21	Formalized processes to select purchased items for supplier integration	4.22	3.91	0.31	0.194
P22	Buying firm focused specific assets on the supplier	4.38	4.08	0.30	0.324

1 = no use, 7 = very extensive/significant use.

Table 4. Project Environment Factors for Supplier Integration Into New Product/Process/Service Development: Comparison of Most Successful and Least Successful Efforts

	Factor	Most Success	Least Success	Diff.	*p*
E1	Familiarity with supplier's capabilities prior to integration in this project	5.64	4.58	1.07	0.000
E2	Strength of supplying firm top management commitment to their involvement	6.14	5.22	0.91	0.000
E3	Strength of consensus that right supplier was selected	4.83	3.88	0.95	0.001
E4	Strength of buying firm top management commitment to supplier integration	5.70	4.95	0.75	0.003
E5	Clarity of performance targets defined by the project team	5.17	4.56	0.61	0.019
E6	Level of complexity of the technology involved in this NPD project	5.08	4.47	0.61	0.021
E7	Frequency of this supplier's past involvement in NPD projects	3.90	3.25	0.65	0.029
E8	Clarity of metrics established to measure performance in this project	4.90	4.35	0.55	0.033
E9	Degree of "newness" or uncertainty of the technology involved in this project	4.13	3.62	0.52	0.104
E10	Strength of design project team's consensus on project goals	4.88	4.52	0.37	0.126
E11	Stability of membership of NPD team during the project	5.12	4.78	0.34	0.223
E12	Degree of difference between this project's goals and the "typical" NPD project	3.87	3.53	0.33	0.248
E13	Strength of consensus in buying company that supplier integration was needed	5.26	5.02	0.24	0.397
E14	Length of time buying company had done business with supplier before project	3.17	2.98	0.18	0.416
E15	Stability/predictability of technology shifts at buying company	4.02	3.92	0.10	0.728
E16	Anticipated degree of difficulty in achieving purchased item project goals	4.88	4.84	0.03	0.864

1 = low rating, 7 = high rating.

the survey are offered to explain how and why greater use of these practices may drive NPD success.

Management Practices

Supplier membership/participation on buying company's project team (P1) was the single largest differentiator between most and least successful supplier integration efforts. Many companies indicated that the extent of supplier participation depended on project characteristics such as technical complexity, strategic importance, and dollar or volume projections. Participation is often facilitated by periodic face-to-face meetings, selective co-location, and/or linked information systems.

Direct cross-functional, intercompany communication (P2) was the most extensively used technique in successful supplier integration into NPD cases. Managers frequently identified open and direct communication as a critical success factor in early identification and rapid resolution of problems. The importance of intercompany communication is reflected in other management practice differentiators as well (participation on project team, common and linked information systems, co-location of personnel).

Shared education and training (P3) is only moderately used in the most successful NPD efforts. However, this management practice does represent the third largest differentiator between most and least successful efforts. This may indicate that shared education and training must be strategically and selectively used to drive success.

The training efforts described by the respondents can be classified into two groups: periodic and ad hoc. Periodic education and training generally involves all key suppliers and addresses various performance improvement areas including management/leadership, quality and quality control processes, problem solving techniques, team building, activity-based costing, government or agency regulations, and continuous process improvement. These meetings allow suppliers to gain a greater insight into the buying company's internal processes without addressing specific NPD projects.

Ad hoc education and training addressed specific issues to facilitate the NPD effort and help establish long-term relationships. The focus is typically greater detail on the NPD processes or technologies employed at either company. Sample topics may include design for assembly techniques, CAD/CAE technology, change order processes, quality control procedures, manufacturing capabilities, and material and product testing.

Some respondents also reported using education and

training sessions to further align suppliers' objectives with the buying company's objectives. These sessions are an opportunity for the buying company to present itself as a good customer to its suppliers (and vice versa). This is one approach to strengthening mutual commitment and trust between the companies.

Common and linked information systems (EDI, CAD/CAM, E-mail) (P4). Common communication linkages for real-time processing of technical data does not currently appear to be in widespread use, though many companies cited implementation of such systems as a near-term goal. Whereas respondents realize the potential advantages of linked CAD/CAM systems, the lack of resources and industry standards creates a significant barrier to implementation. The lack of "seamless" compatible systems means that files often must be converted to a neutral format prior to transmission.

On the other hand, buyer/supplier linked information systems for transaction processing and daily communications are being used with greater frequency. Electronic data interchange (EDI), E-mail and computer coordinated faxes have become increasingly important communication tools. The Internet was also frequently cited as a mode of communication. These tools tended to be used more frequently for production management than NPD activities.

Co-location of buyer/supplier personnel (P5) was not extensively used in either the most or least successful integration cases, though significant individual differences were found. The fact that co-location is used more extensively in the most successful cases (but still not used extensively in an absolute sense) suggests that co-location should be selectively used to facilitate communication and information exchange as the nature of the project requires. Co-location tends to be used more frequently when the technical complexity of the purchased part is high, the supplier is involved in a higher level of assembly (e.g., system versus subsystem level), the purchased part is of strategic importance, and when electronically linked information systems are limited.

Temporary and/or sporadic co-location is frequently used as a NPD strategy. That is, company representatives do not co-locate from concept generation to production. Rather, they co-locate for very specific short-term efforts such as prototype testing, pilot production, or problem solving activities.

Co-location is also being used to drive long-term development objectives in a number of firms. Though the immediate goal of the co-location process is the current NPD effort, the long-term goal is to create a sustainable competitive advantage through early identification of new technologies and markets.

Technology sharing (P6) between companies is unique to each NPD effort. Technology is generally shared on an "as needed" basis and is supplied by whichever party is the expert. With greater frequency, buying companies rely on suppliers to deliver or further develop technologies for the NPD effort. Suppliers benefit from sharing their technologies by gaining long-term business, preferred status and/or market penetration through the buying company's products. Buyers benefit from sharing their technologies through higher quality, more innovative, and lower cost purchased products. Benefits are also realized through the development of a long-term buyer/supplier relationship with a capable supplier. Confidentiality and nondisclosure agreements are widely used to help address technology ownership issues, but mutual trust and strong business relationships are key to making technology sharing work.

Formal trust development (P7). Though all companies cited mutual trust as an essential element of successful supplier integration, formal trust development practices were only moderately used. Many of the respondents claimed that trust is developed more through performance to expectations over time in active business relationships than through formal trust development techniques. That is, many of the management techniques used for supplier integration into NPD (e.g., customer requirements and technology information sharing, direct communication, membership on the product/project development team, joint education and training) foster trust while also advancing product/project goals.

Thus, formal trust development processes tend to be used with greater frequency when integrating new suppliers. By using a set of formalized education courses beginning with synergy training prior to actual product design and development, new suppliers more quickly understand the importance and expectations of a close professional relationship. This early trust building exercise creates the foundation for growing trust as the development effort progresses.

Customer requirements information sharing (P8) is the second most extensively used management practice in both most and least successful integration cases. Many companies provide full uncensored market information with their key strategic suppliers as part of an extended enterprise. This information identifies not only what customers want, but how much and when.

Customer information sharing aligns suppliers with the final customers' requirements and strengthens trust between the supplier and buyer. It also enables the supplier to develop innovative solutions that may not have otherwise been identified.

Less strategically integrated suppliers receive customer information on an "as needed" basis. At this level, the information shared with the supplier is more in the form of specifications than requirements. Even here however, companies emphasized the need for the supplier to understand the role the supplied item plays in satisfying the final customer.

Numerous companies also indicated that they are not only sharing customer requirements information with integrated suppliers, but they are using the supplier to help identify and define requirements as part of a cross-functional value analysis/value engineering team.

Technology information sharing (P9). More frequent and detailed product and process technology information sharing also differentiates most from least successful cases. The original technology information exchange often occurs prior to the supplier being selected for a new product development effort. Both the buyer and supplier may share technology roadmaps that identify current and long-term technology capabilities to generate new product ideas. The companies then continue to share technology information throughout the new product development process to ensure customer requirements are met. Contractual mechanisms such as confidentiality agreements, nondisclosure agreements, and exclusivity clauses are often used to allow for higher levels of technology information sharing and safeguard the interests of both parties.

Shared physical assets (P10) are rarely used in the responding companies' actual NPD efforts. When they are used, they are generally associated with co-location strategies and limited to such items as temporary office space and business machines. During production ramp-up and ongoing production however, the use of shared physical assets is more frequent. Many buying companies either own or share tooling at their supplier's facility. This is especially true for custom parts suppliers. Also, large volume suppliers may manage their stock at the buyer's facility and thus are provided the space and equipment required to accomplish the job.

Formalized risk/reward sharing agreements (P11). Few firms made much use of formal risk/reward sharing agreements in either the most or least successful cases. Though the companies typically agree on acceptable development and production costs (prices) based on projected volumes, few companies reach advance agreements that define expectations when actual volumes differ substantially (higher or lower) from the forecast. Many of the companies indicated that such risks and rewards are shared 50/50 based on a handshake agreement, which again highlights the importance of mutual trust.

Formalized risk and reward agreements may be an area of opportunity for firms. Realizing that volume projections are, at best, accurate within a wide tolerance band, companies may avoid potential problems by agreeing upon expectations when actual volumes deviate significantly from forecast. This may be especially true in new relationships where the level of trust is just developing.

Joint agreement on performance measurements (P12). Early agreements on performance measures that took a total cost of ownership perspective were often cited as a key to success. A performance measurement agreement keeps the project on track by providing a common way to evaluate progress, and serves as the base for making tradeoffs and resolving conflicts over the life of the project.

Environmental Factors

Four environmental factors were found to be statistically significant differentiators between most and least successful cases. Two of these differentiators, "strength of supplying firm's top management commitment to their involvement" (E2) and "strength of the buying firm's top management commitment to supplier integration" (E4) were the highest rated success factors in the most successful cases. Though these factors were also rated high in the least successful cases, it appears that unquestionable commitment from top management is a critical enabler of the various management practices previously discussed.

The two other significant differentiators, "familiarity with the supplier's capabilities prior to integration in the project" (E1) and "strength of consensus that the right supplier was selected" (E3) are also key enablers that give the development team the confidence to actively involve the supplier in the development effort.

NonDifferentiators

Perhaps as interesting as the significant differentiators between most and least successful supplier integration

efforts is the set of nonsignificant differentiators. Among the project environment factors, it was expected that the level of difficulty of the project goals would have an impact on the success of integration efforts. The results of questions E12 (degree of difference between this project's goals and the typical NPD effort) and E16 (degree of difficulty in achieving purchased item project goals) however, indicate that difficulty of project goals did not distinguish between the most and least successful integration efforts. Technological complexity, uncertainty, or instability (see results on questions E6, E9 and E15) also did not seem to be determining factors in successful integration. The fact that "consensus that the right supplier was selected" (E3) is a differentiator may help explain why goal difficulty and technical challenge did not differentiate best from worst cases. It is possible that matching the supplier's capabilities to the project goals regardless of goal difficulty or technical challenge is the important decision making criterion.

Among the management practice factors, neither the use of formalized processes for selecting suppliers to be integrated (P21) nor formalized processes to select purchased items for which to involve suppliers (P24) helped to distinguish between successful and unsuccessful integration efforts. This may mean that firms are applying more or less the same process for selecting the suppliers and the items for which to involve suppliers in each effort, and it is really the way the relationship is managed that will determine success or failure.

Confidentiality agreements, which were widely used in both most and least successful cases, also did not distinguish best and worst cases (although the p-value would have made the difference significant in a single-comparison test). This is of interest because it would seem that confidentiality agreements would enable greater use of many of the factors that were found to be differentiators (e.g., customer requirements and technology information sharing, supplier membership on the project team, technology sharing.) Qualitative responses suggest that confidentiality agreements are a necessary evil that must be universally applied, but that the real key to active participation and success is the business relationship.

Discussion

The potential benefits of integrating suppliers into new product development are compelling. The companies responding to our survey reported important benefits in the areas of purchased material cost and quality, as well as reduced product development time. Benefits also stem from better access to and application of technology. Particularly in industries using complex product and/or process technologies, no single company is likely to be a master of all the relevant technologies. The ability to tap the knowledge and expertise of suppliers, for design as well as manufacturing, is likely to lead to better technology decisions and ultimately, better designs. Furthermore, involvement gives a buyer company an opportunity to influence the direction of suppliers' technology development efforts, in order to align those efforts with the buyer company's needs. A number of the companies responding to our survey reported sharing technology roadmaps with suppliers and holding formal discussions about how to align the companies' technology plans. At a more basic level, regardless of the technology issue, design involvement by suppliers can help in identifying potential problems and solutions earlier, reducing both time and cost of the design effort.

Although the potential benefits are substantial, integrating suppliers into new product development efforts is a relatively new and sometimes uncomfortable way of doing business for many companies. It appears that a variety of internal and external barriers must be overcome to make such integration work well.

The barriers result from a variety of issues and concerns. First, there may be resistance at a number of levels within the organization to sharing proprietary information with suppliers. The usual concern is that such information may be revealed, intentionally or unintentionally, to competitors. This may be a particularly critical issue when the supplier company itself is also a competitor. Second, in many organizations, a "not invented here" culture poses a challenge to the acceptance of ideas coming from suppliers, and buyer company designers and engineers may resist giving up any control over design decisions. Finally, there may be resistance within the supplier's organization as well, based on concerns about revealing proprietary information or technologies. Particularly, a supplier dealing with a more-powerful buyer may worry about inequitable treatment.

Two important conceptual themes regarding how companies can overcome or minimize these barriers emerge from the differentiators discussed in the Results section. One is relationship structuring. Relationship structuring factors help to break down barriers

and expand the boundaries of the relationship between the buying and supplying companies, open communication channels, build trust, and define expectations of both parties. These factors include shared education and training (P3), formal trust development processes/practices (P7), formalized risk/reward sharing agreements (P11), joint agreement on performance measurements (P12), top management commitment from both companies (E2 and E4), and confidence in the supplier's capabilities (E1 and E3).

The second theme is asset allocation. Intellectual assets such as customer requirements (P8), technology information (P9), and direct cross-functional intercompany communication (P2); physical assets such as common and linked information systems (P4), technology (P6), and shared plant and equipment (P10); and human assets including supplier participation on the project team (P1), and co-location of personnel (P5) all were significant differentiators.

Relationship structuring practices facilitate integration and sharing of assets, but do not directly affect the speed, cost, and quality of NPD. The asset sharing practices more directly influence the results of the NPD process. In this sense, the relationship structuring factors are "enablers" for the asset allocation practices. For example, top management commitment at both companies helps to change and align the cultures of the organizations by indicating that it is "okay" to share information and that resources will be made available to support the integration effort. Shared education and training, formal trust development processes, and formalized risk/reward sharing agreements help minimize concerns that either party will take advantage of the other. Joint agreement on performance measures provides clear directions and expectations for the project and allows each party to identify the mutual benefits of the integration effort.

The allocation of intellectual assets provides the

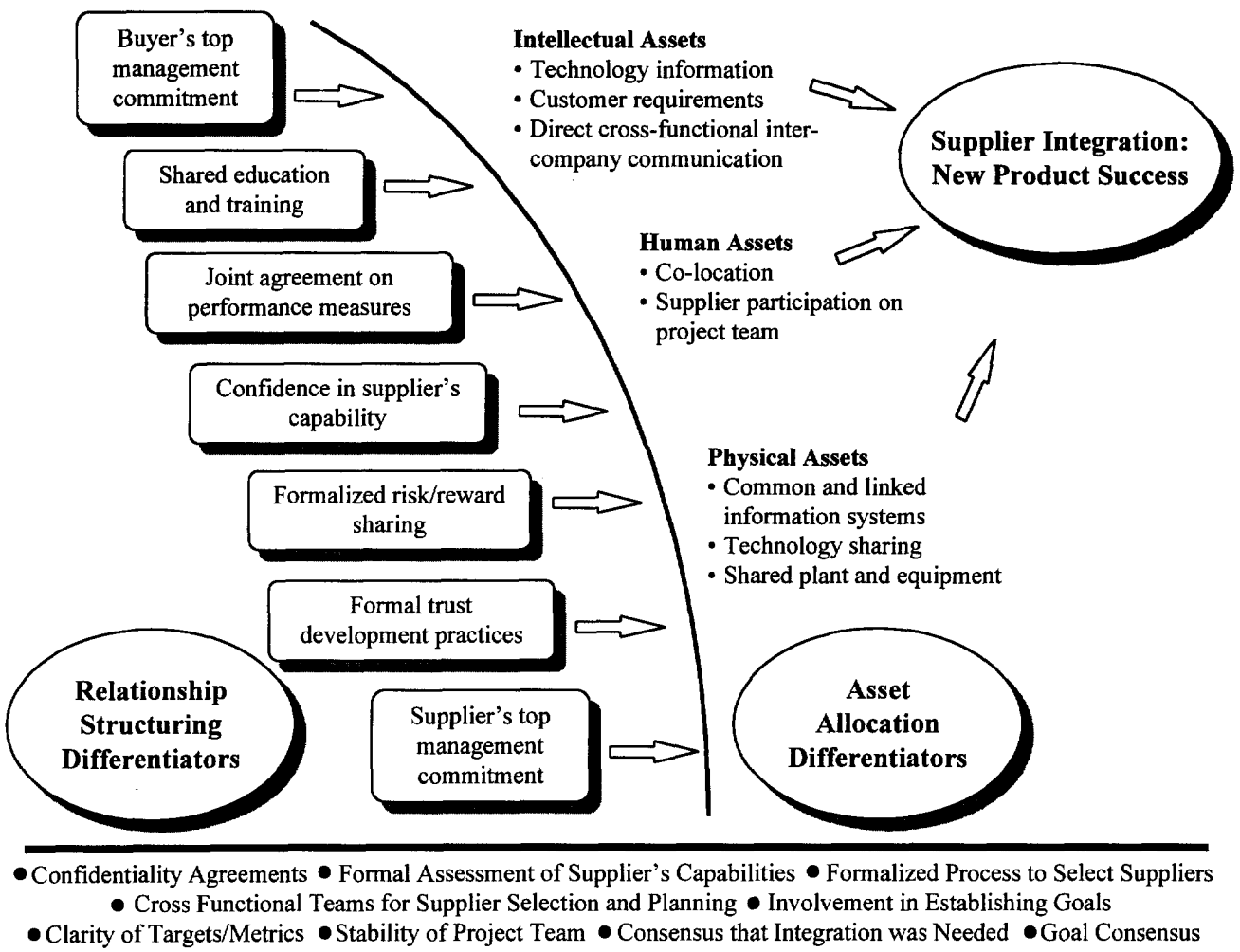

Figure 4. Explanatory model: Successful supplier integration into new product development.

detailed knowledge base to facilitate better decision-making and to see that customer requirements are met. Physical asset allocation ensures that the necessary technical tools and resources are available to both parties to perform coordinated design and development activities. Human asset allocation leads to interaction between buyer and supplier personnel, encouraging joint problem identification and resolution.

Another observation based on the data in Tables 2 and 3 is that a number of items earned relatively high scores in the most successful cases, but did not help in differentiating between most and least successful cases. One possible explanation for this result is that these factors form a necessary foundation for supplier integration which, if absent, would hinder the success of the effort but which, by its presence, does not necessarily guarantee success. For example, many of the respondents indicated that confidentiality agreements and formal supplier assessment and selection processes are "must do" practices. These ideas are depicted in Figure 4.

Conclusions

The responses to the Global Procurement and Supply Chain Benchmarking questionnaire regarding Supplier Integration Into New Product Development clearly indicate that supplier involvement in new product development is a strategically critical issue. It is also clear that the responding companies plan to integrate suppliers earlier and in greater depth in future new product development efforts to generate new ideas, develop and apply new technologies, reduce cycle times, improve quality, and reduce costs.

Supplier integration has led to significant performance improvements and competitive advantages for the firms in this study, though not all integration efforts are successful. Specific management practices and environmental factors were found to differentiate the most and least successful integration efforts, and were categorized into two interrelated sets: relationship structuring practices and asset allocation practices. A number of practices were extensively used by the companies but were not found to be statistically significant differentiators. These may be required practices which form the foundation for the use of key differentiators, or they may simply be widely accepted practices that are implemented because the "conventional wisdom" dictates it. Further research is required to explain the role(s) of these factors.

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