Involving Suppliers in New Product Development

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Within the last decade, the rapid rate of technological change, shortened product life cycles, and globalization of markets have resulted in renewed executive focus on new product development processes. In a competitive environment, suppliers are an increasingly important resource for manufacturers. Across all worldwide manufacturers, purchased materials account for over 50 percent of the cost of goods sold. In addition, suppliers have a large and direct impact on the cost, quality, technology, and time-to-market of new products. Effective integration of suppliers into the product value/supply chain will be a key factor for manufacturers in achieving the improvements necessary to remain competitive. As integration increases, joint resource dedication will follow. For instance, it is now commonplace for companies to dedicate engineers who learn the systems, procedures, and processes of suppliers in order to improve communication, reduce errors, and understand capabilities.[1] Many companies have recognized that involving suppliers in new product/process/service development efforts has the potential to provide significant results.[2] A number of reports in the popular press have highlighted the fact that supplier participation in product development projects can help reduce cost, reduce concept-to-customer development time, improve quality, and provide innovative technologies that can help capture market share. For instance, in developing its compact sedans (the Chrysler Cirrus and Dodge Stratus), Chrysler Corporation presourced 95 percent of the parts required for

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production. Chrysler used a team approach and chose the suppliers before the parts were even designed, which meant virtually eliminating traditional supplier bidding.[3] The results of this effort included significant reductions in cost, quality improvements, and innovative new designs. While such results typically go undisputed, there is mounting evidence that not all such efforts are successful.

Moreover, successful supplier integration involves a large number of variables. Questions that arise include tier structure, degree of responsibility for design, specific responsibilities in the requirement setting process, when to involve suppliers in the process, inter-company communication, intellectual property agreements, supplier membership on the project team, and alignment of organizational objectives with regard to outcomes. While the benefits of supplier integration appear to be obvious, successful supplier integration projects have special common characteristics. Specifically, successful supplier integration initiatives result in a *major change to the new product development process*. Further, the new process must be formally adapted by multiple functions within the organization to be successful. One of the most important activities in the new development process is understanding the focal suppliers' capabilities and design expertise, conducting a technology risk assessment, and weighing the risks against the probability of success.

This article presents a model of the product development process and the opportunities for supplier integration at various points of the process. This model is based on case studies of 17 manufacturing organizations and on results of a recent survey on supplier integration in 134 companies worldwide.

Prior Research

Several prior studies allude to the specific processes that occur when suppliers become involved in new product development. Kamath and Liker examine Japanese product development practices and identify a variety of roles that suppliers may play.[4] Littler, Leverick, and Bruce examined the key success factors for collaborative new product development efforts in 106 UK firms in which the collaborative partner could be a supplier, customer, or competitor.[5] They concluded that frequent inter-company communication, building trust, establishing partnership equity, ensuring that parties contribute as expected, and employing a product or collaboration champion increased the likelihood of success. There is evidence that the way firms organize their product development efforts has an impact on results. Larson and Gobeli found the project matrix and project team to be the most useful organizational structures for product development projects.[6] In their study of 108 cross-functional sourcing teams, Monczka and Trent identified a preliminary, yet strong link between formal supplier involvement and team performance, including teams responsible for new product development.[7] Smith and Reinertsen reached a similar conclusion, suggesting that "suppliers particularly need to be included as team members when the

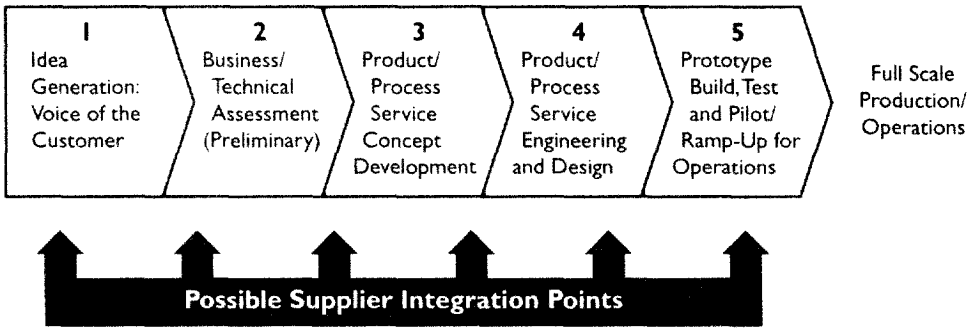
new product involves critical technologies in which the company is not expert."[8] Hartley, Meredith, McCutcheon, and Kamath found that the time of supplier involvement was significantly related to the perceived contribution to the new product design.[9]

A number of differences in supplier integration practices exist between companies in the U.S., Japan, and Europe. Clark[10] and Clark and Fujimoto[11] compared Japanese and U.S. manufacturers' use of suppliers in new product development and found that the contribution of suppliers to competitive advantage is especially critical in cases where R&D activities are shared. Several studies have also found that Japanese manufacturers made more extensive use of supplier involvement than American manufacturers.[12] A study by Liker, Kamath, Wasti, and Nagamachi found that the gaps between U.S. and Japanese automakers' use of supplier involvement in new product development has narrowed significantly.[13] However, the study found that Japanese automotive companies rely on target prices, performance monitoring, competition, and mutual dependence more than their U.S. counterparts to control suppliers entrusted with the design of complex auto systems. In general, all of these studies found performance improvement outcomes from supplier integration in the form of reduced cycle time, improved quality, greater technological improvements, and reduced costs.

A second body of literature emphasizes the importance of relationship development as a precursor to successful supplier involvement in new product development. Dyer and Ouchi suggest that the length of a buyer/supplier relationship has a positive effect on product development efforts.[14] 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. Kanter argues that a well-developed ability to create and sustain fruitful collaborations can provide significant advantage, especially in new product development ventures.[15] This research further concludes that North American companies, more than others throughout the world, take a narrow, opportunistic view of relationships between buyers and sellers. Slade concurs that collaboration can create competitive advantage by saying that "the supplier relationship is only one of the many aspects of management that contribute to a company's performance. But . . . the management of this relationship [is] of paramount importance to any company's success."[16] While the importance of supplier involvement is unarguable in these works, it is apparent that organizations still struggle with the fundamental changes to the new product development process that must occur to facilitate supplier integration. Some of the major questions that arise include:

- Which suppliers should be involved?
- Is the supplier able to meet our requirements?
- Is the supplier's technology roadmap aligned with our roadmap?

FIGURE 1. New Product Development Process



- Given the level of technical complexity, to what extent should the supplier be involved in the project?
- When exactly should the supplier be involved in the project?

Supplier Integration Approaches

The possible forms of supplier integration can be framed within the context of the "generic" new product development process shown in Figure 1. The new product development process is a series of interdependent and often overlapping stages during which a new product (or process or service) is brought from the "idea" stage to readiness for full-scale production or service delivery. As the product concept moves through these stages, the idea is refined and evaluated for business and technical feasibility, the design is firmed up, prototyping and testing are done, the design is finalized, and preparations for full-scale operations (e.g., tooling, layout, personnel, equipment) are finalized. During this process, cost, performance, timing, quality, and other problems often crop up, which results in tradeoffs and changes in the design. The design may be modified numerous times before it is finalized.

In the first stage (idea generation), designers and marketing personnel consider the need for the product and typically tap customers for their ideas and input on what such a product/process/service might do, how much it might cost, and so on. Potential technologies may also be assessed at this point, especially if an existing supplier possesses an exciting new technology. In the second stage, the team may perform a business assessment of the product, and also identify the technical solutions to the customer's requirements. In product and service design, tools such as Quality Function Deployment may be used to develop technical specifications that specifically address customer requirements. In the third stage of development, the product/process/service concept is effectively conceived, with performance specifications "frozen". In the case of product

development, a preliminary prototype model may be created for purposes of concept definition. Next, the actual development process begins, wherein designers from both the supplying and buying organizations create blueprints and design specifications. A working prototype is created, which enables testing and verification of existing production systems. Finally, the product enters full-scale production and supplier volumes are ramped up.

Outside suppliers provide materials and services that constitute a majority of the cost of many new products. In addition, suppliers may provide innovative product or process technologies that are critical to the development effort. The supplier may have better information or greater expertise regarding these technologies than the buying company's design personnel. Supplier input and/or the active involvement of suppliers may be sought at any point in the development process (see Figure 1).

While the concept and design engineering phases of new product development incur a relatively small portion of the total product development costs, these two activities commit or "lock in" as much as 80 percent of the total cost of the product. Decisions made early in the design process have a significant impact on the resulting product quality, cycle time, and cost. 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.

The NSF/MSU Supplier Integration Research Project

This study was part of a larger project funded by the National Science Foundation and 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. Based on a preliminary model developed by Sussman and Dean[17] specifying methods of integrating internal cross-functional team members into new product development, the researchers carried out seventeen field studies in the U.S. and Japan to validate and verify the model. To further enhance the validity of the discussions, documentation of purchasing policies were obtained at each site when possible, as well as organization charts, product descriptions, marketing reports, and so on. Following each interview, the field notes were written up in typeface. The next step involved coding this data.[18] The transcribed field notes were reviewed several times by the researchers in order to code the events into their appropriate categories (consistent with an a priori conceptual model developed by Sussman and Dean) and to compare field notes taken during the same interview. In so doing, the events and processes observed at each site were

classified according to the conceptual structure they described. The resulting process model of supplier integration is shown in Figure 2.

Concurrently, a survey was developed, which was pre-tested and reviewed by a team of industry experts and a team of academics from organizational behavior, marketing, operations management, and purchasing. An initial 2 page commitment letter and fax response form was mailed to approximately 3000 companies in 18 countries around the world, and of these 225 indicated that they would be willing to participate.[19] Surveys were mailed to the 225 companies, and 134 responses were received. The responding companies represented a wide range of industry groups, including aerospace (12), automotive (24), chemicals (11), computers and electronics (19), consumer products (18), Industrial equipment (20), medical products and services (6), process industries (10), telecommunications (9), and government services (6). About 12.5% of the responses came from non-manufacturing organizations. The companies' 1996 sales (in U.S. dollars) ranged from $3 million to $160 billion with a median of $3.1 billion. A majority of the responses (68%) came from U.S. and Canadian companies. Just over 20% of the responses came from Western Europe, 7% from Asia/Australia, and 4% from South America.

A five-stage New Product Development 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.

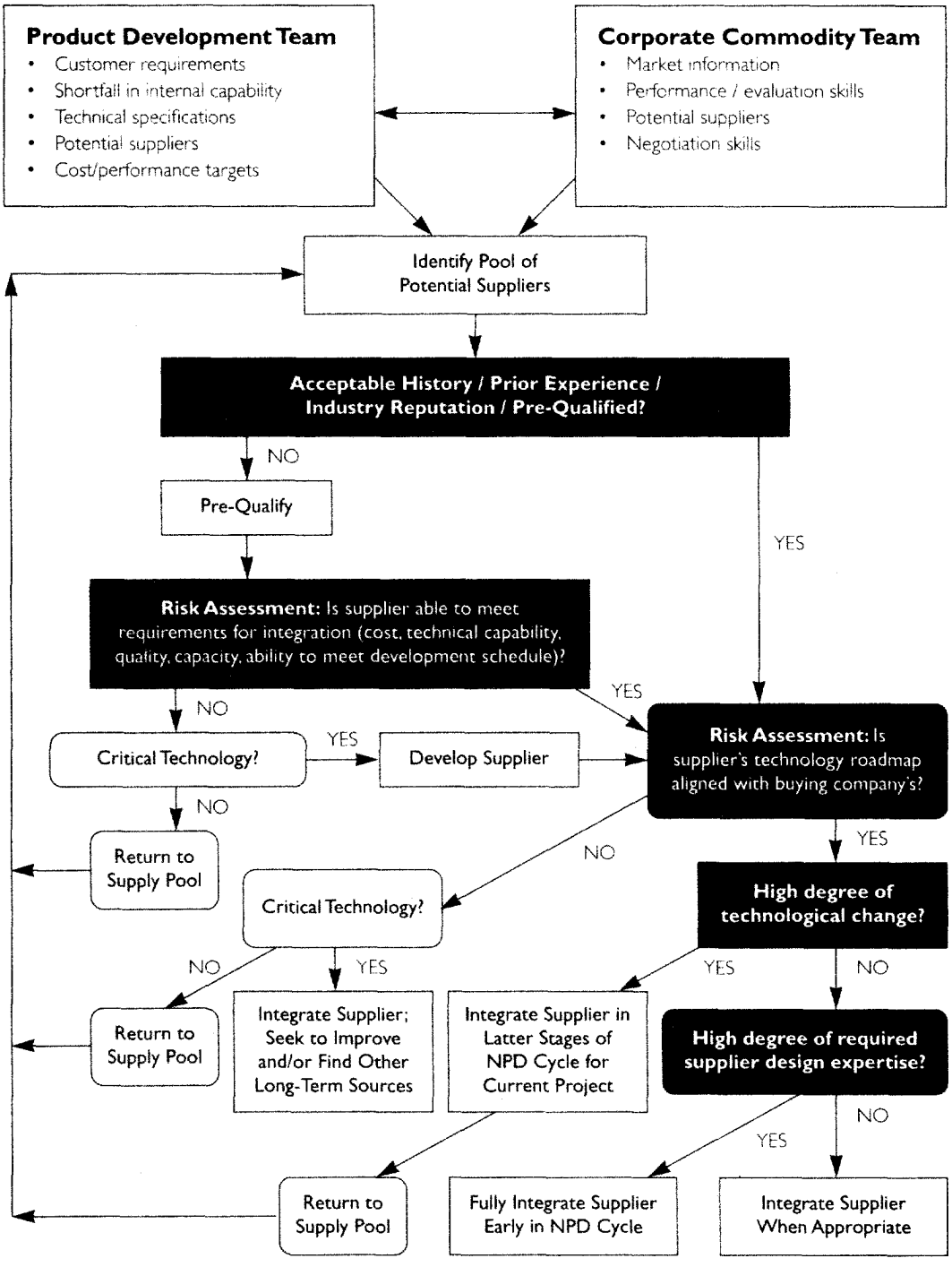
"Supplier integration into new product/process/service development suggests that suppliers are providing information and directly participating in decision making for purchases used in the new product/process/service. This integration can occur at any point in the five stage new product/process/service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

The survey was divided into two major sections. The first section addressed questions related to the organization's overall strategy and experience with supplier integration. The second section asked the respondent to limit their responses to a single supplier integration experience. Both sets of responses were used to derive the results discussed in this study.

In addition, companies whose development plans are well aligned with those of their key suppliers can shorten overall development time.

Based on a detailed analysis of our case studies, we developed a process model of supplier integration shown in Figure 2. This model was developed after reviewing a number of companies' supplier integration processes and compiling their best practices into a generic process model. Additional insights into

FIGURE 2. Process Model for Reaching Consensus on Suppliers to Integrate into New Product Development Project



company practices at various stages of the model are provided in the form of summary statistics from our mail survey results.

Identifying Desired Supplier Capabilities and Potential Suppliers

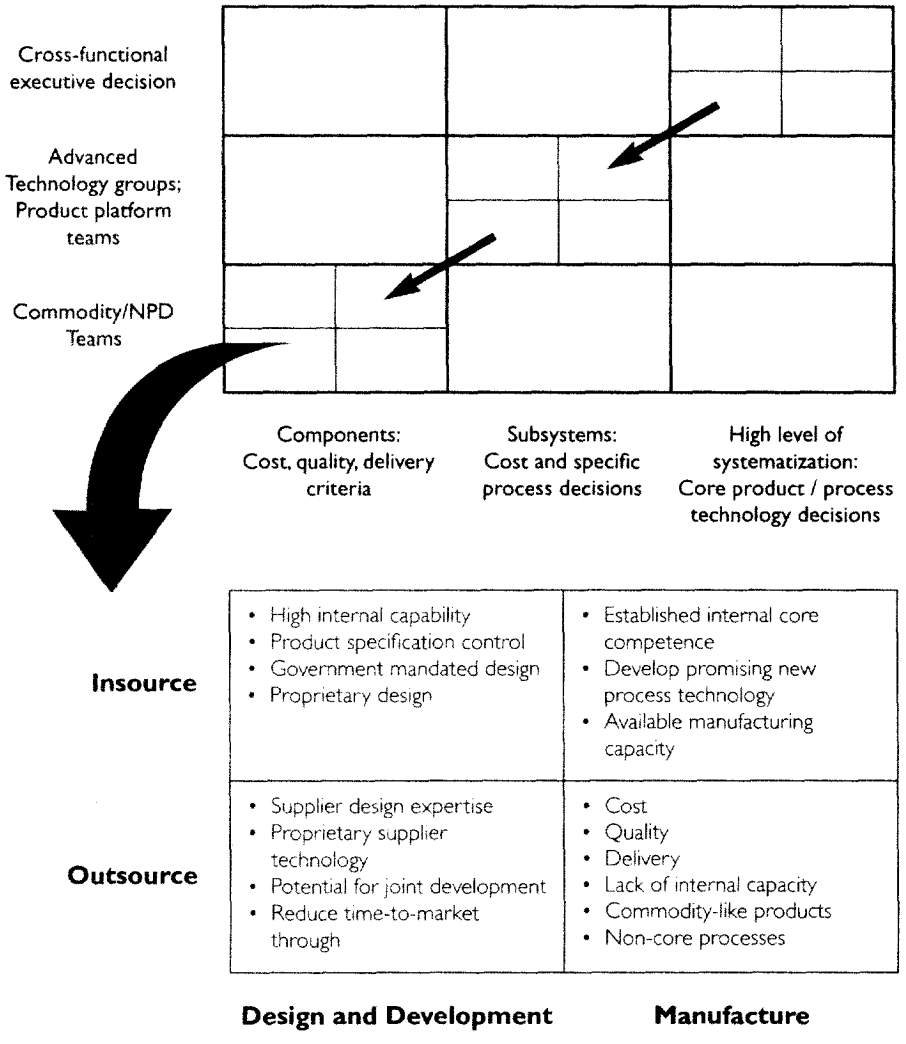
In all the companies studied, the importance of the design/manufacturing decision is being subjected to a much more thorough analysis than in the past. An important initial decision involves a formal statement on the level of insourcing/outsourcing that will occur in core technology development. In reaching a consensus on difficult insourcing/outsourcing decisions, successful organizations have developed a *systematic process* for defining the level and types of product/process technologies to be outsourced. Whenever possible, companies are approaching the outsourcing decision from a systems perspective and are asking suppliers to increase their responsibility for subsystem integration. This was observed to be the case across a variety of products and processes, including chemical molecules, automobiles, installation and maintenance of new processes, and computer components.

The decision-making process begins at a high systemization level, where strategic core competencies in product and process design and manufacture are assessed (see Figure 3). At this level, the unit of analysis involves decisions regarding core technologies, system integration, and return on investment for resource allocations leading to internal technology development. Our study revealed a trend towards outsourcing commodity-like items and focusing internal efforts on added-value activities such as system integration. In all of the companies, this decision was made at higher levels in the organization and involved a strategic vision regarding the organization's future markets and technology roadmap in the next ten to twenty years.

Most of the supplier integration cases reported in our survey involved the supplier of either a customized product component or a product sub-assembly, sub-system, or system. Several cases also dealt with suppliers of materials, process technology, or capital equipment. A few cases dealt with suppliers of services or commodity-type components.

Once consensus is reached, executives formalize the insourcing/outsourcing technology strategy and communicate it to the divisions, who are then responsible for establishing current and future new product requirements. The process of cascading the decision to the next organizational decision-making level is achieved through a variety of means. One of the prevailing organizational structures to interpret and deploy technology strategies is the advanced technology group. These groups are typically located centrally and are assigned the task of identifying major new subsystem and component technologies required in new products. Another approach involves integration of suppliers into process development and start-up. Some companies use institutionalized "platform teams," responsible for new product development with suppliers on a permanent basis. Finally, other divisions employ a "letter of intent" that formally specifies the nature of the relationship. Note that the decision making at this

FIGURE 3. Insourcing/Outsourcing Decision



stage is typically done by product development teams, which use the executive core competence vision as a guide.

The final insourcing/outsourcing decision-making hierarchy occurs at the component level, where decisions are typically made jointly by the product development and purchasing commodity teams (see Figure 3). Purchasing is responsible at this level for identifying leading suppliers within a commodity class and sharing this information with the commodity team. In some cases, however, the decision may be made independent of a commodity team.

After completing this initial stage of the strategic process, teams should have identified a vision statement regarding the company's internal core competencies, established a set of requirements for success in current and future new products, and have a general idea of the technology needs within these product groups. In addition, the company should have a general idea of the specific roles and responsibilities it wishes to place on suppliers that are selected for new product development. Product development and commodity teams should seek to formally specify these objectives in as much detail as possible. As shown in the next three stages in Figure 2, they become the primary criteria used in supplier selection, negotiation, alignment, and relationship management.

A number of case examples illustrate this process. At a major manufacturer of printers and faxes in Japan, the primary metric used to drive all supplier integration projects is target cost. For example, a target cost for a fax machine was first developed based on marketing's input and was broken down into different categories of parts based on historical costs. The mechanical parts target cost was broken down into a target cost for all metal parts, of which about 90% were within the scope of the single metal parts supplier's production capability. This target cost was submitted to suppliers. Suppliers share their cost data with engineers, and provide information on labor, overhead, and material costs. To achieve the target cost, changes in processes and changes in materials are discussed first (avoiding the topic of profit margins). If the supplier still cannot meet the target cost, the company initiates negotiation of profit margins based on volume considerations.

Other considerations that may influence the decision to integrate suppliers include a lack of internal design capability and the need to develop a non-core technology. For example, a major electronics components manufacturer relies extensively on its suppliers to deliver state-of-the-art process technology that it cannot develop internally. The key strategy within this organization involves holding suppliers responsible for delivering, installing, servicing, and maintaining machine tools costing well over one million dollars each. Suppliers are responsible for process ramp-up and maintenance of equipment in wafer fabrication facilities. While the company is also involved in supplier integration into new product development, process integration represents a truly unique application in a non-traditional area. Suppliers are first fully responsible for the maintenance of these machine tools and the maintenance tasks are then gradually turned over to internal people. Each supplier is responsible for a single process, which is identically carried out at its three facilities in different parts of the world. The company emphasized the exact replication of processes across all of the facilities—this principle is emphasized throughout all of its business strategies. The principle refers to the fact that any time a specification or task is transferred between functions or suppliers, the other party is responsible for exactly reproducing the requirements.

In another case, a company's core competency is considered to be an overriding factor. A chemical manufacturer considered portions of molecules

as building blocks in assessing supplier competence. The company's strategy was to accelerate the rate of new product development by focusing on fewer compounds annually and integrating suppliers who have proven capabilities and can perform multiple steps in the intermediate product process. Instead of asking suppliers to supply basic elements only, they are actively asking suppliers how to make the intermediate molecules with the final molecules in mind. This involved showing them a bigger picture (not just a small piece of the process), posing the question more broadly, and getting the supplier to perform a greater share of the process. Supplier integration was facilitated by having broader secrecy agreements to cover more issues as the supplier gains access to more pieces of the molecule puzzle. In some cases, the company even licensed parts of molecules from university research centers. The strategy driving this integration was to push increasingly higher up the compound chain, becoming more of an "assembler" of the final compound or molecule.

Supplier Risk Assessment

Once the product development/commodity team has reached consensus on the key objectives for integrating suppliers, a set of specific performance measures related to customers' needs and requirements should be used to reach a consensus on potential supplier capabilities and subsequent selection. Cost, quality, and delivery are, of course, relevant, but evaluating suppliers for potential integration into new product development should involve criteria beyond those used to evaluate ordinary material/service suppliers. Based on the experience of the companies studied, the following elements are likely to be important in considering new or existing suppliers for integration:

- *Targets*—Is the supplier capable of hitting affordable targets regarding cost, quality, and product performance/function (e.g., weight, size, speed)?
- *Timing*—Will the supplier be able to meet the product development schedule?
- *Ramp-Up*—Will the supplier be able to increase capacity and production fast enough to meet volume production requirements?
- *Innovation and Technical*—Does the supplier have the required engineering expertise and physical facilities to develop an adequate design, manufacture it, and solve problems when they occur?
- *Training*—Do the supplier's key personnel have the required training to start-up required processes and debug them?

All of the above criteria must be tied into the evaluation/measurement system in order to develop a comprehensive *risk assessment* that answers the following questions:

- What is the likelihood that this supplier has the ability to bring the product to market?
- How does this risk compare to other potential suppliers (if there are others)?

- At what point are we willing to reverse this decision if we proceed, and what are the criteria/measures for doing so?
- What is the contingency plan that takes effect in the event the supplier fails to perform?

It is no longer enough that a supplier be able to design and manufacture a prototype or start-up small volume production. Because of the intense competition and short product life cycles in many industries (such as electronics and computers), suppliers must also be able to meet product introduction deadlines *and* ramp-up their production volumes very quickly. Several of the companies we studied assessed these criteria through a variety of means.

A good example of a commodity team in action involved a U.S. computer manufacturer team negotiation with a European supplier, who was selected after ten suppliers presented their design for a new project. The presentations were formally evaluated quantitatively by the commodity team. During the course of the selected supplier's presentation, the team found it could satisfy its requirements with an "off-the-shelf" chip set from the supplier. The team also visited selected supplier facilities, and the supplier deployed a dedicated engineering team over the course of the project. The commodity team also works in parallel with other commodity teams on the product development group. A key element in the structure of the teams in this company is that it is not a one-hundred percent engineering-led process, even though engineering has traditionally dominated decisions. The new vision is to retain a core set of knowledge to respond to end-customer needs and develop more interfaces with suppliers to identify which technologies can meet these requirements. The company cannot afford to be "shut out" of a new technology, so the group must constantly be transferring knowledge from a variety of sources, including customer requirements, after-market efforts (where new technologies often show up first), trade shows, competitive assessments, and alliances.

For another company (a U.S. computer manufacturer), the supplier's capacity and flexibility are critical issues, and the team will examine what kind of agreements the supplier has with their contract manufacturers and how they affect the supplier's ability to increase output quickly. The supplier must have upside flexibility requirements amounting to:

- 25 percent up in 4 weeks
- 50 percent up in 8 weeks
- 100 percent up in 12 weeks

A U.S. computer peripherals manufacturer faces the problem of having a very limited number of potential suppliers of several of its key components, worldwide. Because of the small number of suppliers, however, the company has done business with most of them and has experience with their capabilities. Supplier selection is based primarily on the supplier's capability to design and manufacture the product in large volumes to performance specifications within the required time.

TABLE 1. Company Objectives for Supplier Integration

Objective	Importance of Objective[a]	Effect of Supplier Integration on Achieving Objective[b]
Reduce design or development time	5.83	5.43
Reduce procured item cost	5.76	5.27
Improved procured item quality	5.70	5.49
Improve procured item reliability/durability	5.65	5.45
Reduce design and development cost	5.45	5.23
Access and improve product technology	5.27	5.20
Develop a long term supplier relationship	5.26	5.45
Improve product features	5.21	5.32
More effectively use human resources at my business unit and at the supplier	5.18	5.31
Improve customer service	5.02	4.98
Reduce technological risk	4.89	5.12
Reduce financial risk	4.78	4.83
Access and improve process technology	4.74	4.87
Improve my business unit's position as a preferred customer to the supplier	4.59	5.19
Comply with environmental regulations	3.88	4.61
Comply with other government regulations	3.77	4.64

a. 1="Totally Unimportant" to 7="Very Important"
b. 1="Strong Negative (Bad) Effect" to 7="Strong Positive (Good) Effect"

At another U.S. computer company, in the first stage of the new product development process (definition and planning), material support involves selection of a technology given the requirements of the product. Once this is complete, corporate materials can come up with a potential list of suppliers. If the supplier is new to the company, the supplier will first perform a self-assessment survey. Then the team will visit for several days and examines eight separate modules (including quality systems, control, reliability, financial analysis) and arrive at a performance score.

In our survey, respondents were asked to indicate the importance of various objectives related to integrating the supplier in this product development effort and also rate the impact that supplier integration had on achieving that objective. The objectives that emerged as most important to the companies are consistent with the competitive/strategic factors that are driving supplier integration (see Table 1). Further, the respondents believed that supplier integration had a positive impact on all of the objectives.

One other result is of interest. For the four objectives on which supplier integration had the least positive impact (financial risk, process technology, environmental regulations, and other government regulations), approximately ten percent of the respondents indicated that supplier integration actually had a negative effect on the objective. For the other objectives, no more than five percent of the respondents reported a negative impact. This suggests that in some cases, supplier integration efforts may not always result in successful outcomes.

In cases when the supplier's capabilities may not be up to desired levels, the product/commodity team has one of two options. If the technology is not critical to the product's functioning, a different supplier may be investigated. However, if there are limited numbers of suppliers available and the technology is critical to the product, than a more detailed technical assessment of the supplier may take place in an attempt to develop and improve the suppliers' capabilities early in the product development process.

Several of the companies carried out detailed assessments of the supplier's technical capabilities prior to selecting them for a new product development project. In most cases, both formal and informal approaches were required to develop a reliable assessment. A typical approach would start with a formal standard survey-type assessment, which would be augmented by informal assessments by internal engineer's assessments, based on face-to-face discussions with the supplier's technical personnel. The most detailed technical assessments considered both of these inputs, as informal discussions can often reveal problems that may not be obvious to an external uninformed party.

A good example of how this decision is made involved a component supplier who made lead frames and overmolding for a U.S. semiconductor manufacturer. Although the company had the capabilities internally, they chose to team up with the supplier to produce them after an insourcing/outsourcing decision was made by the product team (consisting of engineering, design, quality, marketing, and procurement). The outsourcing decision was made because the internal process could not meet the quality requirements (0-6 ppm required by the customer). After requiring the product and process FMEAs and control plans from the supplier and observing their capabilities, the supplier was selected. Next, the team was expanded to include the supplier to determine if they could meet the customer's requirements. Once it was established that they possessed the capability, the supplier became a full-time member of the team.

Suppliers involved early in a U.S. oil and chemical company's development efforts are evaluated using a number of criteria in a "Total Cost of Ownership" type of model that considers:

- reputation for meeting requirements
- cost/availability of raw materials
- difficulty of the process matched against the supplier's capability
- waste generated in the supplier's process

- number of steps required of the supplier
- environmental compliance
- technical competence

The choice of supplier is a decision made by the whole team, but not everyone on the team necessarily gets directly involved. A smaller group within the commercialization team may make a recommendation. Following the recommendation, the company audits the supplier's facilities for contamination, environmental compliance, quality, technical capability, cost, quality, and location—all of which are weighted (weights vary by commodity).

Assessing the Supplier's Technology Roadmap

After a detailed performance assessment has been carried out prior to selection, a second type of assessment must be carried out to ensure the long- and short-term alignment of the objectives and technology plans of the buying company and the supplier. To obtain maximum strategic benefit from the integration of the supplier, both parties must share objectives and have complementary future technology plans. This is most commonly described in terms of a convergence of the companies' technology "roadmaps," which describe the performance, cost, and technology characteristics of future products each company plans to develop/introduce over some specified time horizon.

The specific approaches companies use to assess and achieve alignment of technology roadmaps with suppliers varies considerably. Regardless of the specific approach, sharing information is one critical element of the process. A second important element is providing some incentive or motivation for suppliers to work at alignment with the buying company.

This is reflected in the importance of Supplier Selection Criteria for Supplier Integration (see Table 2). As shown in this table, the criteria for selecting suppliers for integration which are most critical include "soft" elements, such as product/process knowledge, production capability, trust, and design expertise. Prior to establishing the relationship, managers from both organizations should meet and engage in a frank discussion of the types of technologies that they intend to develop. As organizations seek to improve the technological capabilities of their supply base, they will need to first build stronger relationships with suppliers, which involve sharing future product plans and alignment of technology roadmaps. In turn, suppliers may need to adjust their technological plans to align them with those of major customers. As this exchange of information takes place, industry standards may be influenced. This will require an intimate understanding of not only current suppliers' capabilities, but a commitment and willingness to trust the other party.

At the same time, buying companies must maintain a competitive edge and be aware of potential new suppliers and technologies that emerge on the horizon. Organizations may need to create separate organizational groups within the business responsible for advanced technology development and expertise.

TABLE 2. Supplier Selection Criteria for Supplier Integration

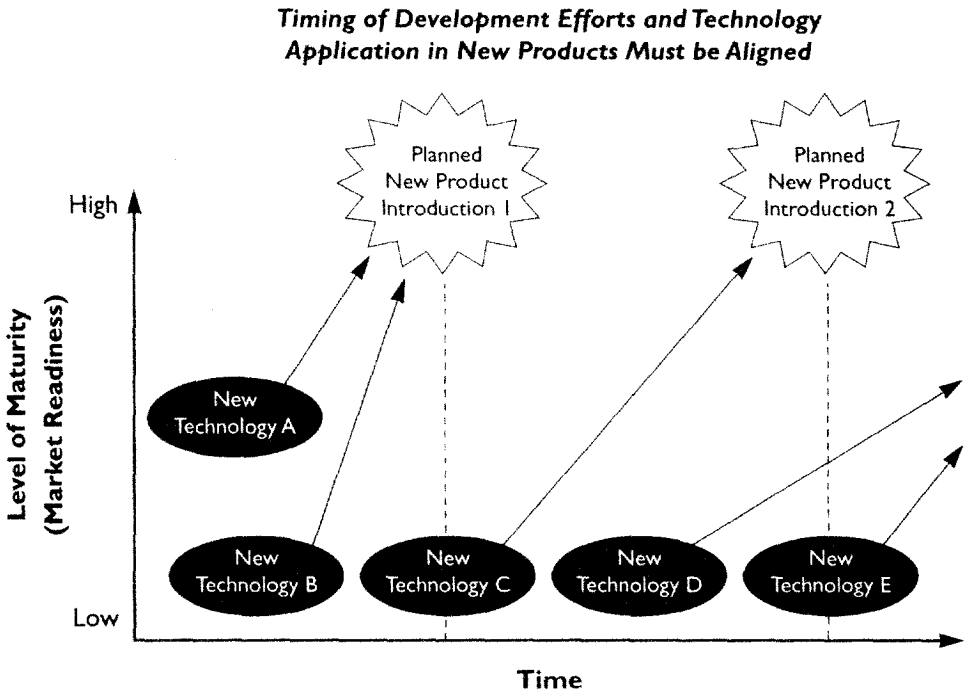
Objective	Mean Response[a]
Supplier's product/service knowledge/capability	6.07
Supplier's process knowledge/capability	6.00
Supplier's production quality capability/certification	5.85
High level of trust between my business unit and the supplier	5.80
Supplier's design expertise	5.76
Supplier's willingness and ability to communicate effectively	5.65
Supplier's innovativeness	5.62
Supplier's flexibility to respond to design changes	5.60
Supplier's commitment to continuous improvement	5.42
Supplier's expertise in reducing/controlling cost	5.36
Supplier's flexibility to respond to requirements volume changes	5.35
Previous experience with supplier	5.34
Supplier's ability to quickly ramp-up to required output level	5.21
Supplier's ability to develop new technologies for *future* products	5.15
Supplier is fully certified by business unit	4.84
Supplier's goals are aligned with my business unit's goals	4.80
Supplier's culture is compatible with my business unit's culture	4.59
Supplier's use of concurrent development/engineering practices	4.51
Supplier's use of JIT manufacturing and purchasing	3.92
Supplier's geographical proximity to my business unit	3.5

a. 1="Totally Unimportant" to 7="Very Important"

These groups will need to continuously monitor competitors' products, processes, and supply bases and will need to suggest modifications to current sourcing strategies. In some cases, joint technology development with suppliers may yield substantive results, providing that appropriate targets can be set. This must occur on a global basis, scouring the world for the best suppliers. (As shown in Table 2, geographical proximity is one of the least important factors influencing the choice of supplier for integration).

Many companies attempt to manage and obtain the best technologies for application by developing a "bookshelf" of current and emerging technologies and suppliers of those technologies. These companies monitor the development of new technologies and, for those that appear to have promising applications, manage their introduction in new product applications so as to balance the benefits of "first mover" status with the risks of the technology. The objective is to maintain a selection of promising and accessible technologies and suppliers on the bookshelf, ready for use when the company wants to apply them in a new product application. The company must understand, influence, and possibly

FIGURE 4. Managing Product and Technology Development



manage the development time of technologies so that they will be available when needed (see Figure 4).

At a U.S. electronics company we studied, the company's most successful supplier integration project was initiated by an engineer in the buying company. The engineer thought he saw synergies in the capabilities of his company and a supplier and began talking informally with a counterpart in the supplier company. This led to a high-level meeting between executives from the two companies. At this meeting, supplier executives shared technology plans and roadmaps, and they identified common research streams in a very broad category of materials. An executive consensus was reached regarding what the buying company wanted to work on to support the next product or product family. A "top four" list of projects was targeted directly to future product needs (both short-term and long-term.) This relationship has now become institutionalized, with the two companies meeting periodically to share their roadmaps and update the top-four project list.

Another Japanese computer company shares technology roadmaps with specific suppliers, based on non-disclosure agreements that are part of a broad general agreement with the supplier. Suppliers also share their technology roadmaps. Both parties may change their designs based on future roadmap

directions. A chip supplier may include specific features for unique customers in what may become a future standard chip design. Only trusted suppliers who currently supply significant volumes are provided with general information on future products.

A different type of roadmap sharing is done by a Japanese electronics company which isn't sure where needed technology developments are most likely to occur. In select cases, internal development groups will share early information about future technology roadmaps with just about any global supplier who will listen in an attempt to ensure that the required technology will eventually be available. For instance, in one commodity, the manager has established a technology map with performance curves and expected target dates. The target area (known as the "sweet spot") is shared with multiple suppliers. Suppliers are told that if they can't hit the "sweet spot" by the target date, they won't get the business. This concept is somewhat different to conventional early involvement wisdom. Because of the volatility of this industry, the company does not have the time or the need to form alliances and go through an early involvement program. Rather, the strategy is to make sure the technology is available by openly sharing technology roadmaps with any qualified supplier who will listen and moving the business around to take advantage of performance at the target price.

Assessing the Rate of Technological Change

Assuming that the buying company can establish that the supplier's technology roadmap is aligned with its own, another important factor to consider is the rate of change in product technology. The current rate of technological change is challenging many companies' capabilities, and they are seeking the help of suppliers with the development and application of critical but non-core technologies in their new products. For instance, the life cycle of some products such as computers is less than three months. One computer manufacturer in the U.S. mentioned that this is the single most important reason for integrating suppliers. Because of the need to quickly bring new products to market, this manufacturer actually skips the prototype stage and goes directly from development to full production.

Although supplier integration is a useful tool for managing the quick pace of technological change, it also represents a double-edged sword. If a particular technology is changing rapidly, then involving the supplier early has potential pitfalls. The buying company may become "locked into" a particular design or technology, release the product, and discover that the technology has now become obsolete or has been replaced by a technology with improved performance characteristics.

Across all of the companies, a large majority of the cases reported dealt with suppliers who were integrated into the development project starting in one of the first three stages of development (see Table 3).

TABLE 3. Breakdown of Sample Integration Efforts by Stage at which Supplier was First Integrated

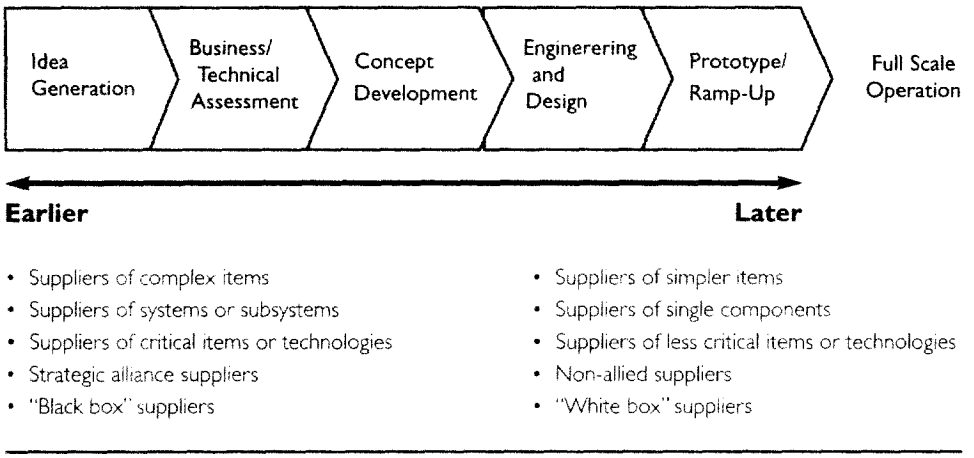
Stage		Number (Percent) of Responses
One:	Idea generation	28 (23.1%)
Two:	Preliminary business/technical assessment	27 (22.3%)
Three:	Product/process/service concept development	45 (37.2%)
Four:	Product/process/service development, engineering, design and/or creation	18 (14.9%)
Five:	Prototype development build, test and pilot/ramp up for operations	3 (2.5%)

Overall, there are two major factors that should be considered in deciding when to integrate the supplier into the product development process: the rate of change of the technology and the level of supplier expertise in the given technology. If the technology is undergoing a significant amount of technological change, it should be delayed in the product development cycle. Second, if a supplier's design expertise is significant and their technology experts can provide key insights that are instrumental to crafting the new product, they should be included early on in the process (see Figure 5).

Our field studies suggest that certain types of suppliers are more likely to be integrated earlier. At a Japanese computer manufacturer, for instance, the extent of interaction that takes place between product development engineers and suppliers appears to depend on the volatility of the commodity technology. Suppliers of critical nonstandard commodities are involved much earlier in the product development initiative. These suppliers are involved in face-to-face discussions with engineers on a regular basis. On the other hand, suppliers of non-critical, standard items are not integrated until the final stages of the development cycle, and communication appears to occur more in the form of computerization (i.e., CAD is used with non-critical items such as PCBs, keyboards, and chassis). In general, face-to-face discussions are quicker and information can be exchanged more effectively. However, because suppliers are located within a day's travel to the operating divisions, co-location is often unnecessary.

At another U.S. electronics manufacturer, the level of involvement of the supplier may vary. To get a good quote, the supplier must be brought in early and sit in on the customer negotiation meeting. A supplier could be both an internal or an external party (i.e., fabricate both parts and processes.) The company typically relies on suppliers for their process technology, not their product technology (i.e., they are involved in bringing in new processes that are not internal areas of expertise.) This was done because suppliers often understand the total design earlier and how they can influence the design. In this case,

FIGURE 5. Integrate Suppliers at Different Stages



the functional specifications are defined and they work with the company to jointly ensure they are met.

One of the companies studied uses supplier-provided technologies extensively in its new products and has established an "Advanced Technology Group" that is charged with managing the development and adoption of new technologies for the company's products. The Advanced Technology Group monitors the supply market for new technologies and also takes a proactive role in developing technologies called for by the company's product line teams. This company has also implemented what it calls a "window of technology" process to help improve its access to new or developing technologies. The process provides a single point of contact in the company for a supplier who wants to propose a new technology or new product idea to the company. The supplier's idea gets a fair hearing, but the information is handled confidentially by the Advanced Technology Group, so the idea is protected. If the company is interested in the idea, it may commit to specific volume with the supplier or may work with the supplier to develop the technology further.

Another U.S. electronics company has an on-going partnership with a supplier for development of new technologies that leverages the core competencies of each firm. Periodic meetings are held to discuss ideas for advanced technology development projects and to jointly select a set of future projects to pursue, based on such things as applications potential and resources required. The companies try to have a set number of projects underway at all times. At least one project is under way in each of three categories: "blue-sky" technologies, rapidly emerging technologies, and "maturing" technologies. As one project is completed—or terminated—the firms select a replacement from the queue.

In sharing roadmaps, it must be recognized that supplier involvement in new product development can have impacts, both positive and negative on technology risk/uncertainty:

Positive

- The supplier may have greater experience or expertise with the technology and, as a result, may have better information about where the technology can be successfully applied.
- Some (or all) of the technological risk may be taken on by the supplier.
- The buying firm may have some ability to influence the direction of the supplier's R&D efforts in order to match developing technologies with the buying firm's technology strategy.
- If a closer relationship between the buying company and the supplier develops as a result of supplier involvement, the supplier may be more willing to share information about its new/emerging technologies with the buying company.

Negative

- Involvement with a supplier may have a tendency to lock the buying company in to the supplier and its technologies. This makes initial selection of the supplier a more critical issue, as the buying company needs to anticipate whether the supplier will remain a technology leader.
- A supplier with "inside track" may not have as much incentive to innovate, slowing the pace of technological advancement. The buying company must find a way to make sure it is getting the supplier's best efforts.

One company has found that second tier raw material suppliers are often the technology leaders in its industry, rather than the first tier suppliers who process the raw material. Thus, the company is trying to get raw material suppliers involved in it development process. Often, to achieve this involvement, the company must make early commitment of its business. This is a risky proposition because some of the technologies are changing rapidly.

One U.S. company we studied uses a coding system to describe the maturity level of various technologies it is using or considering. Each is designated as a green, amber, or red dot technology:

- *Green dots*—well-known technologies that are internally developed and perfected
- *Amber dots*—not well known
- *Red dots*—brand new technology (high failure rates)

The company avoids using red dot technologies in new products, and tries to minimize the use of amber dot technologies.

TABLE 4. Overall Performance Improvements Achieved Through Supplier Integration[a]

Performance Dimension	Median % Improvement	Range[b]
Purchased Material Cost (n=71)[c]	15.0%	2.6%–50.0%
Purchased Material Quality (n=52)	20.0%	2.0%–50.0%
Development Time (n=65)	20.0%	5.0%–50.0%
Development Cost (n=54)	15.0%	–1.0%–50.0%
Functionality/Features/Technology (n=53)	10.0%	5.0%–50.0%
Product Manufacturing Cost (n=49)	10.0%	0.0%–30.0%

a. Compared to similar projects in which a supplier was not integrated.
b. 80% of the companies' responses fall in this range — top and bottom 10% omitted.
c. Not all companies reported results on all dimensions.

Conclusions and Future Plans for Supplier Integration

The companies in our sample have a median of 6 years of experience integrating suppliers into new product development. They indicated that they expect to increase their use of supplier integration in the future and that they expect to involve suppliers *earlier* in the development process than they do now. Respondents were asked to characterize the success of the specific supplier integration effort as well as the success of the overall development project in which the supplier was involved. On average, the respondents considered both the supplier integration effort and the overall development project to have been fairly successful.

Results of the survey show that the responding companies achieved significant improvements in project results when suppliers participated, compared to similar new product development projects in which suppliers were *not* involved (see Table 4). These results reveal the potential benefits from involving suppliers in new product development efforts and demonstrate an important competitive advantage for companies that can manage this integration successfully.

Although this is not surprising, the results also indicated companies' level of satisfaction with their supplier integration efforts was quite varied. *Not all companies reported a high degree of satisfaction with the results of their supplier integration efforts.* Moreover, only 20% of the respondents agreed with the statement: "We are currently satisfied with the results of our supplier integration efforts." Over 45% percent disagreed with the above statement. Despite these mixed results, respondents are committed to supplier integration and their expectations for the future are that supplier integration will continue to be important. This is indicated by the fact that over 70% of respondents agreed with the statement: "Expectations about the results to be achieved from supplier integration with increase significantly." Together, these results seem to indicate that many companies realize the importance of supplier integration but have not yet discovered

the means to successfully implement it. In some cases, they have not yet understood the root cause of "what went wrong" with their efforts.

This study clearly illustrates how a critical success factor in supplier integration projects is the level of knowledge regarding the supplier's capabilities. Not only must the project team understand the supplier's ability to meet cost, quality, and ramp-up goals, but they must also assess their technology roadmap, their level of design expertise, and the volatility of change within the particular technology being integrated. In this regard, the purchasing function will play an increasingly important role. We asked the respondents about their business unit's efforts to identify, develop, and maintain a "technologically capable" supply base for competitive advantage. By this we mean suppliers who have the technologies *currently needed* by the business unit for new products and who can be expected to have the emerging technologies that the business unit will need in the future. This is an area in which purchasing can play a major role. An indication of how important purchasing's knowledge of the supply base will be in the future is that 95.1% of the respondents said that developing and maintaining a technologically capable supply base is critically important to their business unit's competitive success. Only 43.9 % of the respondents said that they currently have a more technologically capable supply base than their competitors

The latter result is clearly a cause for concern. Clearly, organizations have not paid enough attention to technology trends and may be overlooking a significant element of supplier performance. In order to capture this information, purchasing managers will need to work closely with product development teams to create new supplier evaluation frameworks that go beyond the traditional dimensions of price, quality, delivery, and service.

As these strategies unfold, the role of purchasing managers will change dramatically. Purchasing managers must become dedicated "commodity experts" and develop specialized knowledge of product family characteristics and trends. A greater focus will also be placed on relationship management and negotiation skills, particularly with regard to future technology development. Managers must have the ability to communicate effectively and will need to develop presentation and team leadership skills. Finally, managers will need to work more closely with design and technology experts in order to communicate to these parties the potential design contributions of leading-edge suppliers. Because of the complex nature of supplier integration strategies, a new breed of relationship manager will evolve, requiring a very different set of skills than in the past.

Notes

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17. G. Susman and J. Dean, *Development of a Model for Predicting Design for Manufacturability Effectiveness* (New York, NY: Oxford University Press, 1992).
18. M.B. Miles and A.M. Huberman, *Qualitative Data Analysis: A Sourcebook of New Methods* (Newbury Park, CA: Sage Publications, 1994).
19. Of the remaining 228 fax response forms that indicated they would not participate:
    - 37 indicated that they do not participate in mail surveys
    - 43 indicated that they do not integrate suppliers into new product/process/service development
    - 24 indicated that they could not respond due to confidentiality issues
    - 102 indicated that they lacked sufficient resources to complete the survey
    - 22 indicated that they did not perceive any value-added in participating

    Given the nature of these responses, non-response bias does not appear to be a factor in the pooled sample of final responses we received. That is, the sample appears to be representative of companies who are actually implementing supplier integration strategies.