Case Study

The Toyota Group and the Aisin Fire

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Together, suppliers organized to save Toyota from a devastating crisis that threatened to halt operations for weeks.

The Japanese model of long-term collaborative partnerships between firms and their suppliers has attracted much attention from business researchers and practitioners. Several U.S. and European auto-makers have attempted to establish similar partnerships of their own, seeking to reduce their supplier base and cultivate relationships with their best suppliers. As a result, the early involvement of suppliers in product-development and cost-reduction efforts is becoming standard practice in the automotive industry and beyond.

A recent crisis involving Toyota and its supplier network suggests, however, that the Japanese model — or at least the Toyota model — involves more than a set of long-term relationships between a firm and a few select suppliers. As the Toyota group's collaborative response to the sudden destruction of a key supplier's plant suggests, the relationships among a firm's suppliers are equally important. More generally, a complex mix of institutions permits self-organization during times of crisis with little need for a leader's direct control. These strong relationships among many firms along with the steady but largely invisible control of a leader promote flexible and coordinated responses to crises. In addition, they foster long-term competitiveness through decentral-
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ized, groupwide efforts to solve day-to-day problems and improve performance.

On February 1, 1997, a fire at one of Aisin Seiki’s plants threatened to halt Toyota-group operations for weeks. Aisin Seiki, one of Toyota’s most trusted suppliers, was the sole source for proportioning valves (or P-valves, in the industry parlance), a small but crucial brake-related part used in all Toyota vehicles. Because of Toyota’s and Aisin’s dedication to the principles of just-in-time (JIT) production, only two or three days’ worth of stock was on hand. A shutdown of Toyota-group plants (including those of several hundred suppliers) seemed unavoidable.

The timing could not have been worse. Toyota plants were operating at full capacity with levels of overtime and use of temporary workers unheard of in years, in anticipation of a last-minute boom in automobile sales prior to the 2 percent consumption sales tax increase slated for April 1. Every day lost meant potentially huge and irretrievable losses in sales and profits for Toyota and related firms.

Yet, remarkably, disaster was averted, and assembly plants were reopened after only two days of shutdown. The recovery was accomplished through an immediate and largely self-organized effort by firms, mostly from within but also from outside the Toyota group, to set up alternative production sites outside of Aisin. Within days, firms with little experience with P-valves were manufacturing and delivering the parts to Aisin, where they were assembled and inspected before being sent to Toyota’s and other clients’ assembly plants. The collaborative effort, which involved more than 200 firms (of which approximately sixty-two took direct responsibility for P-valve production), was orchestrated with very limited direct control from Toyota and with no haggling over technical proprietary rights or financial compensation.

The Toyota group demonstrated its cohesion and resiliency at a time when many observers were discussing the weakening of traditional ties among group members. Based on data collected through in-depth interviews with key players in the incident, we describe what took place during the Aisin Seiki crisis and how individual firms came together to orchestrate the recovery effort. We believe that the episode holds lessons for businesses adopting the Japanese model of long-term supplier partnerships as well as for businesses moving away from that model. Of course, competition for future contracts and the pressure to maintain their reputations motivated the suppliers to cooperate with each other. Nevertheless, we argue, it was the various capabilities developed through institutionalized problem-solving activities within the Toyota group that ensured the effectiveness and rapidity of the suppliers’ collaborative effort. For businesses of many kinds, the capabilities developed through committed partnerships can enhance competitiveness, driving participants to respond effectively to emergencies and to pursue continuous improvement on a daily basis.

The Aisin Seiki Crisis

At 4:18 a.m. on Saturday, February 1, 1997, a fire erupted in Aisin’s Kariya plant number one. By 8:52 a.m., the lines dedicated to P-valves and to two other brake-related parts (clutch master cylinders and tandem master cylinders) were almost completely destroyed, along with special-purpose machinery and drills that could take months to reorder. The near destruction of the P-valve lines was potentially disastrous for Toyota; nearly all of its vehicles used Aisin P-valves manufactured exclusively at the Kariya plant, which turned out 32,500 P-valves a day for Toyota and other Toyota-group assemblers such as Hino and Daihatsu as well as for Mitsubishi, Suzuki, and Isuzu.

Used in all vehicles, P-valves control pressure on rear brakes to help prevent skidding. About the size of a pack of cigarettes, the part is mass-produced using dedicated transfer lines, which keeps costs down and ensures high productivity and reliability. Although structurally simple and inexpensive, costing only between Y770 and Y1,400 apiece, P-valves require complex, high-precision machining to ensure the reliability and durability essential to the safety of any brake system.

That Aisin was the sole supplier of this small but critical part was surprising to many in Japan. To reduce the risk of the very kind of disruption it was now confronting, Toyota had increased parallel sourcing.
Its relationship with Aisin was distinctive, however. Aisin was one of Toyota’s closest suppliers in sales, personnel, and financial linkages; its outstanding cost, quality, and delivery performance record made it difficult to replace.

Toyota suddenly found itself in crisis. As a result of JIT operations, only one day’s worth of P-valves were in immediate stock. Predictably, on Monday, February 3, when assembly lines were still running, Toyota announced the following days’ shutdown of twenty of its thirty assembly lines (including those of Toyota’s contract assemblers); from Tuesday, February 4, to Wednesday, February 5, practically all of Toyota’s and most of its related firms’ plants were closed, bringing to a halt almost the entire Toyota group. As a result, hundreds of tiered suppliers who would have to wait for the reopening of their clients’ plants to resume deliveries were also affected, as were local electricity, gas, and transportation companies. Such is the fragility of JIT: a surprise event can paralyze entire networks and even industries.

How could alternative P-valve production sites be organized and the delivery of the required 32,500 P-valves a day be resumed so quickly?

Indeed, Toyota was facing one of the worst crises in its history. But on Tuesday, February 4, only three days after the fire, the first alternative volume P-valves (as opposed to prototype P-valves that had been delivered one day earlier) were rolling off temporary lines hastily set up by an Aisin supplier, Koritsu Sangyo, marking the beginning of the recovery process. As a result of this and many other firms’ efforts, by Thursday, February 6, Toyota’s Tahara and Hino’s Hamura plants were reopened, followed by the other car assembly plants affected the next day on a single-shift basis. By Monday, February 10, a little more than one week after the plant fire, all Toyota-group assembly plants were back to normal with production volumes of 13,000 to 14,000 vehicles per day. After another week, the plants were in full operation at the previously planned production volumes of 15,500 vehicles per day. At that time, the proportion of P-valves produced by Aisin itself was less than 10 percent of the total amount necessary; it gradually increased, however, reaching 60 percent by March 14 and almost 100 percent by the end of March. The bulk of the P-valve production was taking place at approximately sixty-two firms, including Koritsu Sangyo, which gave full priority to the restoration of P-valve production and often worked double shifts through weekends.

In total, the fire cost Aisin ¥7.8 billion and Toyota about 70,000 vehicles and ¥160 billion in revenues. Although Toyota officials claim to have recouped most of the lost vehicle production through increased overtime and holiday shifts, losses in the range of ¥20 billion to ¥30 billion were unavoidable, mainly because the creation of alternative P-valve sites was costly. In the end, however, Toyota and Aisin could only be grateful that group members achieved a rapid and effective recovery and averted what could have been a much more devastating incident.

The Recovery Effort

How could alternative P-valve production sites be organized and the delivery of the required 32,500 P-valves a day be resumed so quickly? We describe the roles played in the recovery by six firms, which we visited during our field research: Toyota, Aisin Seiki, Denso, Taiho Kogyo, Kayaba Industry, and Koritsu Sangyo. While these firms differ in size, areas of specialization, position in the value chain, and financial linkages to Toyota, they share several characteristics: a commitment to, and capabilities for, JIT production and the ability to solve problems at their source.

From the beginning, it was clear that until Aisin could rebuild its previous capacity, outside help would be indispensable. It was decided then that firms from both inside and outside the Toyota group would be asked to set up alternative P-valve production sites as soon as possible, with Aisin providing technical assistance, design drawings, jigs (e.g., specialized drills), machine tools, and raw materials (e.g., cast iron) salvaged from the fire. Aisin was to immediately begin setting up alternative production sites in its other plants as well.

Sixty-two firms responded to Aisin’s call and immediately began preparations to manufacture P-valves. Responding firms included twenty-two of Aisin’s own suppliers (e.g., Koritsu Sangyo); Toyota itself; thirty-six of Toyota’s regular suppliers (e.g., Toyota keiretsu firms such as Denso and Taiho Kogyo), independent
suppliers such as Kayaba Industry and Akebono Brake Industry, and firms belonging to other keiretsu such as Sumitomo Electric Industries); and four non-regular suppliers (e.g., Nabco).

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Along with these firms were about 150 others, including seventy machine-tool makers that were involved indirectly in the recovery process, since machinery, drills, fixtures, and gauges had to be found to replace the ones destroyed in the fire. Aisin asked machinery makers in Japan and beyond to gather every available machine on hand, including exhibition models taken from showrooms and equipment already promised to other clients. For the sake of fast recovery, both regular and nonregular suppliers of machinery to Aisin were called on. The cooperation of these suppliers was crucial to the success of the recovery effort; undoubtedly, many were hoping to increase sales to Toyota in the future.

Firms were asked to machine the needed parts using Aisin’s design drawings and forged blocks and to deliver them to Aisin. Then Aisin would be responsible for final assembly, quality control, and delivery to Toyota and other customers. A few firms such as Nabco, Sumitomo Electric Industries, and Akebono Brake Industry already produced P-valves of different types, but most had no experience with this particular part. One firm, the sewing-machine manufacturer Brother Industries, had never made car parts. Although the technology and skills involved in manufacturing P-valves are relatively simple, their numerous and complex orifices require highly precise machining. Without the dedicated equipment used by Aisin (which was largely destroyed in the fire), P-valve production would be slow and arduous.

The situation was discouraging; the suppliers recruited lacked sufficient tools, were mostly unfamiliar with P-valve production, and were inexperienced in responding to crises of this magnitude. The problem-solving capabilities developed through long-term collaboration and the flexible deployment of resources enabled the firms to overcome these obstacles and ensured a rapid recovery of P-valve production and of Toyota’s assembly plants.

**Preparations**

The first step involved the establishment at 5:30 a.m. on Saturday, February 1 (while the P-valve lines were still on fire), of an “emergency response unit” at Aisin to centralize and coordinate efforts to deal with the crisis in an orderly and organized manner. At 6:30 a.m., the unit was reorganized and divided into four teams, dealing respectively with production (for example, the setting up of alternative production sites), materials handling (for example, the delivery of materials to those sites), liaison with customers (for example, Toyota, which was immediately contacted), and general affairs (e.g., negotiations with Aisin’s union). The unit’s first meeting was held at noon; twenty-seven meetings subsequently took place until February 21. The second step involved contacting potential collaborators and deciding who would do what, since many kinds of P-valves were needed (there are more than 100 main types of P-valves) and available equipment and capacity differed from firm to firm. After consulting its clients on which P-valves should be given priority, Aisin started as early as Sunday, February 2 (the day after the fire), to fax design drawings to various firms that had already voluntarily offered their help (e.g., Taiho Kogyo, which had contacted Aisin on hearing about the fire on the radio) or had agreed to the request of Aisin or its clients (for example, Kayaba, which was asked for help on the day of the fire by Mitsubishi Motors and the next day by Toyota and Aisin).

In many respects, of course, the firms that “voluntarily” offered their help were forced to cooperate with Aisin and Toyota. Failure to do so might have jeopardized future business relations with Toyota-group firms; moreover, because of JIT, most suppliers were losing millions of yen every day that Toyota plants remained shut down. Still, cooperation worked both ways. For example, Toyota chose not to put pressure on Aisin to give priority to its own models to the detriment of Aisin’s other clients, such as Mitsubishi, even though it could have easily done so given Aisin’s financial and commercial dependence on Toyota. Pressuring Aisin would have yielded Toyota short-term gains, but in the long run, the parties concerned would
remember such actions and possibly retaliate in some fashion.

After reviewing the faxed design drawings, its equipment availability, and its pertinent technical capabilities, each firm had to notify Aisin of its decision on whether to participate in the recovery effort. The process was not easy because most of the firms had never produced P-valves and knew little about the technical implications of P-valve production. Moreover, the design drawings they received lacked necessary technical details for first-timers and needed to be decoded into something more readily understandable.

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To make matters worse, P-valve production had to be organized without Aisin's special-purpose machines and drills because these were seriously damaged in the fire. As noted earlier, P-valves require highly precise machining, and to manufacture more than 30,000 of them a day requires highly customized jigs, drills, and transfer machines. Instead, firms would have to rely on general-purpose machines such as machining centers to manufacture P-valves, which most firms already possessed. This method would mean much higher labor content and lower productivity than usual.

Compounding the problem, Aisin’s know-how was largely restricted to the special-purpose transfer machines, making it difficult for Aisin to instruct firms on how to manufacture P-valves by other means. Furthermore, although a few drills were salvaged from the fire, there were only enough to allocate one drill per firm, which slowed down production because the drill had to be used with extra caution to avoid breaking. Moreover, not one but many different drills were needed, and the scarce ones received from Aisin were not a perfect match for machining centers.

Yet another problem was the difficulty in controlling quality without Aisin's special-purpose gauges. To ensure the reliability and durability of the brake system, quality control is very strict, involving at least seventy inspection steps per piece. Even though Aisin was to double-check every incoming P-valve, firms had to conduct some form of quality control before delivery, using general-purpose gauges.

Finally, in the first few days of the crisis, Aisin was in a state of chaos and was difficult to contact. Indeed, so confused were conditions at Aisin that during the evening of the first day of the fire, Taiho Kogyo’s director of production control was wrongly informed that master cylinders, not P-valves, were the main problem for Aisin. Within days, Aisin installed 250 additional fixed phones and 300 mobile phones in an attempt to accommodate skyrocketing inquiries. The magnitude of incoming calls, however, overwhelmed Aisin’s capacity to respond.

Because Aisin lacked sufficient resources to provide direct assistance to every firm at once, collaborating firms had to figure out by themselves how to program their machining centers for P-valve production and find or make appropriate drills. For example, Denso scrambled for drills from all over Japan and even sourced some special ones from a U.S. maker arranged for by Denso’s Tennessee plant. Although Aisin supported these efforts as much as it could by setting up a “drill center” to coordinate drill purchases and by organizing meetings to discuss technical problems and solutions, firms had to rely largely on their own capabilities to begin P-valve production.

For all these reasons, many firms declined to help at all, judging their equipment and capabilities insufficient to manufacture P-valves. But many accepted, including Denso, Taiho, Kayaba, and Toyota, which agreed to manufacture between two and five types of P-valves each. These and other firms then immediately started preparations for P-valve production.

At this point, significant differences in the firms’ approaches to P-valve production emerged. Denso gave full priority to in-house P-valve production, and some of Denso’s other processes were temporarily outsourced to make room for P-valves. In all, about forty machining centers were made available at Denso for P-valve production. Taiho met with thirty of its suppliers the day after the fire to plan an appropriate division of labor, eventually involving eleven suppliers in the effort, with Taiho itself taking charge of the final processes. Fifty machining centers were made available at two of the firm’s three local plants.

Toyota set up temporary production sites in its Honshu plant, entrusting P-valve production to the
division responsible for experimental prototype production and machinery maintenance, whose engineers and operators possessed considerable know-how in setting up machines for new models and preparing the transition to volume production. Kayaba’s approach involved outsourcing P-values to three of its suppliers, with no actual P-value production taking place in any of its own factories. It chose three prototype specialists, the largest with 110 employees and the others with only sixteen and six employees, respectively. Originally Kayaba had contacted about ten suppliers, of which three were chosen on the basis of equipment availability and technical capabilities.

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At this stage, the collaborating firms established their own “emergency response units” to coordinate P-value production activities. A challenge for many firms was to ensure close collaboration among usually remotely related units. Kayaba set up a special team, under the direction of Kayaba’s director of production engineering, to centralize control and coordinate activities with the suppliers concerned; the team was composed of sixteen employees from the quality assurance, production engineering, and purchasing departments. Three salespeople were also dispatched to Aisin to obtain real-time information and feedback. At Toyota, the production control department was put in charge of coordinating in-house P-value production and direct assistance to Aisin.

Production Begins
The next step involved each firm completing its first prototype to send to Aisin for approval before volume production. It was a tiny second-tier supplier, Koritsu Sangyo, that first delivered its prototype on Monday, February 3, only two days after the fire.° Denso, the largest and most famous supplier in Toyota’s group, was the second to deliver a prototype on the early morning of February 5, followed by Toyota and Taiho Kogyo later that day. Kayaba’s first prototype was ready on February 6, delivered from the sixteen-employee supplier, followed by those from the 110-employee and the six-employee suppliers on February 7 and February 8, respectively.

The operational speed of the firms reflected their familiarity with Aisin or with brake-related parts and their technical capabilities with machining centers and prototype making. In all cases, however, work was complicated by such difficulties as the lack of details in Aisin’s design drawings, appropriate equipment, and direct assistance from Aisin. As a result, in making many of the production decisions, firms had to experiment and exercise judgment, which explains the variety of methods used to manufacture P-values; Taiho used two drills; Toyota used only one for a similar task. At Kayaba, two of the three suppliers, including the six-employee firm, ended up making their own drills.

Once the prototypes were approved, each firm moved to volume production. Koritsu Sangyo began volume production on February 4. Denso started volume production on the evening of February 5, with production volumes of 1,600 units a day (raised to 2,200 on February 11 under pressure from Toyota). Taiho started volume production the next day, beginning with low batches of about fifty units and gradually moving toward volumes of 2,000 units a day.

Kayaba started on February 7 with a daily production volume of 520 units. Toyota began volume production on February 6.

Solving Technical Problems
The next step involved solving the technical problems that emerged during volume production. Since Aisin was unfamiliar with P-value production by machining centers, it was unable to provide solutions on its own. A testimony to the firm’s impressive technical capabilities, Denso assumed an important role, with its engineers quickly solving one problem after another. Denso’s solutions were then disseminated to other participating firms during special problem-solving meetings organized by Aisin. Denso also modified Aisin’s design drawings and process instructions to make them more appropriate for machining centers, which Aisin passed on to other firms.

These problem-solving capabilities are the hallmark of firms ingrained with the principles of the Toyota Production System (TPS), or lean production. The capacity to disseminate solutions quickly is also characteristic of Toyota-group firms; they regularly do benchmarking studies and set up problem-solving study groups in Toyota’s supplier association, the Kyobokai, or as part of jishuken (voluntary study
group) activities, usually in the presence, and sometimes under the supervision, of consultants sent free of charge by Toyota. These efforts, along with the meetings of company presidents, the training programs and internships held for lower-tiered suppliers' employees, and the constant flow of employees among firms, permit rapid horizontal and vertical diffusion of best practices.

Despite these efforts to disseminate the newly found best practices and to standardize P-valve production, the diversity in practices persisted as some firms preferred to stick to their own methods. For example, Taiho declined five out of six design modifications proposed by Aisin because they created discrepancy problems with Taiho's existing equipment.

Once the major technical problems were solved, the firms devoted their efforts to raising productivity and increasing volume through kaizen activities. Again, years of training in TPS principles ensured that the appropriate capabilities and routines were already in place. At Toyota, for example, cycle time was reduced from more than two minutes to one minute, twenty seconds, within a few weeks, by minimizing changeover times through the presetting of the machining centers (P-valve production was still relatively slow because of limits to increasing productivity in the absence of Aisin's special-purpose transfer machines). The results of these efforts were then recorded on video to be stocked as “organizational memory” should the need to manufacture P-valves emerge again.

Flexible employee deployment and procedures, which are also associated with Toyota and many other Japanese firms, were evident throughout the effort.

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The ability of Toyota and the other firms to move quickly toward shortening set-up times and to resume full JIT production demonstrates how deeply ingrained the TPS is in these firms. For example, at Taiho, which used kanban to make P-valves and delivered them to Aisin in eight batches per day, managers stressed that this was the only way they knew how to do it.

Flexible employee deployment and procedures, which

As these examples demonstrate, the P-valve recovery effort involved more than just individual initiatives to set up temporary production sites and increase productivity. The flow of employees within and among firms, the meetings organized to discuss and disseminate solutions to technical problems, and the group-level coordination efforts exerted by Aisin's "emergency response unit" and Toyota's production control department all contributed to a successful outcome that was more than just the sum of individual efforts. These capabilities for groupwide coordination and organizational learning were revealed once again sev-
eral months after the incident, when Aisin Seiki published a booklet on how to organize the rapid recovery of production following a disaster such as a factory fire. Based on lessons learned during the crisis, the booklet was distributed to 500 firms, including all those that had joined the recovery effort and all remaining Kyohokai members. The gesture was a way of thanking the firms for their support and ensuring that mistakes would not be repeated. The lessons from the Aisin incident were thus recorded as organizational memory for all cooperating firms to use should the need ever arise.

**Settling Compensation**

P-valve production continued until March 10 for Denso, until March 6 for Taiho (with one small-volume item lasting until the end of March), until April 10 for Kayaba, until mid-March for Koritsu, and until March 15 for Toyota. Considerable expenses were incurred during the recovery process, including labor costs (which were particularly high because of the lack of specialized machinery and experience in P-valve production and because much of the work included overtime) and machinery and tooling costs.

Firms including Denso and Kayaba had begun production of P-valves without making any explicit agreements with Toyota or Aisin on eventual compensation for their expenses. There was neither time nor reason to do so. Eventually it was agreed that Aisin would fully reimburse all firms for the expenses incurred in P-valve production, including labor costs. For example, Denso would be compensated by Aisin for the more than ¥300 million in labor, equipment, special-purpose oil, and other costs. The arrangement addressed only direct expenses, however. More important were the losses in output during the closure of assembly plants incurred by Toyota and all the suppliers involved.

Toyota settled the issue in a surprising manner: it announced that all its first-tier suppliers would receive a payment equivalent to 1 percent of their respective sales to Toyota from January to March 1997. This amounted to overall payments of more than ¥15 billion, with Denso, for example, to receive ¥1.5 billion. Many of the firms viewed the offer as a reward for cooperation rather than as compensation.

Toyota’s decision was then replicated throughout the network, as most of the first-tier suppliers announced in turn that they would pass on most of these payments to their own (second-tier) suppliers, and some of these then announced their intention to compensate their own (third-tier) suppliers in the same manner.

**Lessons from the Toyota Group**

What lessons can be drawn from the Toyota group’s organized effort to recover from the Aisin fire? While the incident underscores the risk of single sourcing in a JIT setting, the chances of such an event recurring are low. Furthermore, apart from natural disasters or fires, there is usually little need for coordinated responses of the magnitude we have described here. Strikes pose different problems because the setting up of alternative sites at other firms would be viewed as interference and would generally be unacceptable to trade unions. More significant for our purposes are the implications of the recovery effort for everyday situations.

We believe that this episode demonstrates the benefits of clustered firm networks of the kind that Toyota and its partners have constructed. The Aisin incident reveals the capacity of these networks not only for self-organized, flexible responses to a crisis but also for routine problem solving that leads to incremental improvements in firm and group performance. In other words, the capabilities that made possible the reopening of Toyota-group plants in a few days instead of months are the same ones that have made Toyota and its suppliers among the most competitive in Japan and the world under normal circumstances.

A variety of institutionalized practices foster these capabilities. For example, JIT has the effect of immediately revealing bottlenecks, forcing workers and managers to continuously strive to detect and rapidly solve emerging problems. During the recovery effort, JIT made it easier to locate bottlenecks and improve the productivity of the emergency P-valve production sites. In a JIT environment, workers and managers gradually acquire capabilities for effective and pragmatic problem solving, enhancing their ability over time to deal with emerging problems. As the Aisin episode reveals, these capabilities are shared not only by Toyota and its group of first-tier suppliers (for example, Denso and Kayaba) but also by many second-tier suppliers.

These mechanisms also work at the interfirms, level and help foster groupwide problem-solving capabili-
In this case, Toyota “pulled the cord” and stopped the entire value chain, from raw materials providers to assembly plants, forcing everyone to deal immediately with the problem.

tics. Because orders from Toyota would be severely curtailed until P-value production could be restored, it was impossible for firms such as Denso or even Kayaba to ignore Toyota’s and Aisin’s troubles. Just as Toyota encourages its assembly-line operators to stop the line whenever a serious problem arises to promote rapid problem-solving at the source, so, in this case, Toyota “pulled the cord” and stopped the entire value chain, from raw materials providers to assembly plants, forcing everyone to deal immediately with the problem. The Aisin incident revealed the extent of Toyota-group firms’ capabilities for dealing effectively with such problems, which were the product of years of working in an environment where interfirm coordination and collaboration were crucial to keeping operations running smoothly.

Given the increased competition within Japanese keiretsu, it is likely that Toyota suppliers cooperated to the extent they did in the hopes of being rewarded by increased business opportunities in the future. We believe that such incentives to cooperate were insufficient, however; the necessary capabilities to cooperate effectively had to be in place as well.

Many outside observers believed that the Aisin incident revealed the vulnerability of JIT environments, arguing at the time that any unexpected problem quickly leads to the breakdown of the system. Yet neither Toyota nor any other firm that we interviewed was considering abandoning JIT. With each vehicle containing more than 30,000 parts, it is just too costly to keep security buffers for each component; indeed, any production system is vulnerable to unexpected crises such as a plant fire.

Although crises are impossible to predict, the capabilities required to overcome them effectively and rapidly can be developed in advance. The constraints imposed by JIT ensure that firms gradually make the necessary preparations, since even routine problems can become “minicrises” whose resolution leads to new learning experiences. In other words, because of its inherent fragility, firms value JIT for the role it plays in fostering problem-solving and continuous improvement capabilities, at the individual firm and overall group levels and for both routine and major problems.

Several practices institutionalized within the Toyota group support the firms in their quest to develop these capabilities: information and know-how sharing in the Kyohokai and jishukan, regular transfers of employees among group firms, and other practices involving face-to-face contact. These practices facilitate organizational learning, encourage teamwork, and foster a set of common “codes” and understandings among group members regarding technology, management, and the “rules of the game.” Thus they provide the basis for coordination and ease of communication during times of crisis and routine alike, as tacit agreements and understandings ensure that information is transmitted without having to explain everything.

Although the mutual dependence imposed by JIT, the competition for future contracts, and peer pressure to conform to group norms would seem to compel cooperative behavior, in reality, cooperation comes “naturally” in a network where firms have deep and intimate knowledge of each other. Trust was manifested throughout the recovery effort, as firms simply assumed that compensation for their efforts would be forthcoming and fair and that other firms would not take advantage of the situation to steal proprietary secrets or new contracts. Incidents such as the Aisin fire further strengthen these sentiments, as trust and reciprocity are deepened each time a crisis occurs.

Cooperation is also promoted by Toyota; as the recognized leader, it controls the general direction of the group. Toyota’s financial resources and control over the design process make it the natural leader, but in the long run, it is Toyota’s performance record that ensures that suppliers follow its suggestions and initiatives. Firms know that it pays to follow this particular leader, as suggested by Toyota suppliers’ consistently above-average profits. Moreover, suppliers accept the constant pressure to improve performance because various practices ensure that firms are not left alone to develop capabilities and that Toyota does not demand anything that it could not do itself. Toyota’s demands (e.g., cost-reduction targets) are
based on rational calculations and indisputable evidence that Toyota is invariably able to offer.

Toyota’s leadership is undisputed and omnipresent, but at the same time, it is largely decentralized and often invisible. Rather than give direct and detailed orders to its group firms, Toyota disseminates general approaches, or “recipes,” giving firms the tools to self-organize in times of crisis and deal autonomously with emerging problems. These tools are disseminated to first-tier suppliers, which are then responsible for disseminating them to their own network of second- and third-tier suppliers. In this way, similar patterns of behavior are replicated throughout the network without any explicit orders from Toyota (as exemplified by the replication of Toyota’s 1 percent compensatory bonus policy throughout the group).

An advantage of this approach is that responses may be differentiated and flexibly adapted to each firm’s particular situation, as the “recipe” leaves considerable room for discretion.

One might wonder, then, why all firms do not adopt Toyota-group practices, if the benefits are so great. The answer is that emulating Toyota’s model is not easy; it is the product of decades of investments in supplier capabilities and in trust and commitment. Even in Japan, many firms are unable to replicate either the structure or the performance of the Toyota group. Nevertheless, we believe that the Toyota model offers an excellent goal for firms to strive toward. Through earnest and persistent efforts to build supplier capabilities and promote horizontal knowledge sharing among suppliers, firms can reap substantial gains in long-term competitive performance. These efforts should be the next step for the many firms that have already begun the work of restructuring supplier relations in the direction of the partnership model. Moreover, Japanese firms currently under pressure to rationalize their supply base and adopt more market-oriented supplier management practices could also learn from Toyota. Its approach toward supply chain management gives it both flexibility and continuous cost reductions and has proved to be effective even in the current domestic recession.

References

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6. Although, in Japanese, the company’s name is pronounced “Aisin Seki,” we use the registered English name “Aisin Seiki” in this article. Sales to Toyota currently account for 65 percent of Aisin’s total sales.
7. Another interpretation might suggest that the crisis occurred at a relatively good time, that is, when Toyota profits were at their third-highest level ever due to booming sales in Japan, the recent depreciation of the yen, and cost-saving efforts in product development and other areas that have saved Toyota nearly $2.5 billion. See: B. Bremmer, L. Armstrong, K. Kervin, and K. Naughton, “Toyota’s Crusade,” Business Week, 7 April 1997, pp. 44-50.
8. In this article, the term “Toyota group” refers to Toyota’s network of core suppliers, including affiliates (e.g., Aisin Seiki), independents (e.g., Kayaba Industry), and affiliated vehicle assemblers (e.g., Hino Motors). Toyota itself distinguishes the Toyota group, composed of fourteen of its closest affiliates, from the rest of its suppliers. Toyota group affiliates and many of Toyota’s important suppliers belong to the automobile supplier association, the Koyohka (245 members); for more details, see: M. Sakai, “Suppliers’ Associations in the Japanese Automobile Industry: Collective Action for Technological Diffusion,” Cambridge Journal of Economics; volume 20, November 1996, pp. 651-671. Within this association is a core group of about sixty firms that account for 80 percent of Toyota’s total parts purchasing costs.
9. Interviews were conducted on March 24, 25, and 26, 1997, with managers of Toyota Motor Corporation, Aisin Seiki Co., Ltd., Koyo Sanyo, Ltd., Taiho Kogyo Co., Ltd., Kayaba Industry Co., Ltd., and Denso Corporation (formerly, Nippondenso Co., Ltd.).
12. Single sourcing is less common in Japan than is usually thought, as many Japanese automakers use “parallel sourcing”; see: J. Richardson, “Parallel Sourcing and Supplier Performance in the Japanese Automobile Industry,” Strategic Management Journal; volume 14, July 1993, pp. 329-350.
13. Although a particular model’s parts may be sourced to a single supplier, slightly different versions are often sourced to a competing supplier, enabling the assembler to compare each firm’s performance and promote long-term competition between the suppliers. Single sourcing is usually adopted by smaller assemblies in Japan.
14. Like Denso Corp., Aisin Seiki was originally a department within Toyota before it was spun off as a subsidiary in 1949. Toyota presently owns approximately 20 percent of Aisin shares, and several of Aisin’s executives were originally Toyota managers, including Aisin’s current president Toyoda Kanshiro (the son of Toyota Eiji, Toyota’s former president and current honorary chairman). But these formal and
informal linkages are not sufficient to explain Toyota's high reliance on Aisin. The supplier's high performance and reliability must also be considered.  

11. Toyota vehicles are assembled not only in Toyota's own assembly plants but also in plants of Toyota keiretsu firms such as Toyota Auto Body, Araco, Kanto Auto Works, Toyota Automatic Loom Works, Central Motors, Gifu Auto Body, Hino Motors, and Daidatsu Motor Co. On Tuesday, February 4, only Daidatsu's Ikeda plant was kept open. Mitsubishi, which also used Aisin P-valves and had had about two days' worth of stock, had to close some assembly lines on February 5. Isuzu and Suzuki were not affected, however, because they were able to prioritize production schedules for models not using Aisin P-valves and because they had five days' and three or four days' worth of P-valves in stock, respectively.

12. The Ministry of International Trade and Industry's estimates of the loss in output during February 1997 caused by the fire were 0.3 percent for the passenger car transportation equipment industry and 1 percent for all metal-related industries.

13. As a consequence of the Kobe earthquake in January 1995, production was curtailed for several days, but not as severely as in the aftermath of the fire. Most production equipment (e.g., jigs and fixtures, machine tools, transfer machines) of the affected Toyota supplier plants (Sumitomo Electric and Fujitsu-Ten) was salvaged intact or repaired quickly, resulting in only minor disruptions for Toyota's assembly plants and only for a few models. In contrast, Aisin P-valves, which are used in almost every Toyota model, and their assembly lines were burnt down, with three transfer machines seriously damaged. After the earthquake, no temporary production sites outside the affected suppliers were set up, since Toyota assisted them at the suppliers' own facilities.


16. Toyota (60,000 employees) is the world's third-largest automaker and Japan's largest firm in terms of sales. Both Aisin Seiki (11,100 employees) and Denso (65,500 employees) are part of what Toyota defines as the Toyota group. Aisin and Denso sell, respectively, 85 percent and 50 percent of their output to Toyota and are, respectively, 20 percent and 23 percent owned by Toyota. Like many Toyota suppliers nowadays, their clients include all Japanese automakers as well as many foreign automakers in the world. Aisin specializes in brake-related parts (and its subsidiary, WARNER-Aisin, in transmissions). Denso specializes in electric and electronic auto components and is now the world's fourth-largest automotive parts supplier. Taiho Kogyo (3,760 employees), although not formally part of the Toyota group, sells 74 percent of its output to group firms (69 percent to Toyota itself), is 58 percent owned by Toyota, and has many former Toyota managers occupying key positions, including Taiho's chairman (in contrast, Denso has only one Toyota-bred executive). Its main products are engine bearings, aluminum die-cast products, and dies. Kayaba is considered to be an independent supplier in the Japanese auto industry, both with Toyota and Nissan owning approximately the same number of its shares (8.5 percent and 8.1 percent, respectively). Its clientele is diversified, with Toyota accounting for about 15 percent of sales and Mitsubishi and Nissan accounting for 16 percent and 12 percent, respectively. Kayaba specializes in shock absorbers and hydraulic equipment and has 47 percent of Japanese and 22 percent of world market share for shock absorbers. Kurosaki Sango (320 employees) is a second-tier supplier highly dedicated to Aisin Seiki. It specializes in transmission-related parts.

17. Mainly P-valve production was to be outsourced in this way. Existing capacity to produce clutch master and tandem master cylinders in-house was deemed sufficient; these parts were not manufactured solely at Aisin's Kariya plant, whereas P-valves were. Only five firms were needed to assist Aisin with the production of the clutch master and tandem master cylinders.


19. Kurosaki Sango is perhaps an exceptional case. Aisin's president Aisin Seiki's message to its several awards for quality. It is highly dedicated to Aisin (the supplier's president wished he had had thirty hours per day instead of just twenty-four to help Aisin during this incident), the result of decades of continuous and stable relationships involving not only business transactions but also know-how exchange and capability-upgrading activities.

20. Kikyu seiso kikyu tado gado Action guide for the emergency recovery of production, Aisin Seiki Co., Ltd., 30 September 1997. The booklet was edited by Aisin's Corporate Planning Office, following the Aisin president's directive that the office record everything that happened from day one of the incident so that its lessons could be compiled for later use.

21. The booklet contained (1) a list of the major difficulties encountered during the crisis, including those caused by Aisin's mistakes (e.g., distributing drills made for special-purpose machinery that could not be found); (2) guidelines for organizing an emergency response (e.g., how to set up an emergency response unit) and various teams; (3) a list of keys on what made the rapid recovery possible; (4) a flow chart describing Aisin's efforts from the beginning to the end of the crisis; (5) a flow chart describing each team's function; and (6) detailed guidelines for each team's activities (including examples of checklists and order forms used during the crisis).

22. Hundreds of Denso employees were involved daily in P-valve production, working double shifts and weekends for the first two weeks. At Taiho, about seventy people were directly involved in emergency production efforts, including fifty-five people fully dedicated to P-valve production. At Toyota, twenty-to-thirty-five employees were directly involved in-house P-valve production, while hundreds more were sent to Aisin and other firms to assist in the recovery effort.

23. It should be noted that Toyota could afford such payments at the time because profits were higher than expected, mainly as a result of the continued depreciation of the yen. The compensation scheme can also be interpreted as having the objective of spreading the unexpected gains from the lower yen and thus averting criticisms that Toyota was monopolizing them.

24. Suggestions proposed for alleviating the risk of interruptions caused by such disasters included (1) reducing variety of parts, among other reasons because excessive variety of P-valves complicated the setting up of alternative production sites after the fire; (2) dispersing production facilities; (3) increasing education efforts toward fire and accident prevention; and (4) increasing parallel sourcing. Regarding P-valves, however, unconfirmed reports suggest that Toyota will probably continue to rely almost exclusively on Aisin for P-valves, indicating a reluctance to forfeit the major benefits of single sourcing, e.g., possibility of important cost reductions through exploitation of scale economies; simplification of parts procurement and quality-control activities; and building of trusted relationships with a reduced number of suppliers.

25. The examples of 320-employee Kurosaki Sango being the first to complete a P-valve after the fire or of Kayaba's six-employee prototype specialist that made its own drills for P-valve use are telling in this regard.


28. It should be noted that P-valves are relatively mature products and that Aisin's technology was not particularly advanced or of a proprietary kind.


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