The Limits of "Lean"

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SOME OF THE RESULTS OF CONTINUOUS IMPROVEMENT IN JUST-IN-TIME MANUFACTURING AND RAPID PRODUCT DEVELOPMENT HAVE NOT ALWAYS BEEN FAVORABLE. As the author points out, Japan is suffering from increased traffic due to JIT deliveries, a shortage of blue-collar workers, too many product variations, overly stressed suppliers, and a lack of money for new product development. This situation offers an opportunity to companies in the rest of the world to catch up to the Japanese, modify lean production and product development to create a more balanced approach, and seek competitive advantage in new areas, for example, in more flexible automation, new materials and technologies, innovative product features, and expansion into developing markets.

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Japanese competitiveness in a number of industries is the result of a combination of factors. Among the most important are a series of innovations and practices in manufacturing and product development that have been referred to as "lean": aimed at high productivity as well as high quality in engineering and manufacturing, resulting in high price-performance in the value of products delivered to the customer. This article outlines some of those innovations and practices, particularly those in the Japanese automobile industry. It then addresses two other issues: how transferable these practices are outside Japan, and what limits the Japanese themselves have encountered as they have pursued "continuous improvement" in manufacturing and product development management.

Principles of "Lean" Management

Table 1 lists the principles of "lean" manufacturing and product development. In manufacturing, these practices made it possible for Toyota and other firms that followed its approach to achieve extremely high levels of quality (few defects) and productivity in manufacturing (output per worker that was as much as two or three times higher than U.S. or European plants in the late 1980s). Japanese firms also achieved relatively high levels of flexibility by producing relatively small lots of different models with little or no loss of productivity or quality.[1] Toyota developed this small-lot, just-in-time (JIT) manufacturing approach in response to the needs of the post-World War II Japanese auto market, which was very small, with few exports, but with rapidly growing demand for different types of car and truck models.

During the late 1970s and 1980s, the nine major Japanese automakers gradually took advantage of their manufacturing capabilities to shift the primary competitive domain to product development. Led by Honda and Toyota, this shift resulted in fast development times (estimated at forty-two months compared to sixty-five months or so for the U.S. and European producers[2]), a very aggressive expansion of product lines by all the Japanese automakers, as well as adoption of full model changes every four years (a practice started in the 1950s). This rapid change and expansion of products allowed Japanese automakers to introduce new features and technologies into their vehicles more quickly than U.S. or European automakers, which generally had product replacement cycles of six to eight years or more. As indicated in Table 1, an important part of the Japanese process for product development was the relatively independent project teams led by "heavyweight" project managers who controlled the human and financial resources to determine the product's features and move it quickly through the various phases of design and into manufacturing. This Japanese system contrasted with the use of "functional" departments (such as for engine design,

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Table 1 Principles of "Lean" Management

Production (Toyota Model)

JIT "small-lot" production
Minimal in-process inventories
Geographic concentration of assembly and parts production
Manual demand-pull with kanban cards
Production leveling
Rapid setup
Machinery and line rationalization
Work standardization
Foolproof automation devices
Multiskilled workers
High levels of subcontracting
Selective use of automation
Continuous incremental process improvement

Product Development (Honda Model)

Rapid model replacement
Frequent model-line expansion
Overlapping and compressed development phases
High levels of supplier engineering
"Heavyweight" project managers
Design team and manager continuity
Strict engineering schedules and work discipline
Good communication mechanisms and skills
Multiskilled engineers and design teams
Skillful use of computer-aided design tools
Continuous incremental product improvements

body design, or manufacturing preparations), where departments would hand off work slowly to other departments, often in a sequential manner, rather than in overlapping phases guided by a strong project manager.[3]

With this combination of manufacturing and product development skills, the Japanese automobile industry overall rose to exceed the U.S. industry in total production for the first time in 1980, with over 11 million units, and continued to dominate the world industry through the early 1990s. Accordingly, this Japanese style of manufacturing and product development, dubbed the "lean" approach by former MIT student and researcher John Krafcik, has come to be studied and emulated around the world. The best U.S.-owned auto manufacturing plants have now achieved relative parity with all but the most efficient Japanese plants.[4] Some U.S. product development projects are also reported to have been completed as quickly as the average Japanese projects (though they require more people and engineering hours).

But, while U.S. and European automakers continue to study and, at least in part, emulate Japanese manufacturing and engineering practices, it has now become apparent to many Japanese managers, employees, policymakers, and industry observers that the notion of "continuous improvement" — continually pushing for gains in manufacturing and engineering efficiency — has resulted in a new set of problems and some practical limits. The Japanese automakers are now exploring ways to modify or moderate their approaches, even if they become less efficient in manufacturing or less profuse in engineering outputs. Japanese gains in manufacturing productivity and their rapid expansion and replacement of product lines may have indeed reached a limit. If so, given the improvement programs underway at U.S. and European automakers, then the best western and other Asian firms may soon approach parity with the Japanese in basic manufacturing and engineering prowess. This parity will then make it necessary for all firms to seek competitive advantage not simply by following the lean principles that everyone will know and be implementing, but by defining other domains of competition, such as new levels of manufacturing automation, new materials and technologies, innovative product features, or skillful overseas management and expansion into developing markets.

Limitations of "Lean" in Japan

Like U.S., European, and other automakers, not all Japanese companies have been able or willing to follow fully the standards set by Toyota in manufacturing or Honda in product development. Both Toyota and Honda have a unique history and geographic setting that have facilitated practices such as Toyota's famous JIT and kanban systems or Honda's product development system. Other Japanese firms, such as Nissan, encountered some of the problems that JIT and kanban create when they first tried to introduce the techniques into their own organizations during the 1970s. Similarly, no Japanese automaker has matched the product development performance of Honda (at least for models introduced in Japan). There are several reasons why many Japanese, as well as non-Japanese, firms have been unable or unwilling to follow the lean principles to their fullest extent. There are also several solutions or countermeasures to deal with the problems of lean management taken to the extreme (Table 2). The Japanese firms are currently exploring these alternatives, in autos and in other industries.

Urban Congestion and Geographical Distance

During the 1970s, Nissan discovered that the Toyota practice of having suppliers make or deliver components "just in time" to assembly lines several times a day, with deliveries controlled by the physical exchange of production or parts delivery tickets (kanban cards), did not

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Table 2 Limitations of "Lean": Japan in the 1990s

	Problems	Solutions
Production	Urban congestion Long geographic distances Overseas locations Stress on suppliers Too much product variety Shortage of blue-collar workers	Less frequent parts deliveries More electronic data transfers More computerized control systems More attention to supplier needs More parts standardization More manufacturable designs More automation More dispersed Japanese production More overseas production
Product Development	High cost of frequent model replacement High cost of frequent model line expansion Environmental and recycling costs Too much product variety	Less frequent model replacement Fewer model lines and variations Less frequent auto purchases by customers More parts and materials recycling More sharing of parts across products Less "heavyweight" project managers

work well in congested urban areas. As more and more Japanese factories in different industries have adopted the Toyota practice, traffic worsened to the point where, in the 1990s, the Japanese government mounted a media campaign encouraging companies to reduce the frequency of their parts deliveries. Traffic congestion pollutes the environment and wastes time while people are stranded in traffic and in manufacturing plants, waiting for components to arrive.

Nissan's plants have always been more dispersed than Toyota's, so Nissan management was convinced that it was indeed more practical and economical to keep a greater amount of inventory on hand than Toyota did. Nissan did this even though it had adopted the practice in the early 1950s, along with Toyota, of reducing unnecessary inventories to save on operating expenses and catch mistakes that might be hidden or take too much time to identify if parts were stored for weeks or months. Ultimately, Nissan reduced average inventories from a month to a day or so, but not to the extreme of a couple of hours as Toyota did. Other Japanese automakers in other parts of Japan encountered similar problems; traffic congestion even in formerly rural areas like Toyoda City and Aichi Prefecture (where most of Toyota's suppliers are located) has forced companies to make JIT a bit less timely.

Similarly, with companies establishing plants in different areas of Japan to escape the congestion and labor shortages in the major urban areas, the once-elegant kanban system, requiring the physical exchange of production or delivery tickets (originally by workers carrying kanban cards on their bicycles from station to station or carrying boxes of components with the kanban cards attached), is no longer practical. Suppliers now need to deliver larger loads, sometimes by ship to different islands in Japan or to North America, Europe, or other parts of Asia. It is not practical to track or control the ordering of components simply by physically exchanging kanban cards or cards attached to boxes, just as it is not practical to make and deliver very small batches of components.

Of course, the Japanese have not reverted completely to the former style of mass production. In the old system, companies made and stored a month or more of components and controlled production by inflexible schedules that "pushed" components into the system, regardless of what was happening at individual production stations, and then tracked the production process through real-time computer systems with inaccurate information. But the days when even Toyota could operate in a highly predictable and geographically small area within Japan are now over. Other companies, especially U.S. firms that made components in one state or country and shipped them thousands of miles, also noticed this limitation of the Toyota practice years ago, even though they benefited considerably, in productivity and quality, by reducing unnecessary levels of inventory and reducing delivery times from suppliers.

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Supplier Management

Another obvious limitation of lean manufacturing is the need for cooperative and reliable suppliers, which account for approximately 75 percent of manufacturing work in the automobile industry and approximately half of product development, measured by costs.[5] For the system to work, suppliers must agree to manufacture components in small lots and then deliver frequently to assembly plants — otherwise they will simply hold inventory, raising their own carrying costs and eliminating their ability to improve quality and productivity through short production runs and correction of errors or process improvements made with each new setup. As Japanese companies disperse their plants throughout Japan and other parts of the world, however, they have been able to move only some of their suppliers. Non-Japanese suppliers have not complied exactly with Japanese pricing and quality requirements, nor have the Japanese trusted foreign suppliers fully in product development.[6]

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Until the recent recession (which is lasting longer than anybody in Japan predicted), Japan had experienced a severe shortage of factory labor domestically. The Japanese government allowed foreign workers from Southeast Asia, the Middle East, and South America to come to Japan and work in Japanese factories, mostly at the smaller suppliers. This practice helped the labor shortage, but it also introduced new problems: the need to train the foreign workers and manage people with little or no literacy in Japanese. Many companies report quality problems and reductions in worker flexibility as a result of using less-skilled foreigners; this has lowered supplier productivity by forcing managers to reduce work schedules and use more inspection and rework to ensure that they still deliver high-quality components to Japanese assembly plants.

The Shortage of Blue-Collar Workers

One of the brilliant contributions of Toyota managers such as Ohno Taiichi, inventor of the kanban system and director of manufacturing operations at Toyota during its system's formative years from the 1950s through the 1970s, was to view automation with skepticism. Automation, unless it was flexible (easily changed or reprogrammed to handle different product models or variations, or volume fluctuations), introduced rigidity into production processes and was not suitable for labor-intensive assembly operations. As a result, Toyota introduced automated transfer machinery cautiously and used robots in modest numbers only in the 1980s, after they had become programmable, reliable, and inexpensive compared to human workers. Instead, Toyota relied mainly on well-trained workers and gave them broad responsibilities, such as doing much of their own inspection, preventive maintenance, and janitorial work. Line "rationalization" efforts started by Ohno after World War II also ruthlessly eliminated "waste" from all assembly and production activities, until Toyota became by far the most efficient automaker in the world, in terms of labor productivity.[7]

The incremental introduction of automated manufacturing systems meant that Toyota and other Japanese automakers that followed its lead had to rely heavily, at least in part, on large numbers of cooperative and skilled human workers. In turn, managers have asked the Japanese workers to work long hours in physically demanding production systems. The Japanese plants have also been relatively flexible, primarily in terms of their ability to produce a large variety of models in relatively small volumes, averaging around 100,000 units or less per year in the early 1990s, compared to around 200,000 units or more per year per model for U.S. and European auto producers.[8]

Today there are usually more factory jobs than there are young Japanese people willing to take these jobs. The result has been intense competition for blue-collar workers, not only by small suppliers but also by the assembly facilities of major companies. In addition, young Japanese workers leave blue-collar jobs and, increasingly, even white-collar jobs, if they feel overworked or unhappy for other reasons. For example, in the early 1990s, Toyota encountered serious difficulties staffing its factories near Toyoda City because of the severe shortage of blue-collar workers (women are still not permitted to work in most Japanese auto assembly factories) and had employee turnover rates in its factories of approximately 30 percent annually, including the seasonal hiring of temporary workers. Although this is not actually a new problem for Toyota, the labor shortage and turnover problem is likely to worsen rather than improve if the Japanese economy recovers. As a result, a necessary

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change in strategy and tactics will likely reduce the productivity advantage Toyota has enjoyed at home.

Product Variety

The virtual explosion in Japanese product variety during the 1980s and early 1990s, particularly for Japan's domestic market, enabled the most successful companies to expand their market shares and regularly convince customers to buy new versions of automobiles, video recorders, stereos, lap-top computers and word processors, microwave ovens, and dozens, if not hundreds, of other consumer products. Toyota and other companies designed JIT/kanban-like systems to facilitate small-lot production when combined with fast equipment setup or changeover times, synchronized parts production and rapid delivery, and versatile workers who can quickly move to solve problems or shift to parts lines and assembly lines for rapidly selling products.

But large engineering organizations and independent heavyweight project managers, encouraged by marketing organizations, have created too much product variety and offered too many options to customers. The result is that parts makers and assembly plants have to accommodate very small and very rare orders too frequently. This variety requires constant equipment setups and kanban exchanges, as well as many deliveries of small lots of components — just when total sales are stagnant, and workers, suppliers, and traffic systems have reached a sort of practical limit. Not surprisingly, many Japanese firms have concluded that, in the short term, they need better scheduling and control systems to handle so much variety, and, more importantly, they need to treat the root cause of the problem and reduce variety to the 20 percent or so of models and product variations that generate 80 percent of their profits and sales.

> Too much product variety has also created environmental concerns.

It has also become impractical to let the manual exchange of kanban cards "pull" new orders of components into the production system and relay all production information. There are now better methods available (such as the use of bar-code readers and other electronic forms of moving information) for plants with very high levels of variety — which covers most Japanese automakers and producers in many other industries.

Too much product variety has also created environmental concerns. Japanese automakers have been introducing replacements of existing models every four years, in addition to continually expanding their product lines, for example, into new luxury segments. Japanese government regulations and mandatory fees or maintenance charges for automobile inspection also encourage consumers to replace their vehicles every four or five years. One outcome is consistently high domestic demand for new Japanese cars and trucks. But another outcome is the need to dispose of all the replaced vehicles. Some become used-car exports to other parts of the world, but Japanese companies now realize they need to think about how to recycle automobile materials more effectively.

But perhaps the most pressing concern for Japanese managers is the cost of new model development and model replacement now that money is expensive in Japan. Bank interest rates have reached international levels, and banks can no longer make large cheap loans because their portfolios of stocks and real estate (needed as a basis for loan limits as a percentage of bank assets) and the portfolios of their customers (normally used as collateral) have declined in value. And companies can no longer raise much capital on the stock market because of the Japanese investors' reluctance to buy securities in a market that has dropped 50 percent in value during the past several years. The only source of truly "free" money — used in the past for product development as well as capital investment — is operating profits. In the current recession, however, operating profits have also declined dramatically for Japanese firms.

Thus, for the intermediate term, Japanese managers have realized that they need to reduce their overall investments in new product development (which also requires major investments in manufacturing preparations) as well as cut the amount of variety they have in components and final products. Companies in the automobile industry, for example, are now reducing unique parts and product varieties by 30 percent to 50 percent or more for new models. Japanese companies have also been reining in the heavyweight project managers, placing some limits on their budgets and discretion by establishing platform managers and chief engineers. These higher-level managers, who are above the project managers, coordinate the development of a group of technically related models, making sure that they share more key components and manufacturing facilities. These reductions in unique parts and greater sharing of components across models should ease problems in assembly plants and at suppliers, as well as save money in engineering and manufacturing-preparation costs. The risk,

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of course, is that sales will no longer grow as fast as they did when Japanese companies continually introduced streams of new models with lots of new technology and replaced old models quickly. Sales may even decline, although profits may rise as a percentage of sales if the Japanese learn how to generate more profits from each product development effort, rather than simply look for expansion of sales and market share.

Conclusion

In autos and other industries, leading Japanese companies have maddeningly pursued continuous improvement in inventory reduction and just-in-time manufacturing. They have also pursued the continuous expansion of market share through productivity and quality gains and through nonstop investment in new products and upgrading of old products. One result has been great wealth as the Japanese economy has expanded. But another result is that Japan has become a nation in "gridlock": traffic jams are everywhere as factories and retail stores all want just-in-time deliveries. Companies have trouble finding good workers. Banks have trouble making loans. Managers have difficulty finding money for new investment.

In a sense, Japanese companies are now being forced to become more like everybody else in the world: more profit oriented in the short term! How short-term profit oriented the Japanese will become remains to be seen, however. Japanese managers are accustomed to treating themselves and employees as permanent assets (due to lifetime employment and relatively little labor mobility, although these practices are changing). Managers have also tended to evaluate investments for their long-term strategic value. Nonetheless, Japanese companies are facing a host of difficulties that will make them more like U.S. and European companies and less competitive in manufacturing productivity and quality as well as in new product development. This unfortunate situation for the Japanese presents opportunities for companies in the rest of the world — in the United States and Europe, as well as in other parts of Asia, especially Korea and Taiwan. The fate of the Japanese may well depend less on what Japanese companies do than on how well other companies respond to the limitations of "lean" that the Japanese have encountered. ◆

References

1. J.P. Womack, D.T. Jones, and D. Roos, *The Machine That Changed the World* (New York: Rawson/MacMillan, 1990);
Y. Monden, *The Toyota Production System* (Atlanta, Georgia: Industrial Engineering and Management Press, 1983);
M.A. Cusumano, *The Japanese Automobile Industry: Technology and Management at Nissan and Toyota* (Cambridge, Massachusetts: Harvard University Press, 1985);
M.A. Cusumano, "Manufacturing Innovation: Lessons from the Japanese Auto Industry," *Sloan Management Review,* Fall 1988, pp. 29-39;
J.F. Krafcik, "Triumph of the Lean Production System," *Sloan Management Review,* Fall 1988, pp. 41-52;
K.B. Clark and T. Fujimoto, *Product Development Performance: Strategy, Organization, and Performance in the World Auto Industry* (Boston: Harvard Business School Press, 1991); and
M.A. Cusumano and K. Nobeoka, "Strategy, Structure, and Performance in Product Development: Observations from the Auto Industry," *Research Policy* 21 (1992): 265- 293.
2. Clark and Fujimoto (1991).
3. Ibid.
4. Womack et al. (1990).
5. Cusumano (1985, 1988);
Clark and Fujimoto (1991).
6. M.A. Cusumano and A. Takeishi, "Supplier Relations and Management: A Survey of Japanese, Japanese-Transplant, and U.S. Auto Plants," *Strategic Management Journal* 12 (1991): 563-588.
7. Cusumano (1985, 1988);
M.B. Lieberman, L.J. Lau, and M.D. Williams, "Firm-Level Productivity and Management Influence: A Comparison of U.S. and Japanese Automobile Producers," *Management Science* 36 (1990): 1193-1215.
8. Womack et al. (1990).

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